

IMAGE AND DATA PROCESSING 4

Course code	6DEX
GU Credits	20
ECTS Credits	10
Prerequisite course(s)	Engineering Mathematics EE3 (3KKW)
Teaching staff (the first has overall responsibility)	Prof J R Barker (telephone 5221; email J.Barker) Dr Y Li (telephone 4930; email Y.Li)
Approximate size of class	30
Semester	2

Description of course

The course is divided into four blocks comprising lectures, tutorials and a software-based laboratory/project.

1. Image and Data processing

32 lectures and 8 tutorials

Aims

To achieve a theoretical and practical understanding of modern techniques of audio, speech and image processing and pattern recognition within a range of engineering applications. The course integrates traditional methodology with modern neural network based methods.

Objectives

Understanding

The principal concepts of image capture, segmentation, object detection, filtering, measurement and analysis. The representation of audio, speech and images as digital data. The basic concept of artificial neural networks and their applicability to data processing. The representation of data in complex form in the time and frequency domain. Wavelet and other transforms. The concepts of automated learning and selection of training sets. The concepts of pattern recognition.

Knowledge

Methods and applications of audio, speech and image analysis and pattern recognition. The integration of artificial neural network methods with traditional signal processing techniques.

Skills

Design of simple digital filters. Design of simple wavelet transforms. Manipulation of digital transformations. Design of pattern classifiers. Writing pseudo-code algorithms for basic techniques in data processing and image analysis.

Syllabus

Part I: Signal Processing with Neural Networks

Neurons and artificial neural networks: supervised versus unsupervised learning. Real domain versus complex-domain networks. Integration with conventional algorithms. Application areas.

Neurons in the complex domain: Classification networks. Activation function. Computing the gradient. Error functions. Regression.

Data preparation: deterministic components. Differencing. Scaling.

Frequency domain methods: Fourier transform review. The FFT. Aliasing and Nyquist limit. Power spectrum. Data windows.

Signal detection in the frequency domain: detection with known phase. Normalisation for unknown phase. Examples.

Complex data in the time domain: time domain versus frequency domain. Data windows.

Determining the number of Fourier coefficients. Magnitude and offset normalisation. Phase normalisation. Examples.

Time/frequency localisation: Short time Fourier transforms. Frames. The Gabor transformation. Fixed versus variable resolution.

Wavelets: discrete wavelet parameters. Wavelet frames. Wavelet voices. Mexican hat wavelet. The Morlet wavelet.

Applications: Speech understanding and the Gabor transformation, Doppler shift radar. Phase defined events and wavelets.

Part II: Image Processing with Neural Networks

Image processing in the frequency domain: Fourier transform in 2D. Data windows.

Aliasing. The 2D Gabor transformation. The Morlet wavelets in 2D.

Comparison of methods. Fast image filtering. Moment based image features: shape moments. Binary shape moments. Tone and range moments: weight functions. Tone/texture descriptors: windowing. Basics. Neighbour constraints. Variables based on sorted tones.

Training and Learning methods: simulated annealing. Annealing plus conjugate gradient.

Regression initialised conjugate gradients. Error functions. Confusion matrices. Auto-association and mapping

Part III: Digital Image Processing

Digital representation of images. Digital filters. Shape analysis. The Hough transform. Logical combinations of images. Morphology. Stereopsis. Shape from shading algorithms.

Part IV: Pattern Recognition

Vector representation. Principal Components Analysis. Kohonen methodology. Associative memory methodology. Neural network methods. Statistical Pattern Recognition. Examples from audio, speech and image processing. Syntactic pattern recognition – introductory.

4. Laboratory

4 sessions of 3 hours plus informal access to computer laboratory.

Aims

To allow students to acquire practical experience of image processing software using NIH image (public domain package) and to experience the design of simple neural network methods using commercial/public domain software packages.

Objectives

Understanding

Choice of filters for particular problems. The principles of the extraction of features and measurements and their use in simple pattern recognition experiments.

Knowledge

Filters, Transforms. Structure of software packages.

Skills

Manipulating image processing software. Manipulating artificial neural network design packages. Writing pseudo-code.

Syllabus

The laboratories will match the four components of the lecture course.

Recommended books

Authors	Title, edition	Publisher	Year	ISBN	Cost	Code
Milan Sonika	Image Processing, Analysis and Machine Vision	Chapman and Hall	1998	053495393X	£25. 99	B
Timothy Masters	Signal and Image Processing with Neural Networks	Wiley	1994	0471049638	£36. 95	D

Codes : A = compulsory; B = strongly recommended; C = recommended; D = wider reading

Study times

Type	Hours
Lectures and tutorials	40
Laboratories and laboratory reports	20
Tutorial sheets	30
Review and consolidation of course material	85
Final revision and examination	25

These times are a rough estimate of the work required by a typical student. There will be variations between individuals, but you will run the risk of failure if you spend significantly less time on this course than these guidelines suggest.

Assessment

%	Type	Details
15	Continuous assessment	2 written assignments.
85	Degree examination	2 hour paper

The degree examinations are held in week 27 onwards; no resit is available.