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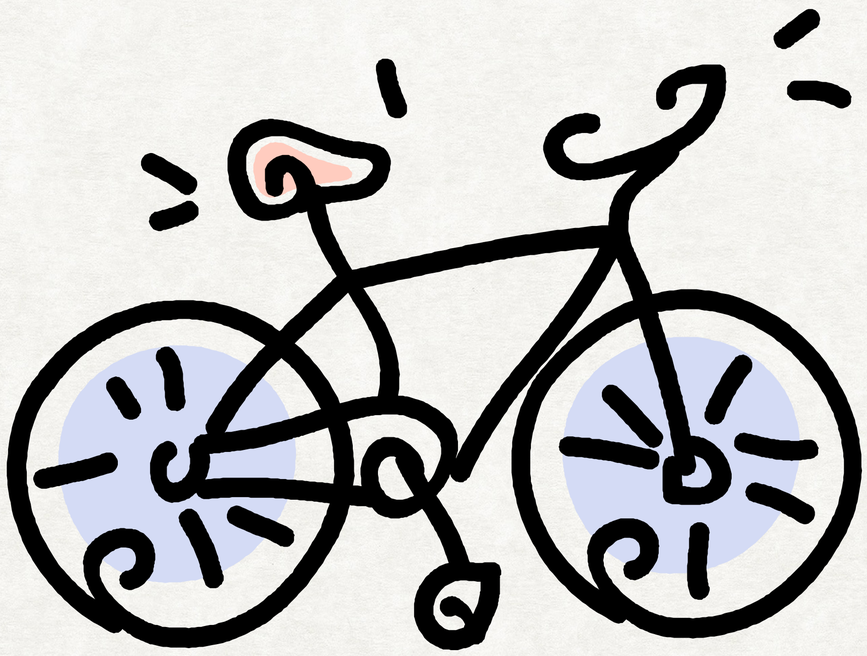
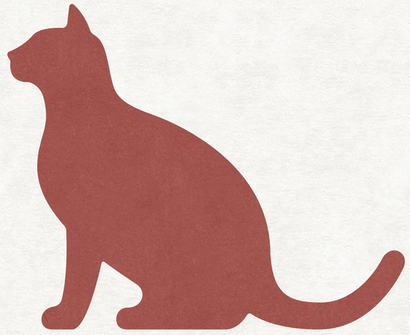
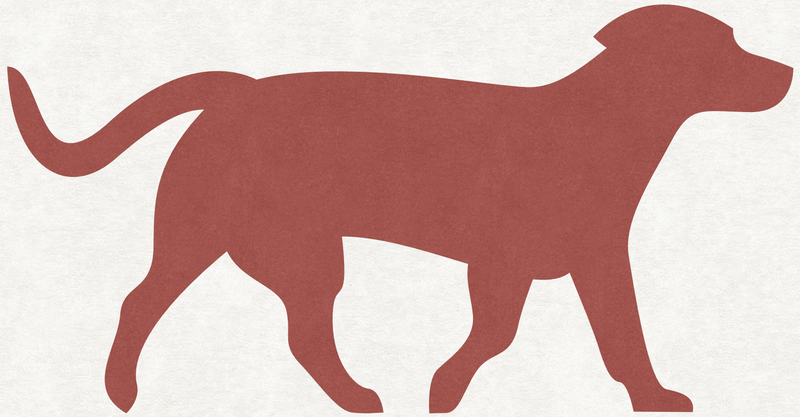
REINFORCEMENT LEARNING

REINFORCEMENT LEARNING

EXAMPLES IN LIFE

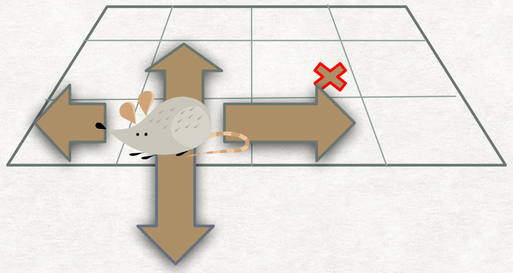


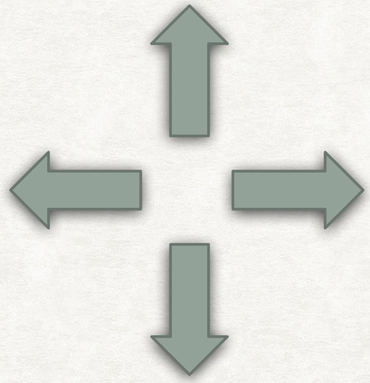




Q-VALUES

IN TEMPORAL DIFFERENCE (REINFORCEMENT) LEARNING





Maximise expected return

Q (state, action)

We do not know the Q values

explore (randomness)

exploit (take “best” action)

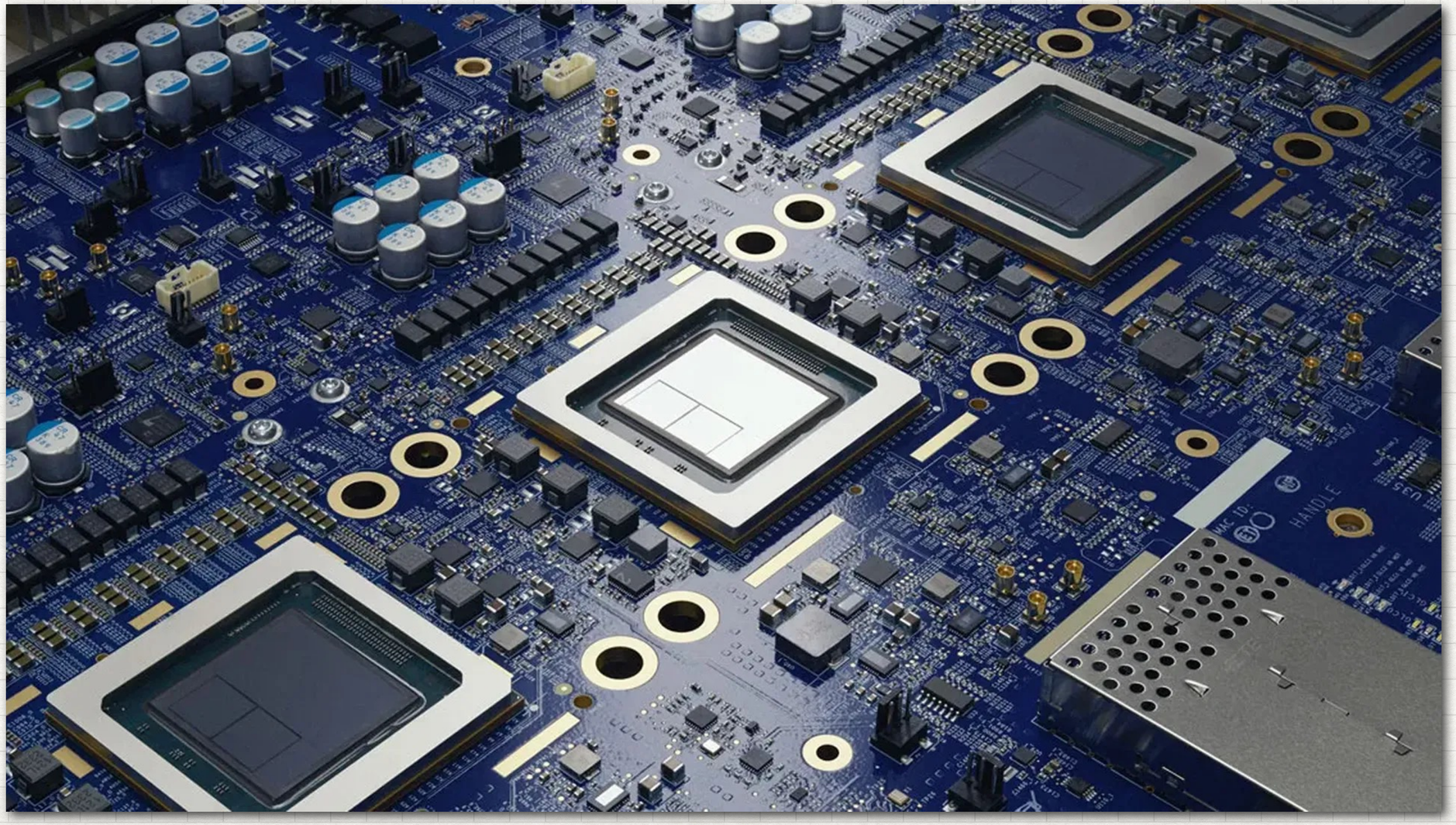
LARGE LANGUAGE MODELS LEARN FROM HUMAN FEEDBACK

OPENAI, ANTHROPIC, GOOGLE / DEEPMIND, ...

https://openai.com/index/chatgpt/

ALPHACHIP OPTIMISED CHIP DESIGN

BY GOOGLE DEEPMIND



https://deepmind.google/research/projects/

MODELLING MARKETPLACE BALANCE

UBER

Uber Blog

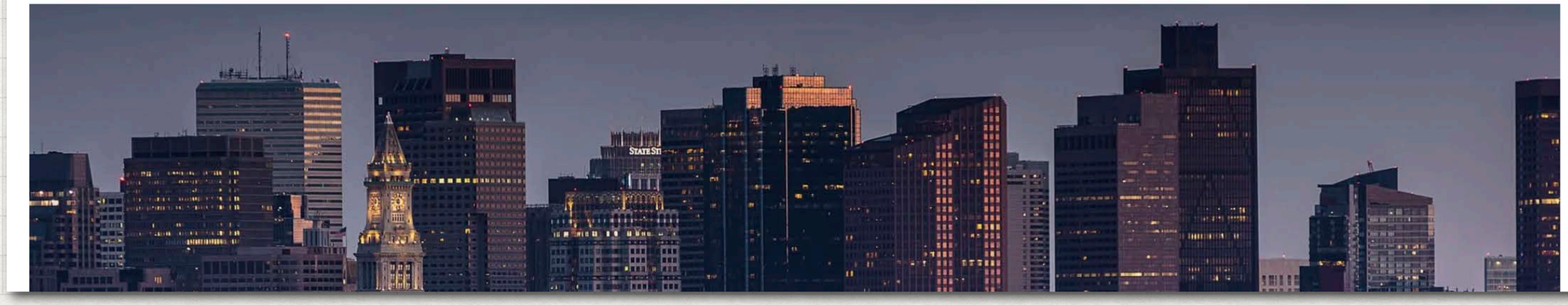
Sign up

Engineering

Engineering, Data / ML, Uber AI

Reinforcement Learning for Modeling Marketplace Balance

2 July 2025 / Global



https://www.uber.com/en-GB/blog/reinforcement-learning-for-modeling-marketplace-balance


GRÆCIA VETUS
ex schædis Sansonianis desumpta,
in quâ
MACEDONIA, THESSALIA, EPIRUS,
ACHAIA et PELOPONESUS,
in minores partes seu populos
distinguuntur;
nec non inter adjacentes insulas speciatim
Creta delinetur Insula.
Samos
Epicurus, (born 341 bc, Samos, Greece—died 270, Athens)


GRÆCIA VETUS
ex schædis Sansonianis desumpta,
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MARE MACEDONICUM
MARE GRÆCUM
MARE CRETICUM
MARE IONIUM
Lampsacus
Occidens
Oriens
Corcyra Ins.
Cephalenia Ins
Cyclades Insulæ
Sporades Insulæ

THE SCHOOL OF EPICURUS

AND HIS MOST PRAISED STUDENT

Themista of Lampsacus (Greek: Θεμίστη), the wife of Leonteus, was a student of Epicurus, early in the 3rd century BC.[1] Epicurus' school was unusual in the 3rd century, in that it allowed women to attend, and we also hear of Leontion attending Epicurus' school around the same time. Cicero ridicules Epicurus for writing "countless volumes in praise of Themista," instead of more worthy men such as Miltiades, Themistocles or Epaminondas.[2] Themista and Leonteus named their son Epicurus.[3]

https://en.wikipedia.org/wiki/Themista_of_Lampsacus


Girton College, Cambridge est. 1869

WOMEN'S RIGHT TO VOTE

SWITZERLAND, 1990

12 December 1971	Bern, Thurgau
23 January 1972	St. Gallen
30 January 1972	Uri
5 March 1972	Schwyz and Graubünden
30 April 1972	Nidwalden
24 September 1972	Obwalden
30 April 1989	Appenzell Ausserrhoden
27 November 1990	Appenzell Innerrhoden (by decision of the Federal Supreme Court of Switzerland)
The Jura, created by secession from Berne on 20 March 1977, has always had women's suffrage.	

https://en.wikipedia.org/wiki/Women%27s_suffrage_in_Switzerland

“

Pleasure is our first and kindred good. It is the starting-point of every choice and of every aversion

— Epicurus’ *Letter to Menoeceus*
Diogenes Laertius, *Lives of Eminent Philosophers*

”

https://classics.mit.edu/Epicurus/menoec.html

“

and to it we come back, inasmuch as we make feeling the rule by which to judge of every good thing.

”

— Epicurus’ *Letter to Menoeceus*
Diogenes Laertius, *Lives of Eminent Philosophers*

https://classics.mit.edu/Epicurus/menoec.html

REWARDS AND PUNISHMENTS

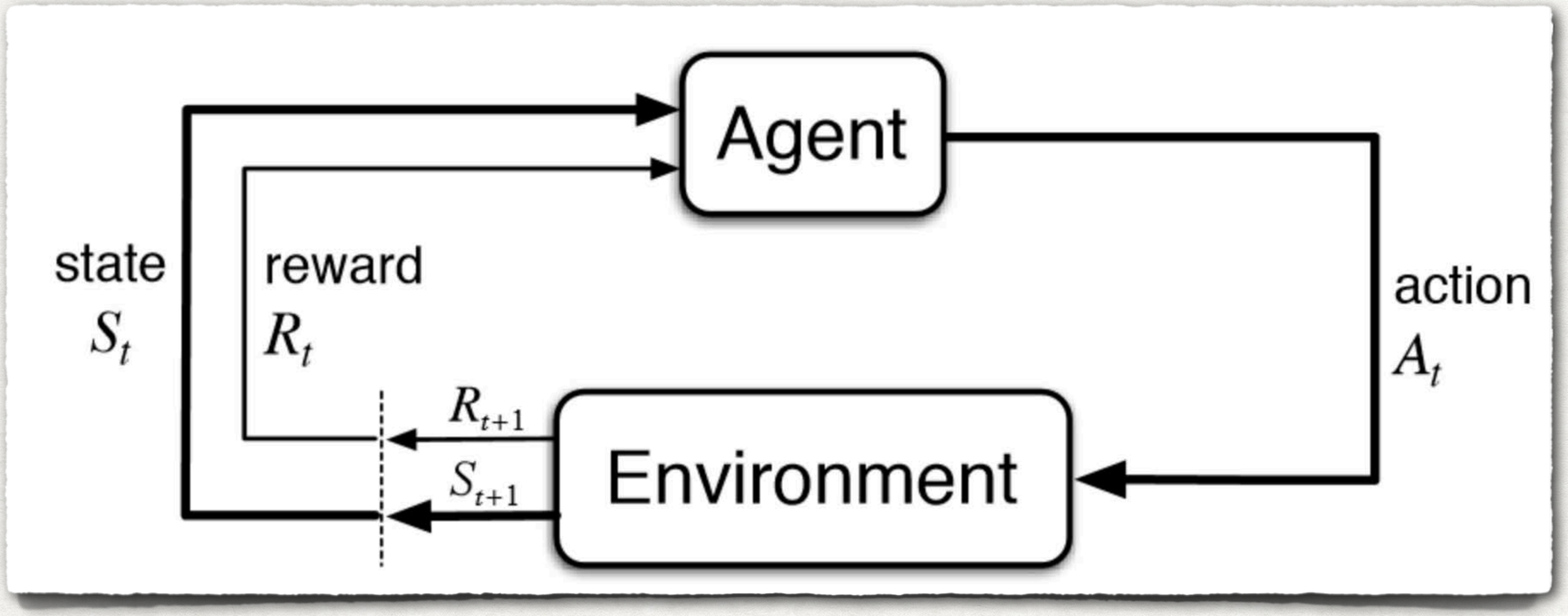
IN EPICUREAN PHILOSOPHY

Good=Pleasure

Evil=Pain

REINFORCEMENT LEARNING SCHEME

COMPATIBLE WITH THE EPICUREAN VIEW OF THE WORLD



Sutton and Barto (2018), with permission

REWARDS AND PUNISHMENTS

IN REINFORCEMENT LEARNING

Good=Reward

Evil=Negative Reward
(i.e. Punishment)

“

By pleasure we mean the absence of pain in the body and of trouble in the soul.

— Epicurus’ *Letter to Menoeceus*
Diogenes Laertius, *Lives of Eminent Philosophers*

”

https://classics.mit.edu/Epicurus/menoec.html

“

It is not an unbroken succession of drinking-bouts and of merrymaking [...], which produce a pleasant life; it is sober reasoning, searching out the grounds of every choice and avoidance, [...]

”

— Epicurus’ *Letter to Menoeceus*
Diogenes Laertius, *Lives of Eminent Philosophers*

https://classics.mit.edu/Epicurus/menoec.html

EXPECTED RETURN

IN REINFORCEMENT LEARNING

$$G_t = R_{t+1} + R_{t+2} + R_{t+3} + \ldots + R_{t+N}$$

Vasilaki (2017) arXiv:1710.04582

https://i.kym-cdn.com/entries/icons/original/000/000/879/garfield-coffee.jpg

DISCOUNT FACTOR

IN REINFORCEMENT LEARNING

$$G_t = R_{t+1} + R_{t+2} + R_{t+3} + \ldots + R_{t+N}$$

$$G_t = R_{t+1} + \gamma R_{t+2} + \gamma^2 R_{t+3} + \gamma^3 R_{t+4} + \ldots$$

$$0 \leq \gamma < 1$$

This is why I am impatient

FRIENDSHIP VS ROMANCE

IN EPICUREAN PHILOSOPHY

$$Q(friendship) > Q(romance)$$

FRIENDSHIP VS ROMANCE

IN EPICUREAN PHILOSOPHY

$$Q(state, friendship) > Q(state, romance)$$

REWARD PERCEPTION
AND THE SARSA ALGORITHM

$$\Delta Q(S_t, A_t) = \alpha \left[(R_{t+1} + \gamma Q(S_{t+1}, A_{t+1})) - Q(S_t, A_t) \right]$$

What I "actually" get — *Anticipated reward*

A positive reward may feel like punishment

A negative reward may feel like reward

REWARD PERCEPTION
AND THE SARSA ALGORITHM

$$\Delta Q(S_t, A_t) = \alpha \quad (1 \quad - \quad 0)$$

What I “actually” get *Anticipated reward*

Reward, Positive Change

REWARD PERCEPTION
AND THE SARSA ALGORITHM

$$\Delta Q(S_t, A_t) = \alpha \quad \big((-1) \quad - \quad 0\big)$$

What I "actually" get *Anticipated reward*

Punishment, Negative Change

REWARD PERCEPTION
AND THE SARSA ALGORITHM

$$\Delta Q(S_t, A_t) = \alpha \quad (1 \quad - \quad 10)$$

What I “actually” get

Anticipated reward

Negative change:

A positive reward may feel like punishment

REWARD PERCEPTION
AND THE SARSA ALGORITHM

$$\Delta Q(S_t, A_t) = \alpha \left((-1) - (-10) \right)$$

What I "actually" get — *Anticipated reward*

Positive change:

A negative reward (punishment) may feel like reward

EFFORT

AND THE SARSA ALGORITHM

$$G_t = R_{t+1} + \gamma R_{t+2} + \gamma^2 R_{t+3} + \gamma^3 R_{t+4} + \dots$$

$$0 \leq \gamma < 1$$

The effort involved in taking an action
can be modelled as a negative reward

Not obvious to an external observer!

HAPPINESS

AND THE SARSA ALGORITHM

- I am better off when I have low expectations.
- I only observe other people successes (rewards). Not their efforts!
- When considering achievements, is an inherent element of luck.

REINFORCEMENT LEARNING

PHILOSOPHY

- The lecture is contained in the lab notes.
- In addition, lab notes have exercises and further explanations.

REINFORCEMENT LEARNING

PREREQUISITES

- Derivatives (& partial derivatives), the chain rule.
- Probabilities & Statistics.
- Matrix Algebra.
- **You will need pen and paper for the lab (and perhaps for the lectures too).**

REINFORCEMENT LEARNING

KEY TOPICS

- Immediate Rewards (Bandit problems).
- Future Rewards (Q-Learning, SARSA, Deep Reinforcement Learning…).
  - For Deep RL we will be covering ANN and Deep Learning.
  - Bellman Equations and Reinforcement Learning.
- Research topics.

REINFORCEMENT LEARNING

GENERATIVE AI

- Is permitted in accordance to the school regulation (see student handbook).
- Organic to exploring the lab material.
- Has been used to support the material of this module.

REINFORCEMENT LEARNING

EVALUATION

- One assignment covering theory and practice (40%, pass/fail).
- A formal exam (60%, 0-100 scale).

REINFORCEMENT LEARNING

CONTACT

- During the lab sessions 3-5 on Thursdays.
- Office hours 11am-12pm on Thursdays.

SUGGESTED READING

- Introduction to Reinforcement Learning, R.S. Sutton and A.G. Barto" http://incompleteideas.net/book/the-book.html

THANK YOU!