The University Of Queensland AUSTRALIA | CREATE CHANGE

Pattern Analysis

Course Introduction

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V1.1

> “A mathematician, like a painter or a poet, is a maker of patterns. If his patterns are more permanent than theirs, it is because they are made with ideas.”
>
> **Godfrey H. Hardy (link)**
> (1877-1947)


$z = z^2 + c$

Deep Learning Revolution!

Artificial Neural Networks revitalising Artificial Intelligence (AI)!

Deep Neural Networks is the main driver.

Takes days to train, runs in milliseconds regardless of task!

Graphics Cards

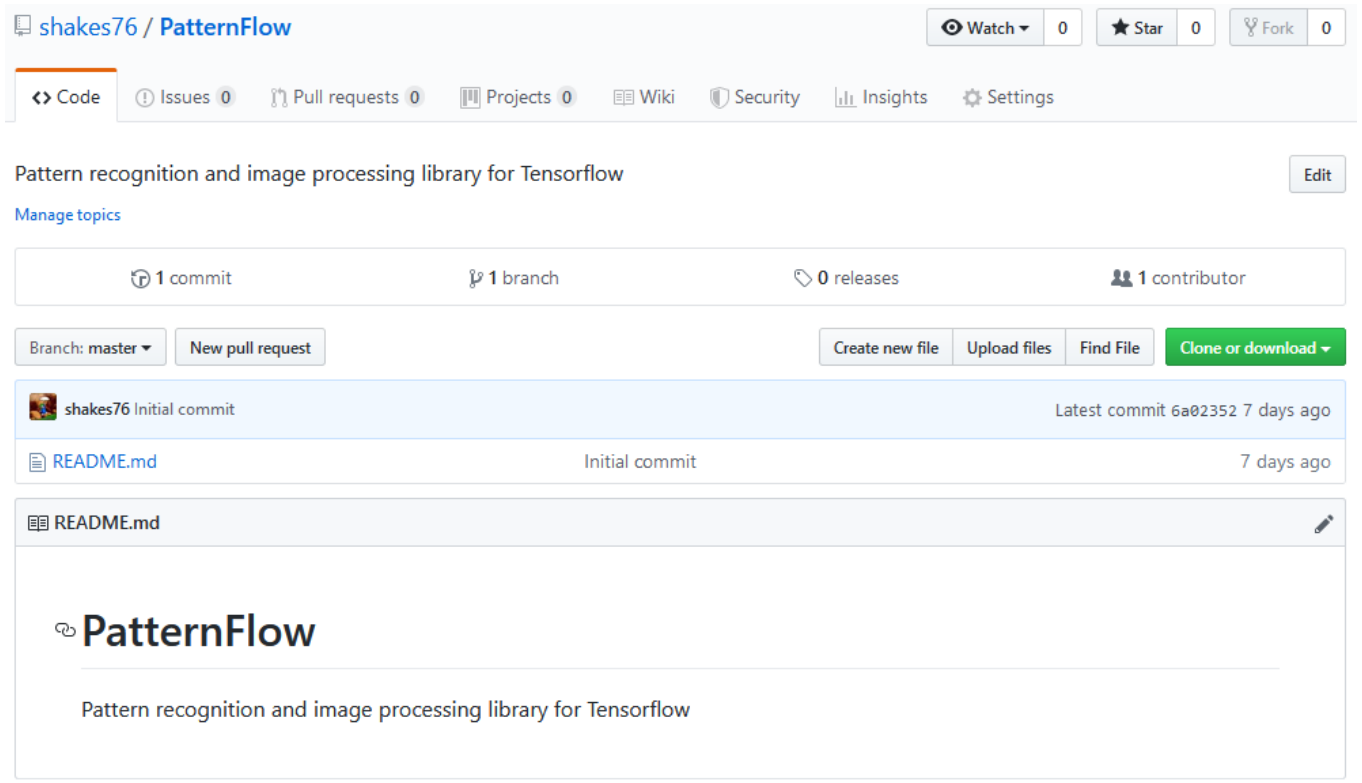
If you use any Google, Facebook, Microsoft and Amazon products, you are already using it!

TensorFlow

- Numpy-like
- Parallel processing under the hood
- Scales to different hardware auto-magically
- Open Source
- Used by industry

TensorFlow

PatternFlow



Your Contribution!

Staying Healthy @ UQ

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Stay home if you are unwell

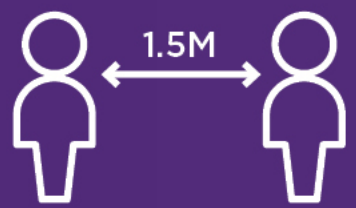
Cover your mouth and nose when you sneeze or cough

Avoid touching your face

Wash your hands thoroughly

Don't share personal items

Clean surfaces



Maintain space between each other

Put used tissues in the bin

Call your General Practitioner (doctor) or UQ Health Care and explain your symptoms

Need the facts? **about.uq.edu.au/coronavirus-advice-uq-community**

Course Coordinators and Teaching Staff

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Webpage

Interests: Image processing, fractals, discrete geometry, medical image analysis, **pattern recognition, machine learning**, MRI, shape modelling and scientific visualisation

Getting Help

Post questions on Piazza
Signup here

All lecturers and most tutors are monitoring this forum!

Use the keyword Noether

If it is a private matter or related to a personal issue

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Getting Help

Think carefully before using email

- Can you get the info via the ECP/External ECP?
- Can you ask the tutors at a tutorial session?
- Is it on blackboard?
- Have you checked the Piazza answers?

Please keep communication concise and polite

Let us know if there are problems

- During tutorials, before and after lectures

Assumed/Helpful Background

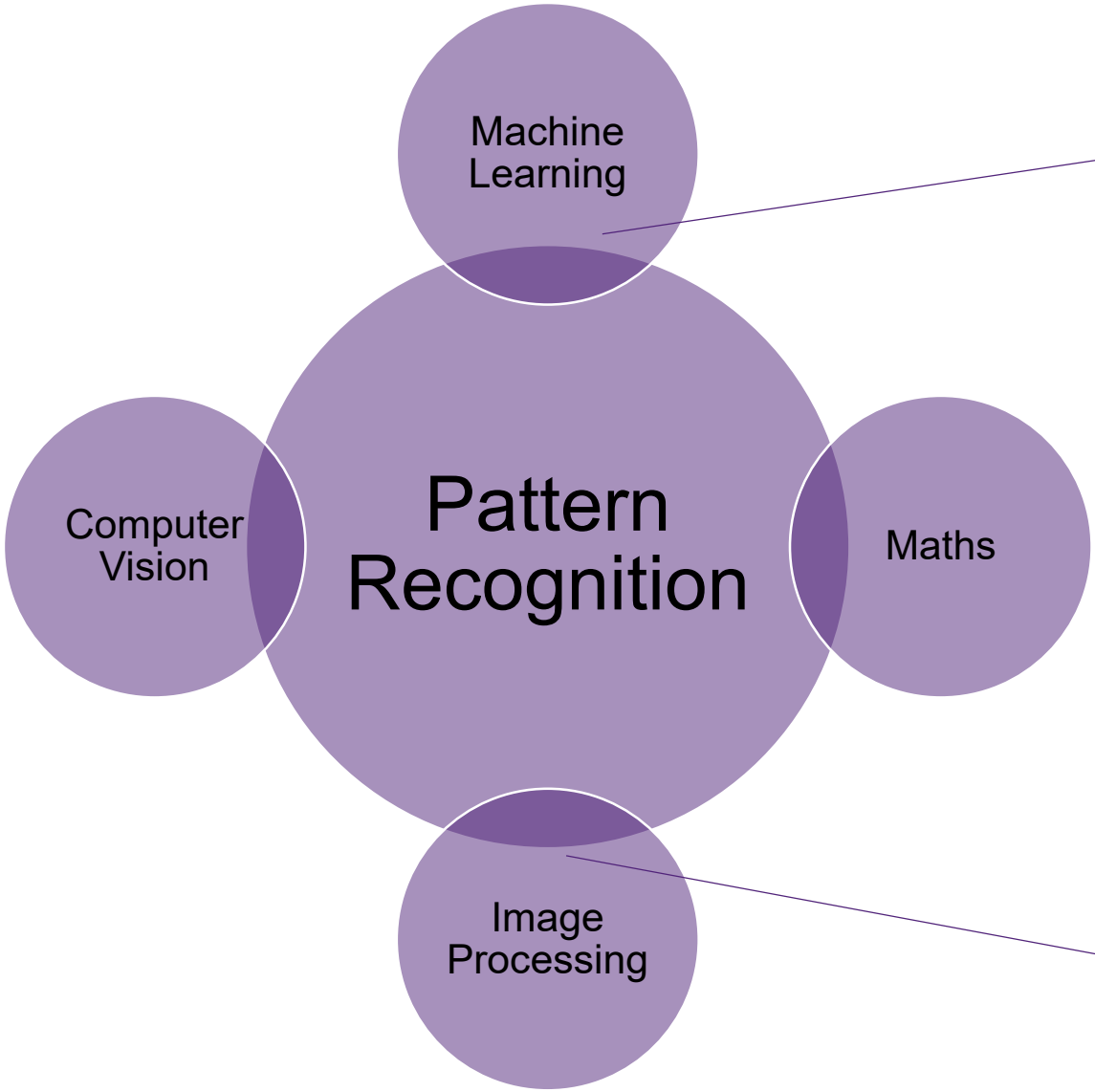
We will be covering material assuming you are familiar with

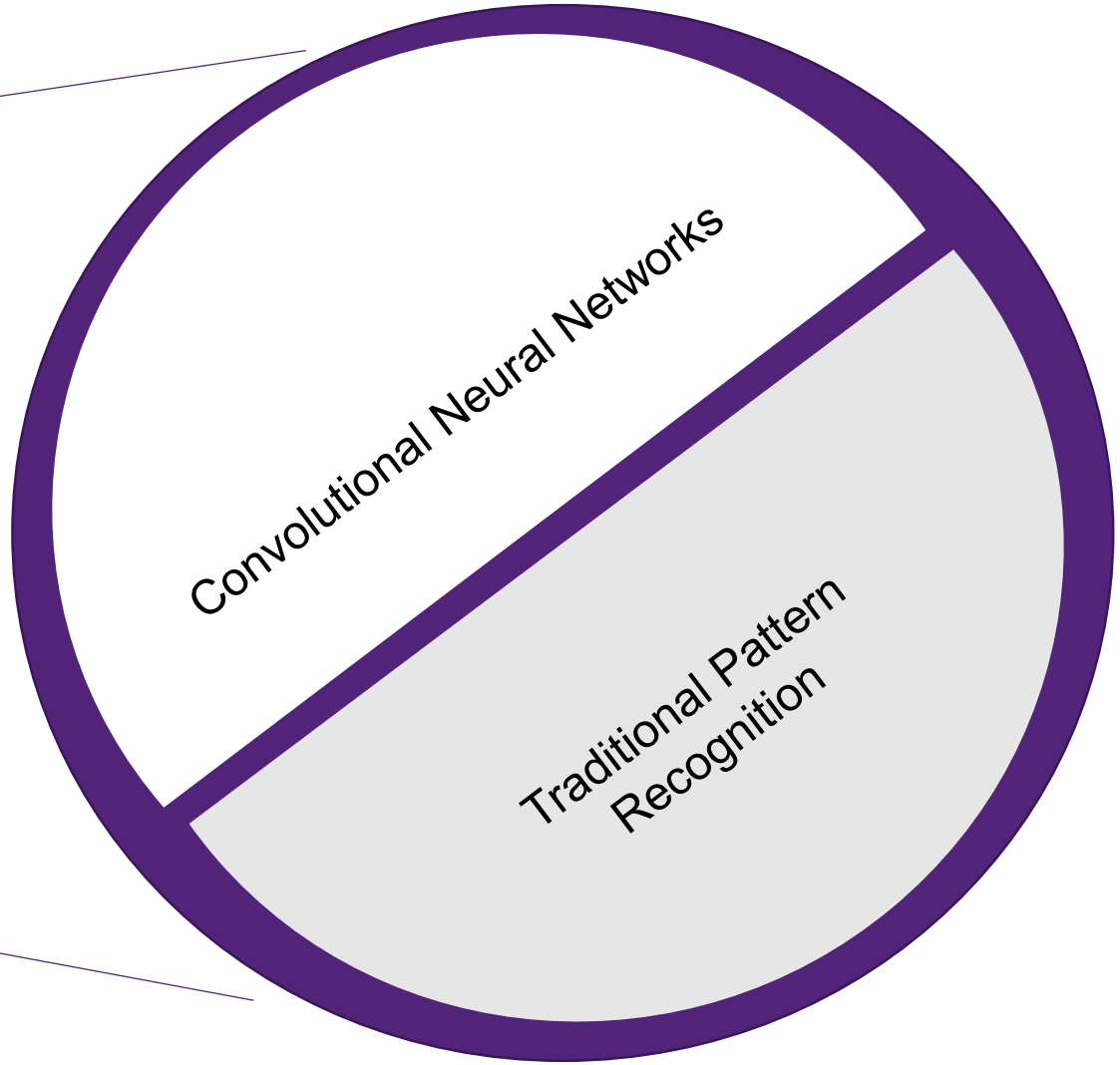
- Linear algebra – vectors, matrices, SVD and vector spaces
- Python programming – dictionaries, lists, recursion, numpy and matplotlib

Important to know any of the following:

- MATH1052 – Vector Calculus
- MATH2302 – Graphs and topology (Basic only)
- COMP3506 – Data structures like trees etc.
- Basic object-oriented programming concepts

If you don’t know any of the above, please read up on and catch up.

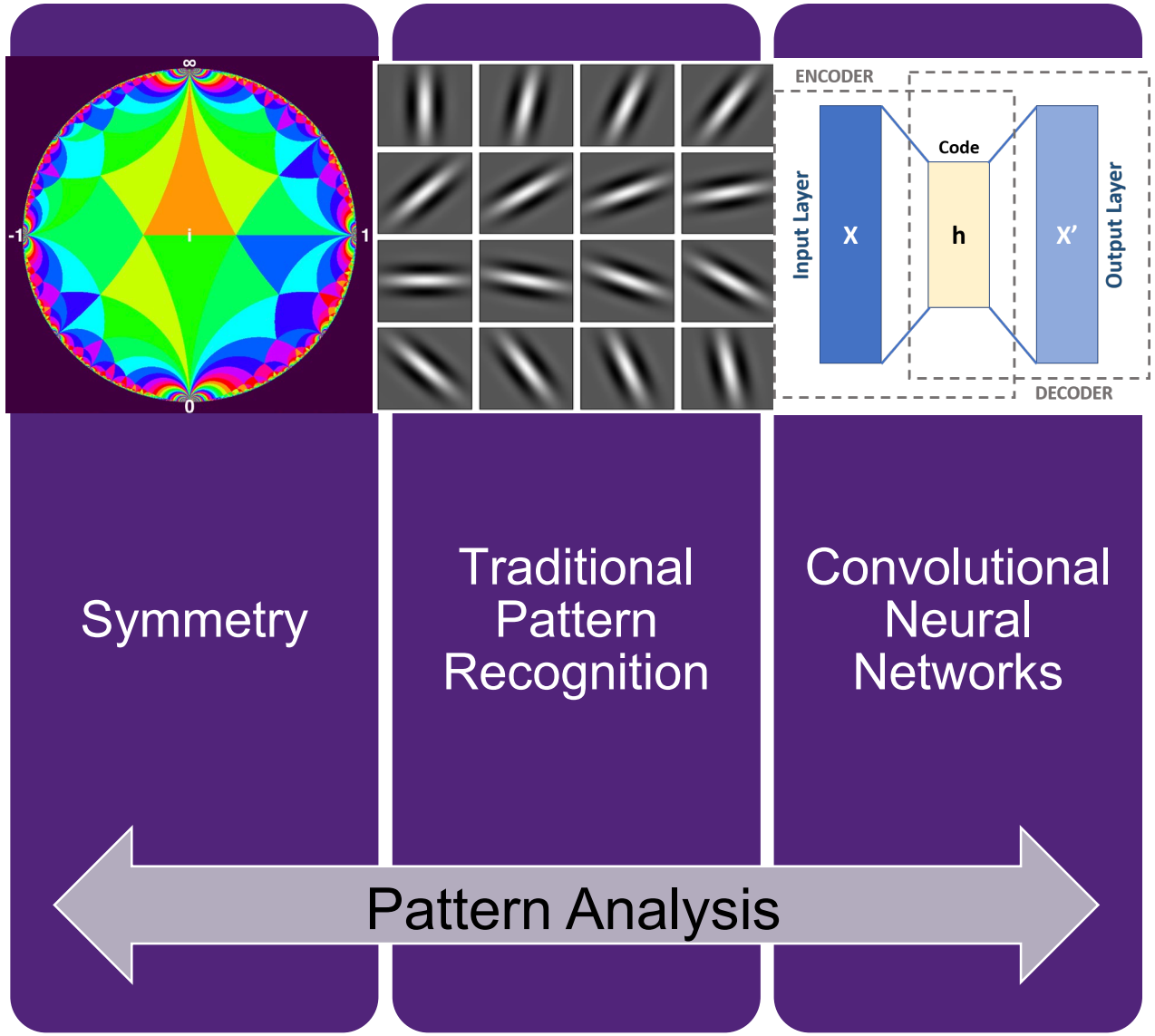

Machine Learning
Computer Vision
Pattern Recognition
Maths
Image Processing


Convolutional Neural Networks
Traditional Pattern Recognition

Course Structure

- Symmetry and Self Similarity
  - Group Theory
  - Fractal Geometry
- Traditional Pattern Recognition
  - Features and Measures
  - Transform Domains/Dimensionality Reduction
    - Fourier Transform
    - Radon Transform
    - Wavelet Transforms
    - Principle Component Analysis
  - Random Forests
- Deep Learning
  - Convolution and Neural Networks
  - Convolutional Neural Networks (CNNs)
  - Deep CNNs

Click on Images for Sources



Glider Gun by By Kieff
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Lecture Schedule

Week	Date	Lectures
1	3/08/2020	Patterns - Symmetry and Self Similarity
2	10/08/2020	
3	17/08/2020	
4	24/08/2020	Traditional Pattern Recognition
5	31/08/2020	
6	7/09/2020	
7	14/09/2020	
8	21/09/2020	Convolutional Neural Networks
Break	28/09/2020	
9	5/10/2020	Convolutional Neural Networks
10	12/10/2020	
11	19/10/2020	Deep Convolutional Neural Networks
12	26/10/2020	
13	2/11/2020	Course Review
		Exam Prep

Course Schedule

Week	Date	Lectures	Pracs	Assessments
1	3/08/2020	Patterns - Symmetry and Self Similarity	Prelim Lab (Not Assessed, No Pracs)	
2	10/08/2020		Fractals with Tensorflow	
3	17/08/2020			
4	24/08/2020	Traditional Pattern Recognition		Demo Code Due and Marked Off
5	31/08/2020		Pattern Recognition Problem	Git Short Course 1 Due
6	7/09/2020			
7	14/09/2020			Mid-Term Due
8	21/09/2020	Convolutional Neural Networks		Demo Code Due and Marked Off
Break	28/09/2020			
9	5/10/2020	Convolutional Neural Networks	Report	Git Short Course 2 Due
10	12/10/2020			
11	19/10/2020	Deep Convolutional Neural Networks		
12	26/10/2020			Report Due
13	2/11/2020	Course Review Exam Prep		

Contact Times

Lectures

Check your timetable

2 hours per week (active learning style)

up to 30 mins per week (video lecture/snippet)

Tutorials/Laboratories

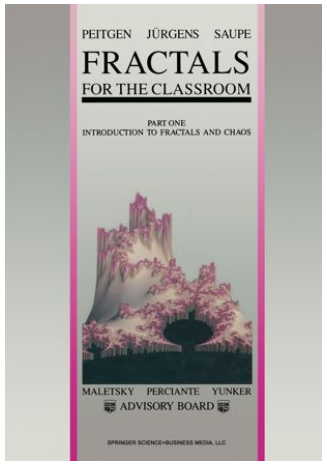
Check your timetable

1 hour tutorial every week (week 2 onwards)

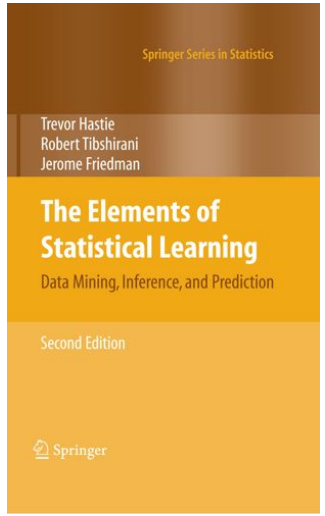
3 hour lab every week (week 2 onwards)

Additional Meeting Times will be announced as needed

Prescribed & Recommended Texts



Peitgen, Jürgens and Saupe **(1992).**
Fractals for the classroom: Part one introduction to fractals and chaos
Oxford University Press.
[eBook – UQ Library]



Hastie, Friedman and Tibshirani **(2001).**
The Elements of Statistical Learning
Springer Series in Statistics
[eBook – UQ Library]

Shekhar Chandra **(????).**
Pattern Analysis: A deep learning approach
Provided on Blackboard

Online Resources

- Google's Python Class website
- Shakes' curated YouTube Playlist of the Course Content
- UQ's partnership with the AWS Educate Program – Sign up using your UQ email
- Tensorflow and Keras Tutorials
- Popular Maths and Compute Science YouTube Channels:
  - Computerphile
  - Numberphile
  - 3Blue1Brown
- Stanford Encyclopedia of Philosophy's entry on Geometry
- Shakes' Book – Pattern Analysis (Coming Soon)

Assessment (Flexible)

Assessment Task	Due Date	Weighting	Learning Objectives
Demonstration Fractals with Tensorflow	28 Aug 20 18:00	15%	1, 6, 7, 8
Computer Exercise Git Introduction Short Course	06 Sep 20 23:59	0% Pass/Fail	6, 8
Online Quiz Online Quiz	14 Sep 20 17:00	10%	1, 2, 3, 4, 6, 8
Demonstration Pattern Recognition Problem	25 Sep 20 18:00	20%	1, 2, 3, 4, 5, 6, 7, 8
Computer Exercise Git Advanced Short Course	09 Oct 20 23:59	0% Pass/Fail	6, 8
Laboratory Report PatternFlow Algorithm	30 Oct 20 18:00	25%	6, 7, 8
Exam - during Exam Period (Central) Final	Examination Period	30%	1, 2, 3, 4, 5, 8

Check the **Late Submission Policy** (5.3 of the ECP)

Lab Demos

Tasks for each **Lab Demo are required to be done and demo'd by due date**.

Tasks for demos are designed to be done within the allocated number of sessions.

No marks will be awarded after the due date, so show up and complete the demo, preferably early!

Tutors will mark off what has been completed and award marks based on tasks completed. They will also test your knowledge with questions and may deduct marks based on your response(s).

Ensure proper shoes and no food or drink in labs, as well as social distancing.

Please complete the necessary OH&S online form if you plan on attending on campus.

Tutorials (Not Assessed Directly)

Tutorials will cover the theoretical material of the course as short answer questions.

Although tutorials are not compulsory or assessed, the content presented in them will be ***directly related to all exams/quizes*** within the course.

Workload

COMP3710 has 7 hours contact per week

- 3 Lecture, 1 Tutorial and 3 Practical
- Tutorials and Practicals begin in week 2

UQ policy assumes that

- 1 hr contact ~ 1 additional hr non-contact

  ∴ **you need to commit a total of <u>10-12 hrs/week</u> for the course**

- Practicals are designed to be completed with lab times
- The report may require more time, but again labs will be dedicated to this

Shakes' Teaching Style

Lectures will be made up of:

1. Lecture Notes – **Notes in formal teaching style**. To be released before the lectures and will be readable without lecture recording.
2. Instructional Material – **Demonstrations**, explanations or other instructional material that will be described in the lecture. These may include **Jupyter notebooks, animations, demos, active learning** etc.
3. Any **slides used during lectures will be uploaded** to Blackboard.
4. **Mathemagics!** Special segments within lectures to help you appreciate maths and (hopefully) keep you awake!

What to expect from Shakes

- Deliver interesting lectures: theory, examples, expert guest lecturers, notes posted on Blackboard
- To make course content meaningful and accessible
- Provide professional development for you through content taught
- Instruct you in proper software engineering and algorithmic design
- Post helpful content on Blackboard
- Answer ALL questions respectfully
- Respond to queries in reasonable time
- Provide feedback in reasonable time
- Guidelines for exam

What I expect from you

- Attend and participate in lectures, tutes, pracs
- Set out calculations clearly, with diagrams, units, interpretation
- Make sure you understand the fundamentals: keep up
- Ask questions if you:
  - don’t understand
  - can’t see/hear
  - suspect/find an error
- Attempt all the assessments, having a go is the first step
- Complete all assessment on time
- Attend and complete demos using the sessions allocated for it
- Use email sparingly, use Piazza instead
- All communication to be courteous and polite
- If you have a problem,
  - let me know **early** and propose a solution if possible

Conclusion

- We will cover the mathematical theory of patterns - groups
- We will look at fractals and learn Tensorflow in the process
- Then explore traditional pattern recognition to explore how it was done before the deep learning revolution
- Complete the course by learning about convolutional neural networks
- We hope you will find the area(s) you're interested in and that you will know who to approach if you are interested in research!

What's Next?

What are patterns and how can we scientifically quantify them? In the next few lectures we will cover the mathematics of patterns – groups!

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Thank you

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