

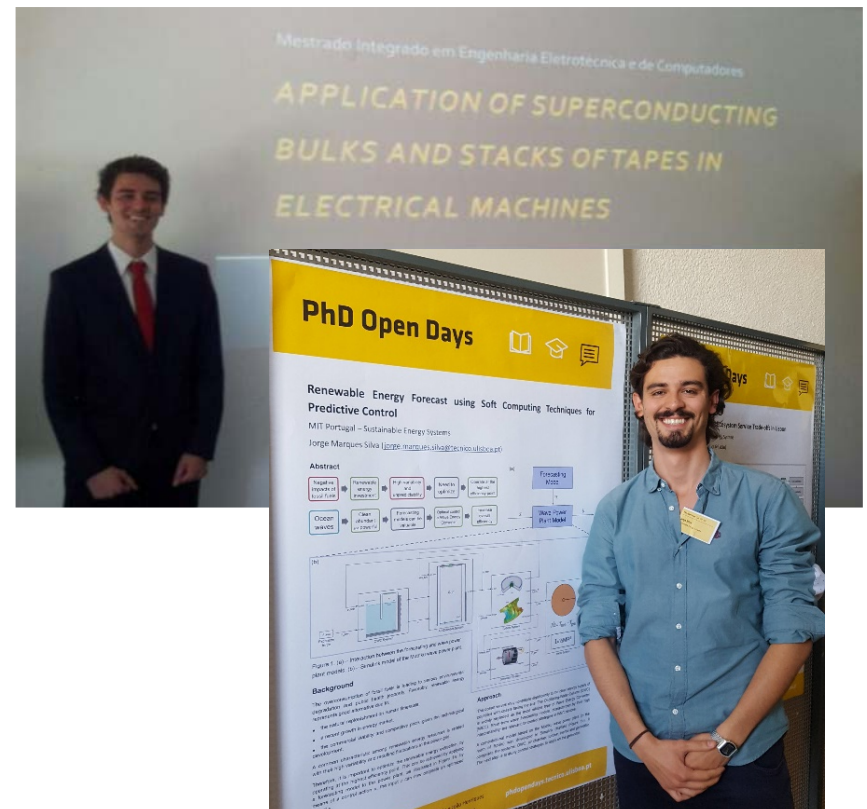
Wave Energy Generation

MODELING OF OSCILLATING WATER COLUMNS

Jorge Manuel Marques Silva

BACKGROUND

- Bachelor + Master in Electrical Engineering (Energy) in 2015;
 - Superconductors in Electrical Machines;
- Started **MIT Portugal** PhD Program – Sustainable Energy Systems in 2017:
 - Renewable Energy (Ocean Waves);
 - Machine Learning Forecasting;
 - Predictive Control.



MOTIVATION

■ Fossil fuels:

✓ Cheap and reliable;

✓ Available and easy to find;

✗ Environmental degradation;

✗ Public health issues;

✗ Limited energy source - depleting at fast rate.



© Capital Capable Media LLC



© Sintranoticias



© Rani Sati Enterprises

© Ecojustice. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <https://ocw.mit.edu/fairuse>.

All rights reserved. These contents are excluded from our Creative Commons license. For more information, see <https://ocw.mit.edu/fairuse>.

THE ALTERNATIVE



© NewsGram. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <https://ocw.mit.edu/fairuse>.

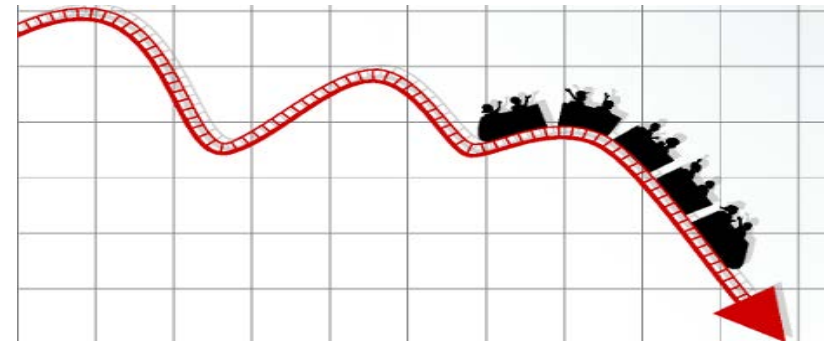


© Tutorialspoint. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <https://ocw.mit.edu/fairuse>.

- Renewable energy resources:
 - ✓ Natural replenishment on human timescale – **sustainable**;
 - ✓ Competitive prices;
 - ✓ Small scale (household) or large scale (city);
 - ✗ Dependent on environmental variables.

THE PROBLEM

- Uncertainty:
 - ✗ Fluctuations in capacity can have negative impacts;
 - ✗ Power plants lack optimal sizes, locations and configurations;
 - ✗ Market's instability.

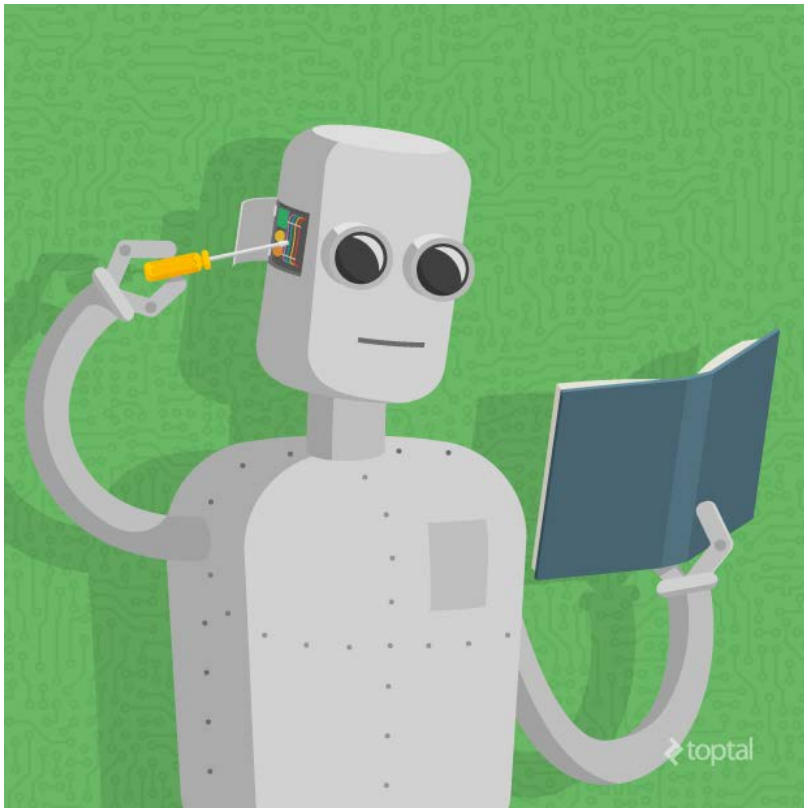


© Online Forex Trading. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <https://ocw.mit.edu/fairuse>.



© Southwire Company, LLC. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <https://ocw.mit.edu/fairuse>.

THE IDEA



■ Machine Learning:

- ✓ Learn and improve from experience without explicit programming;
- ✓ Environmental variables forecast.



© Desert Isle SQL.com. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <https://ocw.mit.edu/fairuse>.

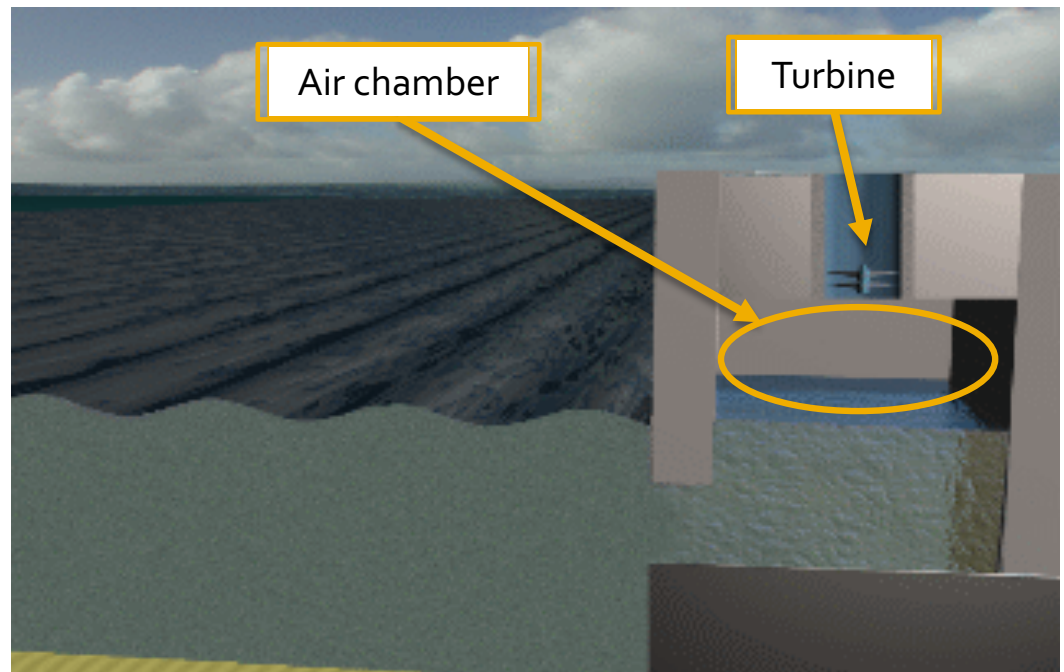
© S-POWER. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <https://ocw.mit.edu/fairuse>.

INTRODUCTION



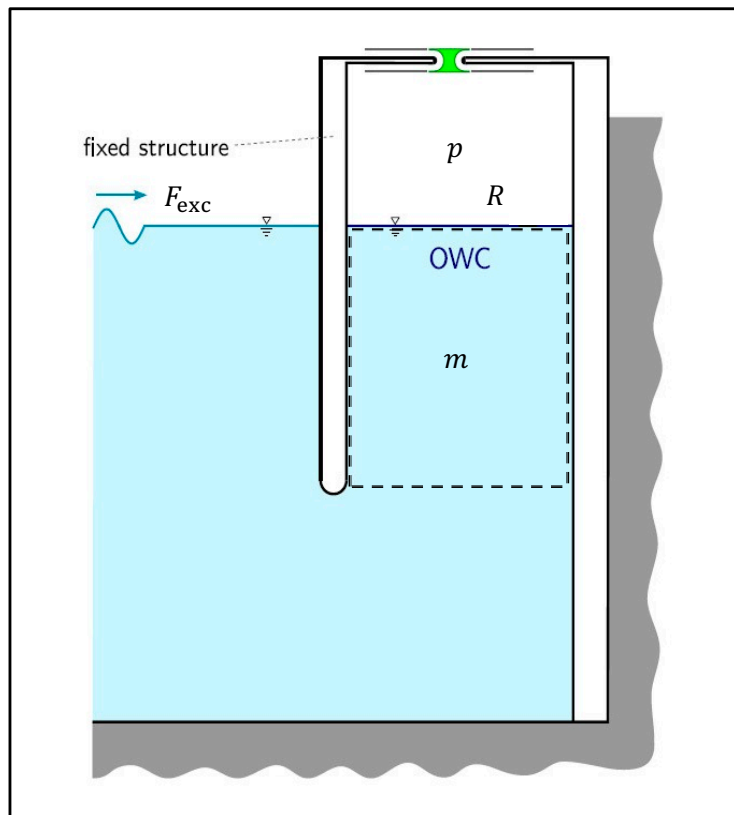
© El blog de Jorge Prospero. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <https://ocw.mit.edu/fairuse>.

■ Oscillating Water Column (OWC):



© AQUARET. All rights reserved. This content is excluded from our Creative Commons license. For more information, see <https://ocw.mit.edu/fairuse>.

COMPUTATIONAL MODEL

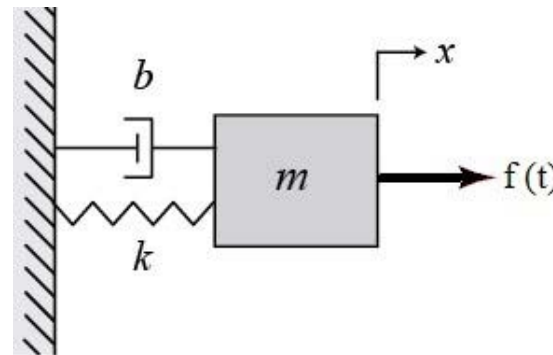


- Hydrodynamics:

$$F_{\text{exc}} = m\ddot{z} + R(\dot{z}) + \rho_w g S z + S(p - p_{\text{at}})$$

($\dot{\cdot}$ denotes $\frac{d}{dt}$)

- Similar to mass-spring-damper system:



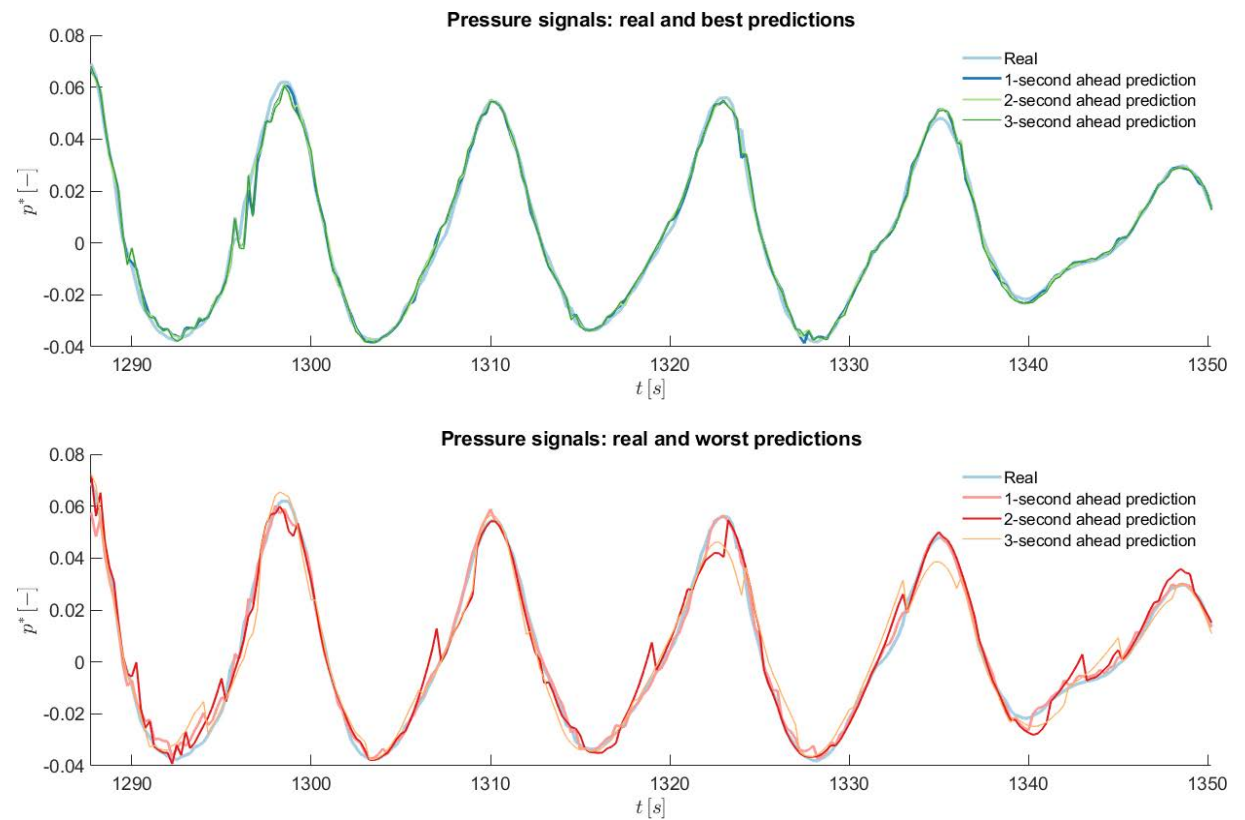
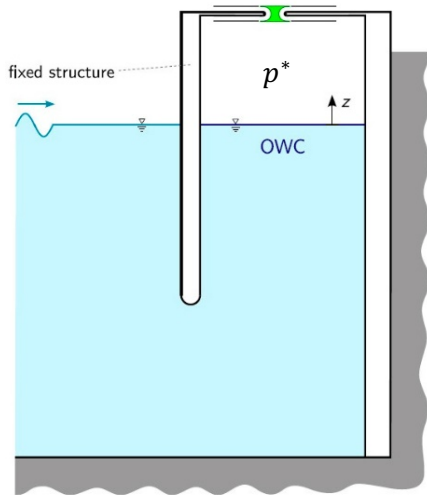
$$\sum F = m\ddot{x}$$

$$f - b\dot{x} - kx = m\ddot{x}$$

$$f = m\ddot{x} + b\dot{x} + kx$$

RESULTS

- Forecasting:
 - Air chamber pressure;
 - Support Vector Machines.



Courtesy Elsevier, Inc., <http://www.sciencedirect.com>. Used with permission.

THANK YOU!

MIT OpenCourseWare
<https://ocw.mit.edu>

18.085 Computational Science and Engineering I
Summer 2020

For information about citing these materials or our Terms of Use, visit: <https://ocw.mit.edu/terms>.