

## **Engineering Tripos Part IB, 2P8: Information Engineering, 2016-17**

### **Lecturers**

[Professor R. Cipolla and Dr J. Lasenby](#) [1]

### **Timing and Structure**

Easter Term: Weeks 1-4 - 14 lectures + 2 examples classes, 4 lectures/week

### **Aims**

The aims of the course are to:

- To teach students about image processing within the context of photo editing software and image search engines (such as Image Google).

### **Syllabus**

There will be quite as strong emphasis on statistical techniques (histograms) and spatial domain filtering methods which will follow on naturally from the material in paper 6 and 7.

#### **A: Photo Editing - Lectures 1-5 (J. Lasenby)**

Part A of the course will discuss basic digital image handling techniques and will cover the following topics:

- Cropping, resizing, rotation and morphing - involving basic ideas of interpolation and filtering for shifting/resampling purposes.
- Colour - conversion between different colour spaces (e.g. RGB, YUV and HSV) and adjustment for colour lighting effects such as colour-cast correction and white balancing.
- Histograms - their use in analysis and correction of lighting intensity problems, such as over/under exposure and shadows.
- Segmentation - for purposes such as red-eye correction and independent contrast correction in areas of shadows, mid-tones and highlights.
- Correcting focus problems - sharpening (deblurring) filters and problems of noise amplification.
- Correcting noise problems - smoothing filters, problems of blurring, and the use of spatially adaptive filters to optimise sharpening and denoising tradeoffs.
- These will be illustrated with the development of Matlab solutions to a range of common photo editing functions such as found in widely used packages like Adobe Photoshop and Microsoft Digital Image Suite.

NB: All filters will be based on separable 1D Gaussian lowpass filters, with combinations of these to produce bandpass and highpass filters. These can be analysed in the spatial domain, so the 2D Fourier and Z transforms will not be taught.

#### **B: Image Features and Matching - Lecturers 6-10 (R. Cipolla)**

Part B will include material on feature and texture descriptors and efficient shift-invariant and rotation-invariant matching techniques using these descriptors. It will cover the following topics:

- Convolution with gaussians and derivatives of gaussians to provide directional bandpass filters.

- Edge detection using directional filters.
- Interest point detection using edge measurement and image autocorrelation measurement.
- Texture descriptors, based on filters or on principle components analysis (PCA) of images
- The SIFT feature descriptor for matching image features
- A case study of a real-time industrial system to match a photograph from a mobile phone to images in a database, and applications of such systems

### C: Image Searching and Modelling Using Machine Learning - Lecturers 11-14 (R. Cipolla and M. Johnson)

Part C of the course will focus on the application of modern pattern recognition and statistical machine learning methods applied to image retrieval and related problems. Although all examples will focus on applications to images, the ideas are generally applicable to other domains. We will cover the following topics:

- Representing images as feature vectors
- Image classification using nearest neighbours
- Introduction to Deep Learning: Neural Networks and Convolutional Neural Networks (CNN)
- Network architectures (number of layers, non-linear elements, pooling) and estimation of parameters (training under supervised learning) using back-propagation and stochastic gradient descent.
- A case study of a state-of-the-art image classification and retrieval system.

### Booklists

Please see the [Booklist for Part IB Courses](#) [2] for references for this module.

### Assessment

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

### UK-SPEC

The [UK Standard for Professional Engineering Competence \(UK-SPEC\)](#) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the '[Accreditation of Higher Education Programmes](#)' (AHEP) document [5] which sets out the standard for degree accreditation.

The [Output Standards Matrices](#) [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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### Links

[1] <mailto:rc10001@cam.ac.uk,jl221@cam.ac.uk>

[2] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364081&chapterid=44271>

[3] <http://teaching.eng.cam.ac.uk/content/form-conduct-examinations>

[4] <http://www.engc.org.uk/ukspec.aspx>

[5] <http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/>

[6] <http://teaching.eng.cam.ac.uk/content/output-standards-matrices>

