ELEC317

Medical Image and Signal Processing

S2 Day 2018

Dept of Engineering

Contents

General Information

Unit convenor and teaching staff
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Credit points
3

Prerequisites
MATH235 and ELEC215

Corequisites

Co-badged status

Unit description
In this unit, mathematical techniques used for image analysis, image reconstruction, image improvement, information extraction and data storage will be discussed. The focus of the first module is on image and signal quality and information metrics. In a second module, image reconstruction methods are discussed such as Filtered back projection, Iterative image reconstruction, Fast Fourier Transform, Inverse transport equations and compressed sensing. The third module focuses on image and signal improvement techniques such as noise reduction and filtering, deblurring, grey level renormalization, artifact compensation techniques and image deformation compensation. In a fourth module, methods for extracting image information will be discussed such as segmentation, registration, statistical analysis, texture analysis, image based physiological modelling The fourth module is dedicated to some advanced methods such as high performance computing and 3D and 4D medical visualization and virtual reality. Finally, concepts of big data analysis and medical image storage and management will be discussed. Practical sessions involve the use of image visualization and reconstruction software and writing snippets of image processing software code.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

1. Demonstrate a solid understanding of concepts on image and signal quality, enhancement, and information extraction.
2. Develop and code algorithms in Matlab (or Python) to apply image and signal processing methods to a range of biomedical image and signal problems.
3. Apply mathematical methods to analyse and enhance image quality.
4. Apply mathematical methods to extract information of interest from medical images.
5. Identify and analyse medical image processing requirements for clinicians and medical researchers.
6. Demonstrate foundational learning skills including active engagement in their learning process

General Assessment Information

Grading and passing requirement for unit

There is no final examination for this course - your mark will be composed of image and signal processing projects which will be completed over the course of the semester in lab sessions and at home, biweekly quizzes/short answer questions, and a presentation. See the Assessment Tasks section for further details.

Conditions required to pass the unit:

In order to pass this unit a student must obtain a mark of 50 or more for the unit (i.e. obtain a passing grade P/ CR/ D/ HD).

For further details about grading, please refer below in the policies and procedures section.

Hurdle Requirements

Participation in tutorial/lab sessions is a hurdle requirement and students are required to attend at least 8 out of 12 sessions to pass this unit. At least 5 of the 8 sessions must include participation in the biweekly quiz. A grade of 50% or more from 5 out of the 6 quizzes must be obtained in order to pass this unit.

Late submissions and Resubmissions

Late submissions will attract a penalty of 10% of marks per day. Extenuating circumstances will be considered upon lodgement of an application for special consideration.

Resubmissions of work are not allowed.

Please note: There will be no lab session in week 1.

Assessment Tasks

Name	Weighting	Hurdle	Due
Biweekly multiple choice quiz	20%	Yes	Weeks 2,4,6,8,10,12
Signal processing	20%	No	Week 4
Image processing	20%	No	Week 8
Neuroimaging project	30%	No	Week 12
Presentation	10%	No	Week 13

Biweekly multiple choice quiz

Due: **Weeks 2,4,6,8,10,12**
Weighting: **20%**
This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

On the 'even' week numbers, i.e. 2,4,6 etc, the lab session will begin with an overview of the material from the previous week's material. This will be an in-class discussion, rather than a lecture. There will be discussions about any reading or online video material that may have been assigned. Example problems may be worked through, and this is an opportunity for students to thoroughly engage with the course material.

The second part of the lab session will consist of a multiple choice and/or short answer questions based on content from the previous week. There will be six quizzes and the five highest scores will be used to calculate an average mark. This is worth 20% of your mark for this unit and is a hurdle requirement. This means that is very important to attend the laboratory sessions, including the discussion portion. You stand the greatest chance of doing well in this course if you fully participate in all sessions.

On successful completion you will be able to:

- 1. Demonstrate a solid understanding of concepts on image and signal quality, enhancement, and information extraction.
- 2. Develop and code algorithms in Matlab (or Python) to apply image and signal processing methods to a range of biomedical image and signal problems.
- 3. Apply mathematical methods to analyse and enhance image quality.
- 4. Apply mathematical methods to extract information of interest from medical images.
- 6. Demonstrate foundational learning skills including active engagement in their learning process

Signal processing

Due: **Week 4**
Weighting: **20%**

You will be given several ECG signals to analyse, using the signal processing techniques covered in class. Some portion of the ECG signals are taken from patients exhibiting ventricular fibrillation. Your mission is to develop a detector to differentiate normal sinus rhythms from ventricular arrhythmias. You will get to evaluate your detector against that of a human expert. This assignment is to be completed using Matlab.

On successful completion you will be able to:

- 2. Develop and code algorithms in Matlab (or Python) to apply image and signal processing methods to a range of biomedical image and signal problems.

Image processing

Due: **Week 8**
Weighting: **20%**

For this assignment, you're going to revisit the cardiac ultrasound machine we last used in ELEC 215. You're going to acquire some images of your own heart through several cardiac cycles and then use the image processing techniques you've learnt to denoise the images and then detect the ventricular boundary in order to calculate left ventricular volume. You will then reconstruct a 3D volume of your heart from the acquired ultrasound slices.

This will be done in Matlab and an ultrasound image reconstruction tool.

On successful completion you will be able to:

- 1. Demonstrate a solid understanding of concepts on image and signal quality, enhancement, and information extraction.
- 2. Develop and code algorithms in Matlab (or Python) to apply image and signal processing methods to a range of biomedical image and signal problems.
- 4. Apply mathematical methods to extract information of interest from medical images.

Neuroimaging project

Due: **Week 12**
Weighting: **30%**

This task is the major assessment task for this unit and is designed to consolidate knowledge gained from weeks 3 to 10 through direct application of standard imaging tools to a common neuroimaging task.

This task essentially consists of building a neuroimaging pipeline to calculate a regional physiological measurement in the brain. It will be worked on during lab sessions, with a new

element added to the pipeline each week as the relevant supporting material is discussed in the lectures. By the end of week 10, it is envisaged that you will have built all necessary steps in your pipeline and are able to process the brain data and write about the steps taken.

You will learn and use tools to for:

- assessing resolution and image structure
- registration of different imaging modalities
- registration to standard templates
- segmentation

As this is an advanced task, step by step instructions will be provided as well as hands on assistance from me in the lab sessions.

On successful completion you will be able to:

- 1. Demonstrate a solid understanding of concepts on image and signal quality, enhancement, and information extraction.
- 2. Develop and code algorithms in Matlab (or Python) to apply image and signal processing methods to a range of biomedical image and signal problems.
- 3. Apply mathematical methods to analyse and enhance image quality.
- 4. Apply mathematical methods to extract information of interest from medical images.
- 5. Identify and analyse medical image processing requirements for clinicians and medical researchers.

Presentation

Due: **Week 13**
Weighting: **10%**

You will prepare and present a 15 minute presentation on a medical signal or image processing topic. You are welcome to source your own topic, or one can be assigned. There are many exciting topics out there and this is an opportunity for you to show us what you are passionate about.

Your presentation will be assessed on the basis of:

- Demonstration that sufficient research has been conducted to allow a high level overview of the topic to be presented in the allocated time slot. It is not expected that you become a subject matter expert.
- Appropriate use of presentation media - please do not subject your audience to 'Death by Powerpoint'. Slides should be used for images, not copious amount of text that your audience will read, rather than listening to you.

- Timekeeping. You will stand a much better chance of keeping to your time slot if you practice and time your talk. Fifteen minutes is not very long!
- Delivery and structure. Your presentation should have a clear introduction, body and conclusion. Your delivery should be clear and engage the audience. Most audiences are lost in the first few minutes of a presentation - can you carry yours all the way to the end?

On successful completion you will be able to:

- 5. Identify and analyse medical image processing requirements for clinicians and medical researchers.

Delivery and Resources

Dr. Ruth Oliver is the course convenor of this brand new unit, which is third in a series of four units with a biomedical image and sensing theme.

This unit will be provided to you in a blended learning format with a combination of face to face lectures, small group tutorials, assigned online reading and video viewing, live coding examples and in class problem solving.

A course handbook containing ALL examinable material will be provided, as well as powerpoint slides of the lectures and links to online material.

Signal and image processing topics are best learnt through hands on demonstrations and tutorials. As such, the lab sessions are going to be structured differently to how you may have come across them in previous units. The lab sessions are a combination of research intensive sessions and content review. They are designed to consolidate your learning from the lectures and group discussions and learn other key skills required to complete the assessments. Therefore, attending both lectures and lab sessions is crucial for doing well in ELEC 317.

Recommended textbooks:

Gonzales and Woods, "Digital Image Processing", Pearson

Sonka, Hlavac, Boyle, "Image Processing, Analysis and Machine Vision", Cengage Learning

Note: these books are both available in the library and possibly in PDF form on the internet.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://staff.m

q.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Grade Appeal Policy
- Complaint Management Procedure for Students and Members of the Public
- Special Consideration Policy *(**Note:** The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

Undergraduate students seeking more policy resources can visit the Student Policy Gateway (https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central).

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/study/getting-started/student-conduct

Results

Results shown in *iLearn*, or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit ask.mq.edu.au.

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

Student Services and Support

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

IT Help

For help with University computer systems and technology, visit http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

Graduate Capabilities

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcomes

- 3. Apply mathematical methods to analyse and enhance image quality.
- 4. Apply mathematical methods to extract information of interest from medical images.
- 5. Identify and analyse medical image processing requirements for clinicians and medical researchers.

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcomes

- 1. Demonstrate a solid understanding of concepts on image and signal quality, enhancement, and information extraction.
- 5. Identify and analyse medical image processing requirements for clinicians and

medical researchers.

Assessment task

- Presentation

Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

Learning outcome

- 5. Identify and analyse medical image processing requirements for clinicians and medical researchers.

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- 1. Demonstrate a solid understanding of concepts on image and signal quality, enhancement, and information extraction.
- 2. Develop and code algorithms in Matlab (or Python) to apply image and signal processing methods to a range of biomedical image and signal problems.
- 3. Apply mathematical methods to analyse and enhance image quality.
- 4. Apply mathematical methods to extract information of interest from medical images.
- 5. Identify and analyse medical image processing requirements for clinicians and medical researchers.

Assessment tasks

- Biweekly multiple choice quiz
- Signal processing

- Image processing
- Neuroimaging project

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

- 1. Demonstrate a solid understanding of concepts on image and signal quality, enhancement, and information extraction.
- 2. Develop and code algorithms in Matlab (or Python) to apply image and signal processing methods to a range of biomedical image and signal problems.
- 3. Apply mathematical methods to analyse and enhance image quality.
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- 5. Identify and analyse medical image processing requirements for clinicians and medical researchers.

Assessment tasks

- Signal processing
- Image processing
- Neuroimaging project

Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcomes

- 1. Demonstrate a solid understanding of concepts on image and signal quality, enhancement, and information extraction.
- 2. Develop and code algorithms in Matlab (or Python) to apply image and signal processing methods to a range of biomedical image and signal problems.

- 3. Apply mathematical methods to analyse and enhance image quality.
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- 5. Identify and analyse medical image processing requirements for clinicians and medical researchers.

Assessment tasks

- Signal processing
- Image processing
- Neuroimaging project

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcome

- 5. Identify and analyse medical image processing requirements for clinicians and medical researchers.

Assessment tasks

- Signal processing
- Image processing
- Neuroimaging project
- Presentation

Socially and Environmentally Active and Responsible

We want our graduates to be aware of and have respect for self and others; to be able to work with others as a leader and a team player; to have a sense of connectedness with others and country; and to have a sense of mutual obligation. Our graduates should be informed and active participants in moving society towards sustainability.

This graduate capability is supported by:

Assessment task

- Presentation