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Digital Image Processing Fundamentals

Chapter 2

Digital Image Transforms

Answers to the Chapter Questions

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Chapter 2

Digital Image Transform Algorithms

2.1 Introduction

Questions/Answers

1. What is the relation between a transform and its basis images?

The transform decomposes an image into a weighted sum of basis images.

2. Why should the image transforms have an inverse transform?

So that we can move from the spatial domain to the transform domain and vice-versa, possibly without loss of image information.

2.2 Two-dimensional discrete Fourier transform

Questions/Answers

1. What arithmetic do we use for 2D DFT?

We use complex arithmetic.

2. What is the relation between the 2D DFT and the 2D circular convolution?

The 2D DFT can be used for the fast computation of the 2D circular convolution.

3. Why do we prefer DFT compared to the discrete time Fourier transform in practice?

DFT is calculated easily on a computer by means of its definition or the FFT. The same holds for its inverse. On the contrary, the discrete time Fourier transform is not easily calculated.

4. Does the circular convolution have practical applications?

Circular convolution is usually not used alone. In practice we often need the numerical calculation of the linear convolution and its reduction to a circular convolution helps in this.

5. If we want to correlate two images of size 300∗200 pixels how much should they be padded with zeros?

The two images should be padded with zeros to size 600∗400.

6. What does it mean if the correlation gives a maximum at: a) (0,0), (b) (10,10), c) (580,380);

It means, respectively: a) the two images coincide, b) one of them is translated by (10,10) pixels compared to the other, c) one of them is translated by (-20,-20) pixels compared to the other.

2.3 Row column FFT algorithm

Questions/Answers

1. Is there any difference if we perform row DFT first and then column DFT or vice-versa?

No.

2. What are the computational complexity gains when using RCFFT?

RCFFT reduces the computational complexity from $O(N^4)$ to $O(N^2 \log_2 N)$.

2.4 Memory problems in 2D DFT calculations

Questions/Answers

1. Are nowadays the memory problems for 2D DFT calculation severe?

Not as in the past. Nowadays RAM is quite large to accommodate the memory needs for 2D DFT calculation in many cases.

2. How much RAM we need for the 2D DFT calculation of a 4096×4096 image?

We need 8×16 Mbytes =128 Mbytes.

2.5 Vector-Radix fast Fourier transform algorithm

Questions/Answers

1. Which 2-D DFT would you implement, the RCFFT or the VRFFT?

VRFFT requires 25% fewer multiplications than RCFFT and, thus, it is preferable to implement the VRFFT. Its source code, however, is more complex to write and debug.

2. If we have routines for 2-D FFT and for 2-D inverse FFT, how can we check simply whether they function properly?

If we provide the output of the DFT as input to the inverse DFT, we should get an inverse DFT output that is identical to the DFT. Of course there are small differences due to numerical errors.

2.6 Two-dimensional power spectrum estimation

Questions/Answers

1. What are the advantages of the AR modelling method for spectral analysis compared to the periodogram?

In AR modelling we can achieve quite smooth power spectrum and sufficient resolution at the same time, by using a suitable size and shape for the prediction window.

2. What are the advantages of the Blackman-Tukey method for spectral analysis compared to the periodogram?

The size of the window in Blackman-Tukey method can be much smaller than that of the autocorrelation function and this leads to a smoother power spectrum estimation.

2.7 Discrete cosine transform

Questions/Answers

1. Why do we prefer DCT instead of DFT for compression?

DCT is preferred for compression because it concentrates the largest percentage of the signal energy in a small percentage of the coefficients, especially in the case of signals having high spatial correlation.

2. What are the advantages of DCT compared to DFT?

DCT is a real transform in contrast to DFT that is complex transform in general and. Thus, only real calculations are required for DCT computation.

3. What are the applications of DCT?

DCT is used in compression standards such as JPEG due to its very strong compression properties. There are chips that implement DCT in hardware.