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Intelligent Environments 2017

Workshop Proceedings of the 13th International Conference on Intelligent Environments

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Introduction to the Proceedings of the Workshops of IE'17

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Intelligent Environments (IEs) refer to physical spaces into which IT and other pervasive computing technology are woven and used to achieve specific goals for the user, the environment or both. IEs have the ultimate objective of enriching user experience, better manage, and increase user awareness of, that environment.

Imagination, invention and innovation are key ideas which mark the path of research and development in the field of Intelligent Environments. The accelerating pace of today's technological developments urges the materialization of IEs with such innovative ideas and the whole community, from scientists and researchers to the general public, yearns for this. As Albert Einstein says in "Einstein on Cosmic Religion and Other Opinions and Aphorisms" (pp. 49, Covici-Friede, Inc., New York, 1931),

> "Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution. It is, strictly speaking, a real factor in scientific research."

The 13th International Conference on Intelligent Environments focuses on the development of advanced intelligent environments, as well as newly emerging and rapidly evolving topics. In the present edition, we are pleased to include in this volume the proceedings of the following workshops, which emphasize multi-disciplinary and transversal aspects of IEs, as well as cutting-edge topics:

- 6th International Workshop on the Reliability of Intelligent Environments (WoRIE'17);
- 1st International Workshop on Intelligent Systems for Agriculture Production and Environment Protection (ISAPEP'17);
- 1st Workshop on Citizen Centric Smart Cities Solutions (CCSCS'17);
- 1st International Workshop on Advanced Multiple Access in Mobile Telecommunications (AMAMT'17).

As it can be understood from this list, these workshops, organized in conjunction with IE'17 main conference, provide a forum for researchers, scientists, engineers and developers to engage in many interesting, imaginative and active discussions that will engage further research in these key areas of Intelligent Environments.

The proceedings contain a series of contributions reflecting the latest research developments in IEs and related areas, focusing on stretching the borders of the current state of the art and contributing to an ever increasing establishment of IEs in the real world.

It is our aim to inspire readers in their own work, in the hope that reading these proceedings plants the seeds for new, interesting, and original ideas.

We would like to thank all the contributing authors, as well as the members of the Organizing Committees and Program Committees of the workshops for their highly valuable work, which contributed to the success of the Intelligent Environments 2017 event. We are also grateful to the conference organizers and local staff that worked thoroughly for the success of this event.

Thank you for your esteemed help, without which this event would not have been possible.

As a final note, the Workshops Chairs would like to take the opportunity to thank Professor Jason J. Jung and Professor Andrés Muñoz, the general chairs of IE'17, and Professor Paulo Novais and Professor Sangwook Kim, the program chairs of IE'17 for their trust in our work, and all the other members of the IE'17 organization for the confidence they placed on us.

We are looking forward to seeing you all in Seoul actively participating in these exciting workshops.

August 2017
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Introduction to the Proceedings of WoRIE'17

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In this section, we compile the papers accepted for presentation at the *6th International Workshop on the Reliability of Intelligent Environments* (WoRIE'17), to be held within the *13th International Conference on Intelligent Environments* (IE'17) in Seoul (Korea) on 21-25 August 2017. The four previous editions of this workshop were held in London (United Kingdom), Prague (Czech Republic), Shanghai (China) and Guanajuato (Mexico), within IE'16, IE'15, IE'14 and IE'12 respectively, while the first one was held in Salamanca (Spain), within the *2nd International Symposium on Ambient Intelligence* (ISAmI'11). Consequently, this event is gradually consolidating as a meeting point of researchers and practitioners working on some aspects related to the development of reliable intelligent environments.

We think this is a necessary forum to build solid bridges of collaboration between the communities involved in the research and development of intelligent environments. These are systems that deploy a network of sensors, processing units and actuators in a given environment (e.g. a home, an office, a factory, a museum, a transportation system, etc.) and use a middleware, communication protocols, location/positioning techniques, smart applications, etc. to provide solutions to problems related to healthcare, social inclusion, people assistance, quality of life, lifelong learning, and intelligent and adapted transport, among other important challenges that developed societies are currently facing linked to the ageing of the population.

The scientific field of Intelligent Environments is really a multidisciplinary domain, which embraces researchers and practitioners of diverse technical areas, such as Software Engineering, Ubiquitous/Pervasive Computing, Artificial Intelligence, Human-Computer Interaction, etc. [1]. These interdisciplinary professionals will have to collaborate and work together to achieve better systems that adequately face to some of the mentioned challenges with a great impact in daily human life and solve a selection of the problems related to them.

The development of this type of systems is a complex and difficult task, and an important challenge, due to they are made up of a varied combination of very diverse components. In addition, as intelligent environments are context-aware systems, it is necessary to apply an engineering process that allows sensing and understanding the specific situations in which services or functionalities have to be provided, in order to accordingly adapt these systems [2]. We also have to think that sensors are unreliable from time to time, networks are sporadically unstable, unexpected events can happen

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occasionally, and users can put the system to the test in circumstances that were not originally foreseen. Moreover, many of these systems are specifically designed to take care of people who are vulnerable or have special needs, such as disable people, chronic sick ones or the elderly, with the aim of increasing their quality of life and supporting an independent living for them.

Consequently, we consider it is indispensable to apply the best methods, techniques and practices, such as the ones coming from Software Engineering [3] (e.g., specification, modelling, verification, validation, simulation, testing, etc.) to analyse and establish the correctness of such error-prone systems, in order to increment their reliability, safety and security, as well as to increase the user confidence in them.

In the last years, a number of methodologies, such as the ones presented in [4], [5], [6] and [7], have been proposed to improve the development as well as the reliability of intelligent environment and related (Ambient Intelligence, Pervasive/Ubiquitous Computing, Multi-Agent,…) systems. However, each is usually more focused on certain development stages and none of them has been universally adopted by the community. For this reason, we think that it is necessary a greater effort and collaboration to provide a more holistic and unified methodology.

With respect to this workshop edition, we would like to firstly thank Eun-Sun Cho for accepting our invitation to be the keynote speaker. She will give us a speech entitled *Toward more reliable intelligent environments*. The selected contributions, with a well-balanced distribution of theoretical and practical contents, will be presented right after the keynote. One of these works addresses the data sharing among smartphones using acoustic waves, in order to increase the communication security. The other paper presents a method to verify a model of a Cyber-Physical System (CPS) using Dynamic Differential Logic (DDL). In addition, Juan Carlos Augusto will give a talk on safety in Ambient Assisted Living. With all this, we hope to have a successful and fruitful workshop, where all the audience actively participate in the activities proposed. We also expect that readers enjoy the selected papers included in these proceedings. Finally, we wish to express our sincere thanks to: the authors of the submitted papers, for their very interesting and high quality contributions; WoRIE'17 Program Committee members, for their excellent work and invaluable support during the review process; and IE'17 Workshops Chairs, for their help and support. All of them have made possible to successfully organize the present edition of this workshop.

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Toward More Reliable Intelligent Environments

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Abstract. Thanks to the significant achievement in IoT, artificial intelligence, and other computer technologies, we envision big changes in our everyday lives in the near future. However, before we accept such a new world, we should ensure that having intelligence around us is not harmful to human lives. Here, we focus on dark sides of technological achievement that would harm to our future, and share some technical insights on safety supports for reliable intelligent environments.

Keywords. intelligent environments, reliability, safety, security

1. Introduction

In the near future, thanks to the significant achievement in electronic devices, artificial intelligence, networks, and other various technologies, we are expected to have big changes in our everyday lives. For instance, we envision that intelligent environments would free us from cumbersome labors, and would help to solve the current intricate problems even including climate changes and diseases. Thus, focusing on the tremendous impact expected to be made on industries, people welcome such a future image.

However, there also exist other people, who doubt that such changes are beneficial to our lives, saying that the technological products are not perfect but always with deficiencies, so in some cases would do harm to humans. Thus, before we accept the new world, what we should do as researchers in this area is to try to ensure that having intelligence around ourselves would be always positive to human lives.

Fortunately, there are various gate keepers to block seriously harmful results that would arise by new environments. Here, we focus on dark sides of technological achievement that would harm to our future, and share some technical insights on safety supports for reliable intelligent environments.

2. Technologies for Reliable Intelligent Environments

For reliability of intelligent systems with highly connected mutiple electronic devices engaged, we expect that commonly adopted methods for prevention, detection and remedy for reliable software and hardware products are also effective. First, formal verification is

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one of the popular methods especially for embedded systems which are building blocks of intelligent environments [1]. As borrowed from automata, logics and other mathematical theories, this method is used to strongly ensure that the product will not malfunction in any cases. However suffering from the lack of scalability, it is limited in real world application, except for unit devices and relatively small embedded systems. There are still a lot of efforts to extend formal methods to enhance scalabilities by collaborating other technologies and heuristics.

Building a testbed to test an intelligent system with possible scenarios before deployment might be effective as well [2]. Once a testbed is built, it can be used to ensure that the real world outcomes would not be harmful. However, it is almost impossible to build a perfect testbed that is possible to simulate all the use cases, due to the complexity of the model of the intelligent system. In addition, some of such cases are liable to cause serious problems after deployment. We expect that recent improvement in computation and networking speed would help us to get over this limitation.

Monitoring and detecting anomalies might be a good alternative; while an intelligent system is running, we would continuously watch its behaviors and detect undesirable situations if any. This method usually assumes that previous measures like formal verification and testing have already taken but failed in catching the problems. It would be even better if we can specify proper actions for the exceptional situations. However, performance degradation due to the continuous monitoring is the main defects of this method [3]. We expect that realtime stream processing technologies will help to overcome this problem [4].

In addition to safety supports, we should consider security for intelligent environments. However, unlike usual network systems and desktop computer security, it is common that the devices engaged in the intelligent environments do not have sufficient resources, not afford to recent advanced defense techniques. In addition to resource shortage problems, we should consider various sorts of heterogenous devices with different chips and vulnerabilities [5], which is also challenging.

3. Conclusions

Toward reliable intelligent systems, there are several candidate technologies for safety and security, but they should be improved together with other technologies. Thus, to get rid of negative side effects of intelligent environments, we should elaborate hard on development of such technologies.

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Creation of Communication Groups Using Sound of Smartphones

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Abstract. The development of capable smartphones and other portable devices has ushered new ways of communication and collaboration. For example, smartphones are widely used for sharing files with friends and colleagues at meeting or a conference. In this case, conventionally, short-range radio, such as Bluetooth or Wi-Fi are used. Encrypted data can be send via Bluetooth radio and be received by any devices in a 10m distance. In public places, this increases the likelihood of security breach and communication eavesdrop as the data may be intercepted by any device within range. In this paper, we propose to improve security by controlling the communication range via acoustic waves. Unlike radio waves, acoustic waves' propagation range can be controlled by modifying their amplitude; thus, it is possible to reduce the data sharing range specifically to a range of a specific device. Our preliminary tests by sharing data between two Nexus 5 smartphones indicate that it is possible to unidirectional control the sharing range while sharply reducing any possibility to eavesdrop on the communication. This increased the communication security since only devices within the specified range and direction were aware of the data sharing.

Keywords. acoustic waves, co-location, smartphone, Wi-Fi Direct

1. Introduction

Data sharing and communication has always been at the forefront of the disruptive technology since the heyday of the World Wide Web. Email, instant message, and VoIP services nearly obsoleted the need for typed letters and telegrams and have noticeably reduced the need for in-person communication. The development of peer-to-peer (P2P) communication services further improved file sharing –albeit at risk of copyright infringement. Recent communication methods were introduced due to advances in hardware and software. This further improved collaboration and data sharing. For example, cloud-based sync and sharing services such as Dropbox, Apple's Airdrop and Google Drive took collaboration and data sharing to the next level. The benefits gained from these technologies include cost and time saving, knowledge and expertise dissemination and a plethora of other benefits that would be impossible otherwise.

Traditionally, desktop computers and laptop were the main computing devices for personal and professional usage. However, a recent development of powerful mobile devices, such as tablets and smartphones, have shifted this trend. Mobile devices are commonplace while desktop computers are relegated to computation intensive tasks.

These mobile devices, unlike their desktop computer counterparts, are convenient for taking pictures, listening to music, viewing, and editing documents at anytime and anywhere. However, this flexibility comes at a cost when it comes, for example, to file sharing. Conventionally, emails and other cloudy services are used for this task. For mobile devices, however, when there is an internet traffic congestion, or in the presence of large files, it takes too long to share, and requires a prohibitively expensive mobile data. Another disadvantage of conventional communication methods is the lack of control of the sharing range which is usually established by the radio waves at approximatively 20 and 10 meters away for Wi-Fi and Bluetooth, respectively. This limitation increases security risk of eavesdropping especially in public places as radio waves can cross through walls. This also makes it difficult to define a co-location to be shared in a room since data shared via radio is always broadcasted in the radio wave range.

In our research, we propose to use acoustic waves for easy devices connecting. Our system allows to establish a communication between two nearby devices. One device shares its IP address, and the second device use it to locate and access data on the first device via Wi-Fi Direct [1], which enables Wi-Fi devices to connect directly to share files. This new approach has many advantage. First, unlike exiting radio wave based technologies, it allows to granularly control the communication range by simply increasing or decreasing the sound intensity. This improves security and reduces the possibility of hacker eavesdropping on the communication. Second, it is more versatile and compatible to all existing systems that support sound processing. NFC is also a short-range connection mean. However, its range is too short and most devices do not have NFC sensors. Using acoustic waves, we improve security and is much versatile. Third, because we use Wi-Fi Direct for data sharing, our system provides a much secure fast data sharing while requiring very little handshaking time. Further, acoustic waves do not require internet services and/or extra communication hardware. Sound can propagate as long as air molecules exist. Thus, sound is can be even used in underground indoor environments. Finally, sound can be emitted by speakers on smartphones, and obtained by microphones on smartphones. Thus, our system does not require any extra hardware. These advantages motivated us to use sound to create a shared communication space. This can be particularly useful for anonymous communication and machine to machine (M2M) communicating between Internet of Things (IoT) devices.

In this paper, we discuss the design and implementation of the sessions establishing system by acoustic waves generated by smartphones and the result of the sharing range by an output acoustic waves intensity. We also discuss the resulting added security and reliability of the communication and explore its feasibility and practicality.

2. Related Works

There is a considerable amount of work on indoor localization in the absence of GPS. Techniques of indoor localization is closely related to our work because it can be applied to the segmentation of real-world space. Chung-Hao et al. [2] used Kalman-filter-based drift removal to achieve fast and precise localization using Radio Frequency IDentification (RFID) readers and tags. In addition to the utilization of decay of wireless signals, some work uses the electrical field. Grosse-Puppendahl et al. [3] installed electrical field sensors into the ceiling of room and detected the location of a person by measuring the variation in electrical field. Thus, the person does not need to wear any

special device in the room. These indoor localization techniques necessitate deployment of some equipment in the environment, which incurs an additional cost of measurement. Furthermore, the electrical field sensor is not robust for detecting multiple people.

Finger printing is a technique to use pre-determined wireless signal strength. He et al. [4] achieved higher precision than conventional methods by combining the information about both terminals and access points.

Although these localization techniques have been improved to increase accuracy, they cannot distinguish two adjacent rooms if their border is separated by walls that penetrate wireless signals. Our work seeks a method of distinguishing different rooms.

BeepBeep [5] is a system for localization using sound emitted from smartphones. Unlike BeepBeep, we use sound for creating a communication group. Also, because we used high frequency acoustic waves, sound emitted from device does not disturb users' talking.

ChirpCast [6] is a system for distributing access keys using ultrasonic transmissions. While ChirpCast is distributing access keys for all devices in a room, our system focuses on devices in a closer range. By narrowing the connecting range, it is possible to eliminate unknown devises.

Dhwani [7] is a system for short-range communicating short using NFC. However, some devices do not have NFC readers. Also, NFC can be used within too narrow range: 20-30 cm. On the other hand, our system uses off-the-shelf microphones and speakers on the smartphones, and sound can go a few meters away by controlling the output intensity.

Since our work is using high frequency acoustic waves, it is possible to detect the co-location without passing through the wall, by controlling the sound wave output intensity, it is also possible to control the range in which the session is established. Also, since acoustic waves are outputted from the speaker built in the smartphone, and sound waves are acquired using the microphone built in the smartphone, the labor and cost of installing special sensors can be reduced. Since it is unnecessary to install a special sensor in the room, there is no restriction on the use environment, and it can be used in any space.

3. Design and Implementation

The objective of creating a common space within a certain range is collaborative work among co-located group members such as file sharing. Since we assume collaborative work with smartphones, we use Wi-Fi Direct as a communication means. Unlike traditional Wi-Fi Direct use, we choose an acoustic wave at frequency fs in a non-audible range to human for establishing a communication session. This system consists of two components: an acoustic wave sender and receiver. The sent data load consists of the IP address of the sender, synchronization signal, and parity bits for error correction.

An essential part in the system is the control of the common space by adjusting the magnitude of the emitted acoustic waves from the sender; when the magnitude of the signal is larger, the range of the common space becomes larger. A space around the sender is divided into shared and non-shared range. Within the shared range, smartphones are shared with the procedure defined in the system (Figure 1).

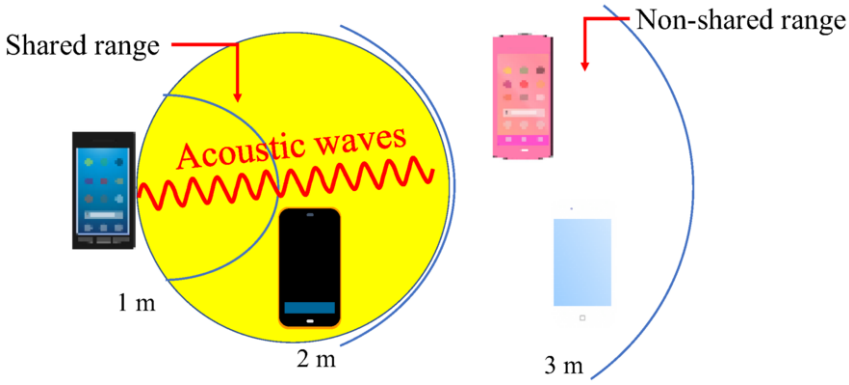

Figure 1. Dividing the space with acoustic waves.

3.1. Acoustic Wave Sender

To establish a session of Wi-Fi Direct, the sender device needs to send its IP address to a receiver device. Here, the IP address is modulated into an acoustic signal at frequency Fs, encoded using On-Off Keying (OOK), and then transmitted at an interval Td. A 1 bit is encoded by emitting a continuous sound for Td milliseconds while a 0 bit is encoded by discontinuing the sound for Td milliseconds as shown in Figure 2.

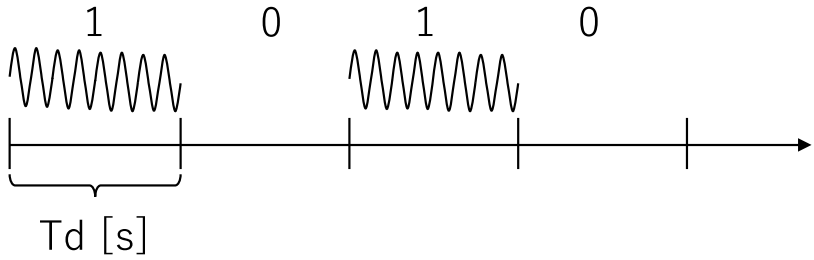

Figure 2. IP bit encoding using an On-Off keying.

By using this encoding mechanism, the IP is represented by a sequence of sounds (1 bit) and no-sounds (0 bit) to represent its 32-bit value. Additionally, to enhance the error recovery capability, we inserted five parity bits and thus the total number of transmitted bits is 39. In addition to the information bits, a preamble synchronization signal (SS) announces to the receiver the start of the transmission.

3.2. Acoustic Wave Receiver

The user places the client device in the reception standby state, and it receives the acoustic wave signal from the host device. Figure 3 shows the flow chart of signal reception and error correction.

Since the synchronization signal, which is 4 bits, exists at the head of the acoustic wave signal transmitted from the host device, after detecting the synchronization signal, the client device starts to recognize the acoustic wave signal and restores the 39-digit

numeric string from the acoustic wave signal. In addition to the IP address, the 39-digit numeric string includes parity bits and synchronization signal. P_6 judges whether the total error detection number is one or less digit, or two or more digits. Since it is impossible to restore the IP address in the case of two or more digits of error detections, it does not attempt to establish a session and returns to the reception standby state and waits for the retransmission of the acoustic wave signal. When there is one or less error detection, since error correction is possible at the client device, it confirms P_0 to P_5. When an error is detected, error correction is performed. When no error is detected at P_0 to P_5, it is determined that the sound wave signal has been properly received, and the client device restores from the binary digit string to the IP address of the host device. After restoring the IP address, the client device attempts to establish a Wi-Fi Direct session with the host device.

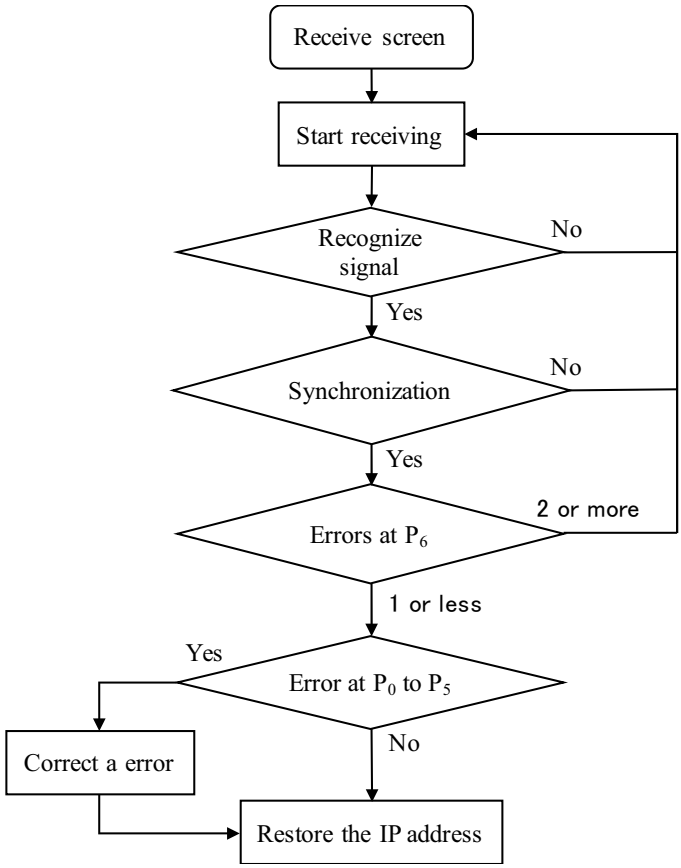

Figure 3. Flow chart of signal reception and correction.

4. Experiments and Results

To test our design, we used two Nexus 5 smartphones. One served as an acoustic wave sender. It encodes and broadcasts its IP address. The encoding is done by modulating the wave signal at fs = 19 kHz, Td = 200 ms, and SS = 0xA. Another smartphone, the

acoustic wave receiver, listens to the incoming wave signal and decodes the sender's IP to establish the communication. In these experiments, we measured the recognizable distance when changing the acoustic wave transmission output intensity. As the use environment of this system is assumed to be at noisy offices or cafes due to environmental sounds, we experimented with noise environment of 60 to 70 dB [8], which is the same noise level as noise which can occur in our daily life. In this experiment, we used a 70 Db white noise to test our range-controlled communication. In the noisy environment, we measured the recognition accuracy between the two devices, initially located at 50cm apart. Then, we increased the distance between the two devices in a 25cm increments up to 2.5m as shown in Figure 4. This accuracy was measure for three acoustic from the sender devices: -15 dB, -18 dB, and -21 dB. For each acoustic intensity, we measured the recognition accuracy of the communication between the two devices and we found that it was possible to control the range of communication between the two devices (Figure 4). In these experiments, only the recognition accuracy for the first sound wave receptions is reported and the results of the second acoustic wave receptions to the recognition accuracy is not reported.

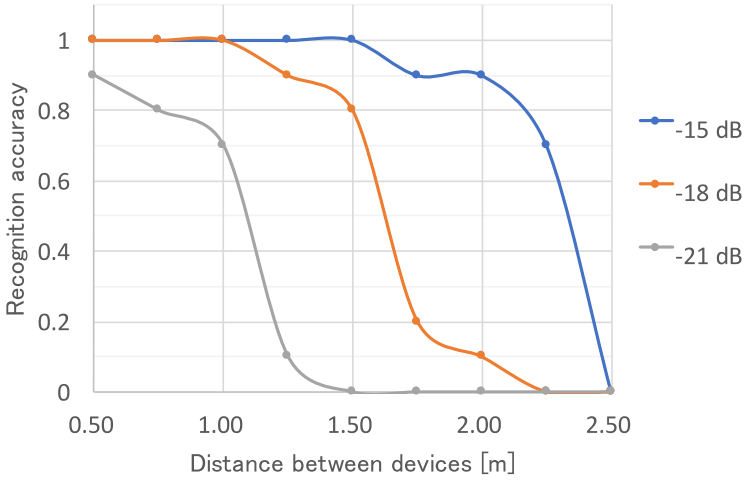

Figure 4. The results of experiments.

In our experiments, we tested at high acoustic frequency (19 kHz). Thus, the two devices could establish a communication only when they are aligned and the microphone of the host device is facing to the speaker of the client device. Indeed, high frequency acoustic waves do not propagate in all directions. Thus, this limitation further increases the communication security by reducing any possibility to intercept the communication unless the interceptor is in the sender's direction.

5. Conclusion and Future Work

In this paper, we have described a system to create a common space for collaborative work with smartphones using acoustic signals. Our preliminary study has shown that the

size of the common space can be controlled with the magnitude of the signal emitted at a sender. As shown in Figure 4, this system can adjust an output acoustic wave intensity to control the sharing range, which is shorter than a radio wave propagates. Sound can propagate as long as air molecules exist. Our proposed system defines arbitrary distance from a host device as the co-location and distinguish a device in the co-location from devices in the same room. This improve security and versatility compared to existing radio based approaches. Because this system is using a high frequency sound, directionality of the communication is much strong. Thus, it is not possible for any communication eavesdropping device to intercept the communication between the two devices. Our approach proves that acoustic wave transfers the signal to connect devices. However, at this point, in order to create a simple proof of concept prototype, we did not encrypt the signal of IP address. We will apply encrypting and Cyclic Redundancy Check to improve security and accuracy more in our future work.

In our future study, we will develop an Application Programming Interface (API) to allow an easy use of the system.

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Verifying CPS Using DDL[1]

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Abstract. With the development of sensor network and embedded system, Cyber-Physical System (CPS) integrating computation, communication and control is becoming the focus of attention gradually. Obvious problems have emerged when CPS applying to various industries. It is crucial that the designed CPS can work as expect. A growing number of researchers are concerned about the property verification of CPS since verification technique has played a key role in improving the security and reliability of systems. It is a commonly used method that transforming generic model to formal model for verification. A formal method of theorem proving has well applied to verify CPS based on Differential Dynamic Logic (DDL) which operating model named Hybrid Program proposed by A. Platzer. This paper introduced HybridUML to model CPS, presented a method to verify CPS using DDL, where model was transformed from HybridUML to Hybrid Program, and verified a case study with the resulting model finally.

Keywords. CPS, differential dynamic logic, HybridUML, model transformation, verification

1. Introduction

CPS are integrations of computation with physical processes. Embedded computers and networks monitor and control the physical processes, usually with feedback loops where physical processes affect computations and vice versa [1]. CPS has brought many opportunities and challenges to various industries, such as intelligent transportation, industrial automation, smart medical, agriculture, national defense. It is crucial that the designed CPS can work as expect. A growing number of researchers are concerned about the property verification of CPS since verification technique has played a key role in improving the security and reliability of system. There is an infinite state in CPS due to the discrete and continuous behavior while traditional model checking techniques are designed for finite state systems. Although model checking have been extended for infinite state systems in many studies [2,3,4], but still could not do well in verifying large-scale CPS. A formal method of theorem proving has well applied to verify CPS which is based on Dynamic Differential Logic (DDL) [5] which operating model named Hybrid Programs (HP) proposed by A. Platzer. Transforming generic model into a formal model for verification is a hot research field of software engineering [6]. This paper introduced HybridUML as a generic model to model CPS, presented a method based on model transformation which mapped from HybridUML to Hybrid Programs, and verified a case study with the resulting model finally. UML has no precise semantics and cannot model continuous state. As a UML extension, HybridUML has no these disadvantages.

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The rest of the paper is organized as follows. The next section presents the whole framework of CPS modeling and verification based on differential dynamic logic. Section 3 describes the verification method of differential dynamic logic. Section 4 discusses how to model CPS using HybridUML and presents the supplements of HybridUML mathematical meta-model. We build model transformation rules in section 5, illustrate the modeling and verification process with examples in section 6. Section 7 concludes the paper.

2. The Framework of CPS Modeling and Verification Based on DDL

Figure 1 shows the framework for modeling and verifying CPS based on DDL, where model transformation HybridUML to HP is divided into two parts. One is Transformation from HybridUML to HP Model, we build model transformation rules and the rule template to generate HP model; the second is KeYmaera [7] input code generation with the resulting Model from part one. KeYmaera is an automated and interactive theorem prover for a natural specification and verification logic for hybrid systems that combines deductive, real algebraic, and computer algebraic prover technologies [7]. This paper defines the transformation rules according to the relation between source meta-model and target meta-model on the basis of model transformation idea in MDA [8].

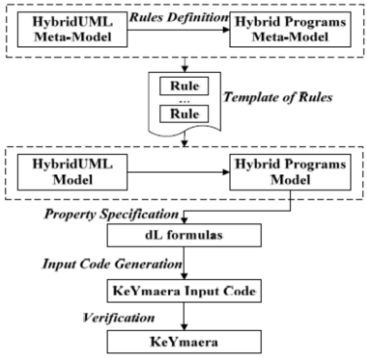

Figure 1. The framework of CPS modeling and verification based on DDL.

3. Differential Dynamic Logic

The method of hybrid systems verification using DDL with equality in theorem proving avoid the rapid increase of state space, cause its working mechanism has nothing to do with the scale of state space. The formulas of the DDL are defined as in first-order dynamic logic but with real arithmetic as a semantic domain and with hybrid programs as system models [9]. A.Platzer has presented the calculus rules of DDL formulas and the proof of its soundness. The method also applies equally to complex CPS [9].

3.1. Hybrid Programs

There are three kinds of constructs in HP: discrete jump sets, differential equation systems, control structure [9]. Discrete transitions are represented by discrete jump sets, composed of instantaneous assignments of values which connected by comma operator (,); Differential equations represents the continuous variation in system and evolution limited by the operator &; The discrete and continuous transitions are combined by regular expression operators $(\cup, ;, *)$ which stand for nondeterministic choice, sequential composition and nondeterministic repetition respectively. Here, we gives a basic HP specification as follows.

$$HPModel = (InitBlock, DJ, CE, HPSkeleton, HPContent)$$

A HP specification is a tuple with a initialize block InitBlock include variables declaration and initialization, a discrete jump set DJ and a continuous evolution CE for describing discrete and continuous transitions, a Hybrid Programs skeleton HPSkeleton, the Hybrid Programs Content HPContent consists of DJ and CE linked by control structure.

3.2. Sequent Calculus

The DDL formulas which specify CPS property are proved by sequent calculus. A sequent is of the form $\Gamma \vdash \Delta$, where the antecedent Γ and succedent Δ are finite sets of formulas, is an abbreviation of $\wedge\phi \in \Gamma\phi \rightarrow \vee\psi \in \Gamma\psi$. The order of reasoning in sequent calculus is goal-directed: Rules are applied backwards, starting from the desired conclusion at the bottom (goal) to the resulting premises (subgoals) [9]. If the expressions deduced are obviously valid, we call the system property satisfied.

4. HybridUML

HybridUML is defined as a UML 2.0 profile based on CHARON. As usual for UML, the syntax of valid HybridUML models is given by a meta-model that separates thee definition of model elements from their corresponding graphical notations [4]. The syntax is provided by meta-model and the semantics is used as in CHARON. CHARON is a kind extension of Hybrid Automata, supports the static structure and hierarchical behavior specification.

In HybridUML, the systems static structure is described by class diagrams and composite structure diagrams, both of which basic modeling element are Agent. Class diagrams contain the definition of Agents and composite structure diagrams defined the internal structure of Agents. There are two kinds of Agents: primitive and composite agents. Primitive Agents have top-level mode for behavior specification while composite Agents dont. Modes are hierarchical Hybrid Automata which contain discrete and continuous transitions. Transitions are entered or exited by control points which divided into entry and exit control points.

Modes are consisting of ModePseudostates, ModeTransitions, Constraints, etc. ModeTransitions are made up of three parts: event, guard, action. HybridUML is not restricted to be used with the HybridUML Expression Language [4] (DifferentiaExpres-

sion, AlgebraicExpression, InvariantExpression). In order to facilitate the transformation, we model CPS using HybridUML with the corresponding expressions in first-order logic.

This paper transforms the HybridUML to Hybrid Programs based on the specification defined by Bisanz in [4]. A HybridUML specification is a tuple

$HybridUMLModel$
$= (A, AI, ai_{tl}, V, \sigma_V, S, P_V, PI_V, C_V, P_S, PI_S, C_S, DT, M, MI, CP, CPI, T, Exp)$

with a set of agents A and agent instances AI, a dedicated top-level agent instance $ai_{tl} \in AI$, a set of properties V and property values σ_V, a set of signals S, a set of ports P_V, a set of variable port instances PI_V, a set of variable connectors C_V, a set of signal ports PS, a set of signal port instances PI_S, a set of signal connectors C_S, a set of datatypes DT, a set of modes M and mode instances MI, a set of control points CP and control points instances CPI, a set of transitions T, and a set of expressions Exp [4]. We add some definitions based on HybridUMLModel as follows:

1. Classification of Modes and Agents. According to whether submodes are existed in Modes, Modes are divided into primitive Modes and composite Modes. Similarly, Agents are divided into primitive Agents and composite Agents by subagents. Primitive Agents have their own behaviors while composite Agents dont. There are premises and conclusions before and after the symbol $\cdot$, the same below.
   $kind_M : M \to \{CompositeMode, PrimitiveMode\}$
   $\forall m \in M, submode_M(m) \neq \phi \cdot kind_M(m) := CompositeMode$
   $\forall in \in M, submode_M(m) = \phi \cdot kind_M(m) := PrimitiveMode$
   $kind_A : A \to \{CompositeMode, PrimitiveMode\}$
   $\forall a \in A, |behaviror_A(a) = \phi \cdot kind_A(a) := CompositeMode$
   $\forall a \in A, |behaviror_A(a) = 1 \cdot kind_A(a) := PrimitiveMode$
2. Only the primitive Agents contain top-level modes for behavior description.
   $TM_A : A \to_A (A), \forall a \in A \cdot kind_A(a) = PrimitiveAgent$
3. We already know that srcT and tarT represent the source and target control point of transition and add the definition of source Mode and target Mode of transition.
   $srcMode_T : T \to \{M \cup MI\}$
   $tarMode_T : T \to \{M \cup MI\}$
   Transitions are not only switch control between Modes and their submode instances but also between submode instances. So $srcModeT$ and $tarModeT$ must satisfy the following expressions:
   $\forall t \in T \cdot tsrcMode_T(t) \in M \vee tarMode_T(t) \in MI$
   $\wedge sreMode_T(t) \in MI \vee tarMode_T(t) \in MI$
   $\wedge srcMode_T(t) \in MI \vee tarMode_T(t) \in M$
4. According to the classification of control points, Transitions are divided into three parts: EntryTransitions, InternalTransitions and ExitTransitions.

   - EntryTransitions represent the Transitions which their source is Modes entry control points and target is Mode instances entry control points.
     $EntryTransitions_T : M \to T$
     $\forall t \in T \cdot src_T(t) \in CP \wedge kind_{CP}(src_T(t)) = enrty$
     $\vee tar_T(t) \in CPI \vee kind_{CP}(cp_{CPI}(tar_T(t))) = enrty$

- InternalTransitions represent the Transitions between Modes and their internal Mode instances.
  $InternalTransitions_T : M \to T$
  $\forall t \in T \cdot src_T(t) \in CPI \vee kind_{CP}(cp_{CPI}(src_T(t))) = exit$
  $\vee tar_T(t) \in CPI \vee kind_{CP}(cp_{CPI}(tar_T(t))) = enrty$
- ExitTransitions represent the Transitions which their source is Mode instances exit control points and target is Modes exit control points.
  $ExitTransitions_T : M \to T$
  $\forall t \in T \cdot src_T(t) \in CPI \vee kind_{CP}(cp_{CPI}(src_T(t))) = exit$
  $\vee tar_T(t) \in CP \vee kind_{CP}(tar_T(t)) = exit$

5. Consistency of Model Transformation

To maintain the consistency of HybridUML and HP is the precondition of model transformation. This paper proves the consistency with respect to both macroscopic and microscopic. From macroscopic to tell, the semantic consistency must be maintained, that is, the result model HP must satisfy the semantic of HybridUML. It is obviously that HybridUML and HP are both displayed interleave of continuous evolution and discrete transition. In the microcosmic view, the consistency means the specification languages of source model S and target model T must meet the following constraints: the equivalence of S and T semantically means the concept set of S has the equivalent concept set in T semantically, and vice versa [10]. According to this, we must assure that HybridUML and HP have the equivalent concept set. Since not all the elements of HybridUML can map to HP, we must refactor the metamodel of HybridUML and make the concept set of metamodel after refactoring has corresponding non void subset in HP metamodel. Figure 2 is the basic metamodel of HybridUML and HP we defined based on MOF standard. Mode is a hierarchical statechart extended from State and StateMachine of UML mapping to HPState of HP. Therefore, Mode must be flatted before transformation. ModeTransition in HybridUML metamodel denotes discrete transition, the source and target of transition are Mode while the source and target of discrete transition HP_D_Transition in HP are primitive state. In order to make the transition semantic equal between HybridUML and HP, we must figure out the primitive state of ModeTransition. The assignment action UpdateActivity and change event ChangeEvent of discrete transition in both metamodel are in symmetrical relationship. Differential constraints (Constraints) in Mode is mapping to HP_C_Transition means continuous evolution. There are three kinds of constraint expression in HybridUML: differentia expression (DifferentiaExpression), Algebraic expression (AlgebraicExpression), invariant expression (InvariantExpression). HybridUML is not restricted to be used with the HybridUML expression language; the application of different expression languages is possible [4]. In order to conform to the expression in HP, we choose first-order dynamic logic expression as HybridUML expression language. Based on the above, it is necessary to build transform rules in line with requirement of concept set refactoring so as to remain consistency of model transformation.

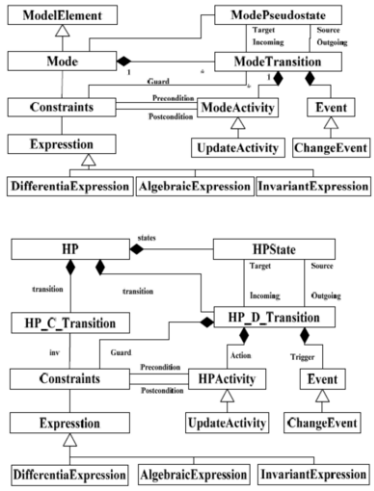

Figure 2. Metamodel of HybridUML (up) and Metamodel of HP (down).

6. Mode Transformation and Input Code Generation

In this section, we build the mode transformation rules and the template for rules application, and apply the template to get result Hybrid Programs. At last, generate the KeYmaera input code. There are two kinds of rules, mapping rules and processing rules. Mapping rules map the elements of source meta-model to target meta-model while processing rules process the source model to intermediate or optimize it for convenience. The common pseudocode is chosen as the rules description language. For instance, control structure contains if...thenelse, while, for each...in, etc. Operator means assignment and so on. The format of transformation rules is shown in Figure 3. In Figure 2, RuleType means the type of rule include MappingRule and ProcessingRule; The variables and data structure of rule are declared in declaration part; The main body of rule is in mapping/processing part; Reture Result part return the rule result.

Transforming from HybridUML to Hybrid Programs mainly involves rules of static structure and rules of dynamic behavior.

```
Ruletype RuleName {
  [Rule Input]
  // Application object of Rule
  [Declaration]
  // declaration part
  [Mapping / Processing]
  // mapping or processing part
  [Return Result]
  // mapping or processing result
}
```

Figure 3. The format of transformation rules.

6.1. Transformation Rules of Static Structure

Agents are the basic element of static structure in HybridUML model. This paper focuses on only one Agent contains continuous behavior among Agents.

6.1.1. Shared Variables Table Building

Variables have their own scope in Agents and share their value via variable connectors among different Agents. There are only global variables in Hybrid Programs which mean that all variables scope is the whole program. To avoid the shared variables are treated as different ones, we build a shared variables table named SharedVariableTable for the sake of signing each shared variable. Each line of SharedVariableTable contains the variable ports and corresponding variable names. The rule of build SharedVariableTable named CreateSharedVariableTable.

6.1.2. Static Structure to HPSkeleton Transforming

Composite Agents dont have their own behavior while primitive Agents do. We focus on only one Agent contains continuous behavior among Agents. In Hybrid Programs, concurrency of Agents is handled as follows. Suppose that AP is a set of primitive Agents, $A_P \in A \cap AI, \forall a \in A_P \cdot kind_A(a) = PrimitiveAgent$. If $a_0 \in A_P$ is a primitive Agent which has continuous behavior, the decisions of AP only depend on the point in time when other Agents only have discrete behavior, not on the communication latency. Thus, the nondeterministic interleaving in CPS where either the A_P or ($\cap$) other Agents chose to take action faithfully models every possible arrival time without the need for and explicit (delayed) channel model. The indicates that the interleaving of A_P and other Agents repeats arbitrarily often [6]. The rule of transform static structure to HPSkeleton named MappingStructureToHP.

6.2. Transformation Rules of Dynamic Behavior

Composite modes must be flattening to primitive modes according to the semantic consistency requirement of model transformation. The rule which submodes inherit all the constraints of its parents mode recursively till the top-level mode named MergeConstraints.

6.2.1. Hierarchical State Chart Flatting

In HybridUML, the modes contain source and target control points of transition may be primitive mode or composite mode, and the control points may be junction, according the source and target state of transition are all primitive state in HP. So the hierarchical state chart which composed by modes must be flatting to primitive state charts. After the rule of MergeConstraints, every mode of state charts in HybridUML has inherited its parents modes constraints. For each transition of state charts, if the source or target mode of transition is composite mode then search up or down to find the final primitive mode. In the process of searching, if the source control point of transition t2 is the target control point of transition t1, then add the transition which source control point is the source control point of t1 and target control point of t2 to the transition set T. After this operation, delete t2, t2 from T. This rule named CreateTransitionPath. For each transition in transition set T in HybridUML, if the target control point of the transition is junction, then apply rule CreateTransitionPath to every transition which target control point is the junction till all the junction have been eliminated. And condition must be satisfied:

$t \in T \cdot kindCP(cp_{CPI}(src_T(t))) \neq junction \vee kind_{CP}(cp_{CPI}(tar_T(t))) \neq junction$

This rule named EliminateJunction. The rule for flatting hierarchical state chart named FlatHierarchyMode.

6.2.2. Transition Transforming

There are only primitive modes and transitions between them in HybridUML after flatten. The entry transitions of top-lever mode are mapping to InitBlock of HP, primitive modes and the transitions are mapping to CE and DJ of HP respectively. The rule is named MappingETtoInitBlock.

We defined TransitionGraph to signify the primitive modes and the transitions between them, correspond to HPContent of HP. TransitonGraph is defined as follows in detail.

Definition 1. TransitionGraph(M_{TG}, T_{TG}) is direct graph which is a made up of primitive modes and transitions between them. The set of vertex M_{TG} is the set of primitive mode of HybridUML, $m \in M_{TG} \cdot kind_M(m) = PrimitiveMode$, and T_{TG} is the set of edge satisfy $t \in T_{TG} \cdot kind_M(srcMode_T(t)) = PrimitiveMode \vee kind_M(tarMode_T(t)) = PrimitiveMode$, the relationship between edges $t = \{< v, w > | t \in T_{TG} \cdot v = srcMode_M(t), w = tarMode_M(t)\}$ represents the transition which source mode is v and target mode is w.

TransitionGraph contains two kinds of dynamic behavior of HybridUML: discrete transition and continue evolution, which are responses to discrete jump and continue evolution in HP. The discrete transitions include trigger event, guard, action are mapping to corresponding element in HP. In order to mark the current active state in HP, we add a variable ActiveState in InitBlock. During the transition transforming, firstly, we compare the mode which current transition belongs to with ActiveState, if it is equal then guard of transition will be judged. And then ActiveState will be assigned the value of target mode of transition after transition action finished. The rule of transition transforming is named MappingTGtoHP.

6.3. Template of Rules Applied

We have builded model transformation rules already. To organize those rules, a template of rules applied is needed. Before build the template, we give two methods: method RenameSharedVariables sets the shared variables same name and method MergeHPModel merges the part of HP which every primitive mode transformed.

6.4. KeYmaera Input Code Generation

After model transformation, we can do the verification use the resulting HP manually. It must be formatted to fit the KeYmaera. A basic KeYmaera input code format is shown in Figure 4. The text between # is the annotation for that area. InitBlock in HP is corresponding to variable value declaration and variable declaration area. And HPSkeleton and HPContent are mapping to dynamic behavior area. DDL formula area represents the system property expressed in terms of DDL formula.

7. Case Study

European Train Control System Level 3(ETCS-3) is guided by moving block principle [11]. Trains are only allowed to travel in the giving MA (Movement Authority). The RBCs (Radio Block Controller) update the MA dynamically based on the current track

```
\functions {# Variable value declaration#}
\problem {
  \[ # Variable declaration # \]    (
     # Initial condition #
-> \[  # dynamic behavior #
     \] # dL formular # )
}
```

Figure 4. KeYmaera input code format.

situation using wireless communication. Figure 5 illustrates the dynamic assignment of MA. Trains speed can be regulated freely in the far mode, and then it switches to *neg* (negotiation) mode for MA extensions from ST (start taking). If there is no new MA updated after SB point, it starts braking in *cor* (correcting) mode.

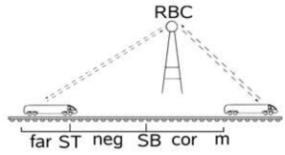

Figure 5. Dynamic movemnett authorities of ETCS.

This case verifies the safety of the ETCS cooperation protocol, that is, whether train can move within MA always. Firstly, use HybridUML to model ETCS, and get state-chart diagram in Figure 6. In the HybridUML model, ETCS is made up of Train agent and RBC agent. Agent Train has continuous behavior while agent RBC only has discrete behavior. Variable A and b represent maximum acceleration and maximum deceleration of train; Variable m represents the value of current MA; Variable z and v represent trains position and velocity in current MA; Variable t is the safety moving time determined by automatic train protection unit dynamically; Variable *message* means whether the train is in emergency situation; Variable *recommedspeed* means the recommend speed is current MA, train must slow down when v beyond this value. Variable *message* and *recommedspeed* are shared between agent Train and RBC in composite structure diagram. When the current position of train beyond SB, we calculate the minimum value of SB using Eq. (1) through KeYmaera.

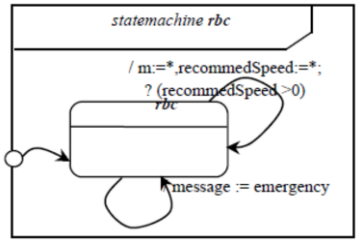

Figure 6. Dynamic movemnett authorities of ETCS.

$$(\forall m \forall z (m-z) \geq SB \wedge v^2 \leq 2b(m-z) \vee v \geq 0 \vee b \geq 0 \vee A \geq)$$

$$\rightarrow [a := A; z' = v, v' = a, t' = 1 \& v \geq 0 \vee t \leq \varepsilon](z \leq m)$$

$$\equiv SB \geq \frac{v^2}{2b} + (\frac{A}{b} + 1)(\frac{A}{2}\varepsilon^2 + \varepsilon * v) \quad (1)$$

The safety of ETCS is specification by DDL formula as follow:
$\Psi \rightarrow [ETCS^*]z \leq m$
$\Psi \equiv ActiveState = drive \vee v^2 \leq 2b(m-z) \vee b > 0 \vee A \geq 0$

$$ETCS \equiv (ctrl; drive) \cup rbc, ctrl \equiv \sigma_1 \cup \sigma_2 \cup \sigma_3 \cup \sigma_4 \quad (2)$$

In Eq. (2), Ψ is the initial condition. There are lots of branches while reasoning, and the process ends when all the branches are reduced to an obviously expression. It costs 236 steps to reduce in KeYmaera, generate 10 branches in all. To sum up, we know that train will stay within its MA all the time when the initial condition Ψ is satisfied. There will not be any crash when all the train moves in its own MA and the train cooperation protocol is safe.

8. Conclusion

In this paper, we propose a CPS modeling and verification method based on DDL. According to the method, we not only get unified model that comprehended by most of system designer easily but also can verify CPS property through DDL reasoning rules using automating theorem prover KeYmaera.

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1st International Workshop on Intelligent Systems for Agriculture Production and Environment Protection (ISAPEP'17)

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Preface

1st International Workshop on Intelligent Systems for Agriculture Production and Environment Protection (ISAPEP'17)

Two of the most important worldwide challenges we need to face are to increase food production and protect the environment against challenges such as climate change and environmental degradation. This requires the development of optimum environmental management strategies supported by the access to better information on environmental media condition (e.g., soils, waters, sediments, wastes). In order to fulfil this requirement, there is a need to increase the spatial density of environmental media data to ensure their right characterisation in a timely manner. This demand is enhanced by the fact that environmental media are highly heterogeneous and diverse temporally. Due to the high cost and time of traditional laboratory analysis, environmental sampling is often restricted. This increases the possibility of having undetected contamination and poor environmental media characterisation leading to environmental degradation and reducing the profitability of economic activities (e.g., agriculture). Intelligent systems represent alternative analysis tools by providing cost effective, rapid and real time measurement of environmental media, resulting in a new era for their characterisation and assessment. The development of this field offers an exciting opportunity for science advance and commercial application to capture the benefits of new technologies to assist the management of global environmental and economic problems. This development has applications in a wide range of areas (e.g., mining, contamination, agriculture, industrial processes) and requires the input of a number of disciplines (e.g., mathematics/statistics, telecommunications/informatics, environmental sciences). In this context, the use of intelligent systems will be paramount to understand, optimize and automate agricultural and environmental processes.

This workshop focuses on the use of intelligent systems to overcome the issues related to the lack of productivity of farming systems and environmental degradation. This involves the integration of solutions from different disciplines such as engineering, telecommunications, mathematics/statistics and agricultural, environmental, and computer science. The workshop represents an opportunity to debate the state-of-the-art, cutting-edge challenges and the collaborations required. Areas of interest include, but are not limited to: Agriculture Information Technologies, Smart farming, Precision agriculture, Environmental degradation assessment and rehabilitation, Environmental monitoring, Linking environmental characterisation and broad management, Intelligent forecasting applications, Intelligent applications for ecological disaster management, Intelligent waste management, Sensor development, Multi sensor and data fusion.

Nine high quality manuscripts have been accepted and will constitute a sound frame for scientific discussion. Each submission has been carefully reviewed by, at

least, two different reviewers, from an international committee composed of 21 members from 8 different countries. The accepted manuscripts cover a wide range of topics such as estimation and characterization of crops using fuzzy logic, image processing or near-infrared spectroscopy, the use of social sensors to detect environmental problems, to the automatic classification of soils by means of ontologies and computer-based reasoning processes.

This workshop has an associated open Special Issue in Biosystems Engineering (I.F.: 1,997) entitled "Intelligent Systems for Environmental Applications" and the information can be accessed through the following website: https://www.journals.elsevier.com/biosystems-engineering/call-for-papers/call-for-papers-on-special-issue-intelligent-systems.

We would like to thank all authors who submitted contributions and members of the Programme Committee. Welcome to ISAPEP'17, we hope you enjoy your stay in Korea, the workshop and find the papers relevant, useful and informative.

Andrés Muñoz (Universidad Católica de Murcia, Spain)
José Martín Soriano-Disla (Universidad Politécnica de Cartagena, Spain)
ISAPEP'17 Workshop Chairs

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Prediction of Soil Sand and Clay Contents via Visible and Near-Infrared (Vis-NIR) Spectroscopy

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Abstract. Visible and near infrared (Vis-NIR) spectroscopy is a non-destructive analytical method that can be used to complement, enhance or potentially replace conventional methods of soil analysis. The aim of this research was to predict the particle size distribution (PSD) of soils using a Vis-NIR) spectrophotometry in one irrigate field having a vertisol clay texture in the Karacabey district of Bursa Province, Turkey. A total of 86 soil samples collected from the study area were subjected to optical scanning in the laboratory with a portable, fiber-type Vis–NIR spectrophotometer (AgroSpec, tec5 Technology for Spectroscopy, Germany). Before the partial least square regression (PLSR) analysis, the entire reflectance spectra were randomly split into calibration (80%) and validation (20%) sets. A leave-one-out cross-validation PLSR analysis was carried out using the calibration set with Unscrambler® software, whereas the model prediction ability was tested using the validation (prediction) set. Models developed were used to predict sand and clay content using on-line collected spectra from the field. Results showed an "excellent" laboratory prediction performance for both sand (R^2 = 0.81, RMSEP = 3.84% and RPD = 2.32 in cross-validation; R^2 = 0.90, RMSEP = 2.91% and RPD = 2.99 in the prediction set) and clay (R^2 = 0.86, RMSEP = 3.4% and RPD = 2.66 in cross validation; R^2 = 0.92, RMSEP = 2.67% and RPD = 3.14 in the prediction set). Modelling of silt did not result in any meaningful correlations. Less accurate on-line predictions were recorded compared to the laboratory results, although the on-line predictions were very good (RPD = 2.24-2.31). On-line predicted maps showed reasonable spatial similarity to corresponding laboratory measured maps. This study proved that soil sand and clay content can be successfully measured and mapped using Vis-NIR spectroscopy under both laboratory and on-line scanning conditions.

Keywords. PLS regression analysis, sand, clay, Vis-NIR spectroscopy

1. Introduction

Soil is one of the most important natural resources on the earth, and it has numerous characteristics resulting from the effects of climate on parent material in a specific topography and from biotic activities over a certain period of time. For sustainable land management, it is necessary to understand the characteristics of soils, their functions and spatial and temporal changes [1, 2]. It is possible to determine the physical, chemical and biological properties of the soil in order to reveal its potential as well as its limitations for agricultural and non-agricultural land use.

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Soil texture, represented by the distribution of the size of mineral particles in the soil (particle size distribution - PSD) is one of the most basic static physical properties of soils. Soil texture can exhibit significant spatial variation within a land area. Simply defined, soil texture is the proportional distribution of sand, silt and clay particles in a soil mass. Many factors are affected by soil texture, including plant growth and yield, the infiltration of water into the soil and its storage, retention and transport, the availability and absorption of plant nutrients, living organisms in the soil, soil quality and productivity, soil temperature, structure and compaction levels, tillage, irrigation, and the effectiveness of fertilizers. Thus, the concept of soil texture has a much greater importance beyond its simple definition and plays a key role in agricultural production. Measuring the spatial variation in soil texture can be of great benefits to site specific land management.

Many soil analysis laboratories generally use the traditional hydrometer and pipette methods to determine PSD. Some errors may result from the use of these methods in routine laboratory analysis. In their particle size analysis study, Klein et al. [3] observed that the highest numbers of particle size fraction classification errors were found in those made for silt and clay. In addition, it has been reported that the inconsistency of obtained clay fraction values was due to the difficulty involved in laboratory analysis of the dispersion of clay particles [4]. The traditional analysis methods for PSD used in soil laboratories are expensive, labour-intensive and require more preparation, especially when working with a large number of soil samples. Moreover, since the analysis process takes considerable time with these methods, they are not practical for application in precision agriculture, high resolution soil mapping or in soil surveys carried out over large areas. Therefore, alternative methods need to be developed for the determination of the proportions of soil mineral fractions. In recent years, various electromagnetic radiation techniques have been used in the prediction of a number of soil properties, and it has been reported that visible (Vis), near infrared (NIR) and mid infrared (MIR) spectrophotometry, nuclear magnetic resonance (NMR) and mass spectrophotometry (MS) could complement traditional laboratory soil analysis methods as alternative techniques [5]. The main components of the soil such as its clay content and mineralogy, the amounts of organic matter and iron oxides and soil moisture, texture and particle size directly affect the spectral behavior of the soil [6, 7]. Vis-NIR reflectance spectroscopy shows promise as an alternative method, making it possible to measure many soil properties at the same time. When compared to traditional laboratory analyses, Vis-NIR reflectance spectroscopy results have been successful to a degree in the determination of soil physical properties like bulk density, soil texture and structure [8, 9, 10], but more successful in the determination of soil content of total nitrogen different forms of carbon, cation exchange capacity (CEC) and soil chemical properties such as pH and P [11, 12, 13, 14, 15, 16, 17]. The Vis-NIR reflectance spectroscopy method is readily adaptable for both in-laboratory and in-situ measurements, and requires very little or no soil preparation using chemical reagents. It is a quick and inexpensive method that does not destroy the sample [11, 18, 19]. Laboratory and in situ applications are possible with the Vis-NIR spectroscopy for the analyses of soil. However, no study on on-line measurement of soil texture fractions can be found in the literature, although measurements under laboratory conditions were performed by many researchers using the Vis-NIR spectroscopy.

The aim of this study was to determine the potential for use of Vis-NIR spectrophotometry in the prediction of the PSD (sand, silt and clay) of the soil under non-mobile (laboratory) and on-line (mobile) measurement conditions.

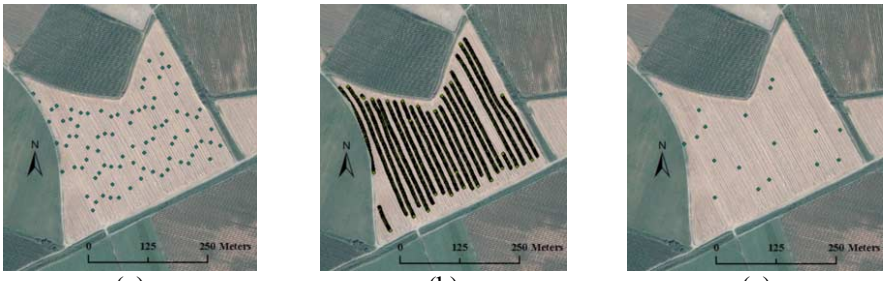
2. Materials and Methods

2.1. On-line soil sensor

The on-line sensor system consists of a subsoiler with an optical probe mounted on the rear of a subsoiler, installed on a tractor-pulled framework [20]. The system was produced at Uludağ University in Bursa, Turkey, using the same design patented by Mouazen [20]. A mobile, fiber type, AgroSpec Vis-NIR spectrophotometer (tec5 Technology for Spectroscopy, Germany) was used to measure soil spectra. A differential global positioning system (DGPS) (EZ-Guide 250 Trimble, USA) was used to record with submeter accuracy the on-line measured spectral positions. In the spectral measurement system, AgroSpec software (tec5 Technology for Spectroscopy, Germany) was employed for the simultaneous collection of the spectral and GPS data.

2.2. Study area and on-line measurement

This study was carried out on a 10.06-ha area of agricultural land in the district of Karacabey in Bursa Province, Turkey. A total of 86 soil samples were collected from the bottom of trench opened by the subsoiler in the study area during the on-line measurement. While the tractor was moving at a speed of approximately 3 km/h^{-1}, the raw reflectance values were collected from the bottom of the trench opened along straight lines parallel to each other with 10 m interval. For the purpose of validation, at approximately 20 m intervals along these lines, soil samples were collected from the bottom of the furrows, and then put in nylon packets and numbered for laboratory analysis. The locations of the points where the samples were taken were recorded via DGPS. The sampling lines and sampling points are given in Figure 1.



(a) (b) (c)

Figure 1. (a) Soil sampling points; (b) on-line soil measurement transects; (c) validation points (Ulusoy et al., 2016)

Each of the 86 soil samples taken from the study area was divided into two parts. One part of the soil sample was used for the laboratory reference PSD measurement, while the second part was used for optical scanning in the laboratory. The PSD was determined using the Bouyoucos hydrometer method [21]. According to the results of the PSD analysis, the texture classes of the soil were determined using the classification system of the United States Department of Agriculture (Table 1) [22].

Table 1. Particle size distribution (PSD) of study area soil

Area (ha)	Crop	Texture class	Sand (%)	Silt (%)	Clay (%)
10	wheat	Clay	26.6	30.4	43.0

2.3. Optical measurement in the laboratory

The soil samples were scanned in the laboratory using the same Vis-NIR spectrophotometer (AgroSpec, tec5 Technology for Spectroscopy, Germany) employed during on-line measurements in the field. After collection, root residues, stubble and gravel were removed and each soil sample was then thoroughly mixed before being scanned with the Vis-NIR spectrophotometer. The soil sample was then distributed into three plastic cup, each having a depth of 2.5 cm and a diameter of 4.7 cm, and the soil was carefully levelled in order to ensure a smooth scanning surface for the soil in the containers [23]. Before beginning the soil sample scanning process, a 100% white reference was scanned by the spectrophotometer and this was repeated every 30 min. Each of the soil samples in the containers was scanned 10 times and the average of the readings was considered for further analyses. By taking the average of the three reflection values collected from the three containers, the final reflection value to be used in determining the properties of the soil sample was thus obtained.

2.4. Modelling

Before the partial least square regression (PLSR) analysis, the entire sample set (86 samples) were randomly split into calibration (80%) and validation (20%) sets. A leave-one-out cross-validation PLSR analysis was carried out using the calibration set with Unscrambler® software, whereas the model prediction ability was tested using the validation (prediction) set. The calibration and prediction sets of the sand and clay measured in the laboratory and on-line and the sample statistics are given in Table 2. Calibration models were developed for the three texture fractions, namely, sand, silt and clay. Calibration models were validated using the spectra of the validation set, scanned in the laboratory under stationary conditions and in the field under mobile on-line conditions. These calibration models were used to predict sand and clay content using on-line collected spectra from the field. Since no correlation for silt content was possible with the PLSR cross-validation, no model was established and on-line prediction of silt was excluded.

The evaluation of model performance was made by examining R^2 value, the root mean square error of prediction (RMSEP) and the residual prediction deviation (RPD).

Table 2. Sample statistics for calibration and prediction sets of laboratory and on-line measured sand and clay

		Sample number	Min (%)	Max (%)	Mean (%)	SD (%)
All samples	Sand	86	12.4	55.8	24.57	9.03
	Clay	86	23.3	62.3	45.85	9.08
Cross-validation set	Sand	68	12.4	55.8	24.20	8.95
	Clay	68	23.3	62.3	46.08	9.06
Laboratory prediction set	Sand	18	13.93	49.9	25.96	9.45
	Clay	18	24.3	60.3	44.99	9.37
On-line prediction set	Sand	18	8.88	49.7	26.10	9.78
	Clay	18	24.67	59.9	44.29	9.42

2.5. Development of sand and clay maps

Five categories of sand and clay maps were developed. These included: (1) a laboratory analysis map based on the laboratory measurements of 86 points, (2) a map of the laboratory prediction set (18 points), (3) an on-line prediction map based on 18 verification points, (4) a map of laboratory reference values for 18 points and (5) an on-line Vis-NIR map based on all 8486 predicted measurement points. The kriging method after semi-variogram analysis was employed to draw the on-line map showing all the predicted points, while for the other maps, the inverse distance weighing (IDW) interpolation method was used. All maps were generated via ArcGIS 10 (ESRI, USA) software [24].

3. Results and Discussion

3.1. Calibration and prediction model performance

The performance of the PLSR model in cross-validation and the laboratory and on-line predictions for the sand and clay content of the study field is shown in Table 3. According to the classification of RPD values suggested by Viscarra-Rossel et al. [11], the performance of the sand model in the cross-validation is classified as "very good" (R^2 = 0.81, RMSEP = 3.84 and RPD = 2.32).

Table 3. Sand and clay model performance in cross-validation, laboratory and on-line predictions

		R^2	RMSEP (%)	RPD	Intercept	Slope
Cross-validation set	Sand	0.81	12.4	2.32	4.27	0.73
	Clay	0.85	23.3	2.66	6.55	0.92
Laboratory prediction	Sand	0.90	12.4	2.99	3.04	0.87
	Clay	0.91	23.3	3.14	6.48	0.85
Cross-validation	Sand	0.80	8.88	2.24	7.17	0.73
	Clay	0.82	24.67	2.31	11.4	0.72

RMSEP: Root mean square error of prediction
RPD: Residual prediction deviation

The performance of Vis-NIR prediction set model for sand content under on-line measurement conditions are not as good as those under laboratory measurement conditions. According to the classification of RPD values suggested by Viscarra-Rossel et al. [11], the on-line prediction model, with RPD of 2.24, is classified as "very good" (RPD 2.0 – 2.5), while the laboratory prediction model, with RPD of 2.99, is classified as "excellent" (RPD > 2.5). Scatter plots of the cross-validation set, laboratory and on-line validation results of sand content are given in Figure 2.

The performance of Vis-NIR prediction set model of for sand content under on-line measurement conditions are not as good as those under laboratory measurement conditions. According to the classification of RPD values suggested by Viscarra-Rossel et al. [11], the on-line prediction model, with RPD of 2.24, is classified as "very good" (RPD 2.0 – 2.5), while the laboratory prediction model, with RPD of 2.99, is classified as "excellent" (RPD > 2.5). Scatter plots of the cross-validation set, laboratory and on-line validation results of sand content are given in Figure 2.

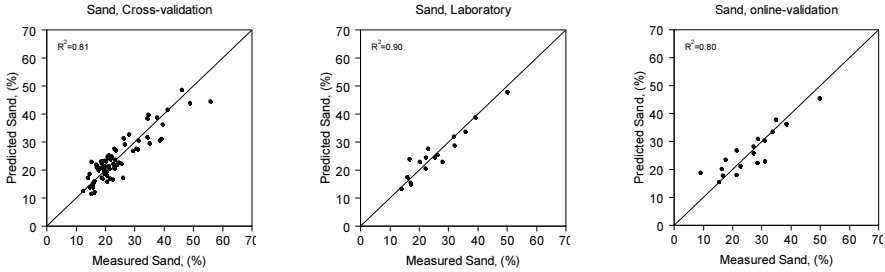


Figure 2. Scatter plot of predicted versus laboratory-measured sand of (a) the cross-validation set, (b) the prediction set for 18 laboratory-scanned samples, and (c) the prediction set for 18 on-line-scanned samples

Just like with the sand, the performance of Vis-NIR models for the prediction of clay content under on-line measurement conditions are not as good as those under laboratory measurement conditions (Table 3). According to the RPD classification system of Viscarra-Rossel et al. [11], the on-line model, with an RPD of 2.31, is classified as "very good", while the prediction model based on measurements made in the laboratory, with an RPD of 3.14, is classified as "excellent" (RPD value > 2.5).

The clay content measured in the laboratory versus the predicted clay content in the prediction sets of soil reflection spectra scanned in the laboratory and scanned on-line, and in the cross-validation set can be seen in the scatter plots in Figure 3.

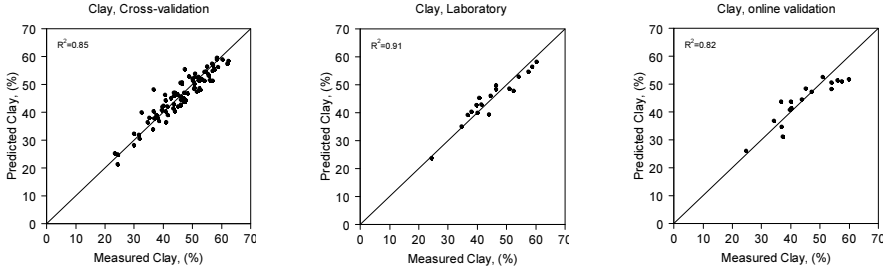


Figure 3. Scatter plot of predicted versus laboratory-measured clay of (a) the cross-validation set, (b) the prediction set for 18 laboratory-scanned samples and (c) the prediction set for 18 on-line-scanned samples

3.2. Mapping

3.2.1. Comparison of laboratory and Vis-NIR maps of soil sand and clay content

The maps of the laboratory-measured, laboratory Vis NIR-predicted and on-line Vis-NIR-predicted data for sand content using the prediction set of 18 soil samples show acceptable spatial similarity when compared. In addition, the low and high sand areas of the field can be clearly distinguished (Figure 4).

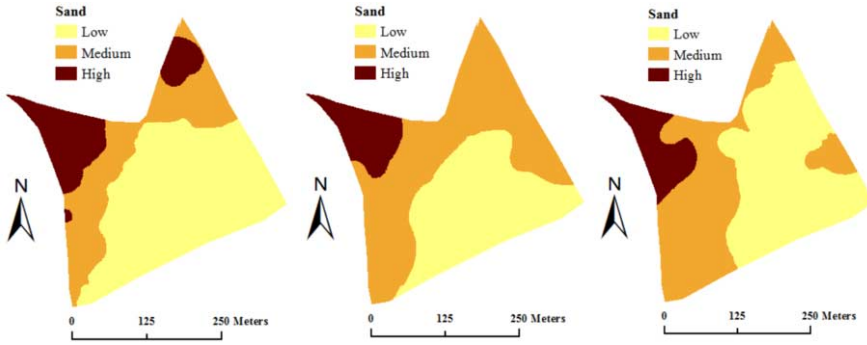


Figure 4. Comparison of (a) laboratory measured (86 points), (b) laboratory visible and near infrared (Vis-NIR) predicted and (c) on-line Vis-NIR predicted maps of sand content (based on the 18 samples of the prediction set)

With minor differences, in general, all the maps show the central-southern part of the study area as having a lower sand content than other parts (Figure 4). The similarity between the laboratory reference (18 samples) and the whole-point (8486 points) sand content maps can be seen in Figure 5. Compared to other parts, the central-southern part of the field on these two maps also exhibits a spatial distribution similar to that seen on the three maps in Figure 4, indicating that it has a lower sand content.

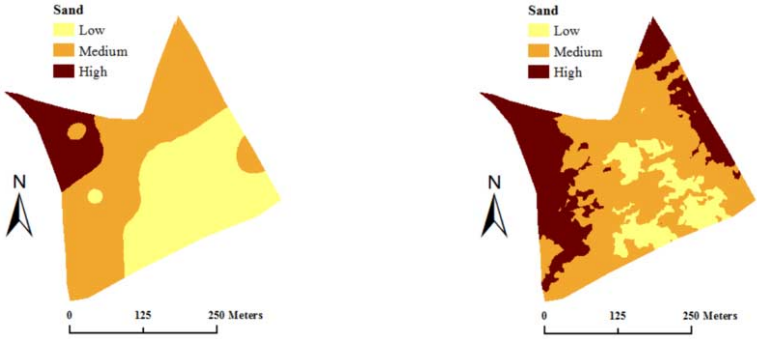


Figure 5. Comparison between (a) the 18 laboratory reference point and (b) the full-point on-line visible and near infrared (Vis-NIR) predicted maps for sand content.

In contrast to the spatial distribution maps of the sand content in the study site (Figure 4), the maps prepared for the clay content using the prediction set of 18 soil samples, based on the laboratory-measured, laboratory Vis-NIR-predicted and on-line Vis-NIR-predicted data, showed very close spatial similarity when compared, and the low, medium and high clay content zones can also be clearly distinguished (Figure 6).

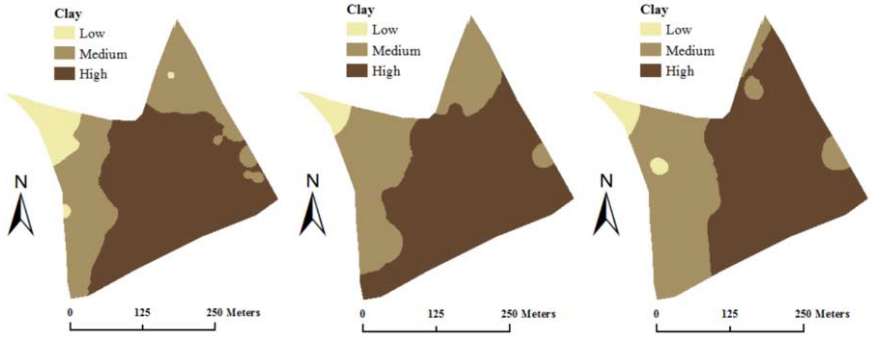


Figure 6. Comparison of (a) laboratory-measured, (b) laboratory visible and near infrared (Vis-NIR) predicted and (c) on-line Vis-NIR-predicted maps of clay content (based on the 18 samples of the prediction set)

As in the spatial distribution maps of the sand content (Figure 4), there are also minor differences seen in all the spatial distribution maps of the of clay content. These maps indicated that the central-southern part of the field has a higher clay content than the other parts (Figure 6). The similarity between the laboratory reference (18 samples) and the whole-point (8486 points) maps of clay content can be seen in Figure 7. These two maps show a very close spatial distribution similarity to the three maps in Figure 6, indicating that the central-southern parts of the field has a higher clay content than the other parts. The opposite spatial distribution of clay compared to that of sand indicates the good model performance in predictions of clay and sand content.

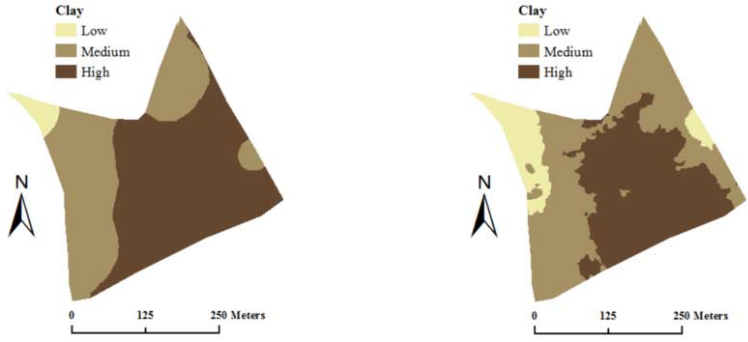


Figure 7. Comparison between (a) the laboratory reference and (b) the full-point on-line visible and near infrared (Vis-NIR) predicted maps for clay content

The high sampling resolution map obtained via the on-site measuring soil sensor has provided detailed information on the spatial distribution of the sand and clay content of the soil. This information is very useful for sustainable and precision agricultural applications and for land, soil and plant management. In addition, it can give direction to agronomists on the economic use of resources and contribute to the planning of plant production strategies.

4. Conclusions

This study evaluated the potential of visible and near infrared (Vis-NIR) spectrophotometry in the determination of the sand and clay content in clay-textured field soil under the semi-humid climate conditions in Turkey. The following conclusions have been determined according to the results obtained under laboratory and in-situ (on-line) field measurement conditions:

1. Vis-NIR spectrophotometry can be used successfully to determine and map the sand and clay in clay-textured soils in a semi-humid climate region.

2. Vis-NIR scanning under laboratory conditions as opposed to on-line Vis-NIR measurement conditions can be expected to provide better measurement accuracy.

3. Vis-NIR-predicted sand and clay maps and the equivalent laboratory-measured maps showed significant similarities. However, when the map developed using a limited number of points (18 samples) as compared with the full-point map, the full-point map showed more detail and displayed slightly different spatial distribution patterns.

As future work, Vis-NIR spectrophotometry application could be extended to provide on-line measurement sand and clay content in soils, to work that will link crop yield with plant characteristics.

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Evolutionary and Bio-Inspired Algorithms in Greenhouse Control: Introduction, Review and Trends

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Abstract. This paper provides a bare-bone introduction to evolutionary and bio-inspired metaheuristic in the context of environmental greenhouse control. Besides presenting general evolutionary algorithm principles, specific details are provided regarding the genetic algorithm, particle swarm optimization and differential evolution techniques. A review of these algorithms within greenhouse control applications is presented, both for single and multiple objectives, as well as current trends.

Keywords. Greenhouse environmental control, evolutionary algorithms, nature and biologically inspired algorithms.

1. Introduction

Increasing the efficiency within greenhouse based cultivation systems involves the use of optimal control techniques [1,53]. The ever increasing computer processing developments allows to use optimization techniques requiring higher computationally burdens. This is the case of evolutionary algorithms and bio-inspired optimization techniques. Following the trend observed in other research domains, artificial intelligence and computational intelligence based techniques have been widely applied within control engineering applications for agriculture purposes [2]. This paper focus on the use of nature and bio-inspired (NABI) algorithms within greenhouse control. An overview of this type of techniques is presented, providing a survey of applications for greenhouse control and current developing trends.

The first issue is what type of techniques are addressed here? These are search and optimization techniques which have some type of nature and/or biologic inspiration. The techniques in question are random-based and involve probabilistic decisions. There are different ways to classify these techniques. A simple way is to divide then between single-solution and multiple-solution. One of the most popular single-solution based technique is the simulated annealing (SA) [3]. Multiple-solution techniques, also re-

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ferred as population based, incorporate evolutionary algorithms (EA), swarm optimization algorithms and physics/ chemical phenomena inspired algorithms.

The most well established EA include evolutionary programming (EP) [4], evolutionary strategy (EG) [5], genetic algorithms (GA) [6,7] and genetic programming (GP) [8]. Other relevant techniques which can be included in the EA group are: differential evolution (DE) [9] and population based incremental learning (PBIL) [10]. From this set, the GA is most popular and extensively used within engineering problem solving, and a section for greenhouse control will be presented here.

Among the most well-established and widely used swarm based metaheuristics are the particle swarm optimization algorithm (PSO) [11] and ant colony optimization (ACO) [12]. Other more recently introduced NABI techniques, which can be included in the swarm optimization group are: bees inspired optimization [13] the cuckoo search algorithm (CS) [14] the firefly algorithm (FA) [15], the grey wolf optimization (GWO) [16] and ant lion optimization (ALO) [17]. Among these techniques the PSO is selected to be reviewed within greenhouse control. Among the more recently introduced techniques which can be classified as physical/chemical inspired, the gravitational search algorithm (GSA) [18] has gained some preeminence. As the majority of real world problems involve optimizing design criteria holding antagonism, most of the NABI have been also proposed to deal with multi-objective optimization.

The review of NABI algorithms within the greenhouse control problematic presented here is organized in the following two main groups:

- Evolutionary algorithms,
- Swarm based algorithms,

The review presented here is not an exhaustive review, and the methodology adopted to perform it was mainly based on the use of the following scientific databases and repositories: Science Direct from Elsevier [44], Springer-Verlag [45], IEEEXPlore [46], b-on [47] and Google search. Examples of the query parameters deployed in the search are greenhouse control, included: evolutionary algorithms, bio-inspired algorithms, genetic algorithms, particle swarm optimization, differential evolution, among other.

2. Evolutionary and Nature Inspired Metaheuristics: a Bare-Bone Introduction

The majority of evolutionary and bio-inspired algorithms are population-based, meaning that they use a set of potential solutions for a given problem. This set is commonly referred as population in the evolutionary algorithms case or swarm within swarm intelligence algorithms. A general algorithm for a population based NABI algorithm is presented in Algorithm 1.

```
1.  t=0
2.  initialize population X(t)
3.  evaluate X(t)
while(!(termination criterion))
   4. generate X(t+1)
   5. evaluate X(t+1)
   6. replace X(t)by X(t+1)
   7. t=t+1
end
```

Algorithm 1. General population based nature or biologically inspired algorithm.

In Algorithm 1, the population (or swarm) is represent by X and t corresponds to the generation (or iteration) counter. Before using any NABI algorithm to solve a particular problem, the user has to decide about the most appropriate representation method to adopt for each population member. Solutions can be represented using binary coding, integer numbers, real numbers, alphanumeric symbols, trees, lists, etc. The selection of the encoding scheme will also constrain most evolutionary operators. Here, for simplicity, a real number encoding scheme will adopted, as the majority of greenhouse environmental control problems involve decision variables which are represented by real numbers. Thus, each population member is represented by a vector concatenating n decision variables. The population size, m, is a heuristic parameter which is selected by the algorithm designer. The higher the population size, the longer the algorithm will take to run. In most cases the population size is fixed, but there are other EA in which it is dynamically changed along the evolutionary time. Here, the population size is considered constant. Also, there are many NABI algorithms considering simultaneously several populations, which are evolved in a parallel form, using several sub-populations (speciation) or implementing artificial co-evolution [e.g. see 48-49].

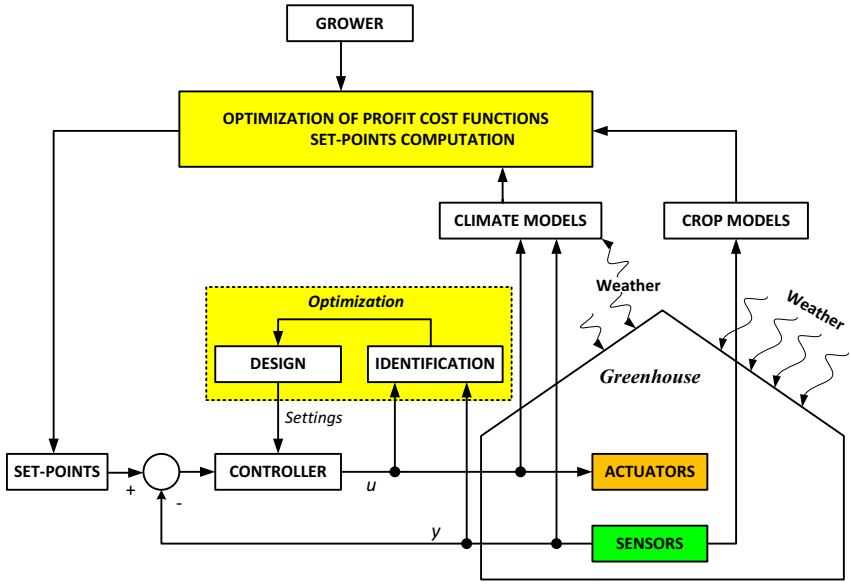

Figure 1. Greenhouse general management and control architecture.

Step 2 in Algorithm 1, consist in initializing the population. Basically the population initialization can be performed by using: i) a completely random procedure, ii) a random procedure subject to minimum objective function criteria, iii) informed initialization procedures. In some cases, in order to speed up the algorithm convergence rate, it is beneficial to define minimum performance thresholds for the initial population solutions or (when available) use heuristic rules to generate the initial solutions. A general exemple regards the case in which a solution represent controller parameters, for which it is better to avoid gains resulting in unstable systems. For instance, in the case of PID controllers, well-known tuning techniques can be used to generate some initial population solutions. Step 3 in the algorithm requires calling the objective func-

tion (or functions in the case of multi-objective), to determine the value of each population element for a specific problem. This value in terms of evolutionary algorithms is known as fitness value. Considering a general management and control architecture depicted in Figure 1, optimization procedures can be executed at different levels. The dynamic model estimation and controller design can incorporate evolutionary algorithms which can also be executed off-line or on-line, given the common sampling intervals (1 to 5 min) used within greenhouse control. Optimization is also currently used in an upper level, for profit maximization or for set-point optimization.

Entering the cycle presented in Algorithm 1, the major distinguishing step among several NABI algorithms is the way the new population elements are generated. Regarding evolutionary algorithms, particularly in the GA case, the reproduction of a new population element results from the three fundamental sequential genetic operators: selection, crossover and mutation. A great deal of different techniques for implementing each of these operators have been developed [7, 50, 51]. In the GA, the selection operator represents a survival of the fittest computational implementation, usually based on a fitness proportionate technique. New population elements are obtained by crossing over the selected progenitors, based on a probabilistic decision which uses a high crossover probability value (e.g. p_c=0.75). The mutation operator, mimicking the real genetic mutation, is performed with a low probability ratio (e.g. p_m=0.1), plays a vital role in the search space exploration and escaping local optima search traps.

Considering the PSO algorithm as a representative example of swarm based algorithms the reproduction of a new element is performed using the following two equations:

$$v_i(t+1) = \omega v_i(t) + c_1\varphi_1\left[p_i(t) - x_i(t)\right] + c_2\varphi_2\left[p_g(t) - x_i(t)\right] \tag{1}$$

$$x_i(t+1) = x_i(t) + v_i(t+1) \tag{2}$$

where, x and v represent particle i position and velocity, respectively. The variables in (1-2) are d-dimensional. The new particle velocity value is evaluated adding to the previous velocity of two disturbed error factors. The first error term (cognitive) represents the difference between particle i current best position p_i and the current particle position, x_i, while the second error term (social) represent the difference between the global best position p_g and the current particle position, x_i. While different neighborhood can be considered, here for simplicity sake the full connected topology is considered. This means that all swarm particles share information, and the global best is the best position achieved by the entire swarm. Each error term is disturbed by two factors which results from the product of a constant (c_1 and c_2) and two uniformly random numbers generated in the interval [0,1]. The previous velocity value is weighted by a parameter ω, which is generally decayed along the search from an initial higher value (e.g. ω=0.9) to a smaller one (e.g. ω=0.4). This is to promote a trade-off between exploitation and exploration.

Regarding the DE algorithm, the generation of a new element can be performed (considering one of its variants) by using equations:

$$\begin{aligned} &x_{vi}(t+1) = x_{r_1}(t) + F\left(x_{r_2}(t) - x_{r_3}(t)\right) \quad 1 \le i \le m \\ &r_1 \in [1,m] \neq i, \quad r_2 \in [1,m] \neq i \neq r_1 \neq r_3 \quad r_3 \in [1,m] \neq i \neq r_1 \neq r_2 \end{aligned} \tag{3}$$

$$x_{ci}(t+1) = crossover\left(x_i(t), x_{vi}(t+1)\right) \quad 1 \le i \le m \tag{4}$$

with v representing a trial element which is is generated for each population element, i, x_{r1} , x_{r2} and x_{r3} representing positions for three randomly selected elements from the population; F is a constant defined prior to the search procedure in the interval [0,2]. The new trial element position, x_v, is submitted to a crossover operation, exponential or binomial [9] with the current element position, x_i, resulting in a new position, x_c. If the new generated element proves to be better than current i element, it replaces it.

Step 6 concerns the population replacement. In GA there are multiple replacement schemes, ranging from the complete old population replacement by the new population, or partial replacement following a specific technique. As GAs may suffer from premature convergence, some replacing schemes can be used based on maintaining the population diversity. In the PSO case, after the new swarm particles position is determined, the individual best position must be updated for each particle, as well as the global best position.

The last step in algorithm 1, increments the generation counter. The main cycle termination criterion can be simply reaching a pre-determined number of generations, or can be a more complex criterion involving problem dependent information. Often, a minimum threshold for the cost function can be also used logically combined with a minimum number of iterations.

Considering problems with multiple conflicting objectives, which constitute the majority of practical applications, also within greenhouse control with different approaches to solve them. If the relative importance among the several objectives is known a priori, the multi-objective problem can be solved using an aggregated cost function. Using weighted aggregated cost function requires taking the decision about the relative importance among objectives, prior to the optimization process. Alternatively Pareto optimal based multi-objective approaches, promote the evolution of non-dominated solutions, with the goal of achieving non-dominated Pareto fronts. From these non-dominated fronts, the end-user can select the most appropriate optimal solution which better suits a given problem. An illustrative example is presented in Figure 2 for the case in which both objectives f_1 and f_2 are minimized. As it can be observed the dashed lines represent cases in which by selecting the weights in an average sum between the two objectives, restricts the search to different lines (dashed in Figure 2). The solid line represents a non-dominated Pareto front. Some multi-objective algorithms use an auxiliary population, called an archive, which is used to store non-dominated solutions. The non-dominated solutions can selected in each generation, to be part of the archive using elite-based techniques [51,52]. The final goal is to obtain a wider Pareto front with good and uniform solutions distribution along the front.

The complexity of multi-objectives problems depends not only on the number of decision variables, but also on the number of objectives. Increasing the number of objectives raises the optimization difficulty level. Many-objective optimization (problems with more than 3 objectives), requires a much higher number of solutions to represent the Pareto front. Also the visualization of the non-dominated solutions require using other type of approaches.

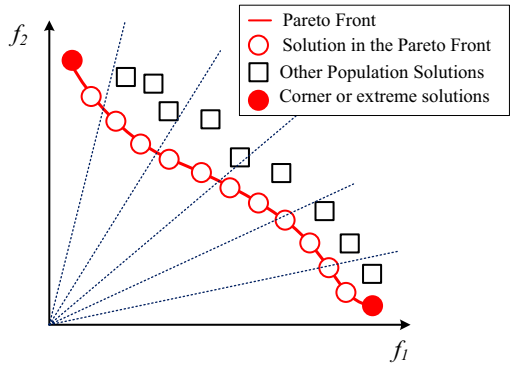

Figure 2. Example of non-dominated Pareto front for a minimization problem.

3. Review of Evolutionary Algorithms for Greenhouse Control

A pioneering work addressing the use of GAs within greenhouse control was reported in [19]. Two evolutionary based algorithms were proposed in [20] to maximize profit in a greenhouse climate control problem. Here the two proposed algorithms (for global and local search) deploy several sub-populations, in which their size can change with time and with different selective pressures, recombination schemes and generation gaps. In [20] the use of informed initialization instead of random-based initialization is also presented, as a way to improve the EA computational efficiency, by incorporating practical heuristic rules regarding greenhouse control. In [21] greenhouse temperature control is studied based on a Fuzzy PI controller designed with an evolutionary based technique.

The use of GA as optimizers within predictive control schemes were reported by [22] considering a multi-input multi-output control. In [23] some evolutionary techniques are explored within optimal control, addressing the use of both GA and DE for environment greenhouse control for lettuce production. In [24, 25] the performance of evolutionary algorithms is explored within a direct control strategy for greenhouse crop production. In [26] several methods are deployed within optimal control of greenhouse gas emissions. Besides other stochastic algorithms the EA used in [26] are DE and Evolution Strategy using Stochastic Ranking (SRES). In [27] a GA based technique is deployed to optimize grow models for greenhouse plants. The evolutionary technique proposed in [27] is based on the use of two different GAs, with a secondary GA optimizing the setting for the primary GA. The primary GA uses several species and optimizes the parameters of the plant grow model. The tuning of PID controllers within a Smith predictor decoupled structured for temperature and humidity control was reported by [28] presenting simulation results. A comparison among several EA is presented in [29] addressing the problem of crop model parameter estimation. The evolutionary algorithms considered in this study [29] are DE and covariance-matrix adaptation evolution strategy (CMA-ES). In [30] a GA is used as to optimize the energy balance within a greenhouse.

Regarding the proposal of technique based on MOGA, some examples are presented in: [31] which proposes an ε-MOGA to perform a robust non-linear identification of a greenhouse model; this study considers climate modelling for temperature and hu-

midity variables within a greenhouse with hydroponics culture. The optimization problem considers the simultaneous design of two objectives, resulting in a Pareto front which allows to select the best trade-off among the considered objectives. In [32] the NSGA-II [51] is deployed to optimize two objective regarding the integral of time square error and a control signal variation index, to design PID controllers (digitally using an incremental algorithm) in a multi-variable control system. In [33] the same authors have proposed a two-layer control architecture involving the use of a MOEA, for greenhouse control optimizing two quadratic cost function for the error and energy. In [34] a comparison of well-known MOGA is presented for non-linear greenhouse climate control, namely NSGAII, ε-NSGAII, ε-MOEA, PAES, PESAII and SPEAII. In [35] a multi-objective immune algorithm is proposed and tested in several benchmark functions and also in a greenhouse crop model. Pareto fronts are presented relating the design objectives of profit increment, CO_2 costs and heating costs.

4. Review of Swarm Optimization Algorithms for Greenhouse Control

In [25] a direct control technique of crop-production in a greenhouse used the PSO as optimization technique The use the PSO algorithm within a model predictive control strategy for temperature control in a greenhouse was proposed by [36], with an extended version reported in [37]. Other PSO applications in greenhouse control are reported in [38] for energy consumption optimization and [39-40] within greenhouse model identification techniques. A hybrid algorithm of the PSO and GA algorithm (HPSO) is reported in [41] for modeling energy demand in greenhouses. In [55] PSO is used to design a support vector machine model to predict photosynthesis for greenhouse tomato production. Here, besides decaying the PSO inertia weight from a maximum initial value to a minimum final value, two heuristic rules are proposed to adjust both the cognitive and social coefficients (c_1 and c_2) along the search evolution. In [56] neural networks and PSO are used to devise an intelligent technique to ventilate a greenhouse. In [57] both PSO and GA are applied to design a decoupled multivariable internal PI controller based on an internal model control formulation.

The cuckoo search algorithm was applied in [43] within an experimental study regarding a greenhouse model identification problem considering a tomato culture. A more recently introduced swarm based algorithm, the GWO, is reported in [54] for designing a receding horizon control to control the greenhouse inside air temperature. In this paper the GWO performance is compared with the results obtained with both a GA and PSO algorithm.

Regarding the use of multi-objective particle swarm optimization algorithms (MOPSO) some techniques were reported by [42], considering the optimization of two objectives regarding the crop yield maximization and the minimization of energy costs.

5. Concluding Remarks and Future Trends

An introduction to nature and biologically inspired algorithms was proposed followed by a review of applications for greenhouse environmental control. Two major groups of techniques were considered in the greenhouse environmental control problematic, based on: evolutionary algorithms and swarm optimization algorithms. Ac-

cording to the number of applications found in the literature regarding the following techniques: genetic algorithms, differential evolution and particle swarm optimization, motivated these techniques to be reviewed with more detail.

From the reviewed application it is possible to conclude that evolutionary and swarm based techniques have been successfully applied to greenhouse control considering both single-objective and multiple-objective problems formulations. Given the current advances both in the computational power available to perform greenhouse environmental control as well as the progresses with this type of techniques, it is expectable that the number of application will increase in the nearby future.

As future work, regarding this paper, a deeper revision of the evolutionary technique, particularly providing more information regarding multi-objective algorithms will be performed.

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A Knowledge-Based Approach to Social Sensors for Environmentally-Related Problems

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Abstract. Social media can serve to contribute to situation awareness, which involves the perception and comprehension of the reality around us, so that future actions can be projected. For example, Twitter can be used as a real-time channel of communication to report on environmentally-related problems. The goal of this paper is to describe a knowledge-based system that is able to detect such problems, so that a protocol of action can be developed. The evaluation of the system demonstrated that our symbolic approach to problem detection can outperform supervised classification methods.

Keywords. Twitter, social sensor, topic categorization, sentiment analysis.

1. Introduction

Sensors are event-driven devices for information pickup. Particularly, sensors are intended to detect changes that occur in the real-world environment, after which a signal is sent to a processor for its analysis and interpretation, thus enabling an event-oriented action to be executed. There are two types of sensors: electronic sensors and social sensors. As explained by Crooks et al. [1], social sensors operate in a manner comparable to electronic sensors: micro-bloggers are the sensors and the microcontrollers, since they collect the information that is important to communicate, whereas the actual micro-blogging service (e.g. Twitter or Facebook) is the transceiver, since it enables the dissemination of the information. Although social sensors are much noisier than electronic sensors, since "users sometimes misunderstand phenomena, sleep, and are not near a computer" [2], social sensors stand out for their low operating cost, wide geographical dissemination and immediate information transfer. Regarding our research, we focus on the automatic analysis of Spanish micro-texts from Twitter to develop a protocol of action to manage environmentally-related problems, such as overflowing rivers, waste discharge or wildfires, among many others. The remainder of this paper is structured as follows. Sections 2 and 3 briefly describe some works related to social sensors and the challenge of our research respectively. Sections 4 and 5 explore the Spanish knowledge resources used in this project and the database of our system respectively. Section 6 provides an accurate account of the methodology, and Section 7 evaluates the research. Finally, Section 8 presents some conclusions.

2. Related work

The use of social sensors for the development of emergency response systems has become a relevant research topic over the last decade, where most of these studies have focused on English texts. For example, Sakaki et al. [3][4] presented one of the first applications to use Twitter as a medium for social sensors to detect real-time events. They devised a SVM classifier of tweets based on features such as the keywords in a tweet, the number of words, and their context. Moreover, a probabilistic spatio-temporal model was used to find the center of the event location. As a result, they developed a reporting system to promptly notify people of an earthquake in Japan. Liu et al. [5] described a tweet-based detection system used by the U.S. Geological Survey to rapidly detect widely felt seismic events. The algorithm essentially scans for significant increases in tweets containing the word "earthquake" or its equivalent in other languages and sends alerts with the detection time, tweet text, and the location where most of the tweets originated.

3. The challenge

In this research, problem detection is going to be addressed as an issue of classification, being comprised of two complementary tasks: topic categorization and sentiment analysis. In comparison with English, there is a small number of studies on topic categorization or sentiment analysis in Spanish [6][7][8][9][10][11][12]. In this regard, two main approaches can be distinguished: a machine learning approach, which is usually implemented through a supervised method, and a symbolic approach, which is based on lexicons and rules. A supervised machine-learning method (e.g. KNN, Naïve Bayes or SVM) requires a training dataset, that is, a collection of text data that have been manually annotated as positive or negative with respect to the target event (i.e. the problem). This training dataset should be carefully tagged as well as sufficiently large and representative. For example, Sidorov et al. [12] recommended having a training dataset containing at least 3,000 tweets. This requirement conflicts with the development of a system like ours, which was intended to classify new tweets on the ground of dynamically created categories of environmentally-related problems. The effort to expand a given training dataset to fit new categories makes applicability to new domains a non-trivial task. This fact actually became a great challenge for the performance of the system, since “successful results depend to a large extent on developing systems that have been specifically developed for a particular subject domain” [11]. For this reason, the solution was aimed at dealing with problem detection from an unsupervised lexicon-based approach.

4. Knowledge resources for Spanish

The degree of success of knowledge-based approaches is closely dependent on the quality and coverage of the lexical resources involved in the system. This section describes the Spanish resources that were used in our research.

4.1. Multilingual Central Repository

The Multilingual Central Repository [13][14] integrates wordnets from six languages (i.e. Basque, Catalan, English, Galician, Portuguese and Spanish) into the same EuroWordNet framework. The Inter-Lingual-Index allows the connection from words in one language to equivalent translations in any of the other languages. In order to provide ontological coherence to the integrated wordnets, this knowledge base has also been enriched with a set of ontologies, such as Top Ontology [15], WordNet Domains [16] and SUMO [17].

4.2. SFU-Review-SP-Neg

SFU-Review-SP-Neg [18] comprises 2,953 sentences, which contain at least one negative structure, extracted from user comments about a variety of topics: books, cars, computers, films, hotels, mobiles, music and washing-machines. This resource focuses on syntactic-level negation, being annotated as (a) simple, expressed with a single particle (e.g. *Nunca han dado problemas* [They have never given rise to problems], *Nadie quedará decepcionado* [Nobody will get disappointed] or *Es un teléfono sin cobertura* [The phone is out of range]), or (b) complex, expressed with two or more particles— continuous (e.g. *Casi no llega* [He almost failed to arrive]) o discontinuous (e.g. *No vino nunca* [She never came]). It should also be noted that sentences that contain negative particles such as *a más no poder* [in the extreme] or *ni que decir que* [it goes without saying that] do not really express negation.

4.3. SentiWordNet

SentiWordNet [19][20] is the result of automatically annotating all synsets in English WordNet 3.0 according to their degrees of positivity, negativity and objectivity. Since WordNet synsets represent abstract concepts, different senses of the same term may have different opinion-related scores. Each of the three scores ranges from 0 to 1, where the sum of the three scores is 1 for each synset. This lexical resource was devised for supporting sentiment classification and opinion mining applications.

4.4. Spanish Emotion Lexicon

The Spanish Emotion Lexicon [21][22] contains 2,036 words that are associated with a PFA (Probability Factor of Affective use) value with respect to at least one of the following emotions: anger, disgust, fear, joy, sadness and surprise.

5. The database

From the previous knowledge resources, our database scheme can be partially characterized as follows:

$$KB = \left\{ \begin{array}{c} SYNSETS: [\{STEM, SYNSET\}], \\ POS: [\{SYNSET, TYPE\}], \\ RELATIONS: [\{RELATION, SYNSET1, SYNSET2\}], \\ NEGATION: [\{OPERATOR, TYPE, SCOPE\}], \\ SENTIMENTS: [\{STEM, POLARITY\}], \\ CATEGORIES: [\{CATEGORY, STEM, POS\}] \end{array} \right\}$$

The complexity of the actual database design is underspecified in this scheme, which includes only those relations that are relevant for this paper.

SYNSETS, POS and RELATIONS were built from Multilingual Central Repository. SYNSETS holds all the synsets that are lexicalized in the Spanish WordNet, together with the stemmed words assigned to the synsets; stemming was performed with the SnowBall Analyzer. POS stores the grammatical category (i.e. noun, verb, adjective or adverb) linked to every synset. RELATIONS holds the semantic relations that can occur between two synsets; the only relations that were relevant for this project were *causes*, *has_hyponym*, *has_subevent*, *derived_from*, *near_synonym*, *pertains_to* and *related_to*.

NEGATION serves as our polarity dictionary, which resulted from the analysis of the negative particles in SFU-Review-SP-Neg. These particles were expanded with synonyms from the Spanish WordNet and stored as operators, which were classified as *neg* and *noneg*. The scope of the operator can be to the left and/or right of the negative particle.

SENTIMENTS holds the stems of words associated with positive or negative polarity. On the one hand, positively-marked words were extracted from those terms whose positive score is equal to or higher than 0.8 and the negative score is 0 in SentiWordNet. On the other hand, negatively-marked words were extracted from those terms that belong to the sentiment dimensions of anger, disgust, fear and sadness in the Spanish Emotion Lexicon. Moreover, complaint words not present in the Spanish Emotion Lexicon were detected from a corpus of 790 tweets. Manual validation of SENTIMENTS was required.

Finally, CATEGORIES is used to store the significant features, in the form of stems and their part-of-speech, that are semi-automatically discovered from a new category of environmentally-related problem.

6. Methodology

6.1. Registering categories

The system was designed to classify tweets, i.e. micro-texts with a maximum of 140 characters, on the basis of user-defined environmentally-related problems. Therefore, a new category implies a semi-automatic process of selecting significant features, that is, relevant words that identify the target event. First, the user decides a few seed terms that are representative of the new category. Second, the system presents the different senses of each seed term, so that relevant meanings (synsets) for the category can be selected. As each seed term becomes a feature, this results in the vector $C_i = (f_{i1}, f_{i2}, \ldots, f_{ik})$, where every f_{ij} identifies a feature in the form of a synset assigned to

the category C_i. Third, a relation-driven expansion of C_i takes place by means of RELATIONS. In particular:

- For each f_{ij} in C_i, expand to other synsets involved in the relations *x-near_synonym-y* and *x-related_to-y*, where f_{ij} instantiates *x*, and in the relations *x-derived_from-y* and *x-pertains_to-y*, where f_{ij} can instantiate *x* or *y*; in both cases, each expansion is added to C_i as f_{ik+1}.
- For each f_{ij} in C_i, expand to other synsets involved in the relation *x-causes-y*, where f_{ij} instantiates *x*; each expansion is added to C_i as f_{ik+1}.
- For each f_{ij} in C_i, expand to other synsets involved in the relation *x-near_synonym-y*, where f_{ij} instantiates *x*; each expansion is added to C_i as f_{ik+1}.

Fourth, every f_{ij} in C_i is mapped into one or several stems (together with their grammatical categories) with SYNSETS and POS. The outcome is stored in CATEGORIES.

6.2. Collecting and processing data

With the aid of the Twitter API, the next step consisted in crawling tweets related to the target event. The tweets were processed as follows. First, some elements were removed from the micro-texts, such as hashtags (i.e. any word starting with #), references (i.e. usernames headed by @) and URLs. Second, texts were tokenized and tagged with their POS by using the Stanford POS Tagger. Third, each token was stemmed with the SnowBall Analyzer, where each stem was in turn refined, so that all the inflectional forms of a given word could be reduced to a single stem. At this point, a tweet is represented as the vector $T_m = (w_{m1}, w_{m2}, \ldots w_{mp})$, where w_{mn} represents an object for every word that occurs in the tweet and p is the total number of words. Each w_{mn} is defined with attributes such as the position, the stem, the part-of-speech, the topic and the sentiment, where the values of the latter two are discovered in the next step.

6.3. Discovering relevant stems

This stage consists in detecting significant stems with respect to the topic (i.e the target event or category) and the sentiment. On the one hand, the weight 1 was assigned to the attribute topic of every w_{mn} in T_m whose stem and part-of-speech was found as an f_{ij} in C_i, which was stored in CATEGORIES. On the other hand, the values *p* or *n* (i.e. positive or negative) were assigned to the attribute sentiment of every w_{mn} in T_m according to the polarity of the stem in SENTIMENTS.

In both cases, contextual valence shifters were taken into consideration. In other words, the scope of negation affects the topic and sentiment values of w_{mn}. In particular, when a stem is found within the scope of a negative particle (i.e. three words to the left and/or right) according to NEGATION, the stem is no longer significant for topic and sentiment, so the values of these attributes become 0 and *o* (i.e. objective) respectively.

6.4. Determining topic and sentiment

On the one hand, as tweets and categories are represented as vectors, a similarity measure may be used to assess the degree of relatedness between both of them. In this context, we used cosine similarity (or normalized dot product) as a measure of

semantic distance. In our case, since we deal with binary values for topic relatedness and the number of topic-related stems in the tweet T_m is equal to or less than the number of relevant features in the category C_i, the relatedness function between T_m and C_i can be reduced to Eq. (1):

$$rel(T_m, C_i) = \frac{\sum_{n=1}^{p} w_{mn}}{\sqrt{\sum_{n=1}^{p} w_{mn}} \times \sqrt{\sum_{j=1}^{k} f_{ij}}} \quad (1)$$

Therefore, a tweet is linked to a given category if the similarity score is greater than 0.

On the other hand, a simple approach to sentiment calculation could have been to sum up the sentiment values of each stem in the text message. However, we chose to assess the degree of sentiment in a given tweet with a metric originally used to assess political positions in texts. Particularly, Lowe et al. [23] proposed the logit scale to locate party positions (i.e. left or right) on a continuous scale from the sentences of political texts that were previously coded into these two categories. Indeed, this scaling procedure allows the system to convert the counts of sentiment-coded stems in the tweet T_m into a point on the sentiment dimension S by means of Eq. (2):

$$rel(T_m, S) = \log(P + 0.5) - \log(N + 0.5) \quad (2)$$

where P and N refer to the number of the positively- and negatively-marked stems in T_m respectively.

6.5. Detecting the problem

In this context, detecting an environmentally-related problem implies to fix a minimum number of tweets where each T_m has been tagged with a given event category (i.e. $rel(T_m, C_i)$ returns a positive value) and categorized with a negatively-marked sentiment (i.e. $rel(T_m, S)$ returns a negative value) for some specific time and location. After the normalization of the sentiment score, we calculated the geometric mean to combine both values into a single measure, i.e. the problem-relatedness perception index (PPI), as shown in Eq. (3), which can be simplified into Eq. (4):

$$PPI(T_m, C_i, S) = \sqrt{rel(T_m, C_i) * \left(1 - \frac{1}{\log(-rel(T_m, S)+2)}\right)} \quad (3)$$

$$PPI(T_m, C_i, S) = \sqrt{rel(T_m, C_i) - \frac{rel(T_m, C_i)}{\log(-rel(T_m, S)+2)}} \quad (4)$$

In other words, the PPI serves to measure how reliable we can feel that a given tweet (T_m) deals with a problem (S) about an environmental topic (C_i). How to determine spatio-temporal indicators of the event categories in the tweet is out of the scope of this paper.

7. Evaluation

This research was evaluated with a corpus of 300 tweets, where 108 were manually categorized as flood (INU), 110 tweets as rain (LLU) and 74 tweets as landslide (DESL). In this experiment, a single seed term was used to expand the relevant features of each event category, as shown in Table 1.

Table 1. Relevant features of the categories DESL, INU and LLU.

Category	Seed term	Features
DESL	deslizamiento	deslizamiento
INU	inundación	aluvión, anegar, avalancha, avenida, diluvio, inundación, inundar
LLU	lluvia	aguacero, empapado, húmedo, llover, lluvia, lluvioso, mojado, pluvioso, precipitar, precipitación

Most evaluation metrics for two-category classification are built over a 2x2 contingency matrix, as illustrated in Table 2, where TP, FP, FN and TN denote the number of true positives, false positives, false negatives and true negatives respectively.

Table 2. Contingency matrix for binary classification.

		Expected	
		1	0
Predicted	1	TP	FP
	0	FN	TN

Typical evaluation metrics that come from information retrieval are Precision and Recall, as shown in Eq. (5):

$$Precision = \frac{TP}{TP+FP} \quad Recall = \frac{TP}{TP+FN} \tag{5}$$

One of the most popular measures that combines Precision and Recall is F1, which is presented in Eq. (6):

$$F1 = \frac{2*Precision*Recall}{Precision+Recall} \tag{6}$$

The evaluation was conducted with our knowledge-based system, which represents the symbolic approach, and with multinomial Naïve Bayes, which illustrates the machine-learning approach. In the context of processing Spanish tweets for sentiment analysis, a popular classification method is Naïve Bayes, because "it is a simple and intuitive method whose performance is similar to other approaches. NB combines efficiency (optimal time performance) with reasonable accuracy" [10]. In this case, a doc-ngram matrix was created from the corpus, whose binary-weighted features took the form of stems filtered by functional stopwords. A k-fold cross validation, where k = 10, was performed. Table 3 shows the values of Precision, Recall and F1 in the topic categorization of DESL, INU and LLU.

Table 3. Evaluation of topic categorization.

	Knowledge-Based			**Multinomial Naïve Bayes**		
	Precision	Recall	F1	Precision	Recall	F1
DESL	0.985	0.930	0.957	0.576	0.623	0.593
INU	0.986	0.724	0.835	0.537	0.628	0.570
LLU	0.960	0.818	0.883	0.586	0.590	0.580

With regard to sentiment analysis, the evaluation procedure was the same as that described above, whose results are shown in Table 4.

Table 4. Evaluation of sentiment analysis.

Knowledge-Based			**Multinomial Naïve Bayes**		
Precision	Recall	F1	Precision	Recall	F1
0.835	0.763	0.798	0.428	0.475	0.450

Finally, Table 5 shows the evaluation of problem relatedness once topic categorization and sentiment analysis are integrated by means of the PPI.

Table 5. Evaluation of problem relatedness.

	PPI		
	Precision	Recall	F1
DESL	0.983	0.830	0.899
INU	0.983	0.622	0.761
LLU	0.956	0.500	0.656
micro-average	0.976	0.638	0.771
macro-average	0.974	0.650	0.779

We conclude that our symbolic approach to problem relatedness can outperform classical methods of classification. Indeed, Fernández Anta et al. [9] presented a comprehensive set of experiments classifying 7,000 Spanish tweets according to topic and sentiment by means of different approaches and techniques. Their experiments showed that the largest accuracy obtained was 0.58 for topic categorization and 0.42 for sentiment analysis.

8. Conclusion

Micro-texts from Twitter and other social media have become very valuable for the real-time detection of the concern that affects people. The automatic detection of such events can be really useful not only for citizens but also for emergency responders. In this research, we address the development of a system that exploits Twitter users as social sensors for the detection of environmentally-related problems (e.g. floods, droughts, landslides or pollution, among many others). The paper primarily focuses on the external knowledge resources that were required, the processing of Spanish tweets, the discovery of relevant features and the detection of the problem as a two-fold task: topic categorization and sentiment analysis. As our system enables the user to dynamically create categories upon which new tweets should be classified accordingly, supervised machine-learning methods turn out to be impractical, since they largely depend on training datasets that should be sufficiently large and representative with respect to the new categories as well as being carefully annotated. In fact, the evaluation of our research demonstrated that our symbolic approach provides better

results than a supervised classification method (i.e. multinomial Naïve Bayes), not only in text categorization but also in sentiment analysis.

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Automatic Rice Yield Estimation Using Image Processing Technique

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Abstract. Precision agriculture enables the dynamic use of technologies to boost up crop production, increase crop yield and at the same time decrease the input variables. Yield monitoring and estimation are considered to be the major steps to implement site-specific crop management or precision farming. Unmanned aerial vehicle (UAV) imaging based automatic rice yield estimation in different growing stages, could be a solution. In this work, we proposed a color-based segmentation algorithm that used Lab color space and k-mean clustering techniques to detect rice grain panicles area. Segmentation of grain from the image background was carried out in two steps. In the first step, a filter was applied to RGB (red, green and blue) images to remove noise and the image converted to Lab color space. The k-means clustering was applied to organize all colors contained in both a and b layers. The pixels were clustered based on their color and special features. In the second step, the variation between colors was measured and labelling of pixels was completed by cluster index. The clustering index was joined to a specific region and the images segmented using color information. The proposed method showed that rice grain can be segmented and that rice grains panicles numbers and area can be estimated from UAV images. The comparison provided significant results. The correlation between the ground truth measure and proposed method for rice grains panicles number and area were found to be around 0.931 and 0.842 respectively.

Keywords. Rice grain, Image segmentation, k-mean clustering, Unmanned aerial vehicle (UAV), Yield.

1. Introduction

Rice is one of the most important crop for the world's population, especially in Asia where more than 60% of the world's population lives [1]. In recent time population growth and climate change brought a huge pressure on food demand and production [2, 3]. In light of this, the desired target is to maximize the rice yield with fewer input costs [4]. Prediction of possible yield during a growing season would be very advantageous to magnify the rice yield [5]. Precision agriculture enables the dynamic use of technologies to boost up crop production, increase crop yield and at the same time decrease the input variables [6].

The advances in precision agriculture have improved the monitoring system of agricultural crops growth and yield estimation [7]. Yield is the most important factor in

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precise decision making for crop management. Early prediction of rice yield within a specific field, could be an option to find out which are the high and lower yield regions. This information will allow to identify any existing problems and apply suitable management practises. Conventional ground-based methods of crop yield estimation showed poor evaluation, time consuming, costly and slow data collection process delayed right steps of decisions [7, 8].

Remote sensing and digital image processing techniques are widely used in agriculture [9, 10]. The use of unmanned aerial vehicle (UAV) platform for remote sensing applications gives several advantages over conventional remote sensing methods [11-13] and has also supported higher density data for real time sensing [14]. Recently, numerous studies have demonstrated the use of UAV for remote sensing and related applications already defined, use UAV henceforth including vegetation cover assessment [15-17], crop monitoring [18-20], crop mapping [21-23], etc.

Research on different remote sensing methods have already been done for yield estimation of different crops. Most of the studies have focused on crop yield analysis using vegetation indexes (VI's). Normalized Difference Vegetation Index (NDVI) is the most common method among all VI's. The relationship of NDVI and yield were shown in different studies using Moderate resolution imaging spectroradiometer (MODIS) image [24], MODIS image and filed observation [25], MODIS image and Leaf Area index (LAI) [26]. All methods showed strong exponential (r^2=0.7 to 0.92) relationship to the rice yield.

Different empirical rice yield prediction models [27, 28] were introduced. The model worked with different spectral band and satellite images with different vegetation indices showing good relationship with yield (r^2=0.75 to 0.89). Vegetation Health (VH) Indices and Vegetation Condition Index (VCI) data were used to estimate two different kind of rice varieties yield [29]. These method showed average (r^2=0.62) and strong (r^2=0.97) relations with yield during growing and reproductive phases respectively.

Numerous practical and prediction models have already been introduced to evaluate rice yield before harvesting. However, these methods and models require crop status data, field condition etc., which cannot be readily found. Sometimes, complex models with huge amount of data make the models improbable for extensive applications. Also these existing models were highly affected by bad resolution satellite data, limited to high expenses of satellite images, effect in radiation calibration and cloud covering. These methods also have problems with weather variation in different seasons and exhibit limitations to environmental conditions. To overcome these situations, UAV imagery based automatic detection of rice grain can be a relevant solution for yield estimation of rice crops during growing seasons.

In this paper, an image processing technique to detect rice grains and estimate yield using low altitude UAV images is proposed.

2. Materials and Methods

2.1. Study Area

The study area for this experiment was located at Jeollanam-do Agricultural Research and Extension Services, Naju, South Korea (latitude 35°1'34.24" N and longitude 126°49'14.21" E). The main experimental field area was 2580 m^2 (Figure 1a) and the

crop was rice (*Oryza sativa* L.). Rice transplanted date was May 25, 2016. Different rice growing stages were captured using UAV mounted RGB camera.

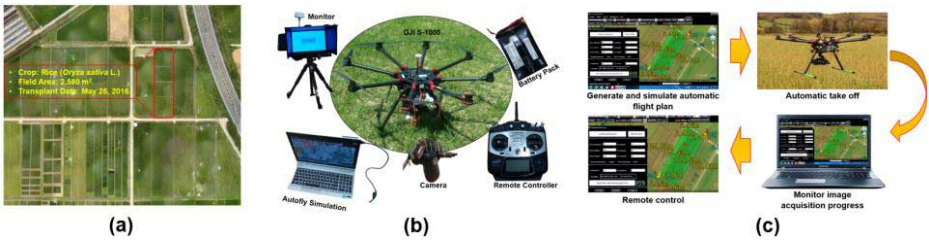

Figure 1. (a) Study Field; (b) Rotary wing type UAV (model: DJI-S1000), (c) Automatic flight simulation path for UAV.

2.2. Data Acquisition Systems

Images were taken during growing periods, under clear and sunny days. The height of the camera was 11 m from the canopy. A Sony Alpha a5100 digital camera (lens: Sony E 50 mm F 1.8) was used. The camera was 24.3 MP, equipped with a complementary metal-oxide-semiconductor (CMOS) image sensor and mounted on a rotary wing type UAV (model: DJI-S1000; Geospatial Information Co. Ltd.) (Figure 1b). The forward flying speed of travel was 2.5 m/s. All specifications of UAV and RGB camera are listed in Table 1. An automatic flying path (Figure 1c) was set and the UAV flew automatically over the rice field and captured the images. Digital images (format: RGB) were then transferred to the notebook and saved for further processing.

Table 1. Parameters that were used for UAV and camera to acquire data from the field.

Rotary wing UAV		Camera (Sony Alpha a5100)	
Parameters		Parameters	
Altitude (m)	11	Image sensor	CMOS
Flying speed (m/s)	2.5	F-stop	f/1.8
Ground sampling distance (cm/pixel)	0.2	Exposure time	1/2500 s
Time for image acquisition (min/ha)	15	ISO	200
Max. flight time (min)	15	Focal length	50 mm

2.3. Image Description and Ground Truth

The original size of the images was 6000×4000 (Figure 2a). 25 images were randomly selected and cropped four different area from the original images. The new image size was 600×400 (Figure 2b). During the random selection and cropping of images, we emphasis was put on different backgrounds, amount of grain and leaves, position of grain and leaves, etc. Approximately 100 test images were made.

Ground truth was performed from test images using Aletheia Pro software (version 3.1.906) (Prima tools, supported by University of Salford, Manchester, USA). A polygonal region (Figure 2c) related to every grain area in the image was created and saved as xml data file. The area of grains in the test images was measured and compared with the proposed method results.

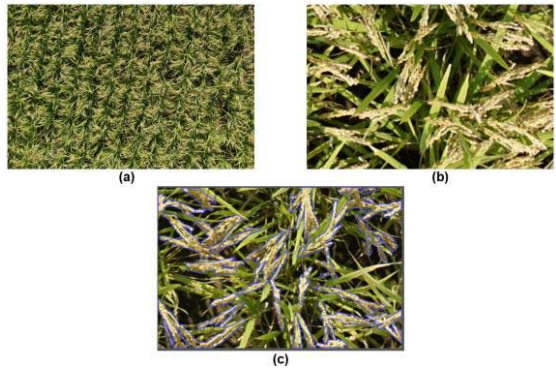

Figure 2. (a) Original Image (6000×4000) taken from the field; (b) Cropped image (600×400); (c) Ground truth image with the polygonal region for the rice grains.

2.4. Image Segmentation

In remote sensing, image segmentation can be described as the quest for similar regions in an image, followed by the categorization of those regions [30]. Let a given image 'I' and image segmentation process splits it into 'n' partitions. Then the partitions (R_i) are represented by the following properties [31]:

$$U_{i=1}^{n} R_i = I \tag{1}$$

$$R_i \cap R_i = \varphi \text{ with } i \neq j \tag{2}$$

$$H(R_i) = \text{TRUE } \forall I \tag{3}$$

$$H(R_i \cup R_i) = \text{FALSE } \forall R_i \text{ and } R_j \text{ adjacent} \tag{4}$$

Eqs. (1) and (2) explain regions form from image I since it splits I into disjoint subsets. Eqs. (3) and (4) explain similar and different regions cluster components characteristics, respectively.

2.5. K-mean Clustering

The algorithm follows very easy and simple approach to classify the data set to K clusters (C_1, C_2, C_3, ……. , C_k), which are represented by centroids. The objective function [32] is followed by Eq. (5).

$$J = \sum_{j=1}^{k} \sum_{i=1}^{n} \left\| x_i^{(j)} - C_j \right\|^2 \tag{5}$$

where, $\left\| x_i^{(j)} - C_j \right\|^2$ is a chosen distance measure between a data point $x_i^{(j)}$ and a cluster center C_j, is the index of the distance for n data point from their particular cluster centers.

2.6. Proposed Method

2.6.1. RGB to Lab Color Space Conversion

The flow chart of the proposed method in this study is shown in Figure 3. The first step of the image processing method is to read RGB images which are taken from UAV. Median filtering is applied to the initial RGB images to make noise free images. The true color image RGB is then converted to Lab color space image. The Lab space consists of a luminosity layer L and chromaticity-layer a and b, which indicates where color falls along the red-green axis and the blue-yellow axis, respectively. The conversion formula calculates the coefficients as the following Eqs. (6), (7) and (8) [33]:

$$X = 0.4303R + 0.3416G + 0.1784B \tag{6}$$

$$Y = 0.2219R + 0.7068G + 0.0713B \tag{7}$$

$$Z = 0.0202R + 0.1296G + 0.9393B \tag{8}$$

The Lab color space is calculated as Eqs. (9), (10) and (11) [35]:

$$L = 116\left(h\left(\frac{Y}{Y_S}\right)\right) - 16 \tag{9}$$

$$a = 500\left(h\left(\frac{W}{W_S}\right)\right) - h\left(\frac{Y}{Y_S}\right) \tag{10}$$

$$b = 200\left(h\left(\frac{Y}{Y_S}\right) - h\left(\frac{Z}{Z_S}\right)\right) \tag{11}$$

$$h(q) = \begin{cases} \sqrt[3]{q} & q > 0.008856 \\ 7.787q + \frac{16}{116} & q \le 0.008856 \end{cases} \tag{12}$$

where, Y_S, W_S, and Z_S are the standard stimulus coefficients.

All the color information are contained in both a and b layers. The proposed method in this study used k-means clustering to allocate the colors in the ab space. Then, the primary segment area containing the cluster area of interest was selected. Using the Euclidean distance metric, the variation between the two colors can be measured.

2.6.2. Classify Colors in 'ab' Space Using K-means Clustering

Clustering is a technique used to isolate a group of objects. K-means clustering assumes the object location and separates the clusters in which the objects are very close to each other. It requires to specify the number of cluster to be separated and the distance between the objects. Since the color information remains in the 'ab' space, the objects pixels are given 'a' and 'b' values. K-means was used with euclidean distance metric to cluster the objects into three groups.

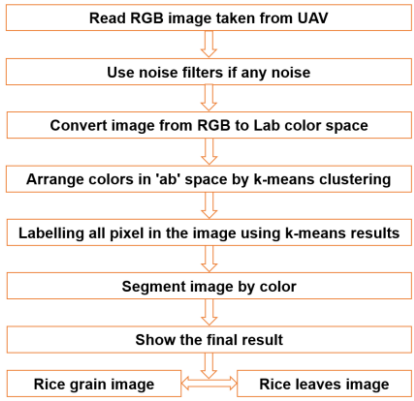

Figure 3. Flow chart of rice grain area estimation algorithm.

2.6.3. Label Pixels and Segment Image by Color

For an input object, K-means returns an index corresponding to a cluster. This cluster index was used to label the pixels of an image. Using this pixel labeling, it is possible to segment the objects in the image by color.

2.6.4. Segmented Rice Grain Image and Area Measurement

After the segmentation process rice grain and rice leaves can be separated from the image background. The segmented grain image is then used to and calculate the grain area by making polygons and compare the result with the original ground truth data.

2.7. Performance Evaluation

For performance measure, Precision, Recall, and F-Measure were used and calculated using the following Eqs. (13), (14) and (15) [34]:

$$\text{Recall} = \frac{\text{TP}}{\text{TP+FN}} \tag{13}$$

$$\text{Precision} = \frac{\text{TP}}{\text{TP+FP}} \tag{14}$$

$$\text{F} = \frac{2\times\text{Precision}\times\text{Recall}}{\text{Precision+Recall}} \tag{15}$$

where, TP is the number of accurately detected rice grain panicles, FN is the number of accurately detected non-rice grain panicles and FP is the number of non-rice grain panicles detected as rice grain panicles.

3. Experimental Results

3.1 Data sets

All the images were taken under a clear sky at a height of 11 m from the rice plant canopy

using a UAV. 100 cropped images were selected from the original images for this experiment and ground truth was performed using the Aletheia Pro software (version 3.1.906). Our algorithm was used to segment rice grain image and measure the grain area automatically. Both, the area of rice grains measured by the proposed method and by the ground truth are listed in Table 2.

3.2 Image Segmentation

The first three steps of the image-processing algorithm are related to the basic conversion of the image format and use of filters to remove noise (Figure 4a and 4b). RGB image was converted into Lab color space (Figure 4c).Followed by color arrangement in 'a*b*' space and pixel labeling by clustering indexes (Figure 4d). Finally, grain segmented images (Figure 4e and 4f) were formed from original image background using colors segmentation.

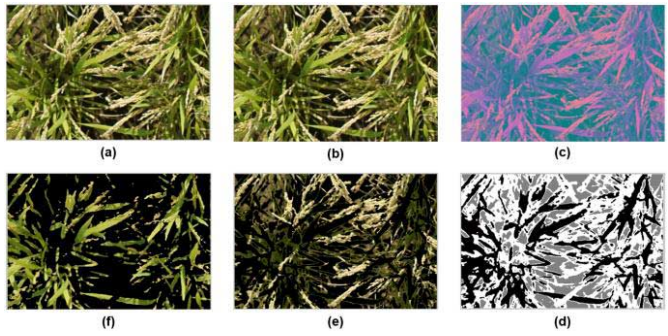

Figure 4. (a) Original RGB image; (b) Filtered RGB image; (c) Converted Lab spaced image; (d) Labelled image by cluster index; (e) Segmented rice grains image; (f) Segmented rice leaves image.

3.3 Performance Evaluation

Test images were randomly selected to assert the true positive, false positive, and false negative numbers of rice grain panicles. Recall, Precision, and F-measure were calculated and the results indicated that 87% by the F-measure, corresponding to a Precision of 84% and a Recall of 90%. The correlation of the rice grain panicles number between the proposed method and ground truth is shown in Figure 5. The R^2 value was approximately 0.931.

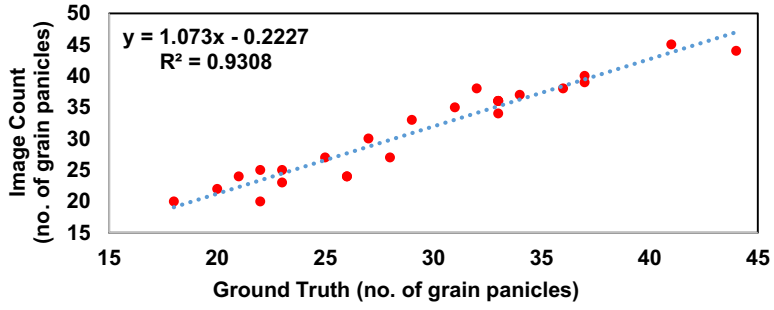

Figure 5. Relation between ground truth and proposed method in terms of rice grain panicles count.

A polygonal region (Figure 6b) to every grain area in the image was created, the area of each grain part using the segmented image was calculated (Figure 6c) and the results compared with ground truth results. The comparison provided satisfactory results. Figure 7 shows the correlation between the ground truth measure and the proposed method which was found to be around 0.842. The proposed method has shown that the grains were detected and the area of segmented rice grains was accurately estimated. The segmentation method is rapid and easy to apply but in some cases, the light and background of the images needs to be adapted.

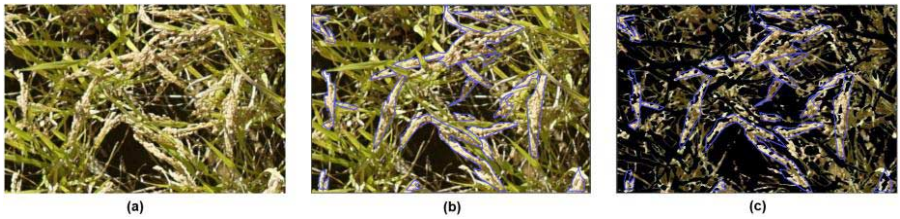

Figure 6. (a) Original RGB image, (b) Original ground truth image; (c) Segmented image (overlapped ground truth result).

Table 2. Result comparison between ground truth and proposed image segmentation method.

Image Area	Ground Truth (pixel)^2	Image Segmented Area (pixel)^2	Ground Truth Area (mm)^2	Image Segmented Area (mm)^2
Area 1	1115	1276	467.5	534.9
Area 2	1690.5	1327	708.7	556.3
Area 3	548.5	398	229.9	166.9
Area 4	2862	2509	1199.9	632.7
Area 5	3883.5	2632.5	1628.18	684.4
Area 6	570	707.5	238.9	296.6
Area 7	804	712.5	337.1	298.7
Area 8	1121.5	1148	470.2	481.3
Area 9	207	182	86.78	76.3
Area 10	1131.5	831.5	474.4	264.8
Area 11	5919	5147	2481.6	2157.9
Area 12	813.5	719	341.1	301.4
* 1 pixel=0.647 mm; RMSE=1.8 cm.				

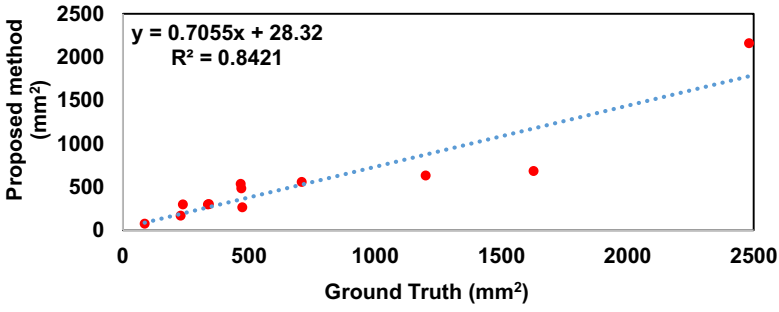

Figure 7. Correlation between ground truth and proposed image segmentation results.

4. Conclusion

In this paper, an image processing technique that rely on color based image segmentation using k-means clustering to estimate rice yield in the field automatically using RGB camera images mounted on (UAV) was proposed. The proposed method showed a precise segmentation of rice grains from the field image background. This methodology proved to be efficient in area estimation of rice grain panicles using UAV images. The proposed method was able to estimate rice grain panicles and is also expected to accurately estimate the volume of rice grain. This knowledge can be used to predict the grain yield and the harvesting time through observation of the grains as well as leaves color and size.

Acknowledgement

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An Ontology-Based Approach for an Efficient Selection and Classification of Soils

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Abstract. Soil libraries represent an invaluable resource in terms of research, management or planning. However, the access to such libraries and selection of soils is often tedious and time consuming thus limiting their usefulness. In this study we propose an ontology-based approach for an efficient and intuitive selection and classification of soils. For this test, a soil library of 458 soils from Australia was used. An ontology was then developed to model the fundamentals concepts and relationships found in the data. The basic capabilities of the ontology are shown to select samples with certain values for a number of attributes. In addition, an inference process known as realization is tested to automatically assign individuals to concepts, in our present case to a soil texture class or soil order (the latter known as soil classification). Results show the potential of ontology approaches to select samples from large libraries in an efficient and intuitive way. In addition, and through the use of reasoning processes, we were able to classify soils from different orders and textural classes with accuracy higher than 80% in most cases. This represents an additional application of ontology approaches to produce hidden data from the original data set.

Keywords. Knowledge representation, Ontology, Reasoning, Soil classification, Soil order, Soil selection, Soil texture.

1. Introduction

Soils represent one of the most important components of earth (FAO, 2015; FAO and ITPS, 2015). Adequate characterization is crucial for a good management and allocation of uses. Soil characterization frequently requires the analysis of a number of chemical, physical and biochemical properties. This is performed at a high sample density since soils are highly variable spatially, with depth and over time (Nocita et al., 2015). This has resulted in the development of soil libraries at different scales (i.e. local, regional, national and international) with associated values for a number of properties. The access to soil samples within soil libraries represents an invaluable resource for soil management, land use and planning, research and monitoring (Nocita et al., 2015).

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In order to have access to these benefits there is the need of selecting samples with the required attributes in an efficient, intuitive, easy to use manner. However, such a method is yet to be developed with traditional tools being tedious and time-consuming. In this context, the use of Semantic Web technologies (Berners-Lee et al., 2001) such as ontologies may represent a compelling alternative to manage soil data in a more automatic and intelligent manner. In a nutshell, ontologies are a formal description of a domain by means of axioms (i.e., assertions representing facts on the domain). These axioms allow defining concepts, relationships among concepts and specific individuals of those concepts.

Due to their formal properties, ontologies offer two main advantages when dealing with any type of data. Firstly, data represented through ontologies can be easily exchanged among different communities since it is expressed in a common and shared vocabulary (Gruber, 1993). It means that different computer applications can access the data in the same manner. Secondly, different reasoning processes or *inferences* (Horrocks, 2008) can be performed on the data using ontology reasoners. In particular for soil data it is interesting to apply a kind of inference known as "realization", namely the automatic assignment of soil samples from a soil profile to a soil order (e.g., Calcarosols or Chromosols; known as soil classification) or to a soil texture (e.g., clay or loam) according to the characteristics of such samples. Soil classification and soil texture class are crucial attributes associated to soil samples which guide soil management and planning.

The modeling of soil libraries using ontologies enables selecting samples by means of queries posed in a specific language, The advantage in this case with respect to traditional database queries resides in that ontology queries can retrieve not only explicit asserted data, as in databases, but also inferred data from the reasoning processes, thus offering possible implicit or *hidden* data derived from the original dataset. Moreover, queries on an ontology model can be more expressive (and more complex, too) than in traditional databases because of the semantics associated to the ontology language (Horrocks, 2008). Thus, the main objective of this study is to test the usefulness of ontology approaches for an efficient selection of soils with characteristics as required by the application. It is also an objective to test such approach for soil classification and allocation of textural class purposes.

The manuscript is organized as follows. Section 2 reviews the state-of-art of this research topic. Section 3 describes our methodology for soil selection and modeling using ontology approaches. Section 4 shows some application examples of the proposed soil ontology for soil selection and classification. Section 5 highlights the conclusions of this study.

2. Related work

Most of the literature related to the application of ontologies in agriculture studies is devoted to achieving interoperability among heterogeneous agricultural libraries. In (Aparício et al., 2005) it is proposed to use ontologies to integrate different relational databases related to agriculture data. Ontology is devised as a software layer to achieve interoperability among the terms defined in each database. Some concepts in the ontology, especially related to soil, are only briefly explained; however the ontology itself is not shown. Moreover, authors only focus on the use of ontology as a common vocabulary and no attention is given to the reasoning capabilities as proposed in this

manuscript. Athanasiadis et al. (2009) offer a more complete approach. The authors develop several interrelated small ontologies to define crop, farm and product concepts among others, as well as agricultural activities and policy assessment. Apart from achieving interoperability among databases, authors also highlight the benefit of cross-programming gained with ontologies for simulation processes in programming languages such as Java or C#, for example. Again, reasoning capabilities are not taken into account.

Similarly, but offering more advances features, Sánchez–Alonso & Sicila (2009) study how to convert AGROVOC, a well-known agricultural vocabulary, into an ontology. In particular, they focus on designing an ontology for fertilization purposes. They take into account reasoning processes enabled by the ontology, in particular for the classification process; i.e., computation of all the hierarchical relationships among the concepts in the ontology. Two case studies are given to show the application of the ontology for educational purposes. While the development of the ontology model is well explained, the domain and the purpose of their developed methodology are totally different to the one proposed here.

A second approach found in the literature consists in the design of ontology-based frameworks to integrate and manage different sources of data related to agriculture. In (Beck et al., 2010) authors use an ontology-based simulation environment named Lyra to build ontologies modeling complex soil–water and nutrient management systems. Ontologies are created using web-based visual tools with the aim of representing terms and equations needed to represent the management systems. These ontologies are then exported to mathematical formats to simulate the dynamics of the aforementioned systems in other programs. Although the methodology proposed in the manuscript offers a complete process to simulate agricultural environments, ontologies are used as a mere vehicle to represent system equations. Moreover, the reasoning process is performed by mathematical tools after exporting the ontology model to XML-based formats, thus losing the semantics in the ontology model. Shoaib & Basharat (2010) propose a different approach for obtaining a framework to integrate agricultural data into ontologies. While a complete framework architecture is presented, the ontology in which the system is based on is not shown. This ontology is claimed to model concepts such as soil, water, crop and production information. However, no case of study to neither illustrate its usage nor mention on reasoning processes are given in the paper.

3. Materials and methods

3.1. Soil samples

The samples used in this study were obtained from the Australian CSIRO National Soil Archive (CNSA), and can be found in http://www.asris.csiro.au/. The final selection comprised 80 soil profiles (n = 458 samples) from South Australia (66 %) and New South Wales (34 %). Soil samples were dried at 40°C and sieved < 2 mm. Samples were sourced from variable depths, from the surface down to 180 cm. Samples represented 9 soil orders (Australian soil classification) which are commonly used for cropping in Australia, mostly Calcarosols, Chromosols, Dermosols, Sodosols and Vertosols. Minor contributions of Dermosols, Kandosols, Kurosols, Ferrosols and Tenosols were observed.

3.2. Soil laboratory analysis

The following properties were determined by the methodology described in Rayment and Higginson (1992) and Rayment and Lyons (2011): Exchangeable bases calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^{+}) and (Na^{+}), alcoholic 1M ammonium chloride at pH 8.5, pre-treatment for soluble salts, and exchangeable bases by compulsive exchange, no pre-treatment for soluble salts; cation exchange capacity, automated determination of ammonium and chloride ions, and compulsive exchange, no pre-treatment for soluble salts; electrical conductivity (EC), 1:5 soil/water extract; pH, 1:5 soil/water suspension; organic carbon, Walkley and Black; bulk density (BD) and drained upper limit Moisture (DUL), volumetric APSRU (Agricultural Production System Research Unit) in situ methodology (Burk & Dalgliesh, 2013); saturated moisture (SAT), calculated from BD (Burk & Dalgliesh, 2013); particle size distribution (clay, silt and sand), hydrometer method (Gee & Bauder, 1986); total carbon and nitrogen (TC and TN), Leco analyser following the method proposed by Matejovic (1997).

3.3. Soil ontology

A basic ontology to model the fundamental concepts and relationships found in CNSA data is proposed (see Figure 1). The main concepts are Soil, SoilLayer, SoilOrder, SoilTexture and Location. SoilOrder is specialized following the soil orders stated in section 3.1. All these soil orders are modeled as disjoint among them (i.e. the same soil sample cannot be classified as two different soil orders). Regarding the texture class hierarchy, our proof-of-concept reduces the classes to clay, loam and sand.

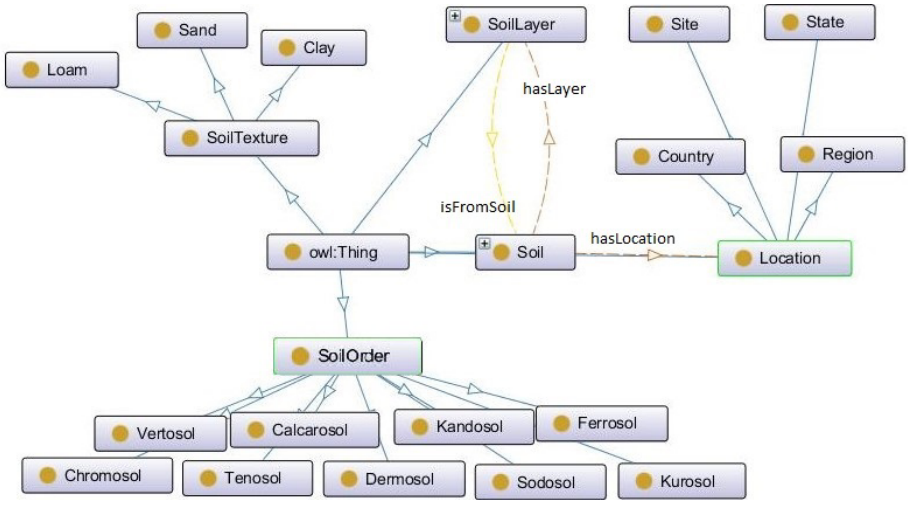

Figure 1. Soil ontology (hierarchical view).

The following relationships among soil concepts have been taken into account, as shown in Figure 1: A Soil has several SoilLayers (and inversely, a SoilLayer is from one and only one Soil) and a Soil has different Location that may range from a specific

site to a country. In section 3.4 it will be described how any SoilLayer is related to a SoilTexture and how any Soil is related to a SoilOrder by means of the realization reasoning process.

Some important data properties have been defined for each concept. Thus, some Soil properties include ID, latitude and longitude. Regarding the SoilLayer concept, it includes properties such as layer depth (ranging from 1 to 4, being 1 the most superficial layer and 4 the deepest layer: typically 0-15 cm,15-30 cm, 30-60 cm and > 60 cm, respectively), as well as physical and chemical attributes described in section 3.2.

The ontology has been modeled in the OWL 2 language using Protégé 5.2[2]

3.4. Realization of soil samples

One of the most important features of ontologies is the ability of automatically assigning individuals to concepts based on the definition of such concepts. This inference process is known as realization. In the soil context presented here, it means that it is possible to assign soil samples to a soil texture class and to a soil order in an automatic manner. Thus, instead of manually classifying each soil sample one by one according to several parameters, it is possible to derive these classification rules in the ontology and perform the realization process to classify all samples in one click. This represents a practical example on how ontologies work. The application is twofold: one allows for the selection of samples of our interest using rules that we define beforehand; the other allows classifying using such rules, which can be very useful especially when a large number of samples are available.

A concept in an ontology can be defined as a logical expression relating concepts, relationships and properties by using operators such as “and”, “or”, “not” and restricting relationship cardinalities and data ranges. Then, any individual fulfilling the logical expression is inferred as a member of that concept.

In our ontology methodology we have defined several logical expressions for soil texture class and soil order. Let us see first the logical expressions related to soil textures. According to the USDA texture triangle, it is possible to classify the soil texture based on the percentages of clay, sand and silt in the sample. As an example, Figure 2 shows the logical expression for clay texture.

This logical expression can be read as “For any soil layer having a clay percentage ≥40% and a sand percentage ≥ 45% and a silt percentage ≤ 40%, then such a soil layer is classified as clay texture”. Similar expressions are defined for loam and sand textures.

Figure 2. Logical expression (axiom) describing “Clay texture” concept.

[2] http://protege.stanford.edu/

For this first version, and regarding logical expressions related to soil classification in orders, we have defined axioms for Vertosol, Sodosol and Choromosol orders. Classification rules for these orders have been adapted from Isbell (2016) to allow us to classify soils using laboratory analyses without knowing horizon distribution. As an example, Figure 3 shows the logical expression for Vertosol. This axiom reads as "For any soil having both layers 1 and 4 with a percentage of clay particles ≥ 35%, then such a soil is classified as Vertosol".

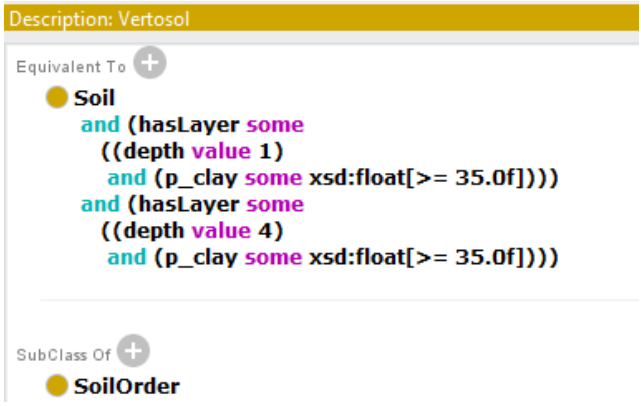

Figure 3. Logical expression (axiom) describing "Vertosol" order.

The logical expressions shown above need to be evaluated by an ontology reasoner in order to perform the realization process. For this study we have used Pellet[3], a well-known ontology reasoner for OWL 2 language included in Protègè.

4. Results

This section shows the application of our proposed ontology for the selection of soil samples. The methodology followed for the usage of the ontology can be summarized in three steps: 1) data loading (i.e. soil sample data) into the ontology; 2) performing reasoning processes on the data and ontology axioms (including the realization inference); and 3) writing the queries of interest. These steps are further explained below.

Before querying the ontology, we first need to load the soil samples data gathered from CNSA into our ontology. The data were originally exported into an Excel spreadsheet. We have used Cellfie[4], a plug-in for Protègè, in order to transform the soil samples in Excel format into ontology assertions. Soil order and soil texture class information for each sample have been excluded when loading the data as it will be inferred by the ontology axioms explained in section 3.4.

[3] https://github.com/stardog-union/pellet
[4] https://github.com/protegeproject/cellfie-plugin

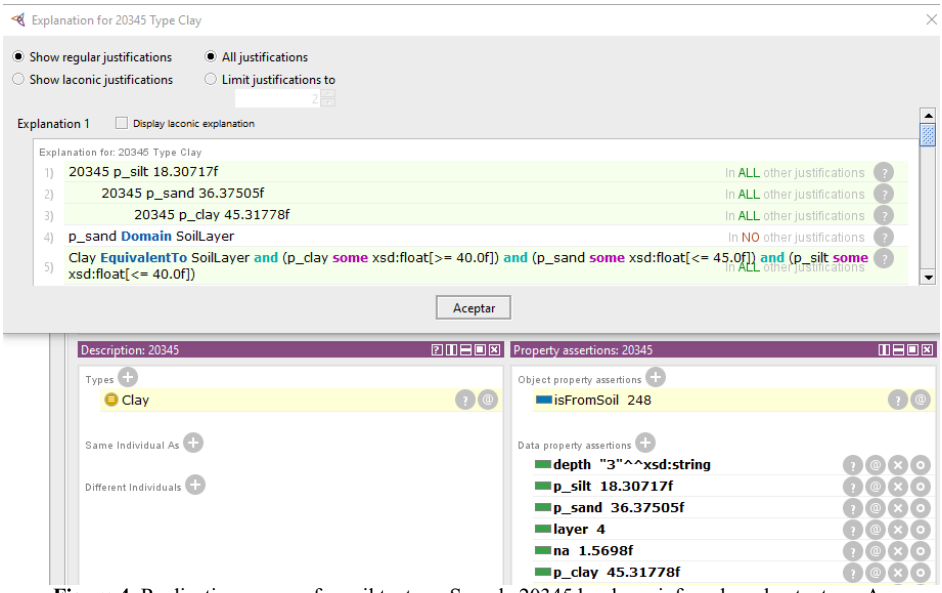

Figure 4. Realization process for soil texture. Sample 20345 has been inferred as clay texture. An explanation in logical language can be retrieved for any inference (in the top of the figure).

Then, we perform the realization process to automatically classify soil texture class and orders for each soil sample. Figure 4 shows an example for the classification of a soil sample (ID 20345) as a clay texture soil. Note that an explanation for any realization can be produced, as shown in the top of Figure 4.

After comparing the outcome of the realization process with the original soil texture and soil order classification given by the CNSA, promising results were found as shown in Table 1. Nevertheless, we will need to refine the logical expressions for sand texture and Chromosol order.

Table 1. Outcome of the realization process for soil texture and soil classification

Soil Texture	**CNSA data**	**Ontology realization**	**Accuracy (100%)**
Clay	206	208	99
Loam	8	8	100
Sand	6	10	60
Soil Order			
Chromosol	19	13	68
Sodosol	11	9	81
Vertosol	9	8	88

It is worth mentioning that soil ID 274 was classified as Vertosol and Sodosol at the same time. This generated an inconsistency in the ontology, as both concepts are disjoint, and the reasoner warns about this through a message in Protègè. As a result, we detected that the logical expression for Sodosol needed to be refined. This validation process is possible due to the formal properties provided by ontologies and enable developers to detect mistakes in the ontology development.

The ontology is then ready to receive queries for selecting soil samples. Similar to traditional databases, queries in ontologies are expressed using SPARQL, a query language similar to SQL but with a higher expressiveness. The first case is a typical search for a soil sample according to some features of interest. For example, query in Figure 5 searches for soils with any soil layer with Na ≥ 10.0 and clay percentage ≥ 50%. This query returns soils 268 and 274 with their respective values.

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX soil: <http://www.semanticweb.org/ucam/ontologies/2017/3/soil#>

SELECT ?soilID ?Na ?clay
        WHERE { ?soil rdf:type soil:Soil.
                ?soil soil:soilID ?soilID .
                ?soil soil:hasLayer ?layer .
                ?layer soil:na ?Na .
                ?layer soil:p_clay ?clay .
                FILTER(?Na >= 11.0) .
                FILTER(?clay >= 50.0) .
    }
```

Execute

?soilID	?Na	?clay
274	11.3	57.0
268	12.0	59.0

Figure 5. A simple SPARQL query for searching soil samples with Na ≥ 10.0 and clay percentage ≥ 50%

A more complex case is proposed. Let us suppose that given only the ID of a specific soil, we want to find other soils classified in the same soil order (we do not know the soil order for the original soil). The query in Figure 6 solves this issue and shows the results. In this case we asked for soil ID 247, which turned to be Vertosol, and the query returns all soils classified as Vertosol according to the realization process explained in Section 3.4. Note that this process will not be possible in traditional databases if soils are not manually classified in the first instance.

5. Conclusion and future work

This study has confirmed the potential of ontology approaches as an efficient, intuitive, and easy to use tool for the selection of soils from large soil libraries. As illustrative examples, we provide basic selection strategies along with more complex queries where samples are satisfactorily selected by their texture class or soil order. Ontologies

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX soil: <http://www.semanticweb.org/ucam/ontologies/2017/3/soil#>

SELECT ?soilID ?soilOrder
        WHERE { soil:247 rdf:type ?soilOrder.
                ?soilOrder rdfs:subClassOf soil:SoilOrder .
                ?anotherSoil rdf:type ?soilOrder .
                ?anotherSoil soil:soilID ?soilID
                FILTER(?soilOrder !=soil:SoilOrder)
    }
```

?soilID	
260	soil:Vertosol
281	soil:Vertosol
280	soil:Vertosol
693	soil:Vertosol
264	soil:Vertosol
274	soil:Vertosol

Figure 6. A more complex query to retrieve similar soils to the one provided based on their orders

also warn about inconsistencies (i.e. a soil classified under 2 orders) which enable users to detect mistakes or special samples.

For the selection of samples that belong to given soil orders there is a need to use a reasoning process. This enables to quickly and automatically classify soils when this information is not available. Thus, we were able to classify soils from different orders, this showing an additional application of ontology approaches to produce hidden data from the original data set.

The proposed approach based on ontologies offers invaluable potential in agriculture and wider environmental applications. For example, ontology can be used for an easy and fast selection of the most suitable soils for specific crops. Likewise, best managerial practices can be easily selected in soil degradation, contamination and ecosystem services studies. In a generic environmental context, ontology can be used to activate alarm situations and to assist environmental managers in decision making processes. Irrespective of the area, tools like the presented in this study represent a necessary alternative for the management and access of increasing volumes of data being produced.

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Detection of Abnormal Region for Pest Prediction in Paddy Field

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Abstract. The aim of this study is to design, implement and evaluate an image-based software solution for automatic detection of abnormal on paddy fields that damages by insects, diseases. The methodology of the proposed is composed of third phases. This content is a combined approach for the segmentation of images. In the first phase, watershed segmentation algorithm, second phases, using the K-means clustering algorithm and final in the third phases reducing noise in image gradients. We have taken paddy filed images as a case study and evaluated the proposed approach using abnormal area paddy field images for the pest prediction. In experimental results, indicate that the proposed approach can automatic detection and of abnormal area on paddy fields for the pest prediction. In conclusion, the proposed methods show that detect abnormal region efficiently.

Keywords. Watershed Segmentation, k-means, Image processing, RGB.

1. Introduction

Nowadays, modern agriculture technology is the main significant role in agriculture's sector to development productivity and improved features, agriculture's technology to protect crops [1]. Recently, with the increasing population, rice is the main key for humanity to eating every day, therefor, modern technology is a signification role in agriculture's developments with increase quality of agriculture productivity, such as the value of product depend on the quality of production, it is important to comparison quality of productivity in agricultural science and technology [2]. Recently, farmer's fields have the resources to cultivation over year but agriculture is not developed as it should [3]. Because they are used fertilizers and pesticides than is necessary and inefficiency, caused disadvantage in the long term and pests are a major problem that farmers' incomes decreased, damage caused by in national level and minimizes economic loss and necessary to accurately assess the pest distribution and damage caused by disease and insects [4].

In agriculture's plants to observation and monitoring crop is the main key for significant of agriculture products on quality and quantity [5]. Observe health crops is the main condition step to controlling plants that damage by disease and insect in agricultural sector, therefore, if crops damage by insects, the yield will loss and bad

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quality and spent on controlling the diseases and the rest is the value of damage caused by the diseases [6]. Therefore, the application of image processing is the key medium of conveying the information, such as forest plant analysis in agricultural crops and insects based on the different color space with RGB image and using image processing techniques [7]. And observation, detection and monitoring crops is the based key role in successful to detect the color symptoms of diseases on crop fields, it is the main proposed to naked eye observation experts to protect on plant level and product quality and quantity of the agriculture product [8].

This image segmentation process partition and detections a color image into a set of separate regions are very important techniques in the area on paddy field images to analysis and watershed segmentation technique has been approach the paths of pixels to modify the original image, then conversional the background image of pixels and the extended maxima, those pixels are forced on the local minima in the image [9]. More importantly, watershed segmentation algorithm has been computer the distances transform of image and distance transform of binary image area [10].

K-means clustering algorithm is based image processing to cluster and divides data groups of cluster on image that are meaningful, useful with image and determine groupings of pixels it is attractive in practice [11]. The each cluster of image is represented by an adaptively changing center, and then it will start from some initial values pixel points and K-means clustering variant that can incorporate from distances level inputs of constraints of centers, and assigns inputs to the nearest center of cluster pixels [12].

In this technique, the gradient magnitude is computed using a prewitt or sobel and any other suitable filter for task. Therefore, demonstrate an image, reduce an image and associated with the image gradients to increase features and remove pixels in images. Those pixels in image gradient magnitude intensities correspond to watershed lines and region binary on that image. In that case, pixel of image is interpreted like an altitude in the relief and the drop of water flows along a path to reach a local minimum [13]. In our experiment fast and accurate new method is developed based on computer image for grading of plant color diseases on paddy fields. After that the original image on paddy fields, then combination of the traditional watershed segmentation within k-means clusters. Image segmentation is an important task for color disease of the image that is the disease spot regions where segmented by using image processing with MATLAB function to operate for detect the color disease spot on paddy field images [14].

The proposed image processing, we use third main phases for experiment, the first phase we conversional and create a color transformation structure for the paddy fields images (RGB) by apply watershed segmentation algorithm, second phases, using the k-means clustering algorithm and finally, third phases reducing noise in image gradients. In conclusion, the proposed detection abnormal area on paddy fields to recognizing on diseases and insects. In this study an automatic detection and classification of the abnormal area on paddy field has been proposed, this method is based on using watershed segmentation algorithm and k-means as a clustering procedure using some textures feature set, has segmented our large areas of paddy field images.

2. The proposed algorithm

The proposed methodology is 3-phases process. The first process, apply watershed segmentation to separate abnormal color area on paddy field image, then conventional the objects in the original image to increase color image, modify the image and remove the background pixels, all those pixel will extended color, second process applies the k-means clustering algorithm modify and classify color in a*b* separate groups of objects and the final process we will apply the image processing technique to accurate feature of an image to reduce an image gradients and convert it to grayscale. In our experiments we flowing the flowchart of the proposed methodology in Figure 1.

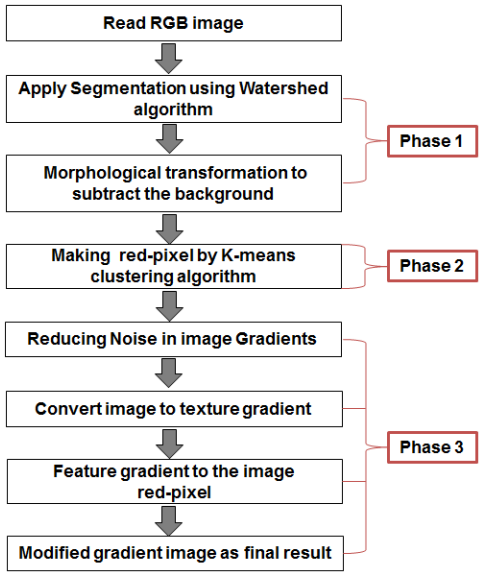

Figure 1. Flowchart of proposed methods.

2.1. Watershed Segmentation Algorithm

Segmentation using watershed algorithm is a very useful to determined manually or automatically using distance transform the image is thresholder the background from an image and then the small feature from image will removing by structuring neighborhood [15]. Automated thresholding technique using distance transformation the image is bi-level thresholding, boundaries are determined and the shortest distance of each pixel to the closest boundary point [16]. Compute the distance transform steepest direction neighboring pixel, those pixels which have large to boundary image and forced only local minima in the image [17]. The loop can be performed also from zero-valued of partitions, constitute to separate and inverted the objects images. We description of this process in here:

- Let R represent the entire image to subtract the background from an image, and then use watershed segmentation as a process that partitions R into *n* sub morphological transformation $R = \{R_1, R_2, R_3 \ldots R_N\}$, where R_i satisfied

by pixels in segmentation partition and N is the subtraction image from the partitions.

- Suppose the flood of the surface has reached the section $\mathrm{R_i}(f)$, when it continue and reach $\mathrm{R_{i+1}}(f)$ the flooding is performed in the zones of influence by:

$$\mathrm{IR}_{R_{i+1}(f)}(X_i(f)) \tag{1}$$

- Let the components of $\mathrm{R_{i+1}}(f)$ which are not reached by the flood are the minima at this level and must be added to the flood area
- Define $\mathrm{W_i}(f)$ as the catchment basins of f at the level i and $M_{\mathrm{i}}(f)$ as the minima of f at height $i+1$ then:

$$W_{i+1}(f) = \left[IR_{R_{i+1}(f)}(X_i(f))\right] \cup M_{\mathrm{i+1}}(f) \tag{2}$$

$$M_{i+1} = \mathrm{R_{i+1}}(f)/\mathrm{R}_{R_{i+1}(f)}(\mathrm{Z_i}(f)) \tag{3}$$

- The initiation of this iterative algorithm to measures neighboring partition is W_{-1}= 0.The and the watershed line is

$$DL(f) = W_{i+1}(f) \text{ When } N = \max(f) \tag{4}$$

- Where L is determination of maximum intensity and minimum intensity of the whole image. D is the input image L is a minimum filter of labeled matrix to binary image to zero. Values at different regions with the watershed ridge lines to modify the image and background pixels extended maxima pixel are forced only local minima image.

2.2. K-means clustering algorithm

K-means clustering method is quite sensitive to the initial cluster assignment and separated the pixels in image and then choice of the distance measure on group's cluster of the object. Additional criterion like within-cluster and between-cluster variances can be included in the objective function as constraints to force the algorithm to adapt the number of clusters k, as necessary for optimization of the objective function [18]. The algorithm following step.

- Computing a cluster by matrix U representing the partition of the data points and binary member value of the j data point to the i cluster such that $\mathrm{U} = \left[\mathrm{U_{ij}}\right]$, where $U_{ij} \in \{0,1\}$ for all i. j

$$\textstyle\sum_{\mathrm{i=1}}^{\mathrm{k}} \mathrm{u_{ij}} = \text{for all j and } 0 < \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{u_{ij}} < \mathrm{n} \text{ for all i}' \tag{5}$$

- Re-computing the centroids using the membership values by

$$\mathrm{V_i} = \frac{\sum_{\mathrm{j=1}}^{\mathrm{n}} \mathrm{u_{ij}} \mathrm{X_j}}{\sum_{\mathrm{j=1}}^{\mathrm{n}} \mathrm{u_{ij}}} \text{ for all i.} \tag{6}$$

- The cluster output from k-mean the matrix doses not change from the iteration. The label every pixel in the image with its cluster index by using k means clustering method optimizes the sum-of-squared-error-based objective function $J_w(U, v)$ then

$$J_w(U, v) = \sum_{i=1}^{k} \sum_{j=1}^{n} \left\| X_j - V_i \right\|^2. \quad (7)$$

2.3. Reducing noise in image gradients

Gradient already offers this capability for small amounts of noise by using the Sobel gradient operator [19]. Compute the magnitude of the gradient, using the gradient magnitude of the primary segmentation is obtained by applying the sobel operator. An image gradient is direction change or color in an image. The effect of noise can be minimized the images by smoothing and image gradient computation before used to extract information from images.

- Reducing noise in gradient, most time the real watershed transform of the gradient to accurate the minimum of the gradient that is produced by small variations, mainly due to nose feature $T(x, y)$ and $MT(x, y)$ is defined as follows:

$$MT_i(x, y) = \text{Median Filter}\left(T_i(x, y)\right). 1 < i \leq n. \quad (8)$$

- Where n is the number of sub bands, the length of the one dimensional median filter is $2^{(i+2)}$. The texture gradient $TG(x, y)$ can be calculated by:

$$TG(x, y) = \sum_{i=1}^{n} \frac{|\nabla(MT_i(x,y))|}{I_2(MT_i)} \quad (9)$$

Where n is the number of sub bands, ∇ is Roberts using a Gaussian gradient calculation algorithm (with the scale parameter σ set to 2.0). $I_i(x, y)$ is the amplitude of the sub band i decomposed by complex wavelet transform. $I_2(MT_i)$ is the I_2 norm energy of MT_i, which can normalize the texture gradient of each sub band [20].

3. Results and Discussion

This experiment result to detection the abnormal area on paddy fields, we applied our methodology of watershed segmentation algorithm to conventional the images, and then adjusted for the image by using our algorithm. The watershed cans increase the abnormal color area that damage by insects and diseases, and then removing the bright objects and dark background from the features that smaller area with abnormal color diseases on paddy fields Figure 2.

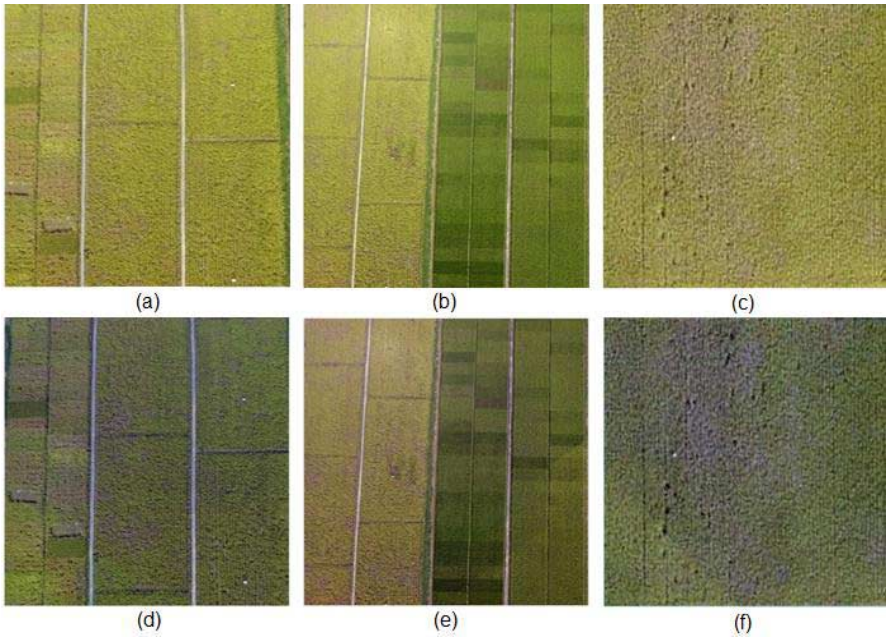

Figure 2. Sample of paddy images with (a) paddy field image disease (b) paddy field image biomass (c) paddy field image brown patch (d, e, f) apply watershed segmentation algorithm to conversional images and increase features that color smaller on abnormal area on paddy fields.

After using conversional image by using watershed segmentation algorithm then, we making red-pixels by apply k-means clustering algorithm to separate image and classify object pixels, those pixels are read, dark green objects in one of the clusters. We set of separate read, dark green from features into k number of layer in color space. However, k-means clustering is used to layer contains the brightness values of each color and contains the blue objects paddy field on abnormal area, damage by disease and biomass. In case our experiments, extract the brightness values of the pixel in this cluster the number of threshold them with a global threshold using binaries of the k-means clustering. That means the red pixels are parts of abnormal area that have disease, biomass, insects and damage caused by insects Figure 3.

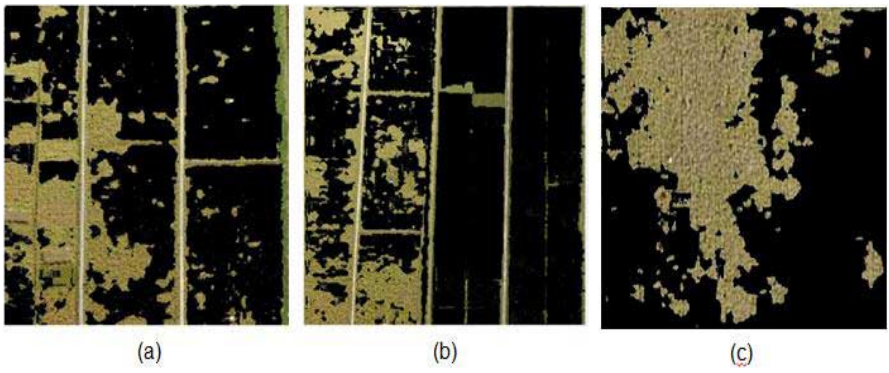

Figure 3. The result while using watershed segmentation algorithm to conversional image, (a, b, c) result k-means clustering for detecting abnormal area on paddy fields that have disease, insect and biomass.

An image gradient to reduce noise in gradient to detecting accurate features from these pixels and statistics for each image were generated. Concisely, then an intensity image to effect of noise can be minimized by smoothing around abnormal area on paddy fields. The pixel of the image gradient is a small amount of noise image to direction measuring horizontal by using the sobel gradient operator. In other words mean, healthy areas inside the infected areas were also removed. The pixels, we noise to the image on red-pixels for unhealthy, because, the paddy fields images infected with disease and biomass Figure 4.

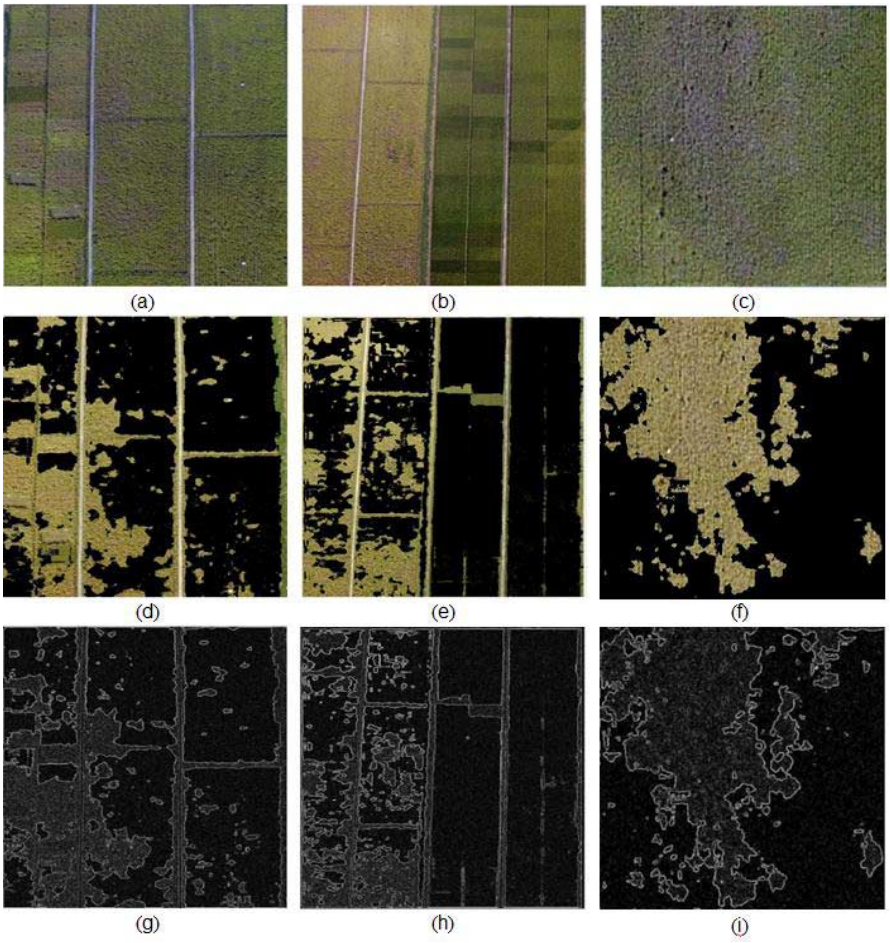

Figure 4. Detection of segmentation results on abnormal area in paddy fields (a, b, c) apply watershed segmentation algorithm to conversional images for finding some abnormal area on paddy fields that damage by insects and biomass, (d, e, f) the experiment result k-means clustering for detecting abnormal area on paddy fields that have disease, insect and biomass. (g, h, i) reduce noise in image gradient of abnormal area.

4. Conclusions

In this paper, watershed algorithm and k-means clustering to reducing noise of color abnormal area that damages by disease and biomass on paddy fields. The algorithm

was tested on abnormal area in paddy field and the results showed that on abnormal area of the initial partition with k-means clustering for modified gradients images to finding in color abnormal area that insects, biomass and fertilizer on paddy filed areas. Because, some of color abnormal areas similar to plants areas, that too hard for detecting on abnormal area in paddy fields. The proposed approach to accurate detection of abnormal area on paddy fields. An experiment results watershed segmentation and k-means clustering based detection of abnormal on paddy fields. These researches are in the initial trial and dedicate our future works on automatically, it still need improving methods to detect color disease on plants.

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Influence of Multivariate Modeling in the Prediction of Soil Carbon by a Portable Infrared Sensor

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Abstract. The determination of carbon is one of the most important in soil analysis. However traditional techniques are costly and time consuming. In this manuscript we propose an alternative predictive approach based on portable mid-infrared spectroscopy data modeled by machine learning techniques. We evaluate the performance of different machine learning models and sample size to predict soil carbon in 457 Australian soils. The results show a good performance of the models. All models are validate by statistical tests. The best performing technique with a 99% of confidence level is the Gaussian Process providing a 98% of accuracy for the prediction of soil carbon. Moreover, this technique is the most robust for the different sample sizes tested. When compared with the commonly used Partial Least Squares Regression technique, the machine learning approaches provide more successful and balanced results.

Keywords. mid-infrared spectroscopy, soil, soil carbon, multivariate regression, machine learning

1. Introduction

Soils play a vital role to life on earth and soil carbon is one of the most important components responsible for a number of their ecosystem services [4], [3]. Soil carbon is characterized by its large variability which require a high spatial density of soil analytical data [16] that traditional laboratory approaches (e.g. wet chemistry analyses) are unable to provide cheaply and quickly. In this way, we try to avoid, wherever possible, traditional laboratory tests. The laboratory tests are time consuming, tedious, quite expensive and they need to be performed by qualified professionals to obtain a reliable result with the smallest possible error, [14]. Sensors relying on mid-infrared (MIR) soil spectroscopy represent an attractive alternative. The technique is rapid, cheap and accurate and portable versions can be used directly in the field [16], [19]. The technique relies on the interaction of infrared light with soil compositional components, and the characteristics of the resulting soil spectrum which is unique to each soil and provides information

about its composition [15]. The technique is well suited to the study of soil carbon [9]. In order to model the complex relationship between spectral signatures and a soil property, multivariate regression methods are required [19]. A number of algorithms are available [18], and their different nature are likely to affect the predictions. Partial least squares regression has been the algorithm more extensively used. However, other approaches may be better suited to deal with nonlinear responses, outliers, complex, diverse and large data sets, etc. Prior to model development, spectra are generally pre-treated by a range of techniques in order to reduce optical interference not related with the chemical composition (e.g. those related with different particle size) and increase the resolution spectral peaks. Thus, spectra pre-processing can have a major impact in multivariate modeling. When developing predictive models, there is also the question of using a single large calibration or the development of site-specific calibrations [19], [6]. The selection or one or another approach also has an effect in the performance of predictions by spectroscopy sensors.

The main objective of this study is to propose new techniques based on machine learning, in order to accurately and efficiently predict soil carbon. Specifically, we study the performance of different multivariate models for the predictions of soil carbon using spectral data provided by a MIR portable sensor. It is also an objective of the article to test the influence of different calibration size (global vs. site-specific models) on the accuracy of the predictions.

2. Approaches to predict soil carbon

Machine learning techniques have been used to solve a wide range of problems in many areas, [10]. Nowadays, machine learning is becoming a useful tool to assist precision agriculture, [12], [1]. Infrared spectroscopy is characterized for having more features than number of samples. This is important to consider because not all techniques handle this properly.

In this manuscript, we propose to apply different machine learning techniques to predict soil carbon. We use techniques are that interpretable, have been extensively tested and are able to provide good performance when the difference between the number features and samples are considerable. The techniques used are: Bagging, Regression Rules, the ensemble Random Forest, the Gaussian Process and Decision Tree. The basics of the techniques are explained as follows:

- The Bagging technique is a classifier that allow us to reduce variance. The bagging technique can work for both classification and regression and it needs to establish a base learner. When it is used as classifier, predictions are generated by averaging probability estimates, not by voting. One parameter to consider is the size of the "bags", that is, the number of samples used in each iteration. This size is established as a percentage of the training set. Another parameter is whether to calculate the out-of-bag error, which gives the average error of the ensemble members [2].
- The regression rules technique derive rules from model tree built. Specifically, we consider the regression rules M5Rules, [8]. This technique generates a decision list for regression problems using separate-and-conquer. In each iteration it builds a model tree using M5 and makes the best leaf into a rule. Moreover, and in order

to reduce the error, the technique creates rules with exceptions by generating the default rule, using incremental reduced-error pruning to find exceptions with the smallest error rate.

- Decision Tree: we use the Decision Stump Tree which consists of a decision tree with a single node that determines how to classify inputs based on a single hypothesis. It contains one leaf for each possible hypothesis value, specifying class levels that should be assigned to inputs whose features have that value. In order to build that value, the hypothesis to be used must be chosen carefully, [21].
- Random Forest ensemble constructs random forests by bagging ensembles of random trees,[5]. The basis classifier used in this study is the C4.5 decision tree. C4.5 builds a decision or regression tree using information gain/variance reduction and prunes it using reduced-error pruning. Optimized for speed, it only sorts values for numeric attributes once. Moreover, this tree can deal with missing values by splitting instances into pieces. The following parameters can be set: minimum number of instances per leaf, maximum tree depth (useful when boosting trees), minimum proportion of training set variance for a split (numeric classes only), and number of folds for pruning, [17].
- Gaussian Processes technique implements the Bayesian Gaussian technique for non-linear regression. This technique needs to have specified a kernel function, along with a "noise" regularization parameter for controlling the closeness of fit. Moreover, the technique allows us to choose the training data normalized or standardized before learning the regression [13].

In the Section 3, material and method employed to collect and measure data feature to predict soil carbon are detailed.

3. Materials and methods

3.1. Soil samples

The samples used for this study were obtained from the Australian CSIRO National Soil Archive (CNSA, http://www.clw.csiro.au/aclep/archive/). The final selection comprised 80 soil profiles from South Australia (66 %) and New South Wales (34 %). Soil samples were dried at 40*C* and sieved < 2 mm. Samples were sourced from variable depths, most of the samples (n = 315) represented the first 100 cm, the rest (n =143) representing depths from 100 to 180 cm. Total carbon was determined by Leco dry combustion (TC). Descriptive statistics for the property analyses were: TC (n = 457, mean$\pm$SD = 1.63$\pm$1.64 %, range = 0.04-9.18 %).

3.2. Spectra

Samples were scanned with a Fourier-Transform infrared (FTIR) portable spectrometer (ExoScan 4100, Agilent, USA) in the frequency range 6000-650 cm^{-1}. For each sample, four replicate scans were recorded using a diffuse reflectance (DRIFT) accessory with a resolution of 8 cm^{-1}, and scanning time of 15 s. A coarse-grained silicon carbide (SiC) reference disc (assumed to have a reflectance $R_0 = 1$) was used as the background. Only the MIR range (4000-750 cm^{-1}) was considered because the energy of the instrument

is optimized for that region. Models were developed following spectra average and detrending correction in the selected spectral range.

3.3. Validation Method

The measure uses to test the quality of machine learning techniques is Mean Absolute Error, this error is defined as follow:

$$Error = \frac{1}{n}\sum_{i=1}^{n} |Y_i^{measured} - Y_i^{predicted}|$$

Being i the sample tested each time and n the total number of samples used as test. The accuracy is defined as:

$$Accurracy = 1 - Error$$

Typical deviation is calculated as:

$$TypicalDev = \sqrt{\sigma}$$

where σ is the variance provides by the model.

In order to evaluate the techniques several calibration/validation approaches are tested. Different sample sizes are randomly selected, to assess the robustness, stability and behavior of the techniques.

Moreover, we are going to execute a statistical test. Since the results do not follow a normal distribution, we develop a non-parametric test. We performed the Wilcoxon Signed Ranks Test [11] in pairs to verify and achieve a raking of robustness of the techniques.

4. Experiments

Using the data described and the techniques presents in Section 2, several experiments have been developed to assess the best techniques to predict the soil carbon.

This initial evaluation is developed in order to test the variability and boundary of classical machine learning techniques for the problem of soil carbon proposed.

The experiments carry out to test the boundary of the techniques regarding the prediction of soil carbon, have been developed using the tool Weka [7]. To ensure the robustness, stability and balance of the results, all the experiments performed have been repeated 30 times.

After showing the parameters used by machine learning techniques in Section 4.1, we present different experiments using different calibration. Specifically, we execute the following type of calibration, modifying the sampling size used to build the different models.

- First evaluation: 80% dataset for training (366 samples) and 20% for test (91 samples).
- Second evaluation: 50% dataset for training (229 samples) and 50% for test (228 samples).

- Third evaluation: 30% dataset for training (137 samples) and 70% for test (320 samples).
- Fourth evaluation: 3-fold cross validation.
- Fifth evaluation: Comparative with other paper, using 75% dataset for training (343 samples) and 25% for test (114 samples).

4.1. Parameters

Table 1 shows the most relevant parameters for the different modeling techniques tested. No parameters have been provided for the decision tree technique since it is not necessary to specify them. For the bagging technique its base classifier is the decision tree C4.5, and the whole training set is used in each iteration. For the the Gaussian Process, the kernel used is a polynomial kernel and the level of noise introduced in the Gaussian technique is 1%. For Random Forest, the number of trees in the forest is 100 and the basis classifier is the C4.5 tree. Finally, for the M5Rules technique, the parameter indicates that a rule is built with a minimum of 4 samples.

Table 1. Relevant parameters of techniques used

Techniques	**Parameters**	
Bagging	Base Classifier:	C4.5
	Iterations:	10
	% Bag Size:	100%
Gaussian Process	Kernel:	Polynomial Kernel
	Level Gaussian Noise:	1%
Random Forest	Base Classifier:	C4.5
	Number Trees:	100
	Minimun Features:	1
Rules	MinNumberSamples:	4

4.2. Pre-processing Samples

Soil data in spectroscopy studies are usually processed before modeling. For example in [19], the authors delete samples with a higher values for carbon, specifically, values greater than 6.5. In addition, the whole features are normalized. For this study, we do not delete samples, we only normalize in the range [0-1] the whole features to avoid distortions due to the large difference in ranges between measured frequencies and the values of carbon.

4.3. Training 80% samples

In this experiment, we use the 80% of the samples to train the model.Table 2 shows the results obtained for each technique, showing the mean square error, accuracy percentage and the standard typical deviation.

Applying all combination with Wilcoxon Signed Ranks Test, the results show with a 99% of confidence level that Gaussian Process is the best technique with the calibration of 80% for training. Thus, techniques can be ranked (from best to worst) as follows: Gaussian Process, Rules, Random Forest, Bagging and Decision Tree.

Table 2. Results obtain training with the 80% samples

Techniques	%Error	%Accuracy	Typical dev.
Bagging	3,09	96,92	0,30
Gaussian Process	2,00	98,00	0,25
Random Forest	2,49	97,51	0,28
Rules	2,24	97,76	0,29
Decision Tree	7,49	92,51	0,50

4.4. Training 50% samples

For this experiment, we predict soil carbon using 50% of the soil dataset. Table 3 shows the results obtained for each technique.

Table 3. Results obtain training with the 50% samples

Techniques	%Error	%Accuracy	Typical dev.
Bagging	3,43	96,57	0,24
Gaussian Process	2,23	97,77	0,18
Random Forest	2,77	97,23	0,23
Rules	2,68	97,32	0,34
Decision Tree	7,54	92,46	0,30

Applying all combination with Wilcoxon Signed Ranks Test, the results show with a 99% of confidence level that Gaussian Process is the best technique with the calibration of 50% for training. The sign ranking obtained is the same as for the previous experiment.

4.5. Training 30% samples

In this case, we reduce the training sample to the 30% of dataset.Table 4 show the results obtained for the different models.

Table 4. Results obtain training with the 30% samples

Techniques	%Error	%Accuracy	Typical dev.
Bagging	3,98	96,02	0,30
Gaussian Process	2,39	97,61	0,17
Random Forest	3,18	96,82	0,25
Rules	3,06	96,94	0,38
Decision Tree	7,69	92,31	0,42

Applying all combination with Wilcoxon Signed Ranks Test, the results show with a 99% of confidence level that Gaussian Process is the best technique with the calibration of 30% for training. The sign ranking obtained is the same as for the previous experiment.

4.6. Training 3-fold Cross Validation

The last sample size is a 3-fold cross validation. In this experiments, the models are training with the 66,3% of samples and tested with the remaining samples. This process is carried out 3 times where all the samples are used once to train the models.

Again, the result obtained for the Wilcoxon Signed Ranks Test indicate with a 99% of confidence level that Gaussian Process is the best technique and the sign ranking obtained is the same.

Table 5. Results obtain evaluating with a 3-fold cross validation

Techniques	%Error	%Accuracy	Typical dev.
Bagging	3,19	96,82	0,27
Gaussian Process	2,13	97,88	0,19
Random Forest	2,55	97,45	0,24
Rules	2,52	97,49	0,28
Decision Tree	7,53	92,47	0,47

4.7. Comparing with a Statistic technique

The last experiments consist of comparing the the machine learning techniques proposed with the Partial Least Squares Regression technique (PLSR) proposed in [20]. In this study the authors use the same datasets and the evaluation is performed using a 75% of samples as training set and the remaining 25% as test set. For the machine learning techniques proposed we execute the same evaluation. It should be noted that the authors in [20] perform a pre-processing by eliminating those samples with a high carbon value, therefore the error shown is subject to this condition. Table 6 shows the results for the machine learning techniques proposed and the result obtained in [20] to predict soil carbon.

Table 6. Comparing the machine learning regression technique with the Partial least squares regression. Results obtain training with the 75% samples

Techniques	%Error	%Accuracy	Typical dev.
Bagging	3,14	96,86	0,32
Gaussian Process	2,08	97,92	0,24
Random Forest	2,53	97,47	0,27
Rules	2,38	97,62	0,27
Decision Tree	7,48	92,52	0,46
PLSR	6,00	94.00	0.30

The result of Table 6 indicate that the technique with the best accuracy is the Gaussian Process.

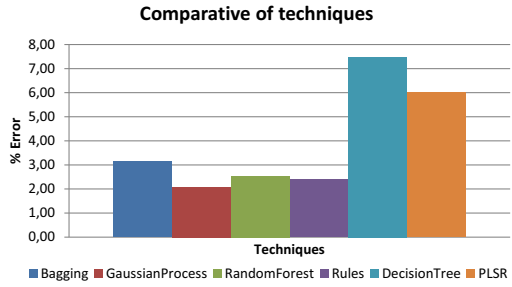

Figure 1. Comparative of typical deviation of techniques using different sample sizes

The PLSR technique obtains the fifth best results being in last position before the decision tree technique. Graphically, Figure 1 depict clearly the differences of errors obtained by the different techniques compared. Applying the Statistical test with a 99% of confidence level demonstrates that Gaussian Process is the best technique. The sign

ranking from better to worse technique are: Gaussian Process, Rules, Random Forest, Bagging, PLSR and Decision Tree. If we take into account the pre-processing performed by [20] deleting some samples, the error for PLSR will be greater and this technique will be the worst.

4.8. Discussion

In Tables 2, 3, 4 and 5, we have shown the results obtained for the different models, and different the sample size for training the models. By comparing different calibration approaches we want to verify the robustness of the machine learning techniques proposed and the variability of results, preventing over-fitting of the models built.

Analyzing the whole of experimental results along with the statistical tests we can conclude that the most accurate models have been obtained by the Gaussian Process.

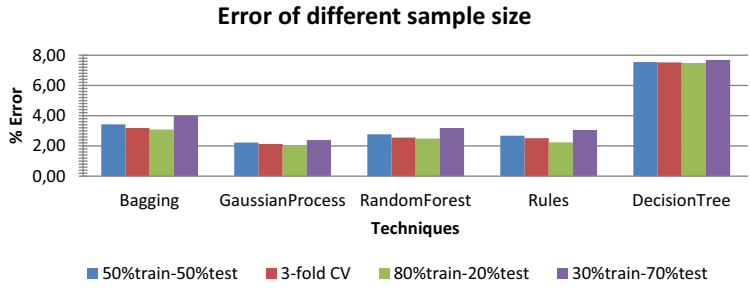

Figure 2. Comparative depicts the error from different sample sizes

A graphic visualization of these results is shown in Figure 2. This Figure depicts the mean square error obtained for the different techniques taking into account the different calibration. The global results indicate an accuracy between 92.4% and 98%. The technique with the worst results is the Decision Tree. The Bagging and Random Forest provide similar results with the latter being slightly better.

The results of Rule technique are better than Random Forest and worse than Gaussian Process. Analyzing from viewpoint of the sample size, Decision Tree provides sim-

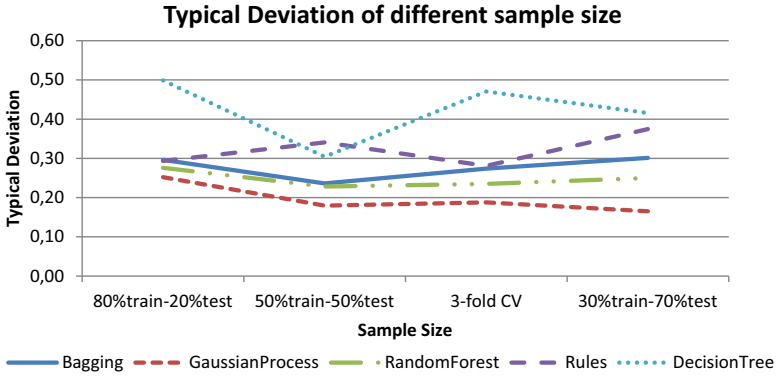

Figure 3. Comparative of typical deviation of techniques using different sample sizes

ilar results, that is, this technique is not affected by the sample size. However its error

is higher than the rest of techniques. Bagging technique losses an 1% of accuracy when the data sample size set is reduced in the train phase. For Random Forest technique the behavior is similar to Bagging, but the results do not vary with the different sample sizes. Rules are greatly affected by the sample size. By contrast, the Gaussian Process technique provides stable results independently of the method chosen for the selection of training samples. Moreover, this technique yields the lowest errors.

In addition, we study the variability of the results obtained, repeating 30 times each experiment. Figure 3 depicts the typical deviation for the machine learning technique proposed considering the different calibration set size. In this Figure there are several aspects that must be highlighted. For the Gaussian Process technique the less training samples use, the less variance they have. However, the Decision Tree is more unstable since the standard deviation is very variable depending on the sample size. The Gaussian Process technique is more stable because it has less variance with less training samples. Thus, the risk of over-fitting using this technique is minimum. These other three techniques provide still stable results. Therefore we conclude that the Gaussian process technique has a stable behavior, obtaining the best and most balanced results.

Regarding the comparative of techniques shown in Table 6, the statistical test indicate that the machine learning techniques provide better results. This comparative is performed according to the conditions exposed in [20]. The machine learning techniques build more global models that are able to adapt from different calibration. Moreover, they are not affected by the noise provoked by high differences in carbon values.

5. Conclusions and Future Works

The soil carbon determination plays an important role in ecosystem services. Traditionally, the soil carbon prediction have been evaluate using statistical techniques. However these techniques do not provide a good performance in the presence of noise in the data, so they need to run a pre-processing phase. In this study we have proposed several machine learning technique to predict soil carbon. We have performed different calibration to assess the robustness and efficiency of machine learning techniques. The results provided by techniques show a good performance, and after executing statistical tests, the best technique is the Gaussian Process. In addition, we compare with other technique of literature (PLSR), being the machine learning techniques more robust than PLSR technique.

As future work, highly complex machine learning techniques such as genetic algorithms and neural networks will be tested. We will execute new prediction for other soil components like nitrogen and particle size. Moreover, instead of predicting soil carbon, we will use the spectral features for soil classification. Finally, we will perform additional tests using other spectrometers, in order to compare the performance of such instruments.

Acknowledgment

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Incorporación" Program). The authors also wishes to acknowledge the support of the Grains Research and Development Corporation (GRDC project CSO00045 Soil infrared capability), and the provision of soils and analytical data by Linda Karssies and Peter Wilson (CSIRO National Soil Archive)

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Monitoring Two Mangrove Forest of Rio Grande do Norte, Brazil, Using Multi-Temporal Satellite Data

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Abstract. This study aims to detect changes in vegetation and evaluate the geographic distribution of two different mangroves of Rio Grande do Norte, Brazil. Data were obtained through visual interpretation of high resolution satellite imagery (Astrium / QuickBird / DigitalGlobe / Landsat) available in Google EarthTM. The visual interpretation resulted in the demarcation of polygons representing vegetated area of mangroves. Data were compared to the images of global distribution of mangroves in 2011, provided by United Nations Environment Programme of Global Conservation Monitoring Centre using GIS. The mangrove forest present in Guaraíras lagoon complex had an increase in vegetated area over the last four years of 5.01 km (52.73%) while the mangrove forest located in Potengi estuary presented a 1.03km (6.06%) of forest gain in the same period. Anthropogenic activities such as shrimp farming, artificial construction, tourism and discharge of effluents are directly related with the conservation status of Brazilian mangroves. The mangrove ecosystem present in the metropolitan region of the Rio Grande do Norte (largest population area), showed a slow growth rate, while the mangrove located further away from urban centers, showed impressive growth of vegetated area.

Keywords. environmental monitoring, remote sensing, cluster algorithm, mangrove forest

1. Introduction

A significant fraction of the Brazilian coast is occupied by mangroves, being found from the state of Santa Catarina, to the state of Amapá. This ecosystem provides various services to the environment, acting on the stability of coastal geomorphology, biodiversity conservation and maintenance of fishing resources [1] because of the social and environmental characteristics of the Brazilian northeastern coast, these servicesare highlighted, making huge the environmental and ecological value of mangroves in these regions [2].

Mangroves provide habitat for many animals, including some with high commercial value that need this environment for food. Mangroves forests are breeding grounds and

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refuge for migratory species, such as mammals, crustaceans and birds. In addition, these sites perform many ecological services: act as natural nurseries of a range of marine species, and are major producers and exporters of biomass to the marine environment near the coast, being responsible for the maintenance of fishing in many regions[3].

Based on the characteristics of this ecosystem, Brazilian law considers mangroves as areas of permanent preservation. However, in spite of the environment ministry's efforts, the mangroves are permanently threatened by various human activities in their surroundings, such as dam on rivers, discharge of pollutants, aquaculture, direct deforestation and urbanization that destabilizes the amount of sediment and water in estuaries [1].

Between one and two percent of the ecosystems present in the mangroves are being devastated for shrimp farming and construction of seashore condominiums and resorts each year. This rate of destruction is comparable to the annual rate of deforestation of rainforests [4].

The shrimp cultivation in captivity (shrimp farming) has expanded exponentially in the last two decades, the fastest growing in the world in aquaculture. In the Brazilian context, especially in the Northeast, technological innovation and public / private investment were decisive for this development [5]. Because of the large areas suitable for marine shrimp farming and the favorable climate conditions, the state of Rio Grande do Norte has becoming the largest exporter and the biggest producer in Brazil [6]. However this activity impact directly on natural resources (estuarine and coastal ecosystems) which has caused great concern in diverse sectors of society [5]. The main environmental and social damage related with shrimp farming are: loss of marshland; water contamination by pond wastewater; riparian and carnauba deforestation; aquifer salinization; buried inlet and tide channels; soil impermeabilization associated to the mangrove; drainage channel erosion; flight of exotic shrimp to fluvial and fluvial-marine environments; extinction of shellfish and reduction of numerous species; expulsion of crab, shellfish, and fish fishermen from their traditional fishing areas; deaths and respiratory diseases from the use of metabisulphite; impeding access to the estuary and mangrove; increased land sales and another consequences [7].

The concern about the conservation of this ecosystem by society, stimulated Herz [8] to perform the first mapping of mangrove areas in the northeastern coast, based on satellite images available for the year 1978. This one was the most comprehensive study so far, and served as the basis for management of fishery resources and conservation programs for the estuarine ecosystem [1].

In addition to anthropic activities, some natural phenomena such as migration of coastal dunes and bars, acting alone or together can significantly alter coastal ecosystems, and consequently the coverage of mangroves, requiring its monitoring systemic way. Due to these characteristics [1] published the Atlas of Northeastern Mangroves of Brazil in 2006.

Considering the high fragility of mangroves against natural processes and permanent interventions in the coastal zone of the State of Rio Grande do Norte, this work aims at the current survey data on the spatial distribution of two state's mangroves front the recent expansion of urbanization and shrimp farming in coastal areas.

This study using geoprocessing tools is an analysis of the variation of the spatial distribution (in meso and short scale) of vegetation at these mangroves in the last four years; identifying locations where there was evolution mangrove forest area and identification of locations where there was suppression of mangrove vegetated area in the same period.

2. Study Area

The study area consist in two different mangrove forests presents in Brazilian Northeast state of Rio Grande do Norte, The location map can be observed at Figure 1. The regional climate at coastal zone is classified as humid tropical, with a two different precipitation seasonal periods: a rainy season (197.7 ± 54.3 mm.month^{-1}) from March to August and a dry season (38.1 ± 25.7 mm.month^{-1}) that normally extends between September and February, with a total of 1500mm.year^{-1}[8].

In this region, lies the estuarine lagoon complex called "Guaraíras located on the east coast of Rio Grande do Norte (6^o 9' to 6^o 15'S and 35^o 5' to 35^o 15' W), consisting of three interconnected lagoons with about 7 km length of estuarine zone bordered by mangrove forest, going through the cities of Nisia Floresta, Senador Georgino Avelino, Ares, Goianinha and Tibau do Sul.

At north of Guaraíras estuarine lagoon complex (approximately 50 km) is the Potengi estuary located between the geographical coordinates of latitude 54^o3'S to 5^o53'S and 35^o09'W to 35^o21'W, with about 20 km length of its estuarine zone bordered by mangrove forest, going through the cities of Natal, São Goncalo do Amarante and Macaíba [9]. According to [10] and [11] the mangrove forest in the Potengi estuary being composed of three species of trees: the most predominant are Rhizophora mangle (cobbler or red mangrove) with a 62% of occupation close to the river mouth and the margins; More towards the inside of the margins Laguncularia racemosa (tame or white mangrove) are present about 21% of occupation; Avicennia germinans (black mangrove) presents together with scattered individuals of L. Racemosa and R. Mangle about 17% in the most inland area of the Potengi estuary.

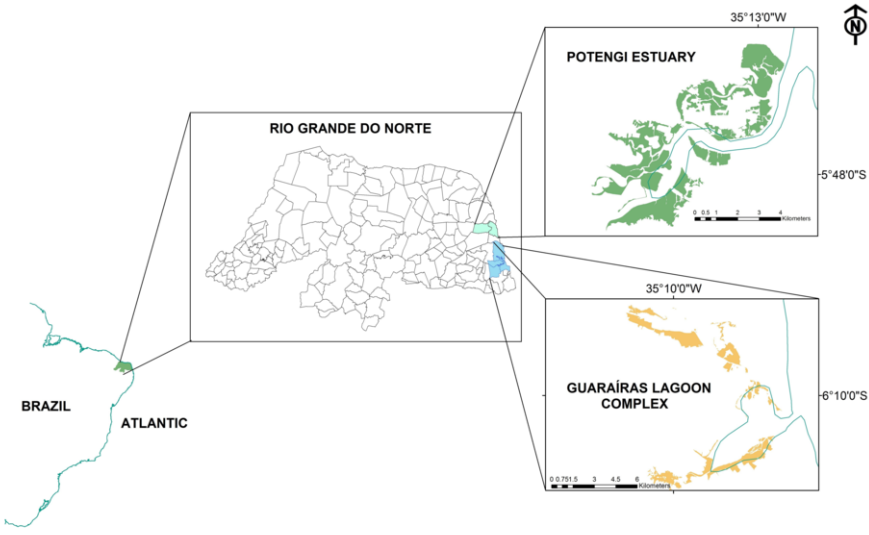

Figure 1. *Potengi and Guaraíras Estuaries with location of mangrove forest areas (Potengi: green; Guaraíras: orange; Coastal line: blue) transect used to study the dynamics of the vegetated area. Forested areas extracted from Global Distribution of Mangroves - USGS 2011*

3. Methods

Geographic data used to determine the spatial distribution of mangroves in the study areas, were obtained in the period of March 2014 to February 2015, using available images of Google EarthTM version *7.1.5.1557 (http://earth.google.com)*.

This software is a component of the Geographic Information System (GIS), freeware, and available on the internet, with high spatial resolution images support, adjusted to a simple cylindrical projection *(latitude/longitude)* and *Datum WGS84* [12]. This software has many applications and is used in various branches of science [13], such as urban environment analysis and three-dimensional modeling of cities [14] analysis of cultivated areas [15]and detection and monitoring of ecological habitats [16] The images used with high resolution for mangrove Potengi estuary and the Lagoon System Guaraíras were obtained from different satellites: Astrium*(SPOT 6 / SPOT 7 - higher resolution to 0.50 m)*; QuickBird / DigitalGlobe *(resolution of 0.60 m)* and a mosaic called Landsat, derived from GeoCover by NASA *(http://www.landcover.org/)* using images from *Landsat 7 + EMT*. In the study in question were not imported or exported any other type of image, due to Google Earth only provide images in the web version.This sattelite images are real color compositions and serve as a database for the present study.

Although some of these sources of images presented limitations on the geophysical spatial analysis, visual interpretation and manual vectorization (onscreen) using these satellite images has been widely used to map and quantify anthropogenic changes in the estuarine environment [1]. In order to achieve the demarcation and segmentation of mangrove areas, for both studies at the Rio Grande do Norte region, was used the polygon creation tool function on Google Earth, resulting in a KML file and subsequent conversion to shapefile, EsriTM. The onscreen vectorization (of vegetated areas in contact with the river and sea), used the altitude of about 1500 m as maximum altitude of remote observation of the Earth's target and the observer an approximate scale of 1:4000. This method is possible because of Google Earth's tool that can enable control of distance and scale of work, allowing a more precisely visual interpretation of these images [12]. This work realized a spatial muti-temporal analysis of mangroves in meso and short scale.

All generated polygons of continuous and discontinuous mangroves areas were saved in .KML format *(Keyhole Markup Language)*, and converted to .SHP*(shapefile)* using TerraView 4.2.2 software also freely available on the Internet *(http://www.dpi.inpe.br/ TerraView)*.

Data obtained were compared to map present at the work carried out by [17] in partnership with the United Nations and with US Geological Survey, which mapped the distribution of mangrove areas in 2011 in whole world, with free distribution on the web: Global Distribution of Mangroves - USGS 2011 *(http://data.unep-wcmc.org/datasets/4)*.

This global map was obtained using Landsat-30m resolution images present at Global Land Survey Project, also was used secondary data as global mangrove database [17] and national and local mangrove database were also collected. This huge work was developt using hybrid supervised and unsupervised digital image classification techniques. Geometric correction was performed to improve the geolocation to a root mean square error of half of pixel. Satellite images were subsetted to include only areas where mangrove is likely to occur (i.e. low-lying coastal areas and inter-tidal zones) and to exclude large areas where mangrove forests are not located (far inland, highlands and open ocean). Then [17] used an ISODATA clustering algorithm present in ERDAS IMAGINE

software that stands for Iterative Self-Organizing Data Analysis Technique It is iterative in that it repeatedly performs an entire classification (outputting a thematic raster layer) and recalculates statistics. Self-Organizing refers to the intelligent way in which it locates the clusters that are inherent in the data. This clustering method uses the minimum spectral distance formula to form clusters. It begins with either arbitrary cluster means of means of existing signature set, and each time the clustering repeats, the means of theses cluster are shifted [17].

All polygons were georeferenced in ArcMap 10.1 program, and their both areas were overlaid, (map from USGS, 2011) as the obtained maps by manual vectorization on Google Earth in 2015 (Figure 2). Comparing the vegetated areas, it was possible to identify the places where there was a recovery of the coastal ecosystem and places that present suppression in area occupied by mangrove forest between the years 2011 and 2015.

Besides, the obtained results were contrasted with the Potengi and Guaraíras vegetated historical data carried out by [1] for the years: 1978, 2001 and 2003

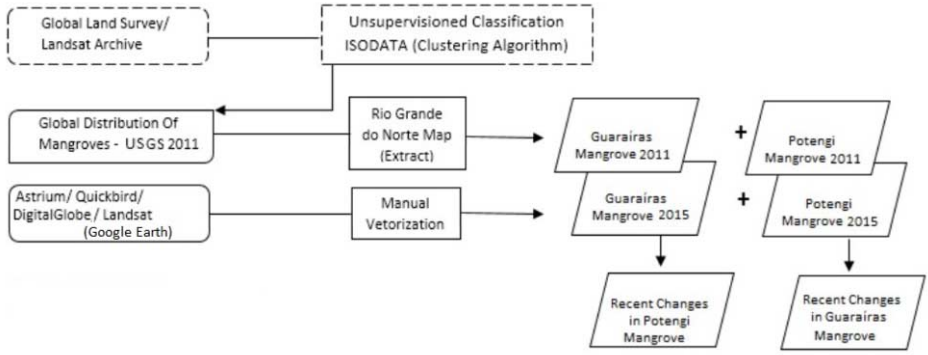

Figure 2. *Methodology used to compare the geographical distribution of the two mangrove forest areas within a periof of four years (2011-2015)*

4. Changes in Potengi Estuary and Guaraíras Lagoon Complex Mangrove Forest Areas

4.1. Historical Changes

Analyzing the Rio Grande do Norte historical series of mangroves distribution: [18],[1] and [17] can be seen that in general the Potengi estuarine mangrove forest and theGuaraíras lagoon complex mangrove forests are increasing (Figure 4)

According to [1], the Guaraíras vegetated area had suffered an increase of 10.02 km in the last 25 years (1978-2003) while the mangroves present in the Potengi estuary, increased approximately 11.03 km in the same period.

The time series shows that the Guaraíras complex features a faster recovery status that presented by Potengi estuary (1978 - 2015). (Increase of 225,5% in Guaraíras vegetated area against 8,08% of deforestation reached by Potengi mangrove). Unfortunly there is no data collected by [1] for Potengi Mangrove forest area in the year of 2003. The historical data was compared, and it was evaluated the variation in terms of area,

Table 1. *Variations in Potengi and Guaraíras Mangrove Vegetated Areas in the past 37 years. Modified from:[18], [1] and [17]*

		1978[1]	2001[2]	2003[2]	2011[3]	2015
Potengi	Area	12,00 km²	16.40 km²	-	10.40 km²	11.03 km²
	Var. Area	-	+4.4 km²	-	-6.00 km²	+1.03 km²
	% Var	-	+36.66 %	-	-36.59 %	+6.06 %
Guaraíras	Area	4.50 km²	10.66 km²	14.52 km²	9.69 km²	14.65 km²
	Var. Area	-	+5.11 km²	+3.86 km²	-4.83 km²	+5.01 km²
	% Var	-	+136.8 %	+36.21 %	-33.26 %	+52.73 %

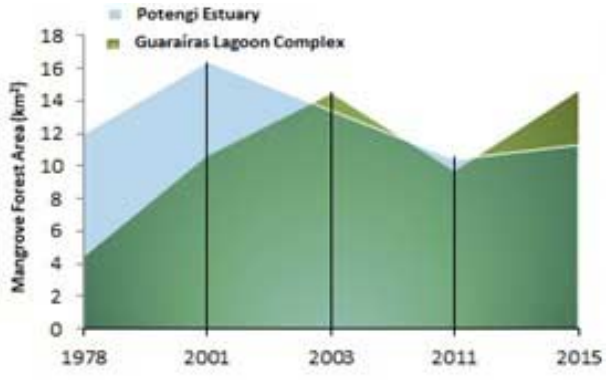

Figure 3. *Dynamic of Potengi and Guaraíras mangrove forest areas (Historical Evolution) modified from [1] and recent changes*

variation of area (comparing with the early year), variation of area in terms of percentage (comparing with the early year) (Table 1).

This difference between the two mangrove forests dynamic of increase can be explained by the intense pressure suffered by Potengi ecosystem due to its proximity to a metropolitan city being directly affected by garbage disposals from companies and local population, in addition this site is constantly threatened by urban and shrimp farming expansion that causes direct deforestation. In recent years the anthropical pressure causes several impacts at Potengi estuary reducing the mangrove capacity of regeneration, resulting in serious environmental and social issues. At the Figure 3 the changes in vegetated mangrove areas at the past 37 years can be graphically compared.

4.2. Recent Changes

The analysis of dynamic and distribution of these forest areas, it is important to define and evaluate public policies aimed at conservation of these ecosystems in Rio Grande do Norte.

Mangroves under study have intermunicipal comprehensiveness and parts are managed independently by the municipalities. Thus, it sought to analyze the geographical distribution of mangroves in the past five years, taking into consideration the areas covered by mangroves in different municipalities jurisprudence.

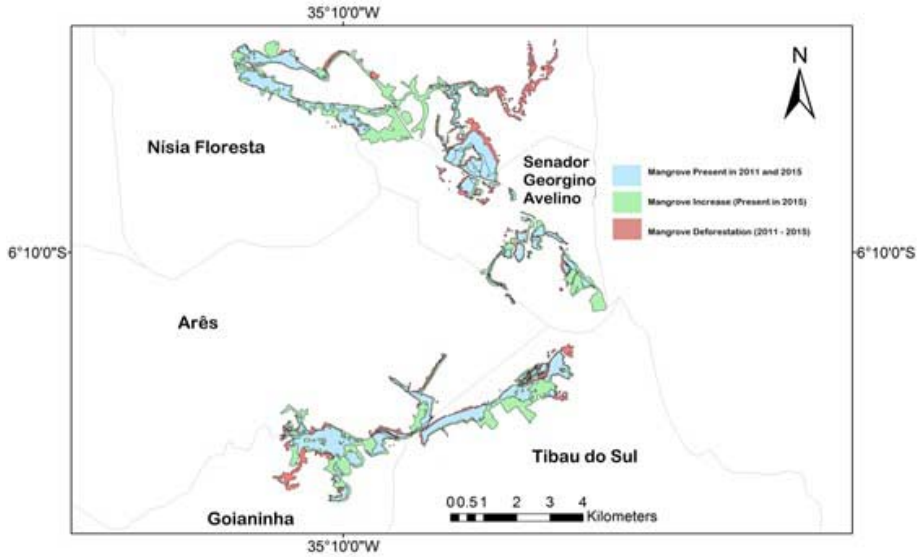

Figure 4. *Dynamics of Recent Changes (2011- 2015) in Mangrove Forest Areas in Guaraíras Lagoon Complex - Mangrove Present in 2011 and 2015 (blue); Mangrove Increase (green); Mangrove Deforestation (red))*

Table 2. *Dynamics Of Guaraíras Mangrove Forest (2011-2015)*

	2011	2015	Var	%	Gain	Loss
Macaíba	1.02 km²	1.37 km²	0.35 km²	33.95 %	0.66 km²	0.31 km²
Natal	10.40 km²	11.03 km²	0.63 km²	6.06 %	2.25 km²	1.62 km²
São Gon. do Ama.	5.28 km²	5.08 km²	-0.20 km²	-3.71 %	1.11 km²	1.32 km²

At Guaraíras Lagoon Complex it was observed a decrease in area of 4,84 km^2 during (2003 - 2011). Four years were needed to mangrove recovery. At 2015 the mangrove area was 14,65 km^2, overcoming 2003 area (14,53 km^2) and being identified as the largest mangrove forest extension recorded at this lagoon complex.

Despite observing an increase in the general extension of the area covered by mangrove vegetation in Guaraíras complex, it was also possible to identify areas of loss and gain of forest by municipality. These areas are identified in Figure 4.

Among the cities where the Guaraíras mangrove covers, the municipality of Nisia Floresta owned the largest extension of mangrove in 2011, totaling 3.88 km^2, the city of Tibau do Sul was the second in mangrove extension, housing 1.85 km^{2}vegetation cover. The city of Senador Georgino Avelino housed 1.70 km^2 and the city of Goianinha owned 1.44 km^2. Finally the municipality of Ares, was the one which possessed smaller mangrove area totaling 0.81 km^2. More details in Table 2.

The vegetation cover losses (in red) occurred in all the cities present at Guaraíras lagoon complex. In absolute terms, NisiaFloresta was the city that had the biggest mangrove loss totalizing 1,19 km^2;Tibau do Sul and Senador Georgino Avelino had similar losses, 0,36 km^2 and 0,34 km^2 respectively; Ares deforestation was 0,16 km^2 and Goianinha 0,16 km^2.

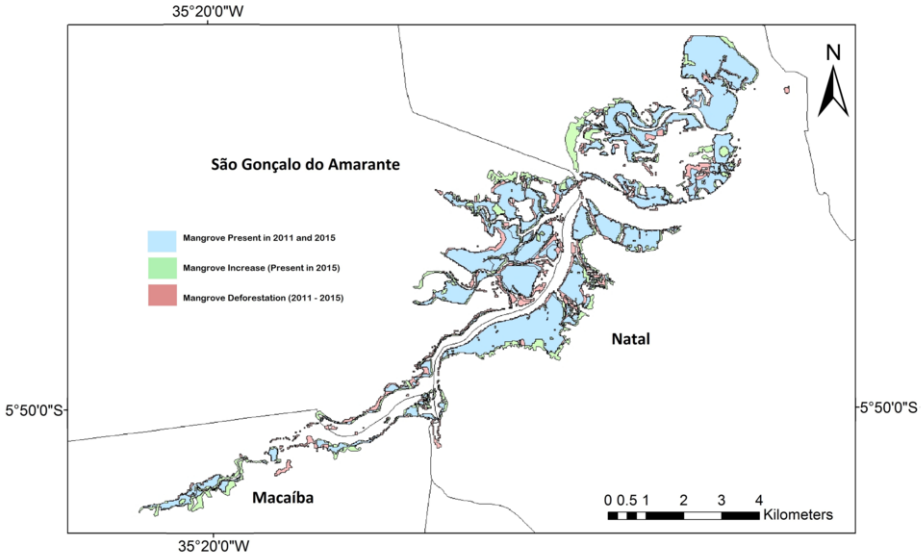

Figure 5. *Dynamics of Recent Changes (2011- 2015) in Mangrove Forest Areas in Potengi Estuary - Mangrove*

Table 3. *Municipal Dynamics Of Potengi Mangrove Forest (2011-2015)*

	2011	2015	Var	%	Gain	Loss
Macaíba	1.02 km²	1.37 km²	0.35 km²	33.95 %	0.66 km²	0.31 km²
Natal	10.40 km²	11.03 km²	0.63 km²	6.06 %	2.25 km²	1.62 km²
São Gon. do Ama.	5.28 km²	5.08 km²	-0.20 km²	-3.71 %	1.11 km²	1.32 km²

The cities that have the greatest increase of vegetation area, and that presented the most expressive mangrove recovery were Nisia Floresta 3,3 km^2; Senador Georgino Avelino and Tibau do Sul presented similar forest gain, 1,28km^2 and 1,22km^2 respectively; Goianinha growth was 1,09 km^2 and Arłs 0,6km^2. In relative terms, Goianinha showed superior increase of mangrove area (2011 - 2015), this city grew up 75,42% of vegetated area

At Potengi Estuary, mangrove forest are distributed only by three municipalities, Natal, the major city of Rio Grande do Norte, Macaíba

Although the reduction rate observed on this mangrove forest during the historical data (1978-2011) and the deforestation of this ecosystem during this period, in the last four years, the Potengi Estuary evidenced a gradual increase of its vegetated area. Adopting the same colors used in the mapof recent changes in Guaraíras lagoon complex, can be observed in blue, the vegetation that remained, in green, the increase of new mangrove areas, and in red color can be observed the mangrove losses within the last four years (Figure 5).

Macaíba was the municipality that most preserved this estuarine ecosystem, presenting a considerable increase in percentage terms of area (33,95%), as well as in absolute terms expanding the mangrove area in 0,35 km^2 More details can be viewed at Table 3.

Differences observed in Guaraíras Lagoon Complex and Potengi Estuarine, dynamics of mangrove spread, seems to be related to antrhopic activities. The Potengi Estuarine Mangrove are located inside of the metropolitan area where antrhopic impact are substantially higher than in Guaraíras region. Also, prosecution is applying judicial restrictions in the shrimp farms of both mangrove forest, and the abandonated farms is going in to a recovery process. This forest areas could present a faster recovery if was addopted an efective planting workn and the destruction of slopes that impede the circulation of estuarine waters.

5. Conclusion

The observed results show the close relationship between the preservation of the estuarine ecosystems of Rio Grande do Norte, the anthropical activity and the governmental inspection.

The mangrove present on the Potengi River had its peak in forested area during the years 2001 and in the following ten years evidenced a constant and accelerated rate of degradation of the ecosystem, showing only slight recovery in the last four years (2011-2015). The mangrove present in the Guaraíras lagoon, in turn, now reached the largest forest area observed in the last 37 years, demonstrating an accelerated recovery compared to the Potengi mangrove. This can be explained because of the difficult access to this region, which leads to less traffic of ships and people, as well as less discharge of effluents and contaminants.

The suppression of Potengi mangrove vegetation during the last decades and its slow recovery evidences the urgent need for regulation of the ZPA-8 (Environmental Protection Area Mangrove Ecosystem and Potengi / Jundiaí Estuary) project that goes to eight years in the municipal and which intends to protect the areas adjacent to the Mangrove, in addition to building a park to disseminate and raise awareness of the importance of this ecosystem, especially in Macaiba and São Goncalo do Amarante where shrimp farms still acting.

The use of orbital and aerial images freely available on WEB platform has a great relevance for the environmental monitoring of mangroves in the state of Rio Grande do Norte, seeing that these platforms are constantly updated with high resolution images and information can be extracted through free softwares.

These methodologies can be adopted by the environmental organizations for a more precise and constant monitoring of environmental impacts suffered by these ecosystems in the territory of Rio Grande do Norte state.

More in-depth studies of the dynamics of mangrove growth or reduction through orbital images may help to identify critical deforestation points in the estuary and, consequently, become a powerful tool for environmental monitoring and support for taking decisions about prevention and mitigation of environmental impacts in the region. Also its important a depth understanding of historical context, thats include problems in shrimp sanity (White spot virus), and dumping allegation by US government, which made this activity unfeasible for small producers. The study in question should naturally expand to other mangrove areas in the state of Rio Grande do Norte, in order to obtain a panorama of the state of conservation of these ecosystems over time. The methodology employed may also be used to monitor other ecosystems, such as Caatinga and the Atlantic Forest presents in Rio Grande do Norte.

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1st Workshop on Citizen Centric Smart Cities Solutions (CCSCS'17)

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Introduction to CCSCS'2017

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Smart Cities can be considered as a new paradigm or a concept that is emerging all over the world as a necessary and unavoidable response to the constant urban population growth and associated technical, material, social, and organizational problems, in order to improve the quality of life of their citizens, and to provide a more economic competitive, sustainable and liveable city. The recent development of important technologies, such as low power miniature sensing devices, high-speed wireless and wired communication networks, and high-performance computing systems, enables the creation of new possibilities and capabilities, fostering the opportunities for smart city realizations.

Intelligent solutions to the referred problems, intended to control pervasive computing systems, such as citizen-aware intelligent environments, will help and contribute to the construction of a sustainable smart city, providing value-added, intelligent, adaptive, context-aware, user-centric and sustainability services, with realizations such as smart home/smart building, smart energy, smart mobility, smart parking, smart health or citizens well-being, that is, providing smart services intended to be more efficient, with reduced resource consumptions and promoting the well-being and good quality of life of their citizens, without neglecting the benefits of a citizen sensor. With the citizen as an active and proactive actor of the Internet of Things, reliable and definitive solutions for problematics such as Road Safety and Vulnerable Road Users, among others, could finally emerge. However, the smart city realization means everything should be considered in large scale, in real-time, dynamically, with uncertainty with restrictions, and adapt to different objectives. Furthermore, the standard computational intelligence algorithms may be insufficient or not robust enough to deal with smart city big data analytics

The purpose of this workshop is to gather and present new and original research towards citizen-centric solutions within the ambit of intelligent environments and smart cities, capable of active context awareness, automatically changing their functioning in response to discovered context, enabling that way the improvement not only of city efficiencies, but also citizens quality of life.

This first edition of the Workshop on Citizen Centric Smart Cities Solutions (CCSCS'17) offers the following four articles.

The first article, "Ad Hoc IoT Approach for Monitoring Parking Control Process", by Joo C. Ferreira and Ana Lúcia Martins, discusses and proposes a smart parking system

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as a solution to the problem of searching for a car parking space in urban scenarios. The authors solution, for which they started to consider the city of Lisbon, follows a service-based approach as it is intended to be integrated with existing mobility support systems, such as public transport information, carpooling systems, parking payment, and Points of Interest. Furthermore, its added-value consists in the unneeded deployment of any sensor infrastructure since car drivers are guided to empty parking slots considering probability estimations based on data history, and on a crowdsensing mechanism, supported by an ad hoc network of users mobile devices, with witch drivers, passengers or walking citizens are engaged, in order to send information about free parking spaces.

Next, "Experiential learning in Data Science: from the dataset repository to the platform of experiences", by Emilio Serrano, Martin Molina, Daniel Manrique and Luis Baumela, deals with the Data Science interdisciplinary field, where it is stressed its growing importance in changing the way citizens live, its particular complexity when handling with Big Data, and the benefits of using the experiential learning approach. The article presents an educational project to develop methods, experiences, and tools for experiential learning in Data Science. In that sense, a platform of experiential learning is proposed, for which the needed requisites are discussed.

The next article introduces an intelligent system that supports people in their daily lives. In fact, "Designing an Intelligent Support Model of a Reading Companion Robot", by Hayder M. A. Ghanimi, Azizi Ab Aziz, and Faudziah Ahmad, describes the process of integration of an agent-based model of cognitive load and reading performance with a reading companion robotic lamp, intended to monitor and analyse reader's conditions and performance so that intervention actions can be generated to appropriately suggest support to them. The support to the readers has three main activities: to prevent exhaustion, to improve persistence, and to detect cognitive overload.

Finally,"CAKNA: A Personalized Robot-based Platform for Anxiety States Therapy", by Azizi Ab Aziz, Ali Saad Fahad, and Faudziah Ahmad, is an example of a smart living application. It presents a robot-based anxiety management system intended to reduce user's anxiety level by means of specific cognitive therapies. The designed robotic platform, named CAKNA, integrates a software agent with two main components, analysis and support components, which models the temporal dynamics of anxiety, allowing anxiety measurements and predictions. The response to user interaction is made by motion control of robots neck and eyes, by a vision system to allow face tracking and text-to-speech voice, synchronized with lip-displays. Preliminary results are evaluated through a pilot study.

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Ad Hoc IoT Approach for Monitoring Parking Control Process

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Abstract. The purpose of this research is to develop a collaborative approach to control the parking in a city using IoT (Internet of Things). This approach is based on Bluetooth Low Energy (BLE) beacons to control the parking process without having to investment in sensors. Parking violations can be easily detected through the proposed collaborative process among user's mobile devices. A reward mechanism incentives users' participation. This approach uses an ad hoc network of users who send information to a central system regarding georeferenced beacon information. Comparing with previous payments associated with a vehicle, the approach can identify parking violations, e.g. parking without associated payment.

Keywords. IoT, Beacons, BLE, Parking, Collaborative approach, Ad hoc Network

1. Introduction

Parking is one of the major issues in the cities due to reduced availability of space and the time consuming process for finding a place. Several studies show that in the majority of cities 20 to 30% of traffic is generated by the search for a parking space, which corresponds to average times of 10 minutes [1]. Drivers cover, on average, distance of 4.5 km to find a parking place [1], which corresponds to an average of 1.3 kg of CO2 per month, or about 100 km per month, and to an additional estimated cost of about 10€ per month. The demand for parking places is responsible for one third of the traffic in the city [1]. In the Lisbon region (Portugal's capital), for example, the average number of vehicles per day is of 250 to 300 thousand[2]; if one considers that the demand for parking spaces affects part of this number of vehicles, an estimate of 100 thousand vehicles could be removed from the roads. In this scenario, it can also be estimated 1 M€ per month of additional expenses and additional production of 130 tons of CO2 that could be avoided. Considering only the example of Lisbon, the annual distance traveled in search of parking place (4.5km-day x 230 days annual work x 100 000 cars) would allow to take about 2800 rounds to the planet and represents about 36 thousand hours of work lost. In the city inner zones the parking spots are difficult to find and often another driver (not involving logistics) has taken the parking spot. So there is a need of solutions to find if a parking spot is free and consequent guidance to these places. One such common system in closed environments (example of parking spaces at malls) has sensors at each parking spot with a light that indicates if it is available or not. The same approach can be applied to street parking and this data can be transferred to a driver's App, but the cost of this solution is prohibitive and involves high maintenance cost. For example Avenida

Liberdade, in Lisbon, has around 1,1 km and a solution with parking sensors was implemented for an investment value of 80K€ with associated annual maintenance cost of 10K€. The proposal in this research aims at avoiding these costs (investment and maintenance) and is based on a collaborative approach to detect if parking spaces are occupied.

2. State of the art in sensors

Many parking systems have been proposed in recent years. These work based on installed sensors that collect information about each individual parking spot. These sensors detect the presence of a vehicle or other objects. They can range from a simple ultrasonic sensor that detects a vehicle based on a threshold distance or RFID chips that are activated based on distance to complex optical sensors. These sensors can be divided into two main categories: namely, intrusive and non-intrusive sensors [3]. Intrusive sensors are sensors that are typically installed in holes on the road surface, including active infrared sensors, inductive loops, magnetometers, magneto-resistive sensors, pneumatic road tubes, piezoelectric cables and weigh-in-motion sensors. The main problem of these sensors are installation and maintenance cost. The non-intrusive sensors, by their nature, do not have the installation problem and encompasses microwave radar, passive acoustic array sensors, passive infrared sensor, RFID, ultrasonic, BLE beacons and video image processing. Non-intrusive sensors can be easily installed and maintained and do not affect the surface involved in the process.

Active infrared sensors detect vehicles based on infrared energy. These can detect the amount of energy reflected and most of the installation effort is based on multiple beams that can measure the vehicle position, speed and class [3, 4]. The main working problem is its sensitivity to weather conditions (example of fog or snow).

The Inductive Loop Detectors are used mainly for getting accurate occupancy measurements based on wire loops with frequencies ranging from 10 to 50 kHz. This frequency oscillation changes with vehicle presence and it is one of the most used sensors to detect the presence of a vehicle in a spot. The main issues are the installation and maintenance costs and the fact that these sensors are sensitive to water, especially if the pavement is cracked.

Fluxgate magnetometers work by detecting perturbation in magnetic field and have as main advantage being insensitive to weather condition such as snow, rain and fog. They are also more accurate and less susceptible to traffic stress than loop detectors. Among the disadvantages of using fluxgate magnetometers are the small detection zones in some models that require that multiple units are needed for full lane detection as well as the close proximity required for accurate detection [3,5].

Magnetometer Induction or search coil magnetometer identifies the presence of a vehicle in a spot by measuring the change in the magnetic flux lines caused by the moving vehicle according to Faraday's Law of induction [3, 6]. Some models can be installed without the need for pavement changes and have the advantage of being insensitive to weather conditions.

Magnetoresistive sensor are in general light and small, allowing versatile installation, low cost and are able to work in all temperature registers in earth surface [7]. They work by simply being energized with constant current [6].

Piezoelectric sensors are created from a material that is able to convert kinetic energy into electrical energy when subjected to vibration or mechanical impact, so it can detect

when the vehicle is on and can detect speed and vehicle distance axle. For parking situations it has the disadvantage of the need to use multiple detectors to detect a vehicle presence in a parking spot.

There is also a diversity of others sensors like: Pneumatic road tube, Weight-in-Motion (WIM) sensors, Microwave radar, Passive infrared sensors, RFID and Ultrasonic sensors.

There is also the possibility of using CCTV with the drawback of some incident position of the working system. This approach works well in closed environments but on the streets there is the problem of the sun light at the beginning and end of the day. They are based on advanced digital signal processing (DSP) that transforms video cameras into intelligent counting sensors. Its stand-alone design enables it to detect and count vehicles utilizing video received from IP and/or analog video cameras The software even stabilizes the video image by removing camera and vibration effects. Advanced background algorithms then ignore any nuisance images, such as shadows or lighting changes uncertain limits. Once an object in detected, a filter is applied to avoid counting nonvehicle items, such as humans and luggage, or vehicles not moving in the desired direction.

Sensors implanted, in general, are expensive to deploy and maintain (e.g.,[8] cost USD$500 per system for each parking space, and [9] cost USD$400 per system for each car). These sensors may underperform in extreme weather conditions. Using mobile phones is cheaper, more convenient, and more flexible.

BLE Sensors - There is a new type of sensor devices that opens several business opportunities in healthcare, sports, beacons, security, monitor and home entertainment industries. This Bluetooth Low Energy (BLE) is a wireless personal area network technology that once compared to the Classic Bluetooth is intended to provide considerable reduced power consumption and cost while maintaining a similar communication range. Bluetooth is a low-cost, short-range wireless technology with small footprint, small power consumption, reasonable throughput and hence suitable for various small, battery driven devices like mobile phones, PDAs, cameras, laptops etc. Also in this context we have beacons with around 3-5 centimeters, a small hardware radio device that broadcasts data over Bluetooth Low Energy (BLE). BLE operates spectrum band (2402-2480 MHz), divided in 40x2MHz physical channels and uses GFSK variation, attaining a data rate up to 1 Mbps. Typical ranges of the radio signal is up to 20 or 100 meters (60-300 feet) and it is easy to fit it in many applications and contexts. Beacons offer the versatility of being placed anywhere - indoors or outdoors position. The challenge arises when beacons are deployed in environments that are disposed to weather conditions such as rain or humidity. Also beacons can be managed centrally without the need of going physically to where they are located.

Together with this, it is very easy to interact BLEs with mobile devices sensors, like GPS, Accelerometer and gyroscope creating a continuous monitoring process since users carry mobile devices all the time. This generates massive data (big data).

3. Crowdsensing

Mobile devices allow accurate tacking of world-related information and (physical) activities of citizens by taking advantage of people willing to collaborate toward a continuous data harvesting process called crowdsensing. According to [10]: “While crowdsourcing aims to leverage collective intelligence to solve complex problems by

splitting them in smaller tasks executed by the crowd, crowdsensing splits the responsibility of harvesting information (typically urban monitoring) to the crowd". In other words, crowdsensing is the process where people or their mobile devices act as sensors and actuators to continuously harvest data and take actions upon the results [10]. It is a challenging task since several socio-technical issues may occur, such as the quantification of the sensing density. The users' participation and cooperation are essential in crowdsourcing [11], but users participation consume their resources such as battery and computing capacity [12]. This problem leads to an inevitable fact that many users might be reluctant to participate, which is a major obstacle to mobile crowdsourcing [13]. To avoid this incentive mechanism are needed to ensure users' participation.

Geo-referencing is available through GPS on mobile devices, and the mobile app only receives the beacon signal. Rinne et al. [14] presented the pros and cons of mobile crowdsensing.

4. Proposed Approach to Control Parking Process

Figure 1 shows the developed approach for mobile device application. It is possible to control parking spots based on the use of BLE beacons in vehicles. These beacons transmit an identification signal that can be captured by mobile devices, which can add GPS position and be transmitted to a central system.

To incentive users' participation a reward mechanisms based on free parking is introduced.

First time drivers should register and request for a beacon. Being part of this network allows them to have reduced parking fees.

Figure 1. Overview of proposed approach to create a parking monitoring facility without investment costs using an ad hoc network of user mobile device collaborative process.

In order to monitor parking activity our proposal is the installation of a beacon in each vehicle (it costs around 3€, with battery life time span of 2 years). These

requirements should be reinforced by law and maintenance should be responsibility of the owner of the vehicle. This works like an electronic plate number that allows vehicle identification. To avoid the creation of infrastructure and networking, our approach is innovative by the usage of citizens and their mobile devices. In this, model users get rewards for each different beacon picked and transmitted to the central parking application. This reward could be free parking time (for instance, 5 minutes parking for each transmission) and the reward could be increased if an infraction is identified. This process is performed centrally, where the beacon ID is used to check if the vehicle-parking place was previously paid for or not. This is performed by an App (in the case of Lisbon the e-parking App from EMEL (epark.emel.pt)). This ad hoc transmission checks the beacon ID and verifies if it is paid for. Infraction data can be immediately sent to the nearest parking agent who can then issue an infraction ticket or the central system can send the invoice directly to the vehicle's owner. Figure 1 shows the main working idea for the main system with beacon signals captured by mobile devices and position is added and transmitted to a central server. This information is used to check if the parking spot was reserved or not. To avoid errors, because users can receive beacons from a moving vehicle in front of the parking place, the system waits for a second notification from a different user before proceeding with the identification of a violation.

In terms of communication, Figure 2 illustrates the process, with a local Bluetooth communication with a range of 20-30 meters between vehicle beacon and user mobile device and a http connection from mobile device to the central server.

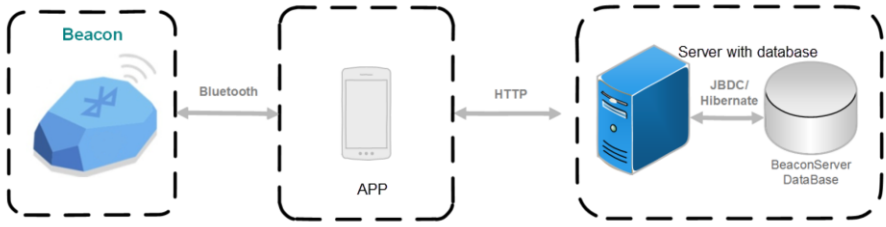

Figure 2 – Communication process used.

5. Identification of free Parking Slots

We developed an interface to allow easy report on the number of free parking places in a street or to alert that the booked parking place will be free within x minutes. This collaborative process only requires power from users' mobile devices and consumes network communication but since we are transmitting data in usual communication packages this communication process does not have any impact in prices. This collaborative reporting can be performed by: 1) drivers in a car using NLP (Natural Language Processing), where the application asks about the number of identified places the driver saw. The application is calibrated to understand numbers in different languages (we tested in English and Portuguese); 2) Pedestrian, to give feedback about number of places available on the street. Geo-referencing is available through GPS on mobile devices. Under these conditions, the user needs only to introduce an estimation of the number of free places he remembers on that street.

These two crowdsensing approaches are complementary and users are incentivized to participate by the reward mechanisms introduced. Every input performed that match

average performed in a pre-defined window time (this is to avoid spam inputs without any sense) gives free parking minutes in a city.

For drivers, it is possible to integrate mobile devices into vehicle's infotainment systems, it is possible to create an easy interface for drivers to give feedback about empty parking places while driving.

We tested several approaches regarding the reward. We tested using a population of 90 (60 drivers and 30 pedestrian) information providers in a three months test.

1) Every input gives 5 minutes of free parking in a green zone (low cost parking area). During the test period, we had an average of 43 notifications per day (monthly notification divided by the working days). This rewards gave around 3,6 hours of free parking in a green zone per day;
2) Every input gives 1 minute of free parking in a green zone. During the test period we had an average of 9 notifications per day. This reward gave around 9 minutes of free parking in a green zone. This meant we should increase the reward.
3) Every input gives 10 minutes of free parking in green zone. During the test period we had an average 58 notifications per day. Perhaps this is too much.

As a model, the system depends on the numbers of users versus the number of notifications performed. Lisbon has around half million person living, a surface of 100 thousands km2 and around 1500 streets [http://www.dgterritorio.pt/ficheiros/cadastro/caop/caop_download/caop_2014_0/areasfregmundistcaop2014_2].

To be able to work in peak times (9am to 6pm) the system needs notifications with a periodicity of 5 minutes; we need around 108 notifications per street. The rest of time: 1) 6pm to 12am and 6am to 9am, we need notifications with a periodicity of about 10 minutes, which gives 90 notifications per street; and 2) the remain time, from 12am to 6am, only hour to hour notifications are required. This gives the need for 200 notifications per day per street, so about 300 thousands per day. Estimating a goal of 50 notifications per user per day, the system needs 6000 users. Figure 3 illustrates this process.

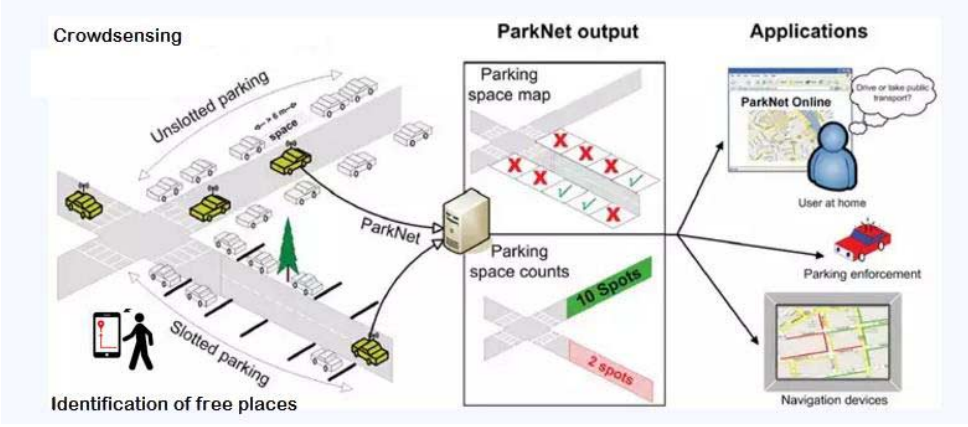

Figure 3- Users notification about free parking places, based on a crowdsourcing mechanism approach

Spam - To avoid spam we need more notifications to extract the average, deviations are treated as spam, and those users can be removed from the system. To avoid the creation of different logins, users are validated based on fiscal number.

6. Lisbon Pilot on Control Parking Process and Results Discussion

Lisbon has around 400 thousands vehicles entering in the city on a daily basis and 150 thousand parking places, according the information from Lisbon Municipality.

Current test is performed in collaboration with EMEL - Municipal Mobility and Parking Company of Lisbon and connected with their App - ePark application, which during its first year of operation has already raised more than 180 thousand users and processed more than 5 million parking spots. This App assumes mobile devices with users in the vehicle and gives georeferenced based on GPS information transmitted. From this users can pay the parking, set the exact time that drivers want to park, with a minimum of 15 minutes, and change parking time at any time. It is possible to view all active / inactive parking spots and ask for invoices from the App itself. From this, it is possible to handle the reservation process from where it is added the beacon information.

So testing is to avoid current control parking process performed by human agents, which goes to the street to check vehicle parking. These agents are distributed per street zones and for our testing purposes, we use one of these zones using as population students and teachers of our university who usually drive to this area and park the vehicle in a testing population of 25 drivers. To these vehicles, we associated a beacon. So, for the proposed test, we bought 25 beacons for 75€ (3€/each). The hardware chosen was the ARM NRF51822 from (Nordic Semiconductors, the SoC (System on Chip) with memory of 256KB Flash, 32KB RAM, serial interfaces I2C, UART. We added the core 51822, a microcontroller powered by the Nordid chipset nrf51822 (see Figure 4). The proposal works with others beacon solutions and a plastic box was also developed to put sensor and facilitate their colocation in the vehicle.

Figure 4 – BLE used from core 51822 with ble200 from waveshare. To this we add the battery and plastic box protection.

A population of 5000 users was invited to participate in the testing of the project. From here we collected data from 454 users. These users participated in a testing for a period of 3 months in 2017 and on average collected data from 17 beacons per day (only working days were considered). The testing was only based on the running in the mobile device a process that capture Bluetooth data and selects only beacon signal (to avoid the capture of others Bluetooth devices). To this beacon data the process adds mobile device GPS information and transmitted to a central server and counts the transmission performed.

This provided around 500 thousands beacon data transmitted. For each beacon data transmitted the users received 0,05€ as reward (this value should be checked in a future test to assess what is the best value to use). From the data received it was possible to identify 634 infractions (parking without the payment) and in these cases the user reward was 0,25€. These rewards are used only for parking purposes in the city. We noticed that

drivers participated on this process to try to collect money for their parking process in the city. As they need to pay a daily fee of at least 2€ for a ful day of parking, most of then try to collect beacons until reaching that amount (around 40 beacons signal collection).

The proposed process system, is based on the principle that if the vehicle is parked the beacon signal can be captured by citizens with mobile device with Bluetooth on. Beacon ID, time and GPS coordinates were captured by mobile device and transmitted through a mobile device data network to a central server. This server collected this data and the identification of mobile device sender for the reward mechanisms. This data was compared (vehicle ID, time and place) with previous reserved information from the parking management system. Deviations were computed and penalties were automatically issued to the vehicle owner. In this initial phase external publicity is needed for citizens to be aware of this service and collect the parking slots data through their collaborative actions. Beacon transmission frequency was set to 30 seconds (pooling time takes effect on battery life time) and each beacon can be transmitted in time windows of 15 minutes to avoid spam (users that transmit data on the same beacon several times just to receive money).

We compared this collaborative control process with the work performed by control agents and we checked that this collaborative process catches more information and infractions but has the problem of beacon information collection distribution process over the day period (in general missing information on periods 15h-16h and 11h-12h) and also streets do not receive as many readings as desirable. There are time periods for which that are too many notifications and others when they are missing. This might be overcome by making the reward money dependent both on the time window and the zone to incentive a more uniform distribution. These problems could also be solved by increasing the population collecting this beacons information. Taking into account that this zone control testing was performed by 3 agents the reward should be based on these agents' salary and perhaps a better reward model can be studied.

7. Conclusions

We show a collaborative network of beacon collection to implement a parking control approach without the existing of dedicated solution. Users can participate in this process and collects free parking minutes for their own usage. This proposal needs a complete electronic solution for parking payment and needs beacons that are not implemented in every vehicle but the economics benefits are considerable because there is not the need of a dedicated infrastructure. Current payment solution can be adapted for the correlation among vehicle plat number to a beacon reference.

Identification of free parking places are important information to handle the problem of guidance of drivers to free parking places. Again, this system can work without big investments on sensors or other related equipment.

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Experiential Learning in Data Science: From the Dataset Repository to the Platform of Experiences

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Abstract. Data science is a revolution that is already changing the way we do business, healthcare, politics, education and innovation. There is a great variety of online courses, masters, degrees, and modules that address the teaching of this interdisciplinary field, where is a growing demand of professionals. However, data science pedagogy has repeated a number of patterns that can be detrimental to the student. This position paper describes an ongoing educational innovation project for the study of methods, experiences, and tools for experiential learning in data sicience. In this approach, the student learns through reflection on doing instead of being a recipient of already made content.

Keywords. Active learning, experiential learning, project based learning, data science, deep learning.

1. Introduction

Data Science (DS) is an interdisciplinary field devoted to extract knowledge from data. This discipline is particularly complex with Big Data: large volumes of data that hinder standard Computer Science technologies from storing, processing, and analyzing these vast amounts of information. DS is a revolution that is already changing the way we address business, health, politics, education and innovation [14].

The great diversity of applications and the growing demand of experts in the DS field has made courses, books and manuals in DS proliferate. The standard pedagogical method that we can appreciate in these courses consists of four steps:

1. The explanation of the different machine learning branches (supervised, unsupervised, and by reinforcement).
2. The detail of some learning paradigms under some of these branches; such as decision trees or artificial neural networks.
3. The illustration of these paradigms using toy datasets such as Weather or Iris [21].
4. Assignments with a straightforward application of the ideas previously exposed using some DS framework such as Weka [9] or Caret [10].

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The existence of different dataset repositories [5,7] on which to build knowledge offers a privileged breeding ground for designing a DS course as a series of experiences in real world problems. Few fields allow students to put themselves in the shoes of profiles as diverse and interesting as: economists, business managers, physicians, biologists, or website administrators. Similarly, few disciplines can offer rewards as attractive to the students as the three million dollar prize for winning a contest in predicting the patients who will be admitted to a US hospital the following year [3]; or the one million dollar prize with which the company Netflix awarded the best predictor of movie ratings [8].

In this position paper, we present an ongoing educational innovation project to develop methods, experiences, and tools for the *experiential learning* (EL) in DS. After introducing the concept of EL in section 2, some shortcomings detected by the authors in the standard pedagogical method for DS are presented in section 3. Then, a framework for EL in DS is presented in section 4. Section 5 offers specific experiences in *Deep Learning* (DL), a popular sub discipline of DS [11]. The requisites of an EL platform are described in section 6. Finally section 7 concludes and gives future works.

2. What is experiential learning?

Aristotle wrote in the Nichomachean Ethics "for the things we have to learn before we can do them, we learn by doing them. Men become builders by building". Although this ancient quote is commonly used to explain the concept of EL, it can also be misleading. EL is more than just getting learners to "do something". As Qualters and Wehlburg explain [17]: " unless experiences outside the classroom are brought into the classroom and integrated with the goals and objectives of the discipline theory, students will continue to have amazing outside experiences but will not readily connect them to their in-class learning".

Therefore, even when the term "experiential learning" is sometimes used to define any training that is interactive, with minimal lecture (and slides) [20], the students reflecting on their product is a fundamental part of EL. Without a careful curriculum involving *structured*, *reflective* skill building, students may never learn what we hope outside the four walls of the classroom [17].

As the "Association for Experiential Education" [1] claims, to ensure that EL is effective, the learner has to be actively engaged in posing questions, investigating, experimenting, being curious, solving problems, assuming responsibility, being creative, and constructing meaning. The educator and learner may experience success, failure, adventure, risk-taking and uncertainty, because the outcomes of experience cannot totally be predicted. Therefore, EL is an approach that encourages collective and critical reflection as well as individual learning [18]. In summary, acquiring skills requires more than "monkey see, monkey do" [20].

3. Shortcomings in the standard pedagogical method in Data Science

The four-step standard pedagogical method in DS is applied in popular online courses such as "Machine Learning" at the Stanford University [6] or the "Data Science Specialization" at the Johns Hopkins University [2]. The authors have also employed this

hegemonic method in Master courses at Technical University of Madrid, such as "Data Mining". The following limitations of this method have been observed by the authors:

1. The student has difficulties in selecting relevant information about how learning paradigms work and the information they offer. They oftenly consider them as black boxes where the model built has no relevance and only quality metrics are studied.
2. As a result, the student usually obviates the details and data of the concrete problem. As Witten [21] declares, nothing replaces a good understanding of the data.
3. Also corollary of the first point, the student does not perceive the iterative nature of DS. The construction of different prediction models provides valuable information about the data that must be fed back into subsequent iterations to achieve more valuable results.
4. Creativity in solving problems is considerably restricted because DS is perceived as the application of well-known solutions to well-known problems. Nevertheless, a fundamental component of the data scientist work is the research on new methods and their extension or variation for new and challenging problems.

EL naturally mitigates these tendencies when learning DS because it focuses on problems to be solved instead of on specific methods. In addition, starting with realistic experiences gives students more experience about real-world problems. More importantly, creativity and divergent thinking are encouraged when searching for different solutions to a concrete experience.

4. A framework for experiential learning in Data Science

Much of the development of EL theory in the past 30 years has gained relevance by the work of David A. Kolb [13], where he synthesizes the principles of this learning approach. Many publications, journal articles, and research studies have explored the explanatory power and usefulness of this theory in various disciplines and professional fields [15].

Kolb's experiential learning style theory is typically represented by a four stage learning cycle. McLeod [16] summarizes these stages in the graph shown in figure 1. According to Kolb [13], effective learning involves progressing through this cycle: having a *concrete experience*; *observation of and reflection* on that experience; the *formation of abstract concepts (analysis) and generalizations (conclusions)*; and, testing them by *active experimentation*, resulting in new experiences (iterations in the cycle). Therefore, every new attempt to address a problem is informed by a cyclical pattern of previous experience, reflection and observation, conceptualization, and experimentation.

In the scope of our educational innovation project, Kolb's learning cycle is revisited and instantiated for the specific field of DS as a framework to provide learners with significant experiences. Although there are recent and relevant works proposing this kind of experiences for information technologies [19], this research project focuses on EL for DS. Practical examples of using this theoretical framework in the DS field are detailed below for each of its four stages:

1. *Concrete Experience*. A new experience or situation is encountered, or a reinterpretation of an existing experience is offered. At the beginning of the course and

Figure 1. Kolb's experiential learning style theory [16].

to justify the machine learning approach, an experience in which it is difficult or impossible to establish algorithms that step by step solve a problem can be facilitated to the learners; for instance, the recognition of faces in images. As the course progresses, the experiences can challenge what has already been learned about DS.

More examples are: the use of unsupervised learning methods to improve the efficiency in training supervised models fed by Big Data; specific methods for artificial vision that consider the variations of position and light in different images of the same object; or, how to process natural language as input when analyses have been conducted only on dense representations.

2. *Reflective Observation*. In this phase, the students need time to detect inconsistencies between experience and understanding before giving possible answers to the problem. Jacobson and Ruddy [12] propose five questions that can be instantiated to the concrete experiences to start the reflection or group discussion: Did you notice...?; Why did that happen?; Does that happen in life?; Why does that happen?; and, finally, How can you use that?.

   For example: Did you notice that Facebook recognizes the faces in the pictures so you can label them?; or, what happened when you try to train a model with millions of instances as training data?.
3. *Abstract Conceptualization*. Reflection brings new ideas to address the problems faced in the experience and observation, or a modification of an existing abstract concept.

   Modifications of already studied methods can be requested to the students as assignments, at least on an abstract level if programming these ideas is too demanding.

4. *Active Experimentation*. The learners applies the new concepts to the world, i.e. the data studied, to see what results. If implementing the new ideas is feasible and there are clear quality metrics, this experimentation can be *gamified* in the context of a contest among the students.
   This is a great advantage of the DS field when is studied under EL. In this vein, Kaggle [4] facilitates academic machine learning competitions where a percentage of the data is retained for testing. This assures an objective ranking of the contestants and discourages them from using overfitted models. Additionally, a reflection on the results and the data they are based on is a must under the EL paradigm. If the implementation of the new concepts is too complex or too time consuming, a discussion of the solution design with the rest of students can be undertaken. Some material addressing the same problem can also be provided to go deeper into the subject in the following iterations.

5. Experiences in Deep Learning

The framework presented in section 4 is being currently used by the authors to create experiences for the "Deep Learning" course of the "Master in Data Science (EIT Digital Master School)" at the Technical University of Madrid[2].

Studying the students' profile is the key to design experiences which are challenging but not frustrating. In our case, this is eminently technical. Hence, they tend to focus on programming; rather than other major topics of DS, such as statistics or reflection on a particular application domain. Therefore, they tolerate programming assignments easily, but they may find difficult to express ideas and solutions in a more abstract manner. Considering this, after the course introduction, three major units with three experiential approaches are proposed:

1. *Artificial Neural Networks* (ANN). This unit follows the classical flow in a DS course. Firstly, ANN architectures, which are the cornerstone of the Deep Learning field, are explained for both the supervised and unsupervised learning. Secondly, practical advice in solving problems with these networks are described along with two DS frameworks (Weka and H20.ai[3]). Finally, a programming assignment is given to apply the explained ideas. More specifically, the practical experience proposes to train and test ANN architectures for breast cancer prognosis to predict whether a breast lesion is malignant or benign giving some attribute values as input [4].
2. *Computer vision*. This unit deals with the computer vision problem, i.e. how computers can get high-level understanding from images or videos. After introducing the topic, a contest is proposed to use the methods learned in the first unit to a computer vision problem: predicting the object depicted in an image. For this purpose, the CIFAR-10 dataset is employed[5]: 60000 32x32 colour images in 10 classes, with 6000 images per class. The experience allows a *reflec-*

[2]Master website: `http://www.fi.upm.es/?id=masterdatascience`

[3]H2O.ai website: `https://www.h2o.ai/`

[4]Breast Cancer Wisconsin (Original) Data Set: `https://archive.ics.uci.edu/ml/datasets/Breast+Cancer+Wisconsin+(Original)`

[5]CIFAR-10 dataset: `https://www.cs.toronto.edu/~kriz/cifar.html`

tive observation of the low accuracy achieved (all students obtained under 57%), and an *abstract conceptualization* of some of the challenges of computer vision. Then, *Convolutional Neural Networks* (ConvNets) are explained along with a DS framework to implement them (Caffe[6]). This allows students to retake the contest and observe the improvement achieved by the new ideas introduced in the course: around 80% accuracy in some cases. Finally, the same approach is followed for a *transfer learning* problem, similar classification with a small dataset, proposing a third contest / experience.

The key in the experiential approach of this second unit is that students get their prior knowledge challenged by new problems. Learners have time to try known methods to new situations and to reflect on the results. Moreover, the contests act as game-based approach for the EL as proposed by Shiralkar [19]. Students are not required to research on new methods for the new experiences proposed.

3. *Applications*. This unit starts with an experience in a new application field of Deep Learning: *natural language processing* (NLP), i.e. how computers can interact with human (or natural) languages. The learners choose a workgroup of up to five members and face a realistic experience: they are members of a research team that wants to apply for a contract offered by a well-known newspaper. They are asked to design a solution to predict the relevance of an article headline regarding its body from a dataset with three attributes: headline, body, and class (relevant / irrelevant). Students have two hours available in a laboratory with computer equipment to carry out an investigation into the problem, and present a manuscript with the solution design. The manuscript should include: a flowchart with the main tasks involved, the DS frameworks that will be used and why, and the bibliographic references. Two short papers discussing NLP methods will be provided at the end of the class to reflect on possible changes in the proposed solution. In the next class, the workgroups will have the opportunity to present their solution to be discussed with the other groups. Finally, a brief lecture on NLP concepts and how to apply them to the study case is thought.

   As in the experiences of the previous unit, a challenging problem considering the prior knowledge is proposed. The text requires a very elaborate preprocessing and word embeddings methods to feed ANNs. A key aspect of this experience is that, instead of a concrete implementation, the design of a solution is requested. This is more demanding for the students' profile in this master. Furthermore, the experience gives freedom in the investigation and proposal of solutions to a problem instead of stating a non debatable approach.

The experiences described here allow professors (or "facilitators" in EL terminology) to provide tools for students or "learners" to build their own knowledge, i.e. learning how to learn. Students' responsibility of obtaining new knowledge is incremental throughout the experiences, requiring to research on a solution for a new problem in the final unit. After finishing the Deep Learning course, students will be surveyed to evaluate different aspects of these experiences.

[6]Caffe website: `http://caffe.berkeleyvision.org/`

6. Requisites for a platform of experiential learning in Data Science

Datasets repositories are a widely used resource in the DS education. Some examples are The UC Irvine Machine Learning Repository [7] and the Kaggle dataset list [5].

UCI datasets are complemented with: descriptive information of the predictive variables, the default task (classification, regression, clustering, recommendation, relational learning, etcetera), and relevant papers which employ the data.

Kaggle, with a significant qualitative leap, offers an immense database of datasets. Moreover, a selection of "featured datasets" particularly well-formatted and documented is selected by the Kaggle team. The website also offers basic tutorials, discussion forums for each dataset, a listing of recent activity, and "Kernels" that users can include to published datasets. Kaggle Kernels is a cloud computing environment that enables reproducible and collaborative analysis. Kernels supports scripts in R and Python, Jupyter Notebooks, and RMarkdown reports. Kaggle is also popular for its active and very lucrative competitions than can be proposed as experiences.

Kaggle is a great approximation to the platform of experiences and it has the potential of engaging students with opportunities to learn through doing. Unfortunately, it repeats the harmful patterns outlined in this paper. This is, the DS is seen as a black box: get the best accuracy you can, nothing else matters. Again, the reflection on the results is essential in EL, and getting insights into the data is fundamental in DS. Under these considerations, some requirements for a platform of experiential learning to offer structure and reflective skill building are:

1. A decision support system for the creation of experiences rather than mere datasets. These include not only the type of problem to be solved (classification, regression)... but the context in which this problem arises for the specific data that permits to elaborate a realistic and engaging experience.
2. The use of this system, not only by instructors, but also by students to propose the experiences that motivate them.
3. A reservation system to allow different workgroups or students to deal with different experiences.
4. A rating system for experiences to allow educators to assess their difficulty, and to articulate a course as a series of experiences.
5. A description of the type of knowledge assumed (ideally indexing previous experiences), and how the new experience challenges that knowledge by posing new problems and situations.
6. A private space for the instructors to consult previous and ongoing results. This prevents students from consulting the answers omitting the reflection and conceptualization phases.
7. The possibility of releasing extra material during a experience that, without giving a solution to the problems, can guide the research and reflection.
8. An anonymous peer evaluation system to facilitate reflection on experiences of other students.
9. Linking or access to environments for reproducing and repeating the experiments such as Jupyter Notebooks.

7. Conclusions and future works

This paper has presented an ongoing educational research project in the use of experiential learning (EL) methods for Data Science (DS). Although there are recent and relevant works proposing this kind of experiences for information technologies [19], this project seems to be the first research work on EL for DS.

This paper lists a number of shortcomings repeated in the hegemonic pedagogical line of prestigious DS courses. Among others, a lack of reflection and critical thinking in the solutions given to programming assignments. To cope with this situation, a framework for EL in DS is proposed based on Kolb's experiential learning style theory. In the scope of a Deep Learning course, several concrete experiences are detailed increasing students' degree of freedom to propose new solutions. Finally, some popular resources in DS teaching are revised and a number of requisites are proposed to move from the dataset repository to a platform of experiences.

Our main future works include the survey on the acceptance and quality of experiences proposed in Deep Learning, studying new theoretical frameworks for DS, and the exploration (or implementation) of software tools for the proposed platform of experiences.

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Designing an Intelligent Support Model of a Reading Companion Robot

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Abstract. Human-functioning models that describe human cognitive and psychological states have been developed and used to serve as a core component in creating intelligent and responsive systems. Endowing such systems with these human-functioning models, it gives them the ability to reason and intelligently acting to attain its ultimate design object which is to assist and support people. The process to integrate these models with new systems remains as a nontrivial challenging task. This paper pinpoints the initial steps of integrating an earlier developed agent-based model of cognitive load and reading performance with a robotic lamp. In regard to this matter, several algorithms that have been developed are also discussed and simulations that were performed to prove the applicability of the proposed algorithms are presented.

Keywords. Dynamics Functioning Models, Robotic Lamp, Reasoning, Reading performance, Cognitive Load

1. Introduction

In the last several years, new technologies in building intelligent systems have improved tremendously and these systems have been integrated with human-functioning models to perform specific tasks. Human-functioning models are developed to understand complex cognitive and psychological behaviours of human. Therefore, by incorporating these models into software or machines, it will create intelligent applications that are capable of performing humanlike understanding and supporting behaviour [1], [2]. Examples of such models are the emotion contagion model in team members [3], aggression de-escalation model for Embodied Conversational Agents [4], and behaviour change model for hygiene and oral care [5]. Hence, these models have motivated a new attempt to come up with a model that can analyze cognitive load and relate to reading performance. This human-functioning model of cognitive load and reading performance has been developed as a building block for a proposed intelligent robotic lamp (reading companion robot). Equipped with this model, the robotic lamp will be able to understand readers' mental states and processes during demanding reading tasks as seen in [6], [7]. This paper aims to present the initial phase in materializing the integration process of the reader's model into a robotic lamp reasoning engine; where a number of algorithms were introduced.

The rest of this paper is structured as follows; Section 2 describes briefly the agent model of cognitive load and reading performance. Later, integration algorithm of the

developed model with robotic lamp is introduced in Section 3. Section 4 discusses a scenario on how the algorithm works. Section 5 evaluates the proposed algorithms. Finally, Section 6 concludes the paper.

2. The Ambient Agent Model

To develop ambient intelligent applications (i.e., reading companion robot) it became necessary and highly desired to be based on modeling mental and physical aspects of humans. These models give clear insights and adequate knowledge to understand and analyze human behaviours. As a result, such applications will perform actions in a more informed, knowledgeable manner, and to show more humanlike behaviours in its interaction with humans [1]. Pertinent to readers' performances in demanding tasks, an ambient agent model of cognitive load and reading performance was developed to explain those processes. The details on our previous work can be seen in [7].

3. Components in Robotic Lamp

According to the pilot study that we conducted earlier, the table lamp was selected as a preferred object to be represented as a personalized medium of a reading companion robot when people read their books [8]. This reading companion robot has been designed by combining an Android smartphone that runs all computational units, table lamp stand as a base, Raspberry Pi microcontroller, and servo motors with four degrees of freedom into a reading-lamp based robotic system. The details descriptions of the robot and the synchronization process between software and hardware components altogether are beyond the scope of this paper. The pictorial idea illustrated in Figure 1 shows how the table lamp robot will be used in the reading environment.

Figure 1. The Pictorial Idea of Table Lamp Robot

4. Integration

One of the important concepts in modeling the dynamics of humans' physical and mental state is that these dynamics models can be used in real time to monitor and analyse related conditions to generate intervention actions [9]. Consequently, the

software engine of this robot will be completely based on the ambient agent model. This model serves as an underlying analytical tool in monitoring and analysing readers' performance. Then, an appropriate support (as stored on support repository) will be suggested to readers. To attain this goal, an integration algorithm was developed to match appropriate supports with the analysed conditions. Figure 2 shows the central role of the integration algorithm. Further details on the ambient agent model of cognitive load and reading performance can be found in [6], [7].

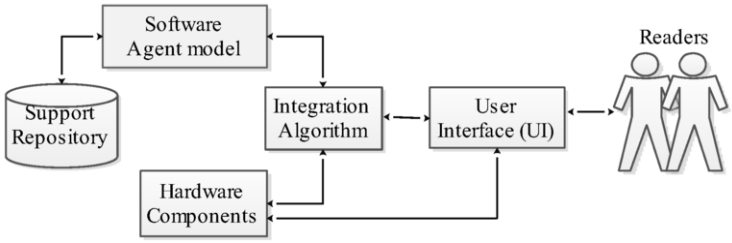


Figure 2. The Main Components in Reading Companion Robot

The generic flow chart of the integration processes is shown in Figure 3. It consists of six related components, namely; 1) input initialization, 2) environmental evaluation, 3) reader's monitoring phase, 4) evaluation mode, 5) support mode, and 6) external interruption by the reader to stop the monitoring mode (force stop mode). The processes will be described in the following sub-sections.

4.1. Inputs Initialization

At the beginning, the robot will initiate all of its observations to generate basic and derived beliefs related to reader's conditions. For example, when the robot observes the level of sound in the room, then it will compute its basic belief about the noise level.

$$observation(robot, sound(level)) \rightarrow\rightarrow basic\_belief(robot, noise(level))$$

In the end, all derived beliefs will be computed and later to be transferred to another component in the integration algorithm (as depicted in Figure 2). Next, we show some formal presentation and its nomenclature of important concepts used in our model.

Table 1. Formal Representations.

Descriptions	Formal
If robot *R* observes *x* condition then the robot will compute basic belief on *y*.	$o(R, x) \twoheadrightarrow b(R, y)$
If robot *R* believes on *y* then the robot will compute derived belief on *z*	$b(R, y) \twoheadrightarrow d(R, z)$
Robot *R* assesses the level of *x* whether it is greater or equal to x_threshold	$a(R, greater(x, xt))$ $a(R, equal(x, xt))$

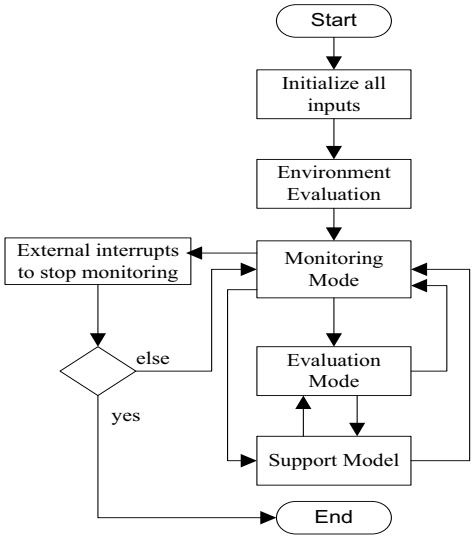


Figure 3. General steps in the Integration Algorithm

Algorithm 1 Environment Module
Input: $d(R, Pe)$
Output: ambient environment.
Start
  Initialization
    Pet, such that $0 \leq Pet \leq 1$
    Ab, such that $Ab \leftarrow$ false
  Evaluate physical environment
    Do
      if ($d(R, Pe >= Pet)$)
        then $s(R, Cp_i)$
          if (Cp_i)
            then $v(R, Am)$
              $u(R, Pe)$
          else $s(R, Cp_{i+1})$
            if (Cp_{i+1})
              then $v(R, Am)$
                $u(R, Pe)$
              else $Ab \leftarrow$ true
      else $Ab \leftarrow$ true
    While (Ab)
  MonitoringMode( )
End

4.2. Environment Evaluation

Reading environment is a crucial factor that affects reading performance [10]. Therefore, our robot will evaluate the environment (i.e., physical environment based on the ambient agent model) before proceed to the next stage. Algorithm 1 shows the steps for the environment evaluation. It will analyse the derived belief of robot towards its physical environment, $d(R, Pe)$. If is the observed value is greater than the threshold Pet, then the robot will display a confirmation message to the reader to inform that the room is not ambience enough for reading process to take place, $s(R, Cpi)$, otherwise a monitoring mode will be activated. When the reader confirms the condition, the robot will advise the reader to perform some actions to reduce potential disturbance from the environment, $v(R, Am)$. Next, the derived belief of on the environment will be updated based on these new settings. The robot will display message again to confirm about the current condition of the environment. All of these steps will be iterated unless the reader makes a change to the ambience environment or he /she agrees with the current environment.

4.3. Monitoring Mode

The core part of the integration is a monitoring mode, where most of the analysis process occurs. The ambient agent (i.e., *the engine of the robot*) will be executed in parallel to compute all instantaneous beliefs and temporal assessments based on its inputs (*derived beliefs* and *initial values*) as in [7], and evaluate reading performance at the pre-determined time intervals. In details, this monitoring process includes:

I. Activate evaluation mode: when reading performance (Rp) is continuously decreasing ($dRp/dt < 0$) and it is lower than threshold Rpt.

II. Provide *praising dialogue*: for positive progress $p(R, Pg)$ if the reading performance is increasing and approaching the threshold ($(Rpt - Rp) > mp$) or maintaining it at $p(R, Pm)$ when changes in reading performance level is greater than threshold ($dRp/dt > 0$ and $Rp >= Rpt$).

III. Perform consistent checking $f(R, Cc)$: to ensure the model reflects real conditions. By doing this, the robot will display a confirmation screen $s(R, Cr)$ to evaluate a reader whether he/she experiences high cognitive load $e(r, H_{cl})$, high exhaustion $e(r, H_{ae})$, or low persistence $e(r, L_{pr})$ prior to provide an intervention part.

IV. Activate support exhaustion (*SupportAe()*): when the robot beliefs the readers have reached maximum hours of reading (based on predefined limit) (*Max_time*) and the reader should get a short break. Algorithm 2 presents the four main actions in monitoring mode.

Algorithm 2 Monitoring Module

Input: $d(R, Tc)$, $d(R, Tp)$, $d(R, Tn)$, $d(R, Pe)$, $d(R, Pp)$, $d(R, El)$, $d(R, Pk)$, $d(R, Rn)$, initial assessments, *regulatory parameters*, *weight parameters*, change rate.
Output: evaluated level of reading performance.
Start
  Initialization
    Rpt, such that $0 \leq Rpt \leq 1$.
    $c \leftarrow 2$; $d \leftarrow 2$; $k \leftarrow 2$
  Repeat every time point ***t***
    Compute all instantaneous *belief*s ^ temporal *assessment*s at timestep *tp*
    For every *x*, *a*(*R*, *Rp*) such that *x* ∈ *tp*
      if (tp/x = c-1)
        then if (dRp/dt ≤ 0 ^ $Rp \leq Rpt$)
          then *EvaluationMode( )*
            $c \leftarrow c+1$
        else $c \leftarrow c+1$
    For every *y*, *a*(*R*, *Rp*) such that *y*>*x*, y ∈tp
      if (tp/y = d-1)
        then if ((dRp/dt> 0) ^ ($Rpt - Rp > mp$))
          then $p(R, Pg)$
      if (dRp/dt >= 0 ^ $Rp >= Rpt$)
        then $p(R, Pm)$
      $d \leftarrow d+1$
    For every *z*, *f*(*R*, *Cc*) such that *z* > *y*, *z* ∈ *tp*
      if (tp/z = k-1)
        then $s(R, Cr)$
          if $e(r, H_{cl})$
            then *SupportCL( )*
          else if $e(r, L_{pr})$
            then *SupportPr( )*
          else if $e(r, H_{ae})$
            then *SupportAe( )*
          $k=k+1$
    if *time_spent* ≥ *Max_time*
      then *SupportAe( )*
    $tp \leftarrow tp + 1$
    $ts \leftarrow ts +$ t
  Until *reader stop monitoring*
End

4.4. Evaluation Mode

The robot will activate evaluation mode when reader's performance is low in order to detect the main factors that cause the undesirable level of reading performance. If the robot senses that the exhaustion level is continuously increasing ($a(R, dAe/dt \geq 0)$) between two intervals and exceeding the threshold *Aet*, then the support exhaustion

model will be activated, otherwise the cognitive load and persistence conditions will be evaluated to provide the necessary help. Algorithm 3 shows the important stages for evaluation purposes.

Algorithm 3 Evaluation Module
Input: *a(R, Cl), a(R, Pr), a(R, Ae), a(R, Rp).*
Output: determine the conditions that need support
Start
  Initialization
    Clt, such that $0 \leq Clt \leq 1$.
    Aet, such that $0 \leq Aet \leq 1$.
    Prt, such that $0 \leq Prt \leq 1$.
  if (a (R, $dAe/dt \geq 0$) ^ $a(R, Ae) \geq Aet$))
    then *SupportAe ( )*
  else if($a(R, dPr/dt \leq 0)$ ^ a($R, Pr \leq Prt$))
      then *SupportPr ( )*
          if ($a(R, dCl/dt \geq 0)$ ^ $a(R, Cl \geq Clt)$)
              then *SupportCL( )*
    else if ($a(R, dCl/dt \geq 0)$ ^ $a(R, Cl \geq Clt)$)
          then *SupportCL( )*
End

4.5. Support Mode

Based on the robot's assessments and evaluations (monitoring and analysis), the support mode will be activated to provide the right support. For example, when the robot recognize that the reader has a high possibility of getting exhausted, then support exhaustion activity will be triggered (i.e., SupportAe()). This is important as exhaustion may deteriorate reading performance. The support mode has three main activities: Support exhaustion (*SupportAe()*), Support persistence (*SupportPr()*), and Support Cognitive Load (*SupportCL()*). The algorithms of these activities are presented as follows:

- *Support Exhaustion*

This type of support will be given in two conditions based on the robot's assessments as in monitoring and evaluation modes. First, when the robot observes and beliefs that the exhaustion level is continuously increasing and exceeding the threshold. Second, when the time spent for the reading task exceeds the predefined time (e.g., more than two or three hours) as mentioned in [13]. These procedures have been implemented in Algorithm 4 and specifically the algorithm decribes the important flows to support a potentially exhausted reader. Once this module is triggered, the robot will prompt a reader by a confirmation message $s(R, Cei)$ to rectify his /her exhaustion level. The short break advice $v(R, Sb)$ will be provided if the positive result has been detected. Otherwise, the second confirmation will be displayed to verify the actual exhaustion level. Next, when the support actions are activated, the robot has to reinitialize its monitoring mode based on default settings.

- *Support Persistence*

Low persistence is often positively correlated with the drop percentage of reading focus and continuation. However, motivational talks (short talk) will improve a reader's persistence. Our robot will activate a motivational talk module $p(R, Mt)$ if a low persistence level has been observed. The algorithm to detect and provide motivational talk is presented in Algorithm 5. In the beginning, a confirmation message $s(R, Csi)$ will be displayed to provide several selected motivational talks $p(R, Mt)$. The robot will re-evaluate the condition upon receiving confirmation from readers. Then the derived belief on motivation will be updated when the reader receives a set of selected motivational talks as in $u(R, d(Mv))$.

- *Support Cognitive Load*

In this condition, readers with a cognitive overload condition will be supported by providing different approaches based on particular derived beliefs. These types of support can be viewed as:

- ❖recommends a similar task (St) when the derived belief on a reader's experience is lesser or equal to the threshold $d(R, El \leq Elt)$,
- ❖provides specific knowledge (Sk) when the derived belief on prior knowledge $d(R, Pk \leq Elt)$ is less than the threshold,
- ❖Advices on suitable materials (Sm) when the derived belief on task presentation is less than or equal to the threshold $d(R, Tn \leq Tnt)$.

Algorithm 6 shows the important steps in supporting cognitive load. In this case, support actions should be prioritized related to the derived belief. For example, the lowest derived belief will be given a high priority in the support actions list. These processes also hold for the support cases in exhaustion and persistence. The robot will provide a particular support action from the list and also update its derived beliefs. In addition, the robot may suggest all support actions in parallel when the reader is experiencing a high cognitive load level.

Algorithm 4 ***Exhaustion Module***
Input: *ts*, *tp*.
Output: To provide short break actions
Start
  $s(R, Ce_i)$
    if $s(R, Ce_i)$
      then $v(R, Sb)$
        $tp \leftarrow tp + 1$
        $st \leftarrow tp + t$
    else $s(R, Ce_{i+1})$
      if $s(R, Ce_{i+1})$
        then $v(R, Sb)$
          $tp \leftarrow tp + 1$
          $ts \leftarrow ts + t$
End

Algorithm 5 ***Persistence Module***
Input: *d(R, Mv)*
Output: *p(R, Mt)*
Start
  $s(R, Cs_i)$
  if $s(R, Cs_i)$
    then $p(R, Mt)$
      $u(R, d(Mv))$
  else $s(R, Cs_{i+1})$
    if $s(R, Cs_{i+1})$
      then $p(R, Mt)$
        $u(R, d(Mv))$
End

Algorithm 6 ***Cognitive Load Module***

Input: $d(R, Pk)$, $d(R, El)$, $d(R, Tn)$
Output: To support cognitive load.
Start
  Initialization
    $i \leftarrow 1$
  Compute Priority // assuming Cl=1
    if $d(R, Pk \leq Pkt)$
      then $Sk \leftarrow Cl * Pk$
        $List[i] \leftarrow Sk$
        $i \leftarrow i+1$
    if $d(R, El \leq Elt)$
      then $St \leftarrow Cl * El$
        $List[i] \leftarrow St$
        $i \leftarrow i+1$
    if $d(R, Tn \leq Tnt)$
      then $Sm \leftarrow Cl * Tn$
        $List[i] \leftarrow Sm$
        $i \leftarrow i+1$
  Bubble sort ($List$) // ascending
  if length.List$\neq (\emptyset)$
    then $s(R, Cd_i)$
      if $s(R, Cd_i)$
      then for $i \leftarrow$ 1 to length_list
        do $g(R, List[i])$
          if $List[i] = Sk$
            then $u(R, d(Pk))$
          if $List[i] = Sm$
            then $u(R, d(Tn))$
          if $List[i] = St$
            then $u(R, d(El))$
          $i \leftarrow 1$
      else $s(R, Cd_{i+1})$
        if $s(R, Cd_{i+1})$
          then for $i \leftarrow$ 1 to length_list
            do g(R, $List[i]$)
              if $List[i] = Sk$
                then u(R, d(Pk))
              if $List[i] = Sm$
                then u(R, d(Tn))
              if $List[i] = St$
                then $u(R, d(El))$
              $i \leftarrow 1$
  else $g(R, Sm \wedge St \wedge Sk)$
    $u(R, d(Tn \wedge El \wedge Pk))$
End

5. Simulation Results

By incorporating an integrated ambient agent model of cognitive load and reading performance to a reading companion robot, this robot will be able to monitor and evaluates a reader's conditions based on certain observations. This section discusses how the ambient agent model works. Specifically, it details out the part on monitoring and assessment components using a scenario that relates to persistence of readers when reading difficult materials.

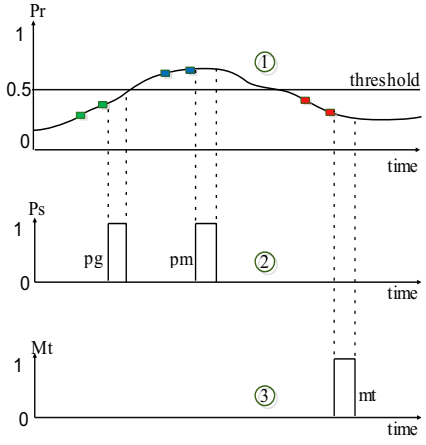
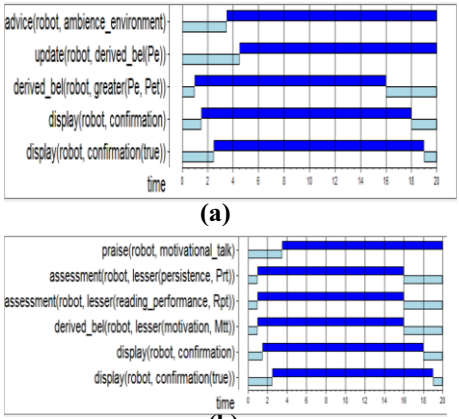


Figure 4. Persistence Support



(a)

(b)

Figure 5. Simulation Results of (a) environment evaluation, (b) motivational talk

Figure 4 visualizes the description on monitoring persistence level (*Pr*) and provided support (i.e., praising (*Ps*) and motivational talk (*Mt*)). In this case, the persistence level at particular time will be acquired and determined the types of support. For example, when the persistence level is continuously increasing and approaching the threshold, a praising message for good progress will be displayed (*Pg*). Similarly, a praising cue to maintain the good progress will be displayed when the persistence level is greater or equal to the activation threshold (*Pm*). Likewise, a continuous and monotonic decreasing level in persistence triggers a motivational talk (*Mt*) mode. To visualize these processes, we have programmed and simulated a set of selected scenarios as depicted in the proposed integrated algorithms using LEADSTO platform. Figure 5 (a) and (b) show the simulation results. Based on the results, we can deduce that the simulation traces described above can satisfactorily explained the relations as summarized in Section 4.2, 4.3, 4.4, and 4.5.

6. Evaluation

This section describes the process to evaluate dynamic properties of the cases considered in the proposed algorithms. To do so, several possible cases were identified from the related literatures and an automated verification using Temporal Trace Language (TTL) was performed. TTL is also comparable to the *Holds*-predicate in the Situation Calculus. Based on that concept, dynamic properties can be formulated using a sorted First-Order Predicate Logic (FOPL) approach.

VP1: Provide social dialogues when the reading performance getting low [11].

$\forall\gamma$:TRACE, t1, t2, t3:TIME, $\forall$M1, M2, D1, D2:REAL
[state (γ,t1) |= belief(robot, persistent_level(M1)) &
state (γ,t2) |= belief(robot,persistent_level(M2)) &
state (γ,t1) |= assessment(robot ,reading_peformance(D1) &
state (γ,t2) |= assessment(robot ,reading_peformance(D2)] &
t1 < t2 &M1 >M2 &D1 >D2] $\Rightarrow$ $\exists$t3:TIME > t2:TIME [state(γ,t3) |=performed (robot,
provide(social_dialogue)]

VP2: Suggestion to find an ambience place when noise level is high [10].

$\forall\gamma$: TRACE, t1,t2, t3:TIME, N1, N2:REAL
[state(γ,t1) |= belief(robot, noise_level(N1)) &
state(γ,t2) |= belief(robot, noise_level(N2)) &
state(γ,t2) |= evaluation(robot, belief_ambience(no)) &
t1 < t2 &N1 > 0.6 & N1 $\leq$N2] $\Rightarrow$ $\exists$t3:TIME > t1:TIME [state(γ,t3) |=performed (robot,
advice(suggest_ambience_place))]

VP3: Advice for a short break session when the reader encounters exhaustion [12].

$\forall\gamma$: TRACE, t1, t2, t3:TIME, E1, E2, d: REAL
[state (γ,t1) |= belief(robot, exhaustion_level(E1)) &
state (γ,t2) |= belief(robot, exhaustion_level(E2)) &
t1 < t2 + d &E1 $\geq$ 0.7 & E1 $\leq$E2] $\Rightarrow$ $\exists$t3:TIME > t1:TIME [state(γ,t3) |=performed (robot,
advice(short_break))]

7. Conclusion

The main goal of developing ambient agent models is to deploy technologies that are able to support people in their daily lives with human-like functionalities and understanding. Apart from this, the integration of an ambient agent model of cognitive load and reading performance into a reading companion robot is introduced in which integration algorithms were developed to serve as an intelligent mechanism for the robot's reasoning ability. For the next step, a thorough analysis of the proposed algorithms will be considered. This step is imperative in materializing the development of a robotic lamp for reading companion.

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CAKNA: A Personalized Robot-Based Platform for Anxiety States Therapy

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Abstract. Anxiety can be defined as an unpleasant state of mental uneasiness or concern that causes physical and psychological discomfort. In this paper, we describe an interactive robot-based platform that is designed to be used to support of person with anxiety traits and states using non-medical treatments including mindfulness, relaxation, and muscle relaxation therapy. We describe CAKNA, whose design is based on theories in anxiety traits and states, social robots, and therapies, along with the results of a pilot study (with 24 respondents) exploring the effectiveness of our robot to support individuals with anxiety.

Keywords. Robot-based Therapy, Smart Living Application, Anxiety State and Trait, Interactive Systems

1. Introduction

In the domain of psychology, anxiety disorder is a term covering several different forms of a type of mental illness of abnormal and pathological fear and anxiety. This condition can be defined as long acting, future focused, broadly focused towards a diffuse threat and promoting extreme caution while approaching a potential threat to the individuals. For example, is common for someone with anxiety to also suffer depression or vice versa. Moreover, nearly one-half of those diagnosed with depression are also diagnosed with an anxiety states and traits. In order to alleviate this cognitive disorder, several computer-based systems have now been developed that allow individuals with anxiety issues to receive therapeutic care from the comfort of their time and places. Despite they are superior to no treatment; these computer-based systems are still less effective or have a gap compared to traditional face-to-face therapy sessions [1-5]. Issues such as social physical embodiment, fluid user interaction, intelligent support, and social feedbacks play important roles in designing a digital application / computer programme to reduce cognitive related problem, e.g. cognitive load, anxiety, social phobia, and unipolar depression[6-14]. To overcome those issues, robots offer an alternative solution as a medium to complement existing digital platforms in providing therapeutic tools of person with anxiety [7][10][13].

In this paper, the design of a robot-based anxiety management system that delivers therapies to reduce user's anxiety level is presented. In Section 2, the context of temporal dynamics of anxiety is described in some detail. The design of CAKNA (our robotic platform) is introduced in Section 3, whereas Section 4, more details of the

types of therapies is discussed. Section 5 presents results from our pilot evaluation study. Finally, Section 6 concludes this paper.

2. The Domain Model: Temporal Dynamics of Anxiety States and Traits

Figure 1 gives a conceptual representation of the computational model developed in [15], which is based on the major theories about anxiety states and traits. This model serves as a backbone to analyse and predict potential anxiety levels.

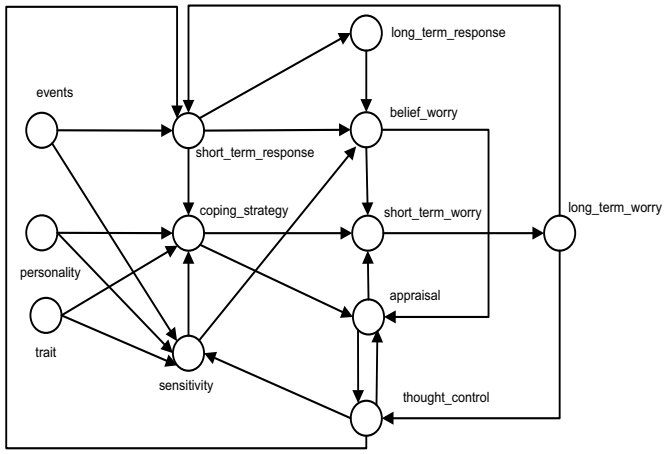

Figure 1. Conceptual Model of Anxiety Traits and States.

According to Well's model (*Meta-cognitive Model*), problematic worry develops over time. It begins with a tendency to use worry as a coping strategy for real or imagined threats. For example, avoidance coping (resulted from high traits in anxiety and negative personality) aims to avoid the *aversive somatic* and emotional experiences which naturally occur when being confronted with non-cognitive events (*external situations or physical symptoms*) and triggers anxiety responses. Higher sensitivity increases the formation of beliefs about worry and reduces the ability to cope accordingly [16]. However, the responses may increase (or decrease) the anxiety state according to the initial condition of the problems. During this stage, the coping strategy and individual's sensitivity will regulate the formation of short-term worry. It is imperative to acknowledge that the engagement in ineffective coping strategies provides a chance about the belief that is uncontrollable [17][19]. Therefore, it escalates short-term worry later experience a negative reinforcement spiral experience of worry that further reinforces the worry and reduces individual's appraisal ability [9][12].

This later increases the long-term worry that will influence individual's thought control over negative events (triggers). The intolerance to uncertainty serves to set off a chain of worrying, negative problem orientation, and cognitive avoidance [16][19]. In short, the following relations can be identified from the literature: (1) a series of psychological and physiological stressor events can lead to the formation of anxiety;

(2) low coping skills will increase the risk anxiety strait; (3) negative personality and personality traits factors aggravate the effect anxiety; (4) prolonged sensitivity will increase belief about worry; (5) good coping strategies and appraisal will reduce worry; (6) prolonged short-term worry will increase the risk of long-term worry in the future.

3. Design of the Robot-based Therapy for Anxiety

Our long-term goals are to develop a fully functional robotic platform to support cognitive therapy, which socially expressive robots are especially useful. As a first step, our goals for the work presented in this paper were twofold; first, to develop a low-cost robotic platform that runs on standard computing devices (such as smartphone or basic laptop) (physical design). Secondly, to incorporate this robot with specific analytics to determine types of therapy needed (software agent and software architecture).

3.1. Software Agent

A basic element in the software agent is the integration of temporal dynamic model of anxiety (*domain model*) within it. By incorporating the domain model, the software agent gets an understanding of the processes of its environment [9].

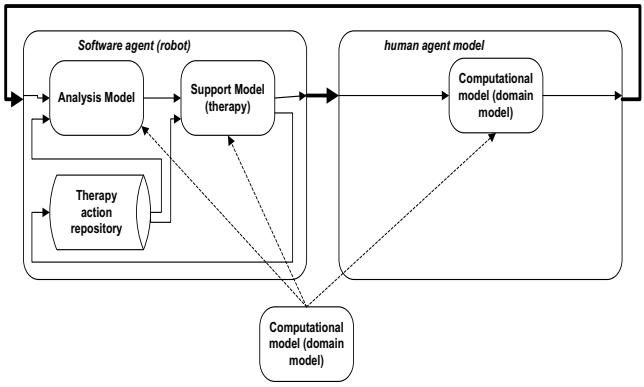

Figure 2. Overall Design of the Software Agent

From Figure 2, the solid arrows indicate information exchange (data flow) and dotted arrows the integration of the domain model within the software agent model. Within the software agent model, two main components have been distinguished, namely;

- *Analysis component*: To perform analysis of the human's states and processes by model-based reasoning based on observations and the domain model.
- *Support component*: To generate support actions for the human by (*model-based*) reasoning based on observations and the domain model.

In the analysis model, a set of different combination of several generated computational specifications is analysed. By analysing these combinations, the person's potential risk in anxiety can be monitored and predicted [9].

3.2. Physical Design

The constructed robot is about half a meter tall and is designed to sit on a table or countertop. As seen in Fig. 3, there is also a small touch-enabled input screen (ASUS 7" smart tablet powered by Android version 4.4.2 KitKat) on the front to allow data entry. Off-the-shelf PC components are used for the computation abilities (Intel Core i3-4030U 1.90GHz processor, 4 GB RAM, Windows 10 64-bit Operating System, x64-based processor, and 444GB hard drive) and an inexpensive servo controller provides robot motion control.

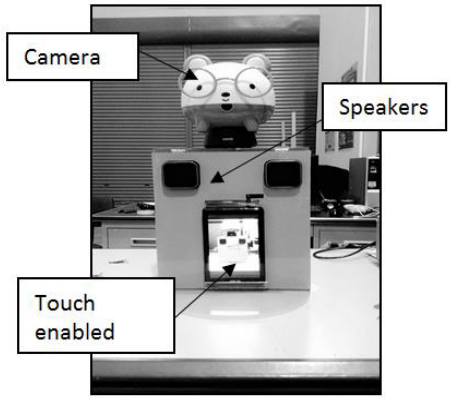

Figure 3. CAKNA Physical Design

The robot has one degree of freedom in the neck and two in the coupled eyes, allowing each a full range of horizontal motion (controlled by *Tenvis P2P* wireless network camera setting). A set of cameras is mounted above the eyes providing a view in front of the robot to the OpenCV face tracker. The CAKNA robot features custom LED mouth displays lip-synched to pre-recorded dialogue spoken using available text-to-speech voice. To measure anxiety, CAKNA utilizes self-report data obtain from the touch screen tablet and analytical results from the software agent module.

3.3. Software Architecture

The main software system handles all input and output, maintains the overall state of the interaction with the user, and handles the flow of interaction based on input from the user. The overall architecture is depicted in Fig. 4.

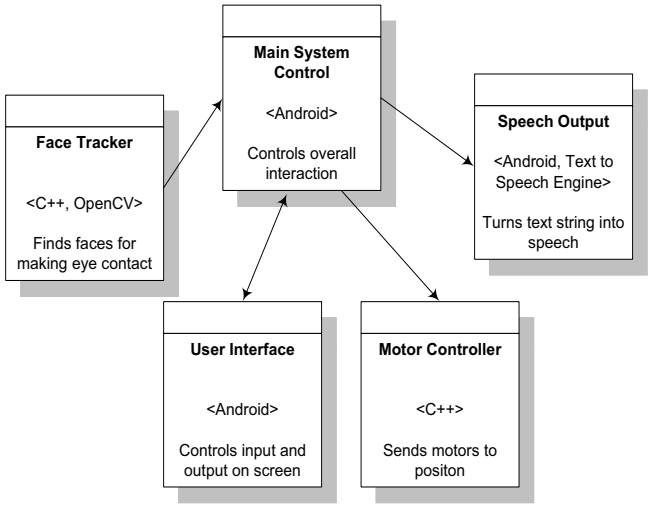

Figure 4. Software Modules

The motor controller codes was written using C++ utilizes an inexpensive servo controller provides motion control. The vision system on CAKNA runs on a set of cameras is mounted above the eyes. These cameras are providing a view in front of the robot to the OpenCV face tracker. The face tracker is implemented in C++ as a standalone piece of software that sends out an (X,Y) coordinate set for each face found in a video frame (face tracker module). The action that the face tracker captures is eye contact that is maintained with a user.

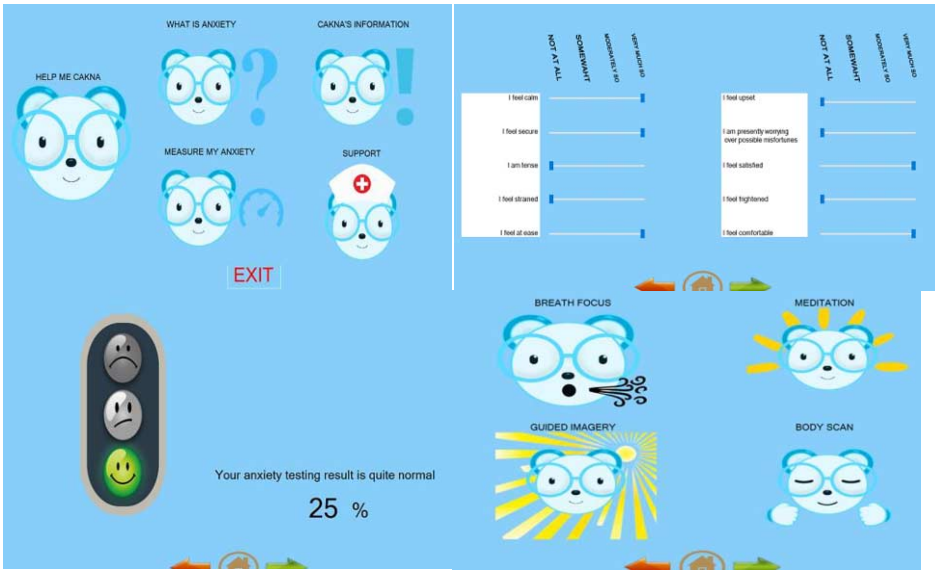

Figure 5. User Interfaces

The speech capabilities of the robot were created using an off-the shelf Android *text-to-speech* (TTS) class. The resulting application written in Android programming language was built as a standalone system that is activated when the user interacts with the robot. Upon receiving the input, it uses the API interface to convert a set of pre-programmed text into speech and plays the result over the robot's speakers. This user interface module is written in the Android programming language produces output screens based on the needs of the interaction for anxiety analytics and therapy management (as depicted in Fig. 5). The actual content of most screens is parameterized so that the main control code can determine the text or data to be shown on a given screen at runtime. User interacts with CAKNA by using a small touch-enabled input screen on the front to allow data entry.

4. Types of Therapy

To date, there is no actual cure for anxiety exists, but a number of studies showed that preventive measures could help avert anxiety in individuals who are at risk. Depending on the specific cause of the anxiety as well as on the individual's preferences, the treatment methods may include *behavioural therapy, physical therapy, relaxation therapy, mindfulness therapy, counselling* and *meditations* [19][20][21].

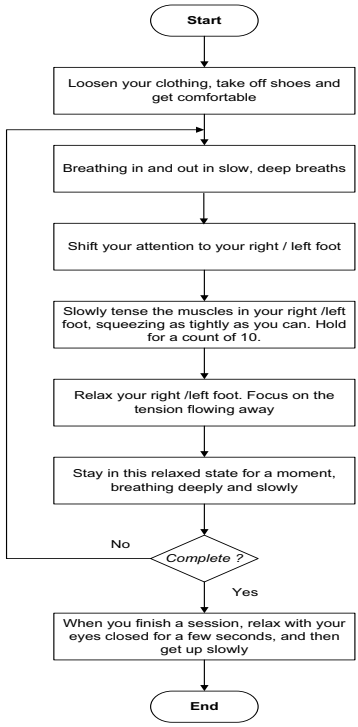

Figure 6. An Example of Body Scan Therapy

As a basic rule, these treatments are designed and administered at reducing the symptoms related to anxiety and assisting individuals in getting back their life [19]. CAKNA is designed to support self-therapies procedures to bring the anxiety level down. There are four types of therapies that were programmed on CAKNA, namely; 1) *deep breathing*, 2) *body scan*, 3) *mindfulness meditation*, and 4) *guided imagery*. Deep breathing exercises are an excellent and easy solution for anxiety relief. This method aims to target on a physiological level by automatically slowing individual's heart rate. The key of deep breathing is to breathe deeply from the abdomen and getting as much as fresh air (oxygen) into individual's lungs [21]. This later will improve oxygen concentration in bloodstream and gives the calming effects.

Another method is the body scan approach, which involves learning to mentally monitor tension in each specific muscle group in the body by deliberately inducing tension in each group (as shown in Fig. 6). This tension is then released with special attention paid to the contrast between tension and relaxation. Mindfulness meditation therapy allows individuals to become more aware of the stream of thoughts and feelings that they experience [21][22]. It involves sitting silently and paying to thoughts, sounds, and bringing attention back to normal. Guided imagery is another type of therapy related to the mind-body intervention aims to evoke and generate mental images that simulate person's sensory perceptions. There are two ways by which guided mental imagery is conducted; *voluntary* and *involuntary*. Involuntary involves the generation of mental imagery based on present sensory while voluntary imagery resembles previous sensory perception recalled from memory or the product of imagination [21]. Both processes require special guidance to avoid potential risk towards generating mental images that may severe individual's thought processes (e.g. post-traumatic stress disorder individuals may recall (*flashbacks*) the disturbing intrusive images based on their past experiences).

5. Pilot Evaluation Study

We conducted a pilot study to evaluate the acceptance and usability of our robot-based therapy among individuals with mild to moderate anxiety traits. Our participants were introduced to the procedures and applications through a series of discussion. The discussion covers some important topics about anxiety, symptoms, and some concepts in self-therapy to manage anxiety.

5.1. Participants and Measures

Participants were recruited via online postings and based on voluntarily approach. Later, they received the Trait Anxiety Inventory (*T-Anxiety Form Y*), and were eligible to participate if they scored a cut point of 40 [17]. Range of scores for each test is 20-80, the higher score indicating greater anxiety proneness. In addition, only participants were not currently enrolled in therapy and not on medication were selected. Selected participants also received a State Anxiety Inventory (*S-Anxiety Form Y*) before and after interacting with the system / robot [18]. After the interaction process completed, participants filled out 4-*point forced-choice* Likert-type response scales to evaluate their current state.

Figure 7. Computer-based Therapy vs. Robot-based Therapy

All interactions with system/ robot were recorded (with consent) for review by our experts. The deep breathing exercises were used as a therapy tool to combat anxiety state among respondents. Figure 7 visualizes the position of the robot during our therapy sessions.

5.2. Quantitative Results

We recruited 24 participants: 60 percent male, aged 19-23 (Mean 21.5, SD=1.6) years old and almost 83 percent of them had never tried any forms of therapy before. Pre-post testing conducted immediately before/following the PC-based and robot interaction to evaluate potential significance differences in anxiety level (*S-Anxiety Form Y*).

Table 1. Outcome Measures (S-Anxiety) from Pilot Study

	Pre-mean (SD)	**Post-mean (SD)**	***p***
Comp-based Therapy (*n*=12)	62.8(12.4)	57.8(10.07)	0.267
Robot-based Therapy (*n*=12)	63.3(11.2)	36.9(5.1)	0.045

From Table 1, it shows there is a significant improvement after using our proposed robot-based therapy (CAKNA) (as compared to the computer- based therapy (PC)).

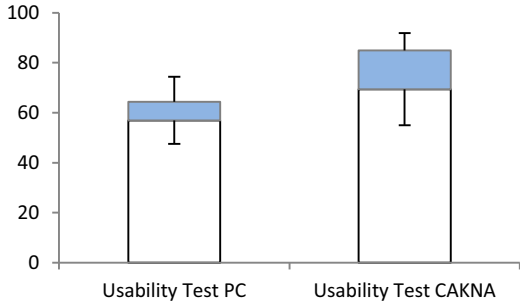

Figure 8. Usability Test

In addition, participants find CAKNA require almost no background knowledge about robotic technology to operate the robot, easy to understand interfaces, and easy to follow instructions (*Mean* = 75, *SD* = 5.5). Fig. 8 depicts the overall usability results from our experiments.

5.3. Qualitative Results

In this study, all respondents reported that the robotic system was very easy to use. For example, one of the respondents (*RSP#5*) mentioned;

> "*I found it to be very easy and straightforward. I think that other people would not need support of a technical person to be able to use this robot*."

When asked about how the system helps them to control their anxiousness, only one of the respondents (RSP #9) felt that the "machine-like" voice seems a bit weird. However, the same respondent also mentioned other than that, everything was nice and looking forward to use this robot again in the future. In addition, all respondents were told that they are allowed to terminate the session early if desired. None of the respondents chose to terminate the therapy session early.

6. Conclusions and Future Work

In this paper, we explore the use of a robot-based anxiety management system that is responsive to user interaction. The designed robot integrates a software agent, physical robot design, and software modules. The dedicated support actions tuned to the circumstances are generated based on the analysis (from a software agent), thereby taking into account guidelines adopted from anxiety management programmes. Additionally, we demonstrate the potential implementation of such a robotic system through our pilot study in which people with anxiety state interacted and followed the therapy session. Currently, we are expanding our experiments using control groups and different types of therapy sessions. In addition, we are investigating possible more human-like voice to support more fluid human-robot interaction in the future. Furthermore, we are planning to build an adaptive bio-feedback system connected to a user for real-time anxiety level analysis over multiple sessions.

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1st International Workshop on Advanced Multiple Access in Mobile Telecommunications (AMAMT'17)

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Preface

The 1st International Workshop on Advanced Multiple Access in Mobile Telecommunications (AMAMT 2017)

Spectrum efficiency is of significant importance and becomes one of the main design targets for future fifth-generation networks. Non-orthogonal multiple access (NOMA) has received considerable attention because of its potential to achieve superior spectral efficiency. Particularly, different from conventional multiple-access (MA) techniques, NOMA uses the power domain to serve multiple users at different power levels to use the spectrum more efficiently. The application of multiple-input multiple-output (MIMO) techniques to NOMA has been considered by using zero-forcing detection matrices, and so on.

NOMA systems allow communication resources, such as time and frequency, to be shared by all users and achieve a higher transmission rate than orthogonal multiple access (OMA) systems. The actual implementation of NOMA in cellular downlink transmission systems requires solving several practical problems. One practical problem is the beamforming design problem at base stations. This is because unlike a mobile phone that is usually equipped with a single antenna, a base station is generally equipped with multiple antennas. The beamforming design problem in multiple-input single output (MISO) channels was discussed, where a clustering and power allocation algorithm was proposed. It is assumed that the base station knows prefect channel state information (CSI) from itself to users. However, in practice, the base station has difficulty obtaining perfect CSI because of channel estimation and quantization errors.

This workshop focuses on the various issues for advanced multiple access in mobile telecommunications, and it will be to bring together the researchers from academia and industry as well as practitioners to share ideas, problems and solutions.

Accepted Articles

1. An Application of Space Shift Keying for Non-orthogonal Multiple Access to Improve Spectrum Efficiency, by Yuchen Yang and Xin Su
   - Non-orthogonal multiple access (NOMA) achieved the high throughput by introducing the power domain multiplexing. To improve the spectral efficiency of conventional NOMA scheme, we introduce the spatial domain to NOMA and the proposed scheme is proved has superior performance in spectral efficiency, compared with conventional space shift keying (SSK). The result of simulation confirms that the proposed scheme effectively improve the performance in the aspect of spectral efficiency.
2. Study on Technologies for Applications in Tactile Internet by Yixin Zhang, Shaoyu Dou and Xin Su

- Tactile Internet has been proposed as a promising technology to innovate the human communication within a very short delay. But now it still cannot solve the problem of high delay, which leads to Tactile Internet cannot be widely applied. Therefore, the low-latency techniques, which guarantee an approximately 1ms round-trip delay, should be developed. This survey paper lists several low-latency technologies which can be considered and applied into Tactile Internet.

3. Application of Bluetooth Low Energy Positioning in Long-Term Care Systems, by Huan-Ting Lin, Pei-Hua Tang, and Jeng-Wei Lin
   - Population aging is a series issue nowadays in many countries. This creates a huge demand of long-term health care. In most long-term care institutes, a caregiver has to take care of many elderly people at the same time. Some of them have been paralyzed in bed, while others are still able to move in the institutes. It is not uncommon that a caregiver has to spend a lot of time to find an elder to perform daily care operations, such as injections, medications, and blood pressure measuring. Elders may move in dangerous places, such as kitchens, stairs, and bathrooms. In this paper, we present an iBeacon-based indoor positioning system for long-term care institutes. Thus, the staffs of long-term care institutes can easily locate the elders, and be notified when some elders move in dangerous places.
4. Security Issues and Solutions in Cloud Computing
   Yujie Xie, Yeonju Lee, Kwangmin Kim, Pankoo Kim
   - The leap development of Internet gives computer science infinite possibility. Meanwhile, the emerging cloud computing has become a tremendous boost of Internet innovation. It alters the traditional IT service models to a remote service and provides massive storage without the limitation of computer processing capacity. This unique storing service paradigm apparently brings a series of benefits and convenience to most Internet enterprises especially start-ups. However, few attentions have been paid to the potential security issues and challenges with the rapid development of cloud computing. During the frequent processing between cloud providers and users, cloud security has been cited as a vital problem as cloud computing outputs data in a virtual environment through the internet. Virtual computing is more vulnerable to various attacks such as data loss and leakage. Hence, comprehensive solutions are significantly necessary to solve these problems in cloud systems. In this paper, we will briefly introduce the definition of cloud computing firstly. And cloud security structure is given in the second part, which includes three main cloud types and three service models. Moreover, crucial security threats and challenges in the cloud computing are illustrated and corresponding solutions are proposed accordingly in the last part.

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Study on Technologies for Applications in Tactile Internet

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Abstract. Recently, Tactile Internet has been proposed as a promising technology to innovate the human communication within a very short delay. But now it still cannot solve the problem of high delay, which leads to Tactile Internet cannot be widely applied. Therefore, the low-latency techniques, which guarantee an approximately 1ms round-trip delay, should be developed. This survey paper lists several low-latency technologies which can be considered and applied into Tactile Internet.

Keywords. Tactile internet, Low-latency, 5G, IoT

1. Introduction

The cellular communications developed for the Internet of Things (IoT) applications, which bridges the machines, devices, and human, become an unprecedented innovation for multimedia and data content exchange. Data rate scaling up to gigabit has been listed on the open issues in 5G communications. On the other hand, once the communication delay among terminals shrinks within a millisecond, human tactile to visual control will be changed around the world. However, the most advanced communication structure, e.g., Long-term Evolution (LTE) only achieves a typical round trip latency of 25ms, which unfortunately exceeds the 10ms requirement to enable real-time wireless gaming. Consequently, the low-latency techniques focused on realizing the millisecond transmissions with a high reliability need to be developed and applied in Tactile Internet [1]. Along with the brief introduction for the applications in Tactile Internet, this survey paper overviews several low-latency technologies which might be potentially considered and applied into Tactile Internet.

2. TACTILE INTERNET APPLICATIONS

2.1. Heading Revolution in Human Living Style

These days, researchers of human engineering have demonstrated that people who use wheelchairs are able to walk with exoskeletons. The exoskeleton is a device strapped to the body and limbs, which enables the people to move limbs with more

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force than muscles as illustrated in Fig.1. Therefore, the reaction time of an exoskeleton has to be fast enough that makes sure the movements are within the tactile latency. This needs to be controlled by wireless systems to recognize the individual's surroundings in order to prevent the individual to harm others or the surroundings, e.g., not falling down stairs or running into objects with the force of an exoskeleton [2]. Another possible variety of applications is vast for the education concept realized by Tactile Internet. The endless possibilities will be provided to improve the education quality. For example, students can possibly interactive in a virtual session, where a classroom jointly engages via a virtual reality setting. For traffic, the automatic driving would be made possible based on Tactile Internet, where vehicles with sensors can regulate velocity automatically through the data exchange among vehicles and surroundings as illustrated in Fig.2 [3]. This also needs that vehicles pass through the intersections with the identification of traffic lights to avoid crash and traffic jam. Digital image processing of video information can be used to synthetically render the viewpoint of the viewer to another spot. An example of interest could be viewing a sports event in a stadium equipped with hundreds of cameras. Real-time rendering of these cameras allows each person to choose their viewpoint of interest. To maximize excitement, the latency between the naturally visible surroundings by a visitor and the free viewpoint video being displayed on the tablet must be minimized.

Figure 1. An example of exoskeleton.

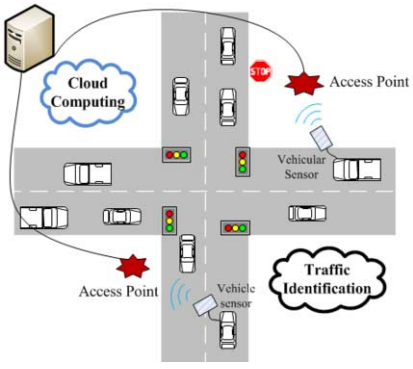

Figure 2. Automatic driving by Tactile Internet.

In recent years, the development of shipping industry is faster and faster, and has been widely applied to business, travel, military, and many other aspects. Therefore, effective

Communication between ship and ship is more important. Reduce the communication delay not only can know the status of the ships in a timely manner, ensure the normal operation of the ships, but also ensure the life safety of the crew. In [4], this paper puts forward the Multi-Hop Clock Synchronization which proposes a logical clock synchronization algorithm with multi-hop function for the SANET, namely multi-hop clock synchronization for SANET (MCSS), which not only reduces the beacon collision probability but also takes care of the propagation delay to improve the synchronization performance. In the case of non-available UTC/GPS, the proposed MCSS works in an ad-hoc manner, and the multi-hop functionality ensures the link reliability for the large-scale SANET, e.g., over 100 km coverage. The selection of synchronization time reference nodes (STRNs) can be optimized by the criteria of "selection of the previous hop boundary ships (HBSs)" and "propagation delay reduction." This greatly reduces the communication delay of the ship, makes the naval force more powerful, people travel more convenient.

2.2. Efficiency Enhancement in Manufacturing

Robots control should be restricted at latency reaction times that are fast enough to manipulate machines in real-time. For many robotics scenarios in manufacturing, this has led to a maximum latency target of a communication link of 100 μs and a round-trip reaction time of 1ms. For example, robotic surgery, which requires zero mistake, is an exciting emerging technology. A small timing drift between the surgeon servers and robotic arm could lead to a severe medical negligence. A diversified product kit should be produced within one assembly environment, where a wireless infrastructure of the Tactile Internet will be necessary. And another application area is the synchronization of suppliers in a smart grid. As synchronous co-phasing of suppliers is necessary to minimize reactive power, this must be achieved within a small angle of phase. For example, an accurate suppliers switching need to be with a 1-ms latency of communications between suppliers that ensures an 18° (50 Hertz Ac network) or 21.6° (60 Hertz Ac network) small phase shift.

3. POTENTIAL TECHNOLOGIES DEDICATED FOR LOW-LATENCY CONSTRAINT IN TACTILE INTERNET

This section lists the potential technologies dedicated for the low-latency constraint networks. And these technologies are provided and discussed at each communication layer.

3.1. Haptics over Internet Protocol in Application Layer

As a wide variety of applications aimed to exploit tactile feedback, it requires the application layer enhancement for the improvement of round-trip delay. An efficient information compression scheme needs to be applied to minimize the data processing delay and to meet the demand of the Tactile Internet. In [5],an novel application layer protocol, namely Haptics over internet protocol (HoIP), for tactile applications has

been proposed. It is designed by adaptive sampling strategies without block processing to reduce the processing delay. Via HoIP, the input and output refresh rate of haptic devices is sampled with 1KHz, and the transmission of haptic signals by using one packet per sample scaling to 1000 packets per second. In order to fulfill the low-latency requirement by reducing the packet rate, [5] applies the adaptive sampling, where the tactile signal is sampled based on two adaptive schemes as follows:

- Weber's sampler [6], which uses the previous sample level Xn−1 as a reference level and takes the following sample, Xn, at the first time t according to

$$\left|\frac{X(t)-X_{n-1}}{X_{n-1}}\right| \geq \delta; \tag{1}$$

- Level crossing sampler, which uses the previous sample level Xn−1 as a reference level and takes the following sample at the first time t based on

$$\left|X(t)-X_{n-1}\right| \geq c. \tag{2}$$

  Here, δ is the Weber constant and c is the level crossing threshold, and these constants can vary significantly depending upon the user and the haptic device, where the details of constants setting can be found in [5].

3.2. Computing Latency in Network Layer

In general, the end-to-end communication delay contains the processing and routing delays from source to destination. In [7], an efficient algorithm, which minimizes the network latency by wormhole switching and credit-based virtual channel flow control, has been presented. In [7], the direction ordered routing is used, where the messages traverse from the row of the source router to the column of the destination router. And the routing distance is given as

$$nR = | R_s \bmod co - R_d \bmod co | + | [\frac{R_s}{co}] - [\frac{R_d}{co}] | + 1 , \tag{3}$$

Where notations are listed in Table.1. In communication under wormhole switching, each packet is set by a number of frame with fixed length. If two packets of the same message are transmitted in a pipeline, the second packet is ensured not to exceed the first until the previous one has moved to the next router. And then, the sender router allocates virtual channel to the packet, and transfers packets over physical channel to the next router based on the available credits. Periodically, the sender forwards to the packet and decreases the credit. After sending the packet to the next destination router, receiver returns the credit to the sender router and increases the credit. The network latency can be defined as

$$\sigma_N = | nI * (aV^{\lambda} + 1) + (nR - 1) | * \sigma_R^P. \tag{4}$$

Via computing the network latency by using (4) in a network flow, [7] obtains a low latency in a single network flow, where the desired results can be obtain by optimal parameters setting.

Table 1. List of Notations

Notation	Description
nR	Routing Distance
Rs	Source Router Index
co	Number of Columns
R_d	Destination Router Index
σN	Network Latency
nI	Number of Iteration
aV^{λ}	Number of Allocated Virtual Channels of Network Flow
σ_R^P	Average Packet Router Latency

3.3. Fixed Resource Scheduling in Media Access Control Layer

The scheduling scheme in [8] provides a method to guarantee the communication reliability and latency for a given channel model. The proposed MAC in [8] assumes the system has a star topology that is known and fixed. As shown in Fig. 3, the protocol has three phases in every cycle, including Controller and Slaver initialization, transmissions from Controller to Slaver, and retransmissions from Slaver to Controller. In the first phase, each node has an assigned time set during system initialization to send the cycle's instructions or observations. The controller starts by broadcasting all of the instructions to the slaves in one code-word. And then, every slave sends its observations as well as an acknowledgment indicating whether it received the controller's data. If a slave does not have an actuator, it can send a fixed value for the ACK; otherwise, it can send only the ACK. The controller then broadcasts a block ACK to all of the slaves indicating which slaves need to retransmit. In the second phase, the controller retransmits data to any slaves that responded with a NAK or whose transmission the controller could not decode. And in the last phase, the sensors retransmit data to the controller if they received a NAK in the block ACK or could not decode it.

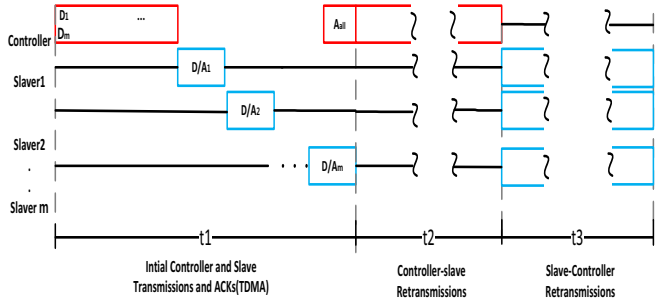

Figure 3. MAC layer timing diagram for low-latency data transmission.

3.4. Universal Filtered Multi-Carrier in Physical Layer

In order to achieve round-trip delay within 1-ms, the very small packets need to be applied in the physical layer. Thus, each packet duration cannot exceed 33μs [1].

However, in LTE cellular systems, the duration of a OFDM packet is close to 70μs which exceeds the desired value.

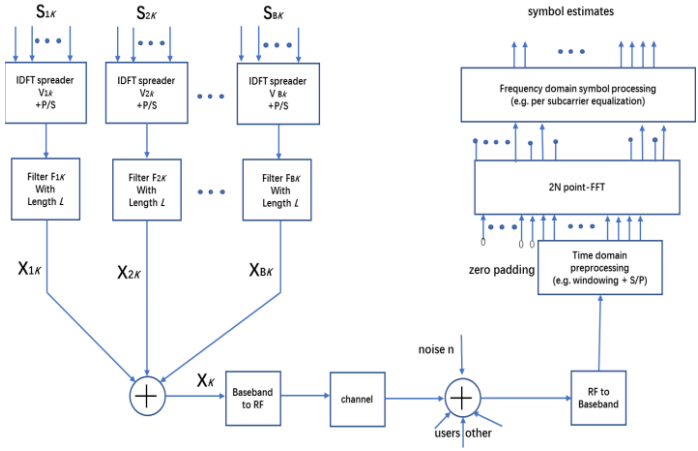

Figure 4. UFMC transceiver

And then, new waveform which is suitable for short packet needs to be developed. In [9], universal filtered multi-carrier (UFMC) scheme is proposed as shown in Fig.4. In general, UFMC is an enhancement of OFDM, and the key idea behind UFMC is applying filter bank at each sub-carrier in order to guarantee the time domain symbols not overlapped. In addition, UFMC does not use a cyclic prefix (but still is able to do so to further improve on inter-symbol-interference protection), and the filter lengths depend on the sub-band widths. As OFDM is only suitable for long packets, UFMC, which appears as an evolution of OFDM, is applicable for both long and short packets transmission.

3.5. Multipolarized Antenna Systems

The next-generation wireless systems are required to possess high voice quality and high data rate services compared to the current cellular mobile radio standards and also provide seamless data service. Recent work has shown that independent spatial channels can be used to greatly enhance capacity under situations subject to scattering, such as urban areas or indoor environments. Multiple input multiple output (MIMO) systems have been shown to dramatically increase the capacity of wireless systems and so have drawn an increasing amount of attention in recent years. All in all, the use of polarized antenna systems has been receiving considerable attention.

In [10], a new type of wireless channel is proposed. The PS multi-polarized Multipath Channel Model. The PS multi-polarized channel models are designed for use in macro and micro cell environments. Therefore, the power delay profile of ITU-R M.1224 Veh. As shown in (5). Consider

$$\mathbf{H}_{\text{multipath}}(t) = \sum_{l=1}^{L} \sqrt{\frac{P_l}{M}} \mathbf{H}_l(t)\, \delta(t - \tau_l), \tag{5}$$

Where L is the number of multi-paths, Pl is the signal power per path, Hl is the polarized flat fading channel, and τl is the time delay of each path. All in all, the use of

polarized antennas can greatly increase the reliability of wireless links, which can be turned into throughput increase, depending on the discrimination capabilities of the cross-channels of the polarized system. The use of a polarized antenna is also an efficient way to reduce the communication delay, which helps improve our lives, and details can refer to reference [10].

4. CONCLUSIONS

Tactile Internet is proposed as a promising method to change the living style of human. Most of the advanced inventions, such as exoskeleton, virtual session and automatic driving, are realized via the technical supports from Tactile Internet. In this paper, we summarize several state-of-art applications of Tactile Internet and list the potential low-latency techniques which might be dedicated for Tactile Internet in the future. The listed techniques are discussed according to the categories of application, network, MAC, and physical layers for the low-latency target.

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An Application of Space Shift Keying for Non-Orthogonal Multiple Access to Improve Spectrum Efficiency

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Abstract. Non-orthogonal multiple access (NOMA) achieved the high throughput by introducing the power domain multiplexing. To improve the spectral efficiency of conventional NOMA scheme, we introduce the spatial domain to NOMA and the proposed scheme is proved has superior performance in spectral efficiency, compared with conventional space shift keying (SSK). The result of simulation confirms that the proposed scheme effectively improve the performance in the aspect of spectral efficiency.

Keywords. NOMA, Space Shift Keying, spectral efficiency

1. Introduction

Despite the current 5G standards are still under construction, non-orthogonal multiple access (NOMA) has been considered as a promising candidate for next generate communication system, it introduces the power domain to improve the system throughput. In NOMA downlink, non-orthogonality is achieved by power domain multiplexing, either in time, frequency or code domains, receivers obtain de-multiplexing by the application of SIC. In this case, all receivers share a same transmission bandwidth, which improves the spectrum efficiency and system throughput. The core idea of NOMA is to improve the complexity of receiver in exchange for spectral efficiency [1-3]. Spectral efficiency is the major key performance indicator of cellular networks. However, few articles discuss abort how to improve the spectral efficiency in NOMA system and apply it to the 5G communication system. In this paper, we introduce the space shift keying (SSK) to NOMA (NOMA-SSK) to further increase the spectrum efficiency of NOMA system. We also evaluate the performance of the proposed scheme via link-level simulations (LLS).

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2. TRANSMISSION SCHEME IN NOMA DOWNLINK AND NOMA-SSK SCHEME

2.1. Transmission scheme in NOMA downlink

Fig. 1 describes the basic NOMA scheme applying SIC in downlink, the base station (BS) transmit information s_i via signal xi to UE_i with power pi. For UE_1, it receive stronger signal because UE_1 is closer to the BS. Therefore, UE_1 execute SIC process for UE_2 signal, decode the signal x_2 and cancel it from the received signal first, then UE_1 could decode the signal for itself (x_1). For UE_2, it can decode x_2 directly without SIC because the power of x_2 is larger than x_1, so that x_2 has the first decode order.

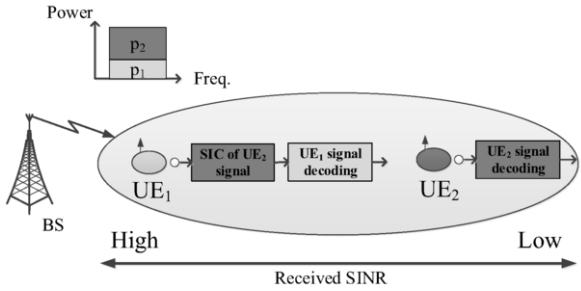

Figure 1. NOMA scheme applying SIC in cellular downlink.

2.2. NOMA-SSK scheme

Refer to [4], SSK is proposed as a modulation strategy for MIMO channels to exploit the spatial domain at transmitter side. Fig. 2 describes the SSK modulation system model combining with NOMA in NOMA downlink. b_i and c_i, which are random sequences of independent bits to be transmitted to UE_1 and UE_2 respectively, enter a channel encoder with output d_k and e_k, which is the source for UE_1 and UE_2. We assume that UE_1 is the user near the BS and hence UE_1 is utilized lower power p_1, on the contrary, UE_2 is utilized higher power p_2. d_k' and e_k' then enters an SSK mapper with output an antenna index. We note that the transmitted symbols themselves do not convey information, but an antenna index does.

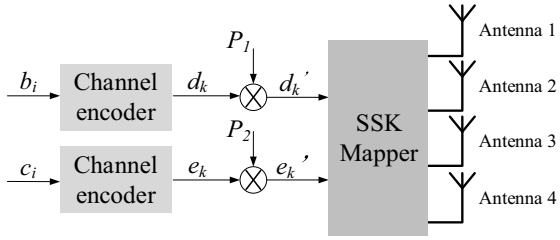

Figure 2. Proposed NOMA-SSK transmitter structure

As mentioned in [4], although four antennas are applied in the scheme, only one antenna is activate, and the antenna index changes depending on the transmitted

sequences. In conventional SSK scheme, 2 bits could be transmitted via four antennas according to the antenna index. An example of NOMA-SSK modulation is given in Table. 1. In proposed NOMA-SSK scheme, antenna index applied to convey information for UE_1 has two antenna positions with lower power, antenna index used for UE_2 has two antenna positions with higher power and therefore, the proposed NOMA-SSK scheme could convey 4 bits simultaneously, compare with 2 bits in conventional SSK with the same number of antennas.

Table 1. NOMA-SSK DATA MAPPING

Source of UE1: bi = [b1, b2]	Antenna index	Antenna Used with P1	Source of UE1: bi = [b1, b2]	Antenna index	Antenna Used with P1
00	1	Antenna 1	00	1	Antenna 1
01	2	Antenna 2	01	2	Antenna 2
10	3	Antenna 3	10	3	Antenna 3
11	4	Antenna 4	11	4	Antenna 4

3. PERFORMANCE ANALYSIS

In this section, we present link-level simulation (LLS) results on proposed NOMA-SSK scheme performance. We note that minimum mean square error (MMSE) SIC proposed by [5] is employed at receiver side. Table. 2 lists the other simulation parameters. Base on the package error rate (PER), the system throughput can be calculate by

$$Data\ rate = \frac{(1 - PER) \times n_{bit/packet}}{T_{packet}(s)} \tag{1}$$

Where the number of bits is transmitted per packet, and is the time duration for one packet. NOMA-SSK's performance improvements is clearly shown in Fig. 3, where we observe that when the signal-to-noise ratio (SINR) is greater than about 9db, the proposed NOMA-SSK scheme has higher spectral efficiency than the traditional SSK scheme. Note that the system reliability would drop while the mobile terminal apply practical SIC. Note that the system reliability would drop while the mobile terminal applies practical SIC.

Table 2. SIMULATION PARAMETERS FOR NOMA-SSK

Number of Tx (BS) Antennae	4
Number of Rx (UE) Antennae	1
Number of Symbols / Packet	10
Channel	4×1 independent Rayleigh fading channel
Modulation	SSK
Power Allocation for NOMA	P1=0.2, P2=0.8 [5]
Channel Estimation	MMSE

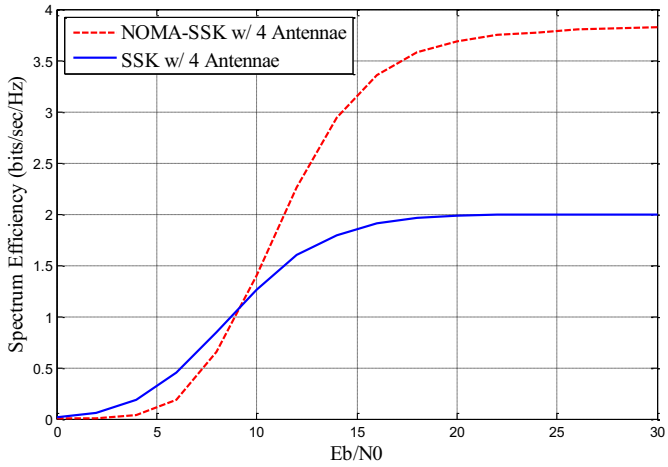

Figure 3. Spectrum efficiency comparison for NOMA-SSK and conventional SSK

4. CONCLUSION

In this paper, we introduce additional spatial domain to improve the spectral efficiency in NOMA system. The analysis results shows that even if the BER and PER of proposed NOMA-SSK scheme is slightly worse than conventional SSK, it shows greater performance in terms of spectral efficiency.

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Application of Bluetooth Low Energy Positioning in Long-Term Care Systems

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Abstract. Population aging is a serious problem nowadays in many countries. This creates a huge demand of long-term health care. In many long-term care institutes, a caregiver has to take care of many elderly people at the same time. Some of them have been paralyzed in bed, while others are still able to move in the institutes. It is not uncommon that a caregiver has to spend a lot of time to find an elder to perform daily care operations, such as injections, medications, and blood pressure measuring. Elders may move in dangerous places, such as kitchens, stairs, and bathrooms. In this paper, we present an iBeacon-based indoor positioning system for long-term care institutes. Thus, the staffs of long-term care institutes can easily locate the elders, and be notified when some elders move in dangerous places.

Keywords. Bluetooth Low Energy, iBeacon, wearable, indoor positioning, long-term health care

1. Introduction

Population aging is a serious problem nowadays in many countries. It is estimated that 14 percent of the population of Taiwan are 65 years old or over by 2018, and 20 percent by 2015 respectively. In other words, Taiwan would become an “aged” society and soon later a “hyper-aged” society. A huge demand of long term hearth care is emerging. As the change of family structure, many people have to send their elders to long-term care institutes. However, the total capacity of long term care institutions in Taiwan is far from enough to care so many elders. Caregivers have to take care of many elders at a same time.

Some elders have been paralyzed in bed, while others are still able to move in the institutes. For example, elders with dementia may wander in long-term care institutes. As people live longer and longer, the risk of suffering from dementia also increases. In Taiwan on an average every three seconds a new dementia patient is diagnosed. Due to the degradation of cognitive function, dementia patients’ ability to think and remember gradually decreases and their daily lives are hence greatly affected. They usually can take care of themselves in some ways. However, they commonly have emotional problems. Their language skills such as read and write degrade and thus they cannot communicate with others well. They may forget things like taking medication. They may repeat things like doing laundry. They may wander restlessly and get lost in new places.

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According to the statistics of Ministry of the Interior, Taiwan, there is 1.07 percent of the total population living with dementia in 2015. It is estimated the number will be doubled in 2031. In other words, one of every thirty-three people is a person with dementia.

Caregivers of a long-term care institutes usually have to pay a lot of efforts on dementia patients. It is not uncommon that a caregiver has to spend a lot of time to find an elder to take him or her back to a location or to perform daily care operations, such as injections, medications, and blood glucose and blood pressure measuring. Dementia elders may wander and get lost, sometimes in dangerous places, such as stairs, bathrooms, and balconies, where however there are no caregivers or others to give first-aids on accidents.

In recent years, many attempts using ICT technologies to improve the efficiency and effectivity of healthcare had been reported. For example, indoor positioning [1] technologies had been proposed to help patients find the room to see the doctor or take an examination in a large hospital [2, 3].

In this paper, we present an iBeacon [4-7]-based indoor positioning system for long-term care institutes. In the long-term care institute, every resident wears an iBeacon bracelet which will advertise itself to other iBeacon nodes fixed in the designed locations. According to the energy levels of the advertised beacon signal received at different iBeacon nodes, the system can locate the iBeacon bracelet and therefore the resident. With the systems, the staffs of the institute can find a resident timely and easily. A lot of time and efforts can be saved. Caregivers can pay more attention to important affairs. As a result, residents in the institutes can receive better care services.

The staffs of the institute can setup several dangerous regions, such as stairs, bathrooms, and balconies. When a resident moves in a dangerous region, the staffs and caregivers in the central control room and near the region will be alerted. They can assign a proper responding to the alerted event. For example, they can take the resident back to a normal region. If an accident occurs to the resident, they can give first-aids at the instant. Consequently, the risk of an accident occurred without witness can be minimized.

The remanding of this paper follows. In Session II, we propose a novel iBeacon-based indoor positioning method. In Session III, the indoor positioning system for long-term care institutes are demonstrated. Finally, we give our conclusions and future works in Session IV.

2. iBeacon-based Indoor Positioning

Nowadays, positioning applications become very popular. For example, GPS is heavily used in vehicle navigations. Friends can use route tracker APPs for jogging, bicycling, and mounting climbing to share their achievements on online social networks. However, GPS positioning is not good for indoor positioning [8]. For indoor positioning, several technologies have been proposed, such as Infrared (IR) [1], Ultrasound [1], RFID [9-10], Wi-Fi [11], Zigbee [12], Bluetooth [3], and Ultra-Wideband (UWB) [13].

In general, triangulation method is used. In such a case, there are usually several beacon nodes, fixed at known positions, and advertising (or broadcasting) beacon signals periodically to others. A position-unknown device, e.g., smartphone, can

estimate the distances from itself to these beacon nodes according to the energy levels of received beacon signals, and then estimate its position according to these distances, as shown in Figure 1. In addition, fingerprint methods had also been proposed [14-15].

Many of these technologies have been adopted in indoor location-based services (LBS), such as museum guidance, and shopping mall advertisements and coupon issuing. For example, Figure 2 shows the data flow in a museum guidance scenario, where only one beacon node is used to provide a basic positioning service.

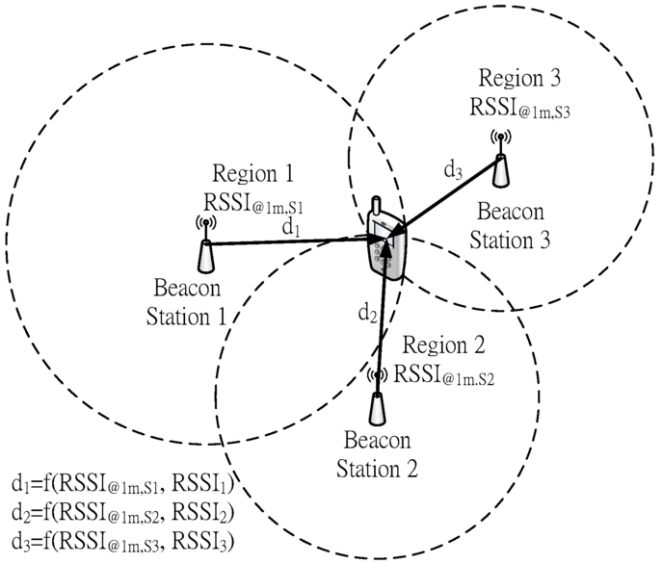

Figure 1. Triangulation Positioning.

2.1. Proposed Method

In this paper, we present an iBeacon-based indoor positioning system for long-term care institutes. In general, iBeacon is based on Bluetooth Low Energy (BLE) proximity sensing. Compared to classic Bluetooth, BLE has improved significantly in terms of power consumption and efficiency.

Distance the between two BLE devices is estimated according to the following formula (1), where $RSSI_{@1m}$ is the expected energy level of the beacon signal received at the distance 1 meter, and RSSI is the energy level of beacon signal at the received iBeacon node. *n* is an environmental factor ranged from 2 to 4.

$$d=10^{\frac{\text{abs(RSSI)-RSSI}_{@1m}}{10n}} \tag{1}$$

To furthermore reduce the energy consumption, we adopt a new model. Unlike the smartphones in Figure 2, the iBeacon bracelets used by the residents in the long-term care institute are very simple. They do not have Wi-Fi or 3G/4G network access and thus cannot connect to Internet. They can only advertise themselves. Several iBeacon sensor nodes are deployed at designed positions. They will report to location database

the bracelet's identify and energy level of the received beacon signal. Therefore, the system can estimate the position of the bracelet, as shown in Figure 3.

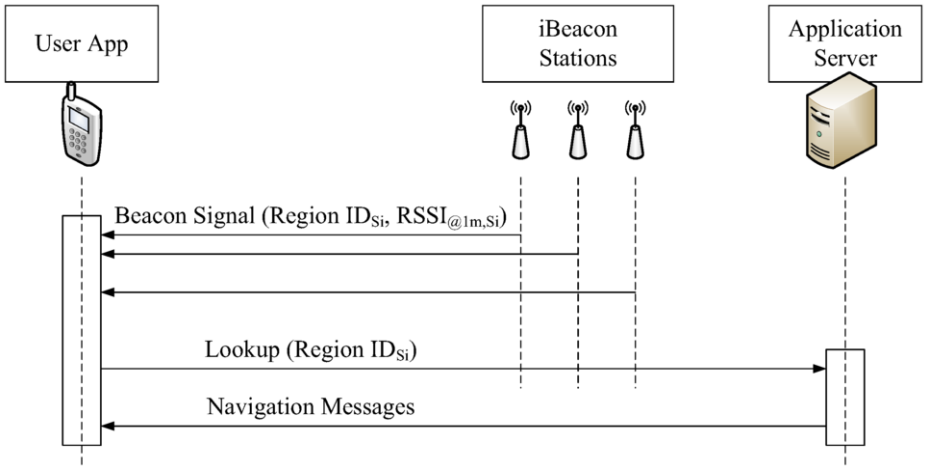

Figure 2. Data flow in a simple mesume guidance scenario.

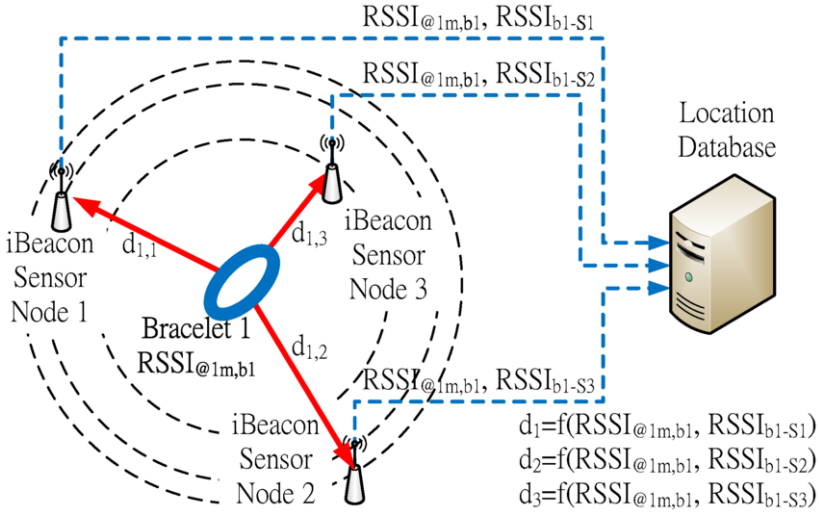

Figure 3. Proposed iBeacon-based Indoor Positioning.

We assume the iBeacon sensor nodes 1, 2, and 3 are deployed at positions (x_1, y_1), (x_2, y_2), and (x_3, y_3) respectively and the iBeacon bracelet moves to (x, y). The estimated distances from the bracelet to the three iBeacon sensor nodes are d_1, d_2, and d_3 respectively. Thus, we can get x and y by solving the following simultaneous equations.

$$\begin{cases} (x-x_1)^2+(y-y_1)^2=d_1^2 \\ (x-x_2)^2+(y-y_2)^2=d_2^2 \\ (x-x_3)^2+(y-y_3)^2=d_3^2 \end{cases} \quad (2)$$

3. Indoor Positioning in Long-term Care Institutes

To help the caregivers of long-term care institutes, we develop an iBeacon-based indoor positioning system based on the aforementioned positioning. It provides friendly Web-based user interface. The functionality of the system includes:

- Staff management. This module includes a database of stuffs, caregivers, and others, and provides an interface for staff management, such as to add a new recruited staff, as well as to assign his or her privilege in the system.
- Resident management. This module records the personal information of the residents in the institutes, and their health information for caregiving.
- iBeacon sensor nodes management. The operators can register and deregister an iBeacon sensor node with its location in the institute. The operators can modify the runtime parameters of the nodes, including internet configuration, server locations, and so on. The system will monitor these iBeacon sensor nodes and notify the operators when some nodes malfunction.
- iBeacon bracelets management. The operators can add and delete a bracelet, activate and deactivate it, and associate and de-associate it with a resident. The operators can adjust the runtime parameters of the bracelets, such as the frequency to send an iBeacon signal.
- Residents tracking and alerts. The system will monitor the status of every activated bracelets, including their locations, lifetime of batteries, and so on.
- Others. For example, the system provides an interface for the operators to label the dangerous regions.

Here, we focus our study on iBeacon-based indoor positioning application for long-term care.

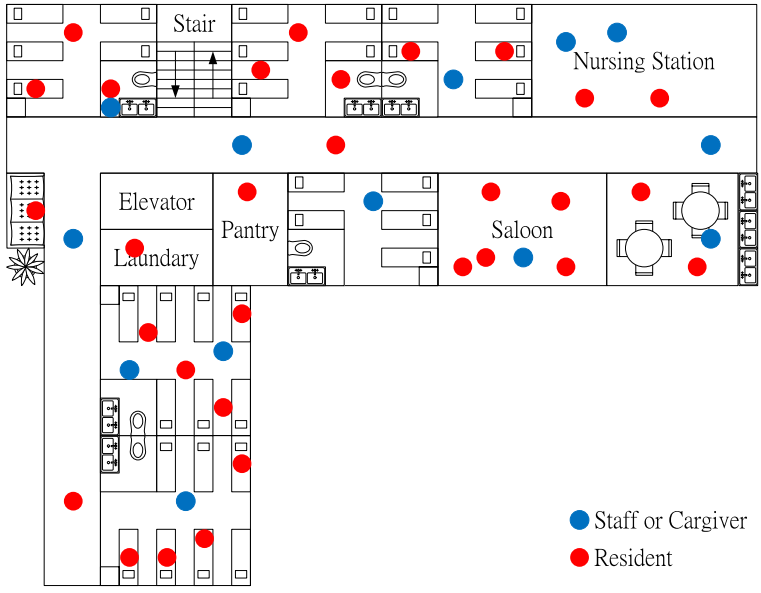

Figure 4. Resident tracking.

As shown in Figure 4, as long as the staffs, caregivers, and residents wear the iBeacon bracelet, the systems can track them and show their positions on the monitors so that all can easily realize the current status of all persons in the institutes.

The staffs can set up dangerous regions. Once a resident moves into a dangerous region and is positioned, the system will alert the staffs and caregivers nearby. As shown in Figure 5, caregivers can instantly know who is in which dangerous region. As well, the information of the resident is also shown, such as the name, gender, age, and medical history. Thus, the responding caregivers can prepare things that might help in urgent situations in advance.

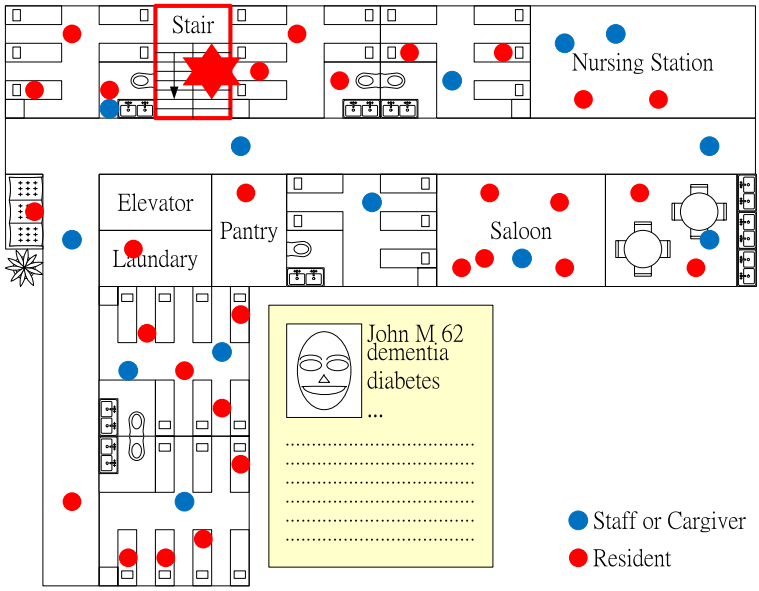

Figure 5. Alert when a resident moves into a dangerous region.

4. Experiments

4.1. iBeacon-based Distance Estimation

We first set up experiment for distance estimations. An iBeacon sensor node was placed in the center of a 9.6m x 7.2m rectangle. Volunteer testers wore an iBeacon bracelet, moved around the iBeacon sensor node, and recorded the energy level of the received beacon signal. As shown in Figure 6, the values of RSSI (Received Signal Strength Indication) in 10 positions were measured. 5 positions are at 1m circle far from the iBeacon sensor node, and the other 5 positions are at 2m circle.

Table 1 shows the experiment results. We performed 5 measurements at every position. On average, when the bracelet is at 1m circle, the estimated distance is 1.154m. When the bracelet is at 2m circle, the estimated distance is 1.708m. The average errors are 15.4cm and 29.2cm when the bracelet is at 1m and 2m circles respectively.

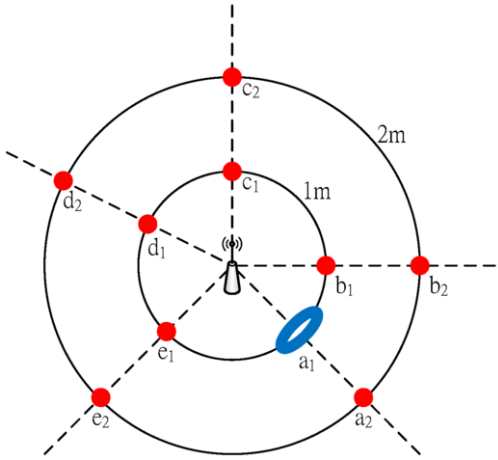

Figure 6. Experiment setup for distance estimations.

Table 1. iBeacon-based Distance Estimation

Position	Average RSSI	Average estimated distance (m)	Error (m)
a1	60.8	0.71	0.29
b1	64	0.91	0.09
c1	64.2	0.92	0.08
d1	68.2	1.25	-0.25
e1	74.2	1.98	-0.98
a2	68	1.23	0.77
b2	74	1.95	0.05
c2	72.2	1.70	0.30
d2	74.6	2.04	-0.04
e2	71.6	1.62	0.38

4.2. iBeacon-based Distance Positioning

The second experiment is set up for the proposed iBeacon-based indoor positioning. In a 9.6m x 7.2m rectangle, three iBeacon sensor nodes A, B, and C are deployed at (9.6m, 4.8m), (1.2m, 0m), and (1.2m, 6m) respectively. Volunteer testers wore an iBeacon bracelet and move to positions D at (5m, 4.5m) and E at (2.8m, and 2.8m), as shown in Figure 7.

We performed 10 measurements at each position. Table 2 shows the error between the real and estimated positions. The errors of the two experiments are less then 1m, which are acceptable in the indoor positioning application in long-term care institutes.

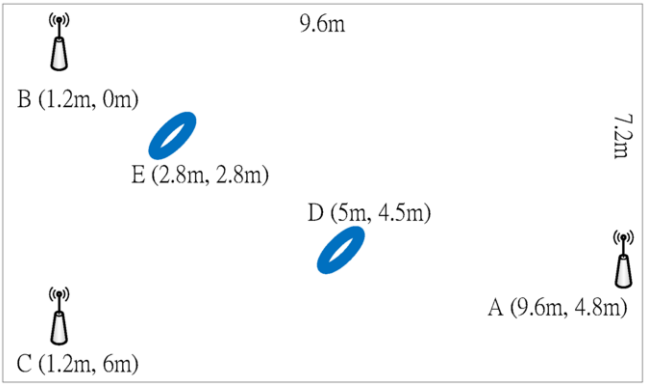

Figure 7. Experiment setup for iBeacon-based Positioning

Table 2. iBeacon-based Indoor Positioning

	Average Error (m)	Standard Deviation of Errors (m)
D	0.66	0.46
E	0.62	0.18

5. Conclusions

In this paper, we present an iBeacon-based indoor positioning system for long-term care institutes. A new model is introduced. The iBeacon bracelet on a resident can only advertise itself by broadcasting beacon signals. Instead, iBeacon sensor nodes, which are deployed fixedly at the designed locations, will report the bracelet's identity and energy level of the received beacon signal to the location database. The positioning system can estimate the distances from the bracelet to the reporting iBeacon sensor nodes, and then estimate the position of the bracelet by triangulation method.

A prototype system is developed. With a friendly web interface, the staffs and caregivers can easily find a resident to do daily care operations, such as injections, medications, and blood glucose and blood pressure measuring. When a resident moves into a dangerous region, the system will alert the staffs and caregivers near the region. As a result, the risk of an accident occurred without witness can be minimized.

Currently, the system is going to be introduced in a long-term care institute in Taichung, Taiwan. We plan to perform a much larger scale evaluation on the system.

In addition to the basic tracking and alerts, we plan to do more data analysis on the wander patterns of the residents in long-term care institutes. For example, when the iBeacon bracelet of a resident has rested for a while, the resident may remove the bracelet or fall unconsciously. When the pattern of a resident changes, he or she may wear another's bracelet. When a resident has wandered in the laundry, moving into and out of the kitchen repeatedly in a short time period, and so on, it might be a sign of dementia. The caregivers can give medical suggestions to the resident's family.

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Security Issues and Solutions in Cloud Computing

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Abstract. The leap development of Internet gives computer science infinite possibility. Meanwhile, the emerging cloud computing has become a tremendous boost of Internet innovation. It alters the traditional IT service models to a remote service and provides massive storage without the limitation of computer processing capacity. This unique storing service paradigm apparently brings a series of benefits and convenience to most Internet enterprises especially start-ups. However, few attentions have been paid to the potential security issues and challenges with the rapid development of cloud computing. During the frequent processing between cloud providers and users, cloud security has been cited as a vital problem as cloud computing outputs data in a virtual environment through the internet. Virtual computing is more vulnerable to various attacks such as data loss and leakage. Hence, comprehensive solutions are significantly necessary to solve these problems in cloud systems. In this paper, we will briefly introduce the definition of cloud computing firstly. And cloud security structure is given in the second part, which includes three main cloud types and three service models. Moreover, crucial security threats and challenges in the cloud computing are illustrated and corresponding solutions are proposed accordingly in the last part.

Keywords. cloud computing, cloud service models, security issues and challenges, solutions.

1. Introduction

Obviously, considered as a new service technology, cloud computing has become a hotspot in recent years.With the rapid development and broad applications in the cloud computing, many small companies, as well as companies of emerging industry, are devoted to build their own virtual machines with the purpose of decreasing the cost. In some cases, large enterprises authorize the third parties to manage the user applications, which is convenient but controversial. Different from traditional computing service, cloud computing adds a virtualization management layer between the IT basic infrastructures and operation systems. Note that it utilizes virtualization technology to manage data center so as to provide flexible services including dynamically altering the memory size instead

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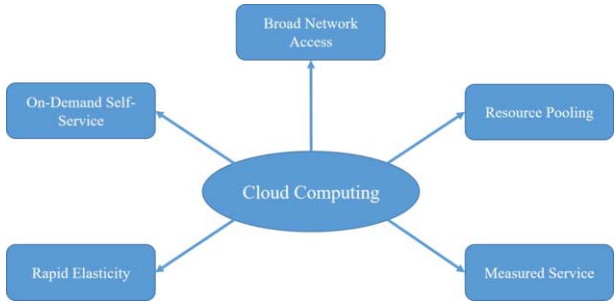

Figure 1. Cloud Computing Characteristics

of purchasing hardware. Some popular virtualization management platform software applications are VmWare, KVM, Xen etc [1]. There are five key characteristics in the cloud computing: on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service. Because of its virtualization and on-demand service, cloud users can access cloud resources only by an end-device in the pay-as-you-go service.

Cloud computing makes it possible to data-sharing and huge computing, but also remains security issues as serious technology leakages. As the success point of cloud computing, cloud security confronts unprecedented challenges due to the complex clouds emergency. Consequently, cloud vendors are expected to offer reliable and enhanced security solutions for clients to maintain their trust relationship. Accordingly, the cloud security structure is presented in the following Section II, which includes the cloud types and cloud service models. Subsequently, the relevant security risks and challenges are illustrated in Section III. Five essential properties are considered and discussed in this section. In the next, typical corresponding security solutions are displayed, including the access control in cloud systems, authentication and identity management, trust management framework, and semantic heterogeneity management. Finally, the conclusion is given.

2. Cloud Security Structure

2.1. Cloud Types

2.1.1. Private Clouds

tailored environments with dedicated virtualized resources for particular organizations [2]. In other words, private clouds only provide services to single organization.

2.1.2. Public Clouds

externally or publicly available cloud environments to provide open access to various organizations, which means multiple tenants can access resources from public clouds. The security of public clouds is mostly maintained by the cloud vendors, which increases the possibility of security risks occurring.

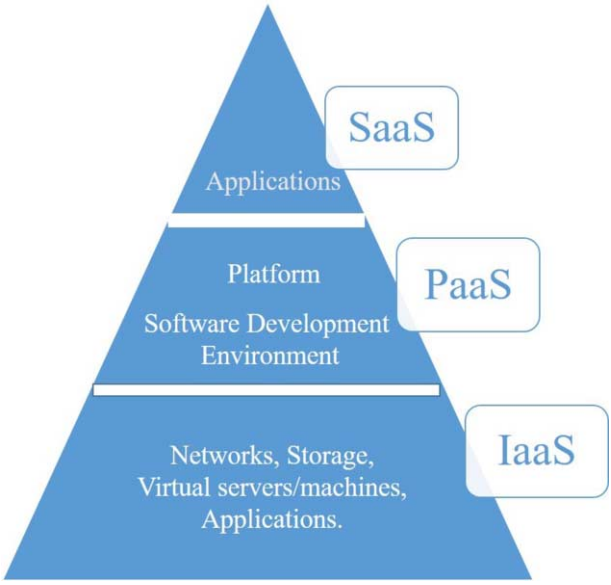

Figure 2. Structure of the Cloud Services

2.1.3. Hybrid Clouds

combination of private clouds and public clouds (or else). Hybrid clouds also has the advantages of both public clouds and private clouds.Note that hybrid clouds are well organized and much securer than public clouds.

2.2. Cloud Service Models

The detailed cloud service model is introduced in this section as shown in Fig. 2, including the SaaS (Software-as-a-service), PaaS (Platform-as-a-service), and IaaS (Infrastructure-as-a-service), which are illustrated as follows.

2.2.1. SaaS (Software-as-a-Service)

It's the first layer to offer software applications running on cloud infrastructure via the internet provided by third-party venders for various clients to communicate and share information in daily life. It is mainly targeted on application security and multi-tenant security [3]. Cloud customers don't have the permission to control the cloud infrastructure directly. Google App and Salesforce are two famous SaaS service providers.

2.2.2. PaaS (Platform-as-a-Service)

In this service layer, it provides a platform instead of software to cloud users, which is more extensible and useful to those IT engineers. It means that customers can control the applications but not manage the basic infrastructure. Google App Engine is the most popular PaaS provider which is a Software Development Environments to offer an environment supporting Python, Java and Go programming languages for customers [4]. Distributed data security, database security and interface security are core related security issues.

2.2.3. IaaS (Infrastructure-as-a-Service)

IaaS is the basic layer in the service model. Users are able to receive services including networks, storage, virtual servers/machines and applications that are totally managed by cloud providers. In this model, scalability and provisions issues of infrastructure are provided without large amount of payments and time [5]. It focuses on security areas of physic security, host security, networks security, virtualizing security.

3. Cloud Security Risks and Challenges

3.1. Privacy Protection

Different from the fixed location of traditional computing, cloud computing is virtual computing that stores the data in various cloud centers in Multi-domain environments [6]. In cloud services, users no longer have full control of their sensitive data and security environments. Not only data attackers but also other cloud providers can easily access clients' data in clouds. Therefore, privacy protection is a vital essential work for cloud vendors to ensure users' data output in a relatively secure environment [7]. It will be disastrous if cloud users' sensitive documents are divulged especially for government

3.2. Data Loss and Integrity

In cloud computing, it is not available for the user to validate the data integrity, to manage the data processing, and to acquire the detailed information of the data center. Data stored in cloud might be deleted and altered optionally by unauthorized person or process without informing the clients, which is a serious security problem since most of the clients don't have extra backup to confirm with [1]. Data loss is another critical risk which may occur when malicious hackers attack data center [8]. Hence preventing data from being tampered and lost should be focused on more.

3.3. Hacked Interfaces and APIS

Insecure interfaces are the access of risks for stored data, which are completely exposed in public and accessible from the internet that can be simply suffered from security issues [9]. API security is really important in the cloud computing. Most of services such as provisioning, management, orchestration and monitoring are provided through them [4]. In some open cloud environments, those third-parties and enterprises usually develop other services on the basic of APIs, which increase the security risks and complexity of Interface management. Insecure Interfaces are managed by cloud providers who should pay more attention on this issue accordingly.

3.4. Effective Encryption and Decryption

Effective encryption and decryption is important for our privacy protection. Sending Email messages, documents and sensitive files over the Internet especially by the virtual cloud computing is really dangerous as they are transmitted in an unsecured form [10]. Then we need to encrypt them first and the encryption software is like a "lock" to pro-

tect our privacy. Therefore, decryption software is the key to "open" it [11]. However, traditional encryptions and decryptions can't meet cloud data security requirements. Enhanced and more effective cryptography system are in need for cloud computing.

3.5. Access Control

Access control is one of the most crucial issues in cloud systems. The users of cloud system are allocated different privilege in accessing the sensitive cloud data. It is of great significance for the cloud server to know the identity of the accessing users, which is different from traditional local server.

One of the purpose of access control is to prevent the possible attacks from insider attackers, which may lead to enormous damage than outsider attackers [12]. In general, cloud services are considered as the ideal targets for criminals, because by conducting a successful attack, the attackers can yield a large amount of vital information. In this case, access control is necessary.

4. Solutions For Cloud Security Issues

Numerous research achievements have been made focusing on the above issues of data security and privacy in cloud computing. And some solutions are given as follows.

4.1. Access Control in Cloud Systems

Generally, in many practical occasions, users' access to data is usually selective and differentiated. It is obvious that various users should be allocated various privileges towards the data accessing. It is worth noting that the outsourced data security is vital to ensure reliable service delivery in cloud systems. In the traditional way of privacy-sensitive data preservation, the access control is achieved by establishing a trusted server to store data locally. Hence the server is able to check the validity of the certificates provided by the requesting user [10]. However, it is not applicable anymore when it comes to the outsourced data in the cloud since the data users and cloud servers aren't in the same trusted domain. In the event of either server compromise or potential insider attacks, users' private data might even be exposed.

In this case, several researchers are focusing on encrypting the cloud data in a differentiated manner and disclose the corresponding decryption keys only to the authorized users, which is, generally, the extension of the traditional cryptographic techniques. However, these approaches usually suffer from severe performance issues [4]. Moreover, the scalability is not available in this scenario. On the other hand, emphasizing on realizing a fine-grained access control design that fully leverages the cloud's computation resource richness is another hot topic in access control of cloud system.

4.2. Authentication and Identity Management

By using cloud services, users can easily access their stored private data and share it to various services across the Internet in a conveniently way. Due to the multi-tenancy design, a proper identity management mechanism is required in order to help authenticate users and services based on credentials and characteristics.

In recent researches, user-centric authentication and identity management have reached many attentions, where the users control their unique identities. Note that it could take away the complexity of authentication procedure from the enterprises [13]. Furthermore, the cloud systems are assumed to maintains the semantics of the context of users' identity information so that they could provide accurate and fast response to the users.

Generally, these authentication strategies in cloud computing apply pseudonyms and accommodate multiple identities to protect users' privacy, which can improve the authentication mechanism [14]. Additionally, the authentication solutions can also be extended with delegation capabilities to address identification and authentication issues in composed services.

4.3. Trust Management Framework

In cloud computing system, with the purpose of facilitating policy integration between different domains, a management framework employing the automated trust-based policy integration is in need [15]. In the existing researches, the proposed cryptographic mechanisms for trust delegation includes complex trust-chain verification and revocation issues. However, key management is another issue to be addressed in these approaches.

4.4. Semantic Heterogeneity Management

The semantic heterogeneity among policies is considered as the vital aspect, especially in complex cloud computing environments. However, the automatic detection for semantic conflicts among different service providers' policies has not been widely researched so far [4]. The adopted XML, which is the preferred language for information sharing, is still not enough for describing information semantics.

In this consideration, the employment of ontology is considered as the most promising approach to the semantic heterogeneity issue [3]. Many researchers use both XML Schema and Resource Description Framework Schema (RDFS) to accommodate the domain-specific concepts. However, these technologies cannot completely subsume the lower technology in clouds. In this consideration, An Object Web Language (OWL) based framework is adopted in order to support semantic heterogeneity management across multiple providers within the cloud. Accordingly, a system-driven policy framework is essential, which could facilitate managing security policies in heterogeneous environments.

5. Conclusion

Nowadays, internet has been full of our daily life. In the big data world, cloud computing will definitely become advancing trend to start a new era. With the purpose of addressing the security issues and challenges in cloud computing, brief introduction towards the cloud model is given in this paper, including three main cloud types and three service models. Consequently, several significant security threats and challenges are displayed. Meanwhile, the corresponding solutions are described, which focus on the user security preservation in various cloud environment. Security issues and challenges will occur constantly with complex clouds emerging. Furthermore, security solution is the core concerned point for cloud providers.

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Tutorials

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Channel Modeling, Capacity Analysis, Transceiver Design for Polarized Antenna Array Systems

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Recently, there has been a gradual increase in the demand for polarized antenna systems, especially for 5G networks. This is mainly because antenna polarization is an important resource employed for the design of space-limited wireless devices. Several techniques such as space-time diversity, multiplexing, and array processing with antenna polarization can be exploited in order to boost the system performances. Therefore, many published research articles as well as ongoing projects have focused on antenna polarization.

For the channel modeling, this tutorial assesses several existing channel models supporting antenna polarization, and the advantages and disadvantages of the existing models are clearly summarized. To maintain the advantages (e.g., supporting the MIMO array extension and considering the antenna radiation pattern) and overcome the disadvantages (e.g., reducing the modeling complexity but preserving the accuracy), we introduce a 3D channel model for polarized MIMO (CM_{3D}-PMIMO) systems. Similar to conventional works, the CM_{3D}-PMIMO is verified via correlations between the polarized links. Monte Carlo simulation reliability for a performance evaluation of MIMO technologies under CM_{3D}-PMIMO is also validated.

Moreover, this tutorial derives the capacity of polarized uniform linear array (PULA) systems by using the beamforming (BF) technique under a practical scattering environment. The results show that for PULA systems, the channel capacity, which is boosted by BF diversity, can be determined using the channel gain, beam radiation pattern, and BF diversity order (BDO), where the BDO is dependent on the antenna characteristics and array configurations.

In order to boost the performance of cell-edge users, we introduce a robust transceiver to explore STBC and BF simultaneously via a triple-polarized uniform linear array (TPULA) system, which relies on the particular characteristics of the polarized array antenna systems. That is, the cross-branch links in the TPULA system are usually uncorrelated, while the cross-array links can be highly correlated by setting the array element space equal to, or less than, a half-wavelength.

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Introduction to KEPCO-KDN Research on Cyber Security

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The smart grid is the next-generation power network which combines the existing power network with information and communications technology (ICT) to optimize energy efficiency through bi-directional and real-time communication between suppliers and consumers. It can encourage rational energy consumption through bi-directional power information interchange and provide high-quality energy and value-added services. It can also create new businesses through the combination and expansion of clean green technologies such as renewable energy and electric vehicles. However, security has become an important issue because ICT technology has converged to the power network and the existing ICT security threat has been inherited. Since smart grid devices are scattered over a wide space, an attacker can easily access them and cause network problems, as well as tamper with important data in the network. Moreover, without an encryption and legal authentication procedure among communication objects, attacks can cause not only device information leakage but also critical damage to the entire smart grid network.

KEPCO-KDN is developing and demonstrating a security infrastructure system that provides certificate issuance, registration, management and verification services for devices operated in the smart grid in order to prevent cyber terrorism against the smart grid and provide a reliable communication environment. And also a lightweight encryption and authentication security solution for a distribution automation system (DAS) that is compliant with international standards and domestic control system security guideline is being developed, including a security solution applying certificate based mutual authentication and lightweight cryptographic authentication technology for advanced metering infrastructure (AMI) environment.

In addition, various technologies are being researched and developed to improve the security of the power control system. For example, an one-directional data transfer system is a system that can block the cyber attack route to the critical system by removing the physical communication path from the low security business network to the high security control network. The whitelist-based abnormal monitoring system is a control system-specific intrusion monitoring system that detects abnormality by detecting the normal communication pattern of the control system in a white list and monitoring the internal traffic of the control system in violation thereof. Finally, a mobile security solution was developed and applied to the field to prevent security threats to the power field work environment. We are also researching IoT platform security technology to cope with the fourth industrial revolution.

In this tutorial, we introduce the research and development of cyber security in KEPCO-KDN that is related to security technology for smart grid and improving security of power control system.

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Future of Korea's 4th Industrial Revolution

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Interest in the Fourth Industrial Revolution is hotter than ever. We can hear 4th industrial revolution every day. The Fourth Industrial Revolution already became a central topic in every field. In retrospect, mankind has undergone three industrial revolutions so far.

In the late 18th century, the first industrial revolution was the mechanization of fossil fuels and coal-fired steam engines. After the second industrial revolution which could make mass-produced system due to the emergence of electricity. The third industrial revolution based on computers and the Internet, so-called the revolution of knowledge information occurred.

Every time the Industrial Revolution happened, mankind evolved step by step. The existing ones have disappeared and new ones have been developed on the spot instead. For the time being, there would be no more industrial revolutions, but technology developed at the exponential rate.

The Fourth Industrial Revolution is another industrial revolution in which people, technology, and imagination are combined to dramatic change of our life style. Sharing, cooperating, and opening up the existing boundaries of the hyper connectivity and hyper intelligence society. The important thing is that technology and human beings must go together. What 'inclusive growth' pursues is the happiness.

Unlike the traditional industrial revolution, which is reminiscent of cold machines, I hope that everyone will be happy with the warm innovation technology that people think in the era of the Fourth Industrial Revolution. It is the fourth industrial revolution.

The future of Korea's 4th Industrial Revolution is under the two goals of 'embracing' and 'growth'. It is to promote the convergence industry centering on ICT and to solve the problem of polarization that is scattered in each field such as education and medical care.

If Korea supports its core ICT competencies and supports national policies that support growth and inclusion, the fruits of the Fourth Industrial Revolution will become clear.

And the fruit is the society where everyone is happy by creating jobs, solving the polarization, and improving the quality of people's lives.

This presentation will explain how ICT can be used to solve social problems through various examples. In particular, it provides a variety of examples and creative ideas that can help in the formulation of detailed tasks, thereby contributing to accelerating the Korean Industrial Revolution. In addition, I will examine the substantive concept of the Fourth Industrial Revolution, the present state of the Korean Industrial Revolution, and the direction.

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