Edinburgh Imaging Academy – online distance learning courses

Digital Image Processing and Analysis

Semester 2 / Commences January 20 Credits

Each Course is composed of Modules & Activities.

Modules:
- Digital Image Basics
- Image Sampling and Quantisation
- Image Perception and Morphological Operations
- Image Transformations and Modelling Application
- Computational modelling in medical image processing
- Validation techniques
- Artefacts and errors
- Retinal image analysis
- Introducing Tractography
- Registration techniques
- Voxel based analysis
- Image segmentation thresholding
- DWI Basic Quantification
- Perfusion Imaging

Each Module is composed of Lectures, Reading Lists, MCQ self-assessments, & Discussion Boards.

The summary table above shows whether the modules are available in the Neuroimaging for Research (NI4R) programme or the Imaging (IMSc) programme or indeed both.
Digital Image Basics:
  Digital image basics

Image Sampling and Quantisation:
  Image processing basics – part 1

Image Perception and Morphological Operations:
  Image processing basics – part 2

Image Transformations and Modelling Application:
  Image transformations and modelling application

Computational modelling in medical image processing:
  Computational modelling in medical image processing: basics

Validation techniques:
  Validation techniques 1

Artefacts and errors:
  Artefacts and errors in image processing
  Methods to reduce the effect of artefacts in structural MRI

Retinal Image Analysis:
  Retinal Image Analysis

Introducing tractography:
  Introducing tractography

Registration Techniques:
  Registration Techniques

Voxel Based Analysis:
  Voxel based analysis

Image segmentation thresholding:
  Basics on thresholding-based image segmentation techniques

DWI Basic Quantification:
  DWI Basic Quantification – Lecture 1
  DWI Basic Quantification – Lecture 2
  DWI Basic Quantification – Lecture 3

Perfusion Imaging:
  Basics
  Advanced

We can also provide a more detailed syllabus showing what lectures will be given for each module, and the learning outcomes for each module.
Digital Image Basics (both NI4R and IMSc)

Lecture 1
Title: Digital image basics
Description: Overview of how the image data is processed by computers and printers
Author(s): Dr Maria C. Valdés Hernández
Learning Objectives
- Identify the Central Processing Unit inside a computer
- Represent a decimal number in binary and hexadecimal formats
- Write the truth table of the main binary operations: using logical operators ‘and’, ‘or’ and ‘not’
- Describe how the printer manages colours and how to convert a colour image from RGB to CMYK

Image Sampling and Quantisation (both NI4R and IMSc)

Lecture 1
Title: Image processing basics – part 1
Description: Introduction to sampling, quantisation and sources of noise in images
Author(s): Dr Maria C. Valdés Hernández
Learning Objectives
- Define sampling and quantisation
- For a given image type, identify the different sources of noise and describe the possible causes and their effects

Image Perception and Morphological Operations (both NI4R and IMSc)

Lecture 1
Title: Image processing basics – part 2
Description: Perception of images and morphological operations on images
Author(s): Dr Maria C. Valdés Hernández
Learning Objectives
- Discuss visual effects that can influence the perception of certain features on images
- Describe the morphological computational operations and how they are done
Image Transformations and Modelling Application (both NI4R and IMSc)

Lecture 1
Title: Image transformations and modelling application
Description: Introduction to Fourier and Laplace transforms, and the Markov chain model and their applications in imaging
Author(s): Dr Maria C. Valdés Hernández
Learning Objectives
- Explain what the Fourier Transform is and discuss some of its adaptations and applications in medical imaging
- Explain what the Laplace Transform is and discuss some of its applications in medical imaging
- Discuss the Markov chain model and mention some of its applications in medical imaging

Computational modelling in medical image processing (both NI4R and IMSc)

Lecture 1
Title: Computational modelling in medical image processing: Basics
Description: Modelling techniques used in medical image processing
Author(s): Dr Maria C. Valdés Hernández
Editor(s): Dr Andrew Farrall
Learning Objectives
- Discuss different modelling types used in medical image processing
- Explain principles of the techniques presented

Validation techniques (both NI4R and IMSc)

Lecture 1
Title: Validation techniques 1
Description: An outline of issues to be considered while evaluating papers on imaging processing techniques
Author(s): Dr Maria C. Valdés Hernández
Editor(s): Dr Andrew Farrall
Learning Objectives
- Critically evaluate the validity of the results obtained from a segmentation technique in the literature
- Analyze the results of a segmentation algorithm performed on medical images
Artefacts and errors (both NI4R and IMSc)

Lecture 1
Title: Artefacts and errors in image processing
Description: Description of the common artefacts in routine structural MRI scans
Author(s): Dr Maria C. Valdés Hernández
Editor(s): Dr Andrew Farrall
Learning Objectives
- Identify common artefacts in structural MRI scans
- Mention the nature and causes of each type of artefact
- Describe the effect of each type of artefact in common structural MRI sequences

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The author of this lecture thanks the contribution of Mrs. Gayle Barclay and Mrs. Cathy Scott, radiographers at the Brain Research Imaging Centre of Edinburgh, in proof-reading, revising and making valuable suggestions to the initial material.

Lecture 2
Title: Methods to reduce the effect of artefacts in structural MRI
Description:
Author(s): Dr Maria C. Valdés Hernández
Learning Objectives
- Identify the main post-processing methods used to reduce the effect of common artefacts in structural MRI scans
- Mention the principles upon which each technique is based
- Describe the image processing techniques applied to each type of artefact

Retinal Image Analysis (both NI4R and IMSc)

Lecture 1
Title: Retinal Image Analysis
Description: Measurement of retinal features following the application of image processing techniques
Author(s): Dr. Tom MacGillivray
Learning Objectives
- Describe the generation of a retinal photograph
- Outline various methods of image processing relevant to brain imaging including:
  - the use of shape information (morphology) to construct shape-sensitive filters
  - the use of image filtering to improve edge recognition for improved segmentation of images
- Cite examples of these techniques applied to measure features in an image
Introducing tractography (both NI4R and IMSc)

Lecture 1
Title: Introducing tractography
Description: The role of tractography in brain imaging
Author(s): Mr. Jonathan Clayden
Learning Objectives
- To show how information on the direction and integrity of white matter tracts in the brain can be obtained using diffusion MRI
- To give an overview of the current approaches to white matter fibre tracking and their relative merits

Registration Techniques (both NI4R and IMSc)

Lecture 1
Title: Registration Techniques
Description: Understanding the what and how of registering images
Author(s): Mr. James Withers
Editor(s): Dr. Andrew Farrall
Learning Objectives
- Explain what is meant by multi-modal MR
- Define registration and segmentation
- Discuss some problems with registration and their solutions

Voxel Based Analysis (both NI4R and IMSc)

Lecture 1
Title: Voxel based analysis
Description: Voxel based analysis means and methods used to research the dependence of psychosis symptoms on structural MRI
Author(s): Dr. Bill Moorhead
Learning Objectives
- Describe the application of voxel-wise analyses for cross-sectional analyses and longitudinal analyses
- Outline the usage hand tracing methods to implement Region of Interest (ROI) Analyses
- Explain the development of automated parcellation techniques that allow protocols to be applied to large cohorts
- Describe the implementation of Automated Gyrification Index A-GI a technique that measures the folding characteristics in brains
- Outline benefits and limitations of these approaches
Image segmentation thresholding (both NI4R and IMSc)

Lecture 1
Title: Basics on thresholding-based image segmentation techniques
Description: Principles of thresholding and its application in medical image processing are explained and some examples are analysed
Author(s): Dr Maria C. Valdés Hernández

Learning Objectives
- Explain what thresholding is and discuss some of its applications in medical imaging
- Explain what the advantages and limitations of thresholding are in medical imaging processing
- Discuss the characteristics of different thresholding techniques and mention some of their applications in medical imaging
DWI Basic Quantification (both NI4R and IMSc)

Lecture 1
Title: DWI Basic Quantification - Lecture 1
Description: The basic parameters that can be extracted from the diffusion scan, methods of extraction and clinical applications
Author(s): Dr. Susana Muñoz Maniega
Learning Objectives
- Define diffusion and explain principles behind it
- Outline the usefulness of the information is extracted from the diffusion image
- Describe ways of displaying the diffusion information
- Recognise actual equations used to calculate mean diffusivity and fractional anisotropy
- Recognise typical normal values in different brain tissues

Lecture 2
Title: DWI Basic Quantification - Lecture 2
Description: The basic parameters that can be extracted from the diffusion scan, methods of extraction and clinical applications
Author(s): Dr. Susana Muñoz Maniega
Learning Objectives
- List a few factors which affect reproducibility of extracted diffusion parameters
- Describe the changes in diffusion parameters in different brain tissues seen in a common disorder like stroke or schizophrenia

Lecture 3
Title: Diffusion MRI processing – Lecture 3
Description: The basic parameters that can be extracted from the diffusion scan, methods of extraction and clinical applications
Author(s): Dr. Susana Muñoz Maniega
Learning Objectives
- Outline how diffusion parameters might change with time after onset of disease
- List time-related factors which affect reproducibility of extracted diffusion parameters
- Discuss the effect that time related factors might have on interpretation of diffusion data from different brain tissues in a common disorder like stroke or schizophrenia
Perfusion Imaging (both NI4R and IMSc)

Lecture 1
Title: Basics
Description: Basic principles of MR perfusion imaging
Author(s): Dr. Trevor Carpenter

Learning Objectives
- Define the Central Volume Principle (CVP)
- Describe Contrast Bolus tracking
- Outline the principles of how MR signal is converted to concentration
- List the relative perfusion measures and how they are obtained
- Distinguish between:
  - Cerebral Blood Volume (CBV) and relative CBV
  - Mean Transit Time (MMT) and relative MTT
  - Cerebral Blood Flow (CBF) and relative CBF
- Name some applications of perfusion imaging and outline its role in studying disease

Lecture 2
Title: Advanced
Description: Advanced principles of MR perfusion imaging
Author(s): Dr. Trevor Carpenter

Learning Objectives
- Understand the how the CVP is related to the residue function
- State the process the residue function describes
- Describe the difference between quantitative and relative measures
- Explain a basic approach to quantification
- State the assumptions this approach makes