Edinburgh Imaging
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Neuroimaging – BIME10009

Semester 1 / Autumn   **20 Credits**

Each Course is composed of Modules & Activities.

Modules:

Module	Lectures covered within the module
Imaging in context	Imaging basics Data protection Image Interpretation
CT techniques	CT Basics Neurosurgery Neuroimaging
MR techniques and practicalities	MR Basics MR health & safety Practical MR for humans
Advanced techniques & applications	Functional imaging basics fMRI practicalities MND Schizophrenia Depression Experimental imaging

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

This course is taught as an elective for the undergraduate on campus Biomedical Sciences Hons
This course is not available for CPD or PPD.

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Lecture content include:

Imaging Basics:
History: past to present
Terminology and orientation
Anatomy basics
Orientation to body imaging

Data protection
Privacy and data protection

Image Interpretation
Human and technical factors

Computed Tomography Basics:
Computed Tomography Basics
Grey scale perception – Technical
Grey Scale Perception – Applications
CT advanced techniques 1
CT advanced techniques 2

Neurosurgery
Imaging in surgery for glioblastoma, a type of brain tumour

Neuroimaging
CT head – acute pathology

MR Basics:
Physics
T1 & T2
Localisation
k-Space

MR Health & Safety
MR Health and Safety
Safe running of an MR unit

Practical MR for Humans
Screening for contraindications and safety
Having an MR scan

Functional Imaging Basics
Neurophysiology techniques
Neurovascular techniques
Applications

fMRI practicalities

    fMRI Practicalities

Schizophrenia

    Functional neuroimaging in schizophrenia

MND

    The neuropsychology of motor neurone disease

Imaging in depression

    Background, advances and limitations
    Example of a study of depression after stroke

Experimental Imaging

    Overview
    Applications

Further details of modules that may be within your course

Imaging Basics

Lecture 1
Title: History: past to present
Description: Historical perspective through to modern imaging departments
Author(s): Dr. Andrew Farrall
Learning Objectives
- Outline the historical development of imaging
- List the techniques used in modern imaging departments
- Identify which techniques do or do not use ionizing radiation
- Distinguish between techniques which use ionizing radiation

Lecture 2
Title: Terminology and orientation
Description: Becoming familiar with how radiology looks at the body
Author(s): Dr. Andrew Farrall
Learning Objectives
- Use and interpret radiological orientations, directions and convention

Lecture 3
Title: Anatomy basics
Description: A look at common anatomical landmarks and features
Author(s): Dr. Andrew Farrall
Learning Objectives
- Identify common anatomical landmarks and features including:
- Anatomical landmarks of the head surface anatomy
- Skull features
- Lobes, fissures and sulci
- Grey and white matter
- Arterial supplies to the brain

Lecture 4
Title: Orientation to body imaging
Description: A look at common body imaging descriptors and features
Author(s): Dr. Michael Jackson, Dr. Andrew Farrall
Learning Objectives
- Recognise the three conventional anatomical planes: axial, coronal and sagittal as they relate to the body
- Appreciate the direct relevance of these planes to cross-sectional imaging
- Be aware of the concept of the anatomical position
- Understand the terms proximal and distal in different settings
- Be familiar with the meaning of the anatomical terms dorsal, ventral and cranio-caudal

Data Protection

Lecture 1
Title: Privacy and data protection
Description: Rules and regulations around using imaging data in research
Author(s): Prof.. Andrew Farrall
Learning Objectives

- Describe what data is associated with images
- Distinguish between personal data, sensitive personal data and non-personal data
- List the eight (8) UK Data protection act 1998 principles and specific exceptions for research
- Define the various terms in Basic interpretive provisions section (1(1)) of the UK Data protection act 1998
- Explain anonymisation and pseudanonymisation
- Outline principles behind sharing data

Image Interpretation

Lecture 1
Title: Human and technical factors
Description:
Author(s): Prof.. Andrew Farrall
Learning Objectives

- List stages in the imaging pathwa
- Define perception and analysis in the context of image interpretation
- State Garland's three objectives
- Discuss the sequelae of Garland's three objectives
- List factors which influence interpretation error rates
- Describe solutions to causes of interpretation error

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Computed Tomography Basics

Lecture 1
Title: Computed Tomography Basics
Description: History, principles and practice
Author(s): Dr. Andrew Farrall
Learning Objectives
- Outline the historical development of scanners
- State the difference between generations of scanners
- Define "pitch" and collimation
- Describe attenuation in CT
- Outline back projection reconstruction
- Outline beam hardening artefact
- Discuss applications of modern CT techniques

Lecture 2
Title: Grey scale perception - Technical
Description: Physics and other relevant concepts behind the grey scale in radiology
Author(s): Dr. Andrew Farrall
Learning Objectives
- Describe the pathway of perception
- Explain radiological imaging and how it uses the grey scale to represent images

Lecture 3
Title: Grey Scale Perception - Applications
Description: How perceiving the grey scale has important clinical ramifications
Author(s): Dr. Andrew Farrall
Learning Objectives
- Describe how the human eye perceives contrast and brightness off grey scale images
- Explain factors which alter human perception of grey scale images
- Discuss the limitations of grey scale imaging

Lecture 4
Title: CT advanced techniques 1
Description: Maximum and minimum intensity projections
Author(s): Dr. Michael Jackson, Dr. Andrew J. Farrall
Learning Objectives
- Describe production of maximum (and minimum) intensity projection images
- Describe the effect of varying slice thickness on MIPs and MinIPs
- Explain the difference between intensity projection and windowing
- Demonstrate clinical uses for intensity projection images
- Describe the limitations of intensity projection images

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Lecture 5
Title: CT advanced techniques 2
Description: Multi-planar and 3D reconstructions
Author(s): Dr. Michael Jackson, Dr. Andrew J. Farrall
Learning Objectives
- Understand the role of multi-planar reformatting
- Discuss the advantages and limitations of 3D CT reconstructions
- Be aware of 3D editing techniques
- Name endoluminal visualisation techniques
- Understand differences between orthographic rendering and immersive perspective rendering
- Explain when 3D techniques are complementary to conventional imaging

Neurosurgery
Lecture 1
Title: Imaging in surgery for glioblastoma, a type of brain tumour
Description: Imaging in surgery for glioblastoma, a type of brain tumour in particular the surgical approaches
Author(s): Prof. Ian Whittle
Learning Objectives
- Describe how imaging is used to investigate, guide treatment of, and follow-up brain tumours
- Give an overview of advances in surgical neuro-oncology made possible with imaging
- Give an overview of the impact of technology on management of malignant gliomas

Neuroimaging
Lecture 1
Title: CT head – acute pathology
Description: History, terminology & orientation
Author(s): Dr Ana Casado
Learning Objectives
- Recogize trauma situations where CT head scanning is appropriate
- List reasons why CT is more appropriate than other techniques
- Identify & describe CT imaging findings expected in cases of trauma situations

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MR Basics

Lecture 1
Title: Physics
Description: Basic principles behind MR
Author(s): Dr. Paul Armitage, Dr. Andrew Farrall
Learning Objectives
- Describe "spin" and its relevance to Magnetic Resonance
- Explain the relevance of protons in MR
- Know the Larmor frequency equation
- Describe "relaxation"
- Define the "Free Induction Decay"
- Distinguish between T1 & T2

Lecture 2
Title: T1 & T2
Description: Using relaxation parameters in imaging
Author(s): Dr. Paul Armitage, Dr. Andrew Farrall
Learning Objectives
- Recognise different tissues have different T1 & T2 values
- Understand how the differences are exploited to generate image contrast
- Differentiate between T1 weighted & Proton Density weighted imaging
- Understand what T1 imaging is useful for clinically
- Understand T2 weighted imaging
- Understand what T2 imaging is useful for clinically
- Discuss how FLAIR & STIR imaging relate to each other
- Know why FLAIR & STIR imaging are used

Lecture 3
Title: Localisation
Description: Overview of how MR signal is associated with the point from which it originates
Author(s): Dr. Paul Armitage, Dr. Andrew Farrall
Learning Objectives
- Explain MR slice selection
- Describe how localization is performed in the MR image plane
- Recognise the difference between frequency and phase encoding
- State the difference between pixel and voxel

Lecture 4
Title: k-Space
Description: Relating raw MR data to the image we see
Author(s): Dr. Andrew Farrall, imaging provided by Dr. Trevor Carpenter
Learning Objectives
- Explain what information lies in k-space
- Describe how k-space relates to MR images
- State the role of the Fourier Transform
- List some common artefacts in MR images which result from errors and problems in k-space

MR Health and Safety

Lecture 1
Title: MR Health and Safety
Description: Health and safety aspects of working within high magnetic fields and other aspects of MR safety
Author(s): Mrs. Iona Hamilton, Mrs. Elaine Sandeman
Learning Objectives
- Explain how to work in a high magnetic field safely
- Describe differences in safety aspects of different types of MR scanner
- List items which may cause hazard in a magnetic field
- Discuss subject-specific factors that may affect safety

Lecture 2
Title: Safe running of an MR unit
Description: Key factors in running a safe and effective human MR scanning facility
Author(s): Prof. Joanna Wardlaw
Learning Objectives
- Outline the key factors involved in setting up and running an MR scanning facility for research in people
- Describe how to ensure safety of staff and subjects or patients being scanned
- Discuss current areas of debate concerning safety of magnetic fields and contrast agents

Practical MR for Humans

Lecture 1
Title: Screening for contraindications and safety
Description: To outline the relative and absolute contraindications to MR imaging and ensure safety while having an MR scan
Author(s): Mrs. Iona Hamilton, Mrs. Elaine Sandeman
Learning Objectives
- Describe the individual steps in preparing for an MR examination
- Summarise the major contraindications to MR
- Summarise the key things to watch out for to ensure safety

Lecture 2
Title: Having an MR scan
Description: A description of the steps involved in having an MR scan
Author(s): Mrs. Iona Hamilton, Mrs. Elaine Sandeman
Learning Objectives
- Explain what it is like to have an MR scan, from start to finish

Functional Imaging Basics

Lecture 1
Title: Neurophysiology techniques
Description: Various techniques including Magnetoencephalography (MEG) &
Electroencephalography (EEG) and intra/extra-cellular recordings
Author(s): Dr Cyril Pernet, Dr. David McGonigle
Learning Objectives
- Discuss the relative strengths and weaknesses of neurophysiological techniques, in particular Electro- and Magneto- Encephalography
- List the main human, whole brain imaging techniques
- Explain the difference between intra- & extra-cell recordings

Lecture 2
Title: Neurovascular techniques
Description: Physiological & physical basis of PET & fMRI
Author(s): Dr Cyril Pernet
Learning Objectives
- Explain the physiological mechanisms recorded
- Describe the basis of PET and fMR
- Contrast the techniques' strengths vs. weaknesses

Lecture 3
Title: Applications
Description: Review of MEEG & fMRI / PET applications
Author(s): Dr Cyril Pernet
Learning Objectives
- Identify the key areas in which functional imaging can be used

fMRI Practicalities

Lecture 1
Title: fMRI Practicalities
Description: A practical overview of how fMRI experiments are prepared, conducted and analysed
Author(s): Liana Romaniuk
- **Learning Objectives**
  Describe the initial administrative steps of fMRI
- Compare the various hardware/software options
- Describe scanning parameters for fMRI
- Explain the procedure of a normal experiment

Schizophrenia

Lecture 1
Title: Functional neuroimaging in schizophrenia
Description: The role of functional neuroimaging as a research tool in schizophrenia
Author(s): Prof. Stephen Lawrie
Learning Objectives
- Briefly describe basic background information about schizophrenia including:
  o epidemiology
  o symptoms
  o risk factors
- Outline current theories of what brain abnormalities underlie schizophrenia
- Explain how different imaging techniques have been used in studies of schizophrenia, including some examples of studies
- Discuss the difficulties and limitations, as well as the advantages, of using imaging as a research tool to study a complex disease like schizophrenia

MND

Lecture 1
Title: The neuropsychology of motor neurone disease
Description: Imaging and the cognitive consequences of motor neurone disease
Author(s): Dr. Sharon Abrahams
Learning Objectives
- Define:-
  o Motor Neuron Disease (MND)
  o MND-Dementia
- Outline the role that imaging has played in improving the knowledge of how MND affects regions of the brain other than the motor system
- Using the example of Classical MND studies, discuss how imaging can be used in conjunction with other approaches, in particular neuropsychology, in research and clinical practice

Imaging in depression

Lecture 1
Title: Background, advances and limitations
Description: Current theories about what causes depression and how imaging techniques have helped elucidate these mechanisms
Author(s): Dr. Kristin Haga
Learning Objectives
- Outline depression as a disease,
- Outline some of the possible mechanisms that lead to depressive illness
- Describe how imaging techniques have helped to understand those mechanisms
- Discuss how different imaging techniques can be used together to provide complementary information in exploring disease mechanisms

- Explain the application of these imaging methods to study one aspect of depression, i.e. post-stroke depression

Lecture 2
Title: Example of a study of depression after stroke
Description: An example of a study of depression after stroke and use of imaging techniques illustrating difficulties, results and opportunities for future work.
Author(s): Dr. Kristin Haga
Learning Objectives
- Explain how imaging can be used in a study of depression following stroke
- Discuss some of the practical difficulties in using imaging to study a complex disease like depression in the elderly
- Discuss how different imaging techniques can be used together to provide complementary information in exploring disease mechanisms

Experimental Imaging

Lecture 1
Title: Overview
Description: Overview of preclinical imaging
Author(s): Dr. Maurits Jansen
Learning Objectives
- Understand differences between small animal and human imaging
- Know how MR experiments are performed in animals
- Understand applications of cardiac cine MR in animals

Lecture 2
Title: Applications
Description: Recent applications & techniques
Author(s): Dr. Maurits Jansen
Learning Objectives
- Know what is meant by cell tracking
- Describe examples of experimental imaging
- Describe the term molecular imaging
- Describe manganese enhanced MR