Engineering Tripos Part IIB, 4F8: Image Processing & Imaging Coding, 2017-18

Module Leader

Dr J Lasenby [1]

Lecturers

Dr J Lasenby

Timing and Structure

Lent term. 16 lectures (including examples classes). Assessment: 100% exam

Prerequisites

3F1 assumed; 3F3, 3F7 useful

Aims

The aims of the course are to:

- introduce the key tools for performing sophisticated processing of images by digital hardware

Objectives

As specific objectives, by the end of the course students should be able to:

- understand the main elements of 2-dimensional linear system theory.
- design linear spatial filters for a variety of applications (smoothing etc)
- understand techniques for the restoration and enhancement of degraded images.
- show familiarity with the main characteristics of the human visual system with particular reference to subjective criteria for image data compression.
- understand techniques for image coding using transform methods including the Discrete Cosine Transform (as used in the JPEG coding standard) and overlapped transforms.
- understand methods for coding transform coefficients to provide maximum data compression.

Content

Sophisticated processing of images by digital hardware is now fairly common, and ranges from special effects in video games to satellite image enhancement. Three of the main application areas are video data compression, image enhancement, and scene understanding. This module introduces the key tools for performing these tasks, and shows how these tools can be applied. The module will be split into two courses of 8 lectures each: Image Processing, and Image Coding. Lectures are supported by computer demonstrations. There will be one examples sheet for each of the two 8-lecture sections.

Image Processing (8L, Dr J Lasenby)

This course covers the following topics, relevant to most aspects of image processing:

1. *Two-dimensional linear system theory, as applied to discretely sampled systems:*
    - The continuous 2D Fourier transform and its properties
    - Digitisation, sampling, aliasing and quantisation
    - The discrete 2D Fourier transform (DFT)
2. *2D Digital Filters and Filter Design*
    - Zero phase filters
    - Ideal 2D filters: rectangular and bandpass
    - Filter design: the window method
3. *Image Deconvolution*
    - Deconvolution of noiseless images -- the inverse filter
    - The Wiener filter (conventional and Bayesian derivations)
    - Maximum Entropy deconvolution
4. *Image Enhancement*
    - Contrast enhancement
    - Histogram equalisation
    - Median filtering

Image Coding (8L, Prof N Kingsbury)

This course concentrates on image and video data compression techniques, and covers the following topics:

1. *Characteristics of the human visual system which are important for data compression:*
    - Spatial and temporal frequency sensitivities
    - Distortion masking phenomena
    - Luminance and colour (chrominance) processing
2. *2D block transforms and wavelet transforms:*
    - Discrete cosine transforms
    - Bi-orthogonal and orthonormal wavelet transforms
    - Energy compaction properties of transforms for typical images
3. *Optimal quantisation techniques of coding transform coefficients for maximum data compression*
    - Huffman coding
    - Run-length coding
    - JPEG 2-dimensional run-size coding
4. *Video coding techniques*
    - Motion analysis
    - Motion vector coding
    - MPEG coding standards

Booklists

Please see the Booklist for Group F Courses [2] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

IA2

Demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

D1

Wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations.

D4

Ability to generate an innovative design for products, systems, components or processes to fulfil new needs.

E1

Ability to use fundamental knowledge to investigate new and emerging technologies.

E2

Ability to extract data pertinent to an unfamiliar problem, and apply its solution using computer based engineering tools when appropriate.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to

assess the limitations of particular cases.

E4

Understanding of and ability to apply a systems approach to engineering problems.

P1

A thorough understanding of current practice and its limitations and some appreciation of likely new developments.

P3

Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology, development, etc).

P8

Ability to apply engineering techniques taking account of a range of commercial and industrial constraints.

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US2

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

US4

An awareness of developing technologies related to own specialisation.

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Links
[1] mailto:jl221@cam.ac.uk
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364101&chapterid=55581
[3] https://teaching.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching.eng.cam.ac.uk/content/uk-spec