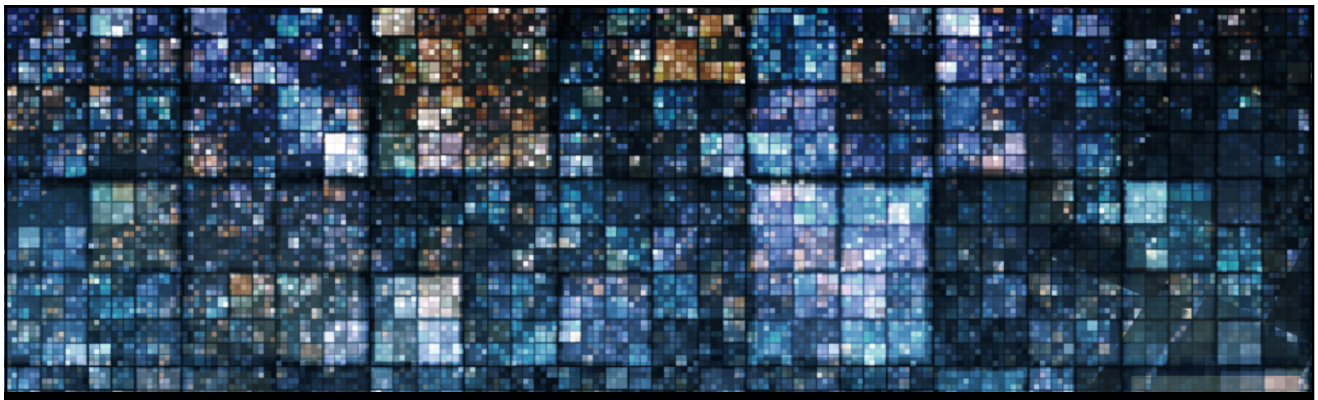


COMP47590
Advanced Machine Learning
Exam Structure

Dr. Brian Mac Namee

Assessment

Exam (50%)
- End of semester exam
- Details later in the semester

Continuous assessment (50%)
- In semester assignments
  - Developing machine learning algorithms
  - Using advanced machine learning algorithms

Exam Structure

The structure of your exam will be as follows:

- Answer 4 questions out of 5
- Question 1: Ensembles
- Question 2: Deep Learning Fundamentals
- Question 3: Deep Learning CNNs & RNNs
- Question 4: Reinforcement Learning
- Question 5: General ML, Evaluation & GDPR

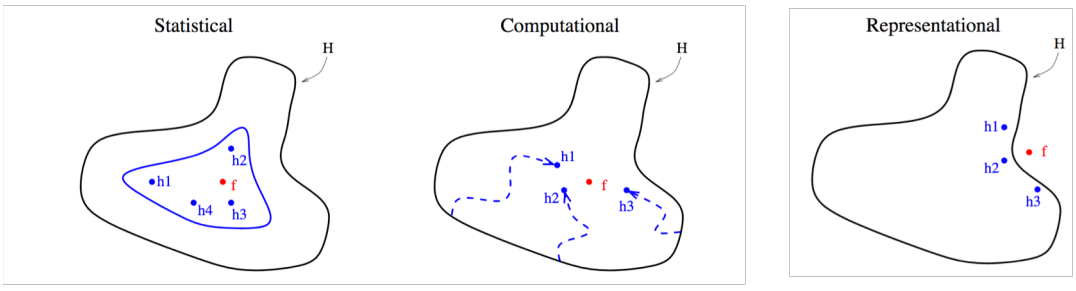
Exam Structure

Some points to note

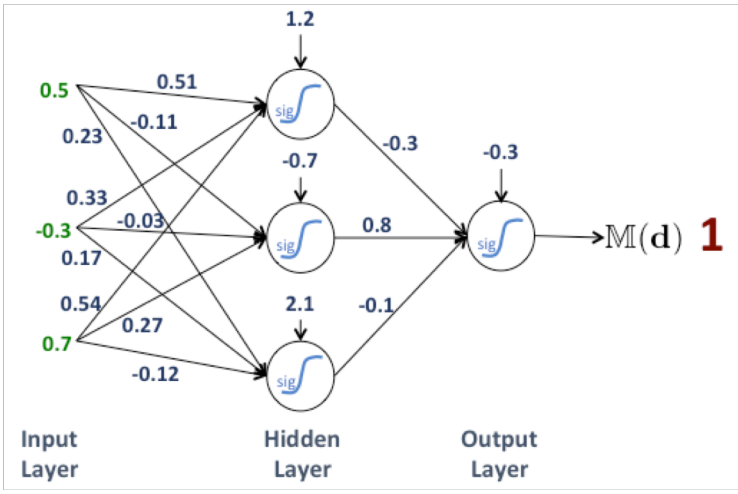
- There will be no code
- You will be asked to perform calculations
  - Bring a calculator
  - You will not be heavily penalised for calculation mistakes, but show your work
- You can be asked about any part of the course
- Questions have a weight associated with them - allocate time accordingly
- Always write some answer

What Follows IS NOT A List Of What Is And Is Not On Your Exam

Question 1: Ensembles



Question 2: Deep Learning Fundamentals

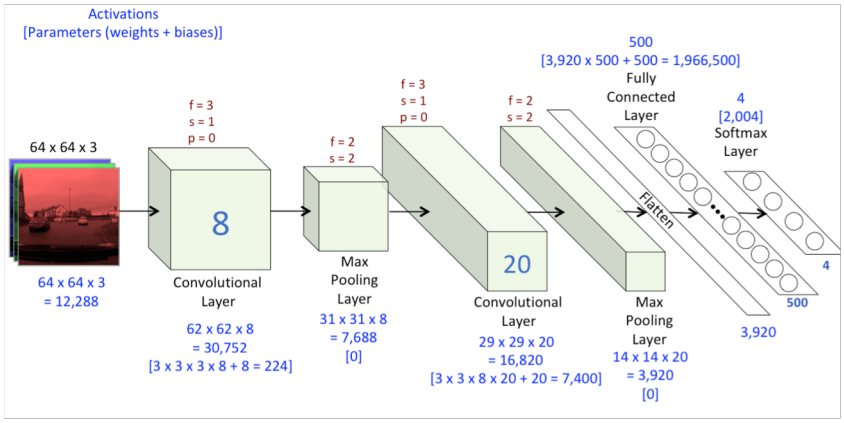


Perform a forward pass through the network

Calculate loss

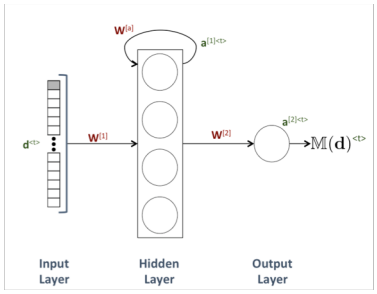
L2 regularisation and optimisers less important

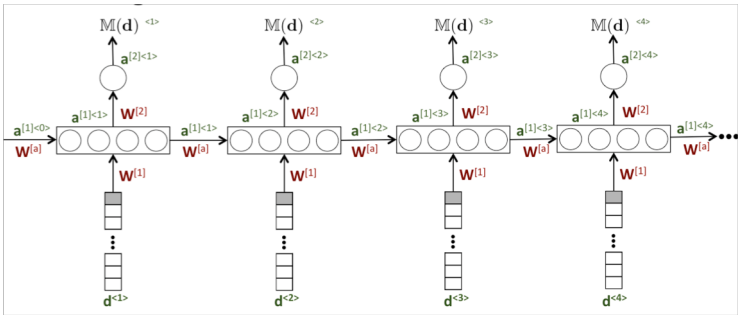
Question 3: Deep Learning CNNs & RNNs



Calculating number of parameters

Question 3: Deep Learning CNNs & RNNs





Unrolling an RNN through time

Also what is difference between different types of RNN

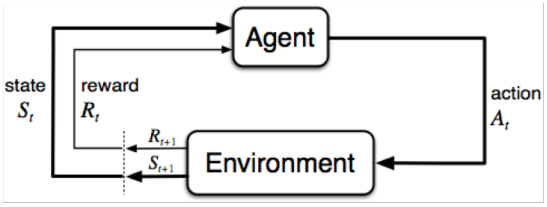
Question 4: Reinforcement Learning

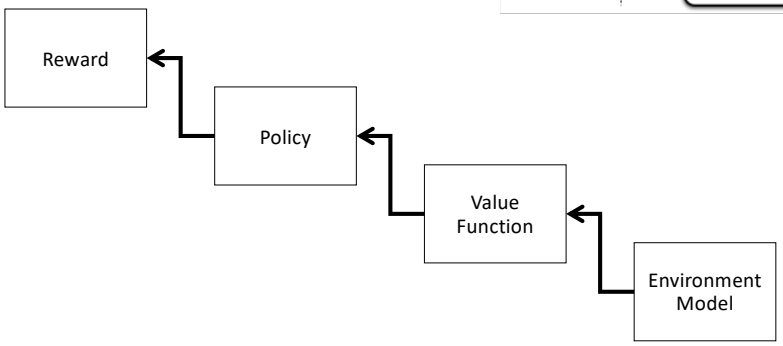
Multi-armed bandits and MDPs are less imortant

Understanding the SARSA (on-policy) and Q-learning (off-policy) algorithms is important

Understanding how deep learning is brought into reinforcement learning framework is important

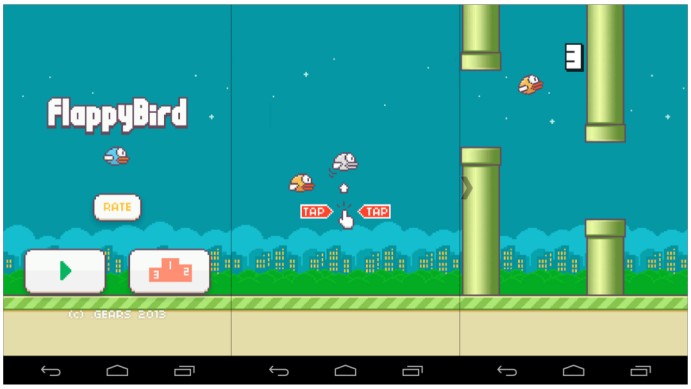
Question 4: Reinforcement Learning





Reinforcement Learning: An Introduction , Second edition, in progress
Richard S. Sutton and Andrew G. Barto, MIT Press, 2017
www.incompleteideas.net/book/the-book-2nd.html

Question 4: Reinforcement Learning



Describe what constitutes a **state**, an **action**, and a **reward**

Question 5: General ML, Evaluation & GDPR

Why might deep learning become illegal?

- General data protection
- Prohibition on profiling and automated decision making
- Right to explantion

	Data 1	Data 2	Data 3	Data 4	Data 5	Data 6	Data 7	Data 8	Data 9	Data 10	Avg Rank
Approach 1	6	7	4	2	8	4	5	1	4	2	4.3
Approach 2	10	10	10	10	10	10	10	10	10	10	10.0
Approach 3	8	6	6	5	7	8	9	7	8	5	6.9
Approach 4	4	1	3	4	6	3	8	6	1	3	3.9
Approach 5	**1**	**5**	**1**	**1**	**1**	**1**	**2**	**4**	**1**	**1**	**1.8**
Approach 6	3	8	5	3	3	5	6	5	6	9	5.3
Approach 7	9	9	9	7	9	9	7	9	9	8	8.5
Approach 8	5	3	7	6	5	7	3	3	7	7	5.3
Approach 9	2	2	2	8	2	2	1	2	1	6	2.8
Approach 10	7	4	8	9	4	6	4	8	5	4	5.9

We recommend a two step process:

- **Friedman aligned rank test** to first test whether a significant difference between the performance of the algorithms over the datasets exists
- If a difference does exist then a pairwise **Nemenyi test** should be performed to show between which algorithm pairs the significant differences exist

What is machine learning?

Machine learning is ill-posed

Overfitting versus underfitting

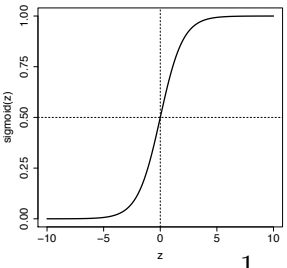
BBY	ALC	ORG	GRP	M_1	M_2	M_3	M_4	M_5	...	M_{1001}
no	no	no	couple	couple	couple	single	couple	couple		couple
no	no	yes	couple	single	couple	single	couple	couple		single
no	yes	no	?	family	family	single	single	single		family
no	yes	yes	single	single	single	single	single	single	...	couple
yes	no	no	?	couple	couple	family	family	family		family
yes	no	yes	family	couple	family	family	family	family		couple
yes	yes	no	family	single	family	family	family	family		single
yes	yes	yes	?	single	single	family	family	couple		family

Equations You Should Know

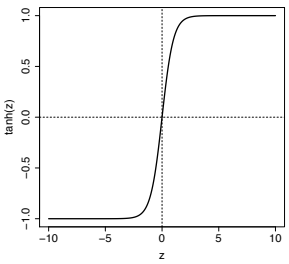
You should be able to reproduce the following equations

- Activation functions
  - sigmoid
  - relu
  - tanh
- Other
  - Log loss
- Reinforcement learning algorithms
  - sarsa
  - q learning

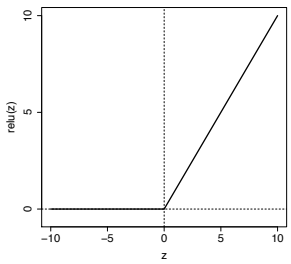
Activation Functions



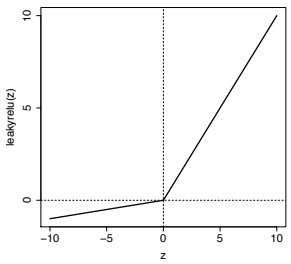
$$sigmoid(z) = \frac{1}{1+e^{-z}}$$



$$tanh(z) = \frac{e^{z}-e^{-z}}{e^{z}+e^{-z}}$$



$$relu(z) = max(0, z)$$



$$leakyrelu(z) = max(0.1\,z, z)$$

Log Loss

$$\mathscr{L}\left(\mathbb{M}(\mathbf{d}), t\right) = -\left((t \times log\left(\mathbb{M}\left(\mathbf{d}\right)\right) + (1-t) \times log\left(1-\mathbb{M}\left(\mathbf{d}\right)\right)\right)$$

Sarsa: On-Policy TD Control

Take action A, observe R, S'
Choose A' from S' using policy derived from Q (e.g., ε-greedy)
$Q(S,A) \leftarrow Q(S,A) + \alpha[R + \gamma Q(S',A') - Q(S,A)]$
$S \leftarrow S'$; $A \leftarrow A'$;

Q-Learning: Off-Policy TD Control

Take action A, observe R, S'
$Q(S,A) \leftarrow Q(S,A) + \alpha[R + \gamma \max_a Q(S',a) - Q(S,A)]$
$S \leftarrow S'$;

Algorithms You Should Know

You should be able to describe the following algorithms

- Ensembles
  - Bagging
  - Boosting
  - Gradient boosting
- Deep learning
  - Gradient descent (stochastic, batch, mini-batch)
  - Forward propagation
  - Backward propagation of error
- Reinforcement learning
  - Sarsa
  - Q learning

Study Readings

L01 Introduction	FMLPDA Chapter 1
L02 Supervised Learning Ensembles 1	FMLPDA Section 4.4.5
L03 Supervised Learning Ensembles 2	FMLPDA Section 4.4.5
L04 Supervised Learning Ensembles 3	FMLPDA Section 4.4.5
L05 Deep Learning Artificial Neural Networks 1	FMLPDA Chapter 7
L06 Deep Learning Artificial Neural Networks 2	FMLPDA Chapter 7 DL Chapter 6
L07 Deep Learning Artificial Neural Networks 3	DL Chapter 6
L08 Deep Learning Artificial Neural Networks 4 CNNs	DL Chapter 9
L10 Deep Learning Artificial Neural Networks 5 Regularisation	DL Chapter 7
L11 Deep Learning Artificial Neural Networks 6 Optimisers	DL Chapter 8

FMLPDA: Fundamentals of Machine Learning for Predictive Data Analytics, MIT Press, John D. Kelleher, Brian Mac Namee and Aoife D'Arcy
https://mitpress.mit.edu/books/fundamentals-machine-learning-predictive-data-analytics
DL: Deep Learning, MIT Press, Ian Goodfellow and Yoshua Bengio and Aaron Courville
http://www.deeplearningbook.org/

Study Readings

L12 Reinforcement Learning 1 (Intro)	RL Chapter 1
L13 Reinforcement Learning 2 (Basics)	RL Chapter 2
L14 Reinforcement Learning 3 (MDPs)	RL Chapter 3
L15 Reinforcement Learning 3 (TD Learning)	RL Chapter 6
L16 Reinforcement Learning 4 (Deep Q Learning)	DL Nature Paper
L17 Evaluation	FMLPDA Chapter 8
L18 Deep Learning Artificial Neural Networks 7 RNNs	DL Chapter 10

FMLPDA: Fundamentals of Machine Learning for Predictive Data Analytics, MIT Press, John D. Kelleher, Brian Mac Namee and Aoife D'Arcy
https://mitpress.mit.edu/books/fundamentals-machine-learning-predictive-data-analytics
DL: Deep Learning, MIT Press, Ian Goodfellow and Yoshua Bengio and Aaron Courville
http://www.deeplearningbook.org/
RL: Reinforcement Learning: An Introduction Second edition, in progress, Richard S. Sutton and Andrew G. Bart
http://incompleteideas.net/book/bookdraft2017nov5.pdf

Questions