ES9ZQ-15 Image Analysis and Reconstruction

24/25

Department
School of Engineering
Level
Taught Postgraduate Level
Module leader
Jay Warnett
Credit value
15
Module duration
10 weeks
Assessment
100% coursework
Study location
University of Warwick main campus, Coventry

Description

Introductory description

This module introduces students to the different facets of image analysis required to understand the outputs of imaging systems. Imaging has been a fundamental innovation for medical diagnostics and interventions since its inception. In the last few decades it has been further popularised as an industrial tool for non-living objects given its non-destruction capability to observe internal structures. To this end it is now commonly used to assess bio-medical devices and implants for imperfections and to check it meets the required standard.

Module aims

The module aims to introduce students to image analysis and reconstruction through a practical lens of the outputs from imaging systems, and will learn the tools to analyse and understanding them.

Outline syllabus

This is an indicative module outline only to give an indication of the sort of topics that may be covered. Actual sessions held may differ.

1. Introduction to X-ray imaging systems and other modalities (1 lecture)
   a. Different systems that generate images and process
   b. X-ray generation
   c. Difference between “medical” and “industrial systems”
2. Grey values and histograms (2 lectures)
   a. X-ray interaction with matter (lambert beer law)
   b. Dosimetry
   c. Imaging outputs – grey level, histogram, image statistics
   d. The data problem, quality vs dose
3. Image Quality Metrics (3 lectures, 2hr demo session)
   a. Parameter impacts
   b. Sharpness, contrast, noise
   c. Resolution and MTF
4. Reconstruction (4 lectures. 8hrs labs)
   a. Analytical Reconstruction
   b. Iterative Reconstruction (exact and semi-covergence)
   c. Limited data, Region of Interest and advanced methods
5. Analysis (2 lectures. 8hrs labs)
   a. Visualisation
   b. Filters – denoising, edge detection, grey-scale transformation
   c. Segmentation methods and feature extraction
   d. Porosity measurement
   e. Deep learning

Includes

- lab tour
- physical introduction with imaging systems, changing parameters
- Guest speaker on forensic’s and X-ray CT

Learning outcomes

By the end of the module, students should be able to:

- Describe the imaging process from sample to image stack
- Explain the impact of parameter choices on image quality
- Calculate different image quality metrics and statistics
- Explain and implement analytical and iterative reconstruction
- Implement image analysis techniques on reconstructed data to produce outputs dependent on the task
- Appraise the impacts of limited data on reconstruction and analysis

Indicative reading list

None are required, but are supplementary material to acquire a deeper knowledge
Buzug, T (2008) Computed tomography: from photon statistics to modern cone-beam CT

Herman, G T (2009) Fundamentals of computerized tomography: image reconstruction from projections
Mamourian, A C (2013) CT imaging: practical physics, artifacts and pitfalls
Carmignato, S (2018) Industrial X-ray Computed Tomography
Hansen, P C (2021) Computed Tomography: Algorithms, Insight and Just Enough Theory
Toda, H (2021) X-ray CT: Hardware and Software Techniques

Interdisciplinary

A split of clinical and engineering focussed image reconstruction and analysis methodologies. These will require a mix of mathematical and computational approaches, while developing an image based intuition.

Subject specific skills

1. Understand how medical systems acquire and reconstruct imaging data
2. Characterise the image quality and advise how this can be improved
3. Learn how to implement analysis techniques in Matlab and Avizo
4. Interpret the outputs of X-ray radiography and CT data in medical contexts

Transferable skills

1. Formulate imaging analysis workflows for specific tasks across a variety of healthcare and industrial data
2. Apply image reconstruction (Python) to other trajectories and modalities
3. Adapt methods to interrogate image data for interdisciplinary research

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Study

Study time

Type	Required
Lectures	12 sessions of 1 hour (8%)
Seminars	1 session of 2 hours (1%)
Practical classes	8 sessions of 2 hours (10%)
Private study	70 hours (44%)
Assessment	60 hours (38%)
Total	160 hours

Private study description

Students will revise the lecture work and where necessary enhance their learning through directed reading. With practical computer lab classes, additional exercises will be provided to hone their skills.

Costs

No further costs have been identified for this module.

Assessment

You must pass all assessment components to pass the module.

Assessment group A

	Weighting	Study time	Eligible for self-certification
Limited data impact on task assessments - Project Report	100%	60 hours	Yes (extension)

Often you are required to limit the amount of data you acquire due to the geometry or dose. This can result in sub-optimal images. This coursework is an open exploration of these issues to understand the impact on reconstruction and the subsequent analysis

Feedback on assessment

Project report - general feedback will be given at a cohort level with respect to the marking criteria. Individual feedback will also be returned.

Availability

Courses

This module is Core optional for:

- Year 1 of TESA-H1CA Postgraduate Taught Diagnostics, Data and Digital Health

This module is Core option list B for:

- Year 1 of TESA-H1CA Postgraduate Taught Diagnostics, Data and Digital Health