Adaptive Systems

Lecture 1.1: Introduction to the Adaptive Systems module

University of Sussex

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Contacting me

Email

- I will normally reply within 2 working days

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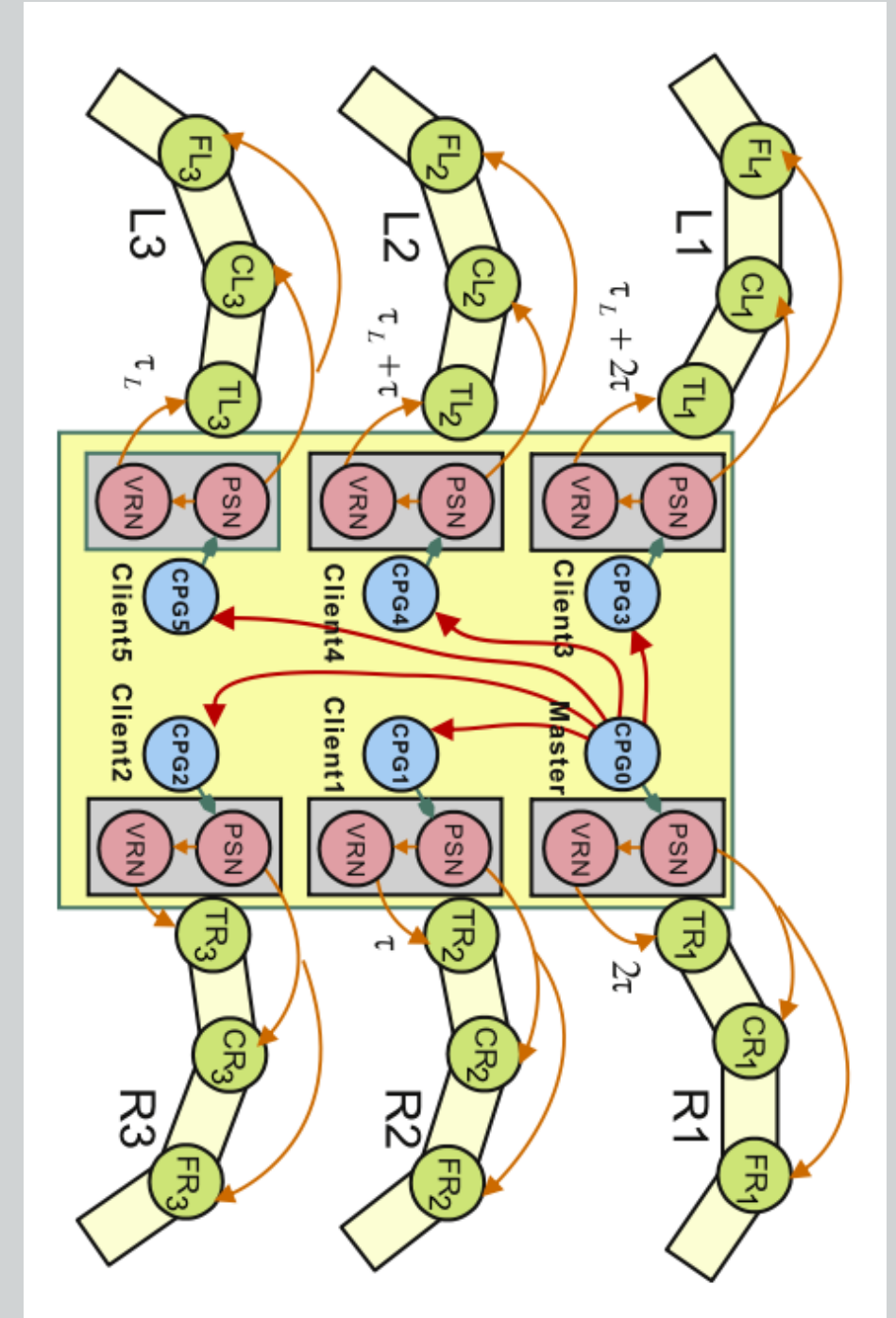
Canvas discussions

- Everyone can see my answers

- I will normally check these at least twice a week

My office hours

- TBD

Lecture outline

1. Introduction to adaptive systems
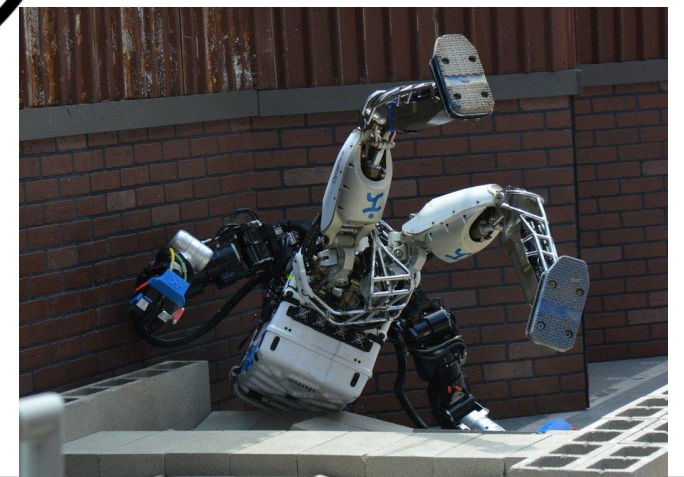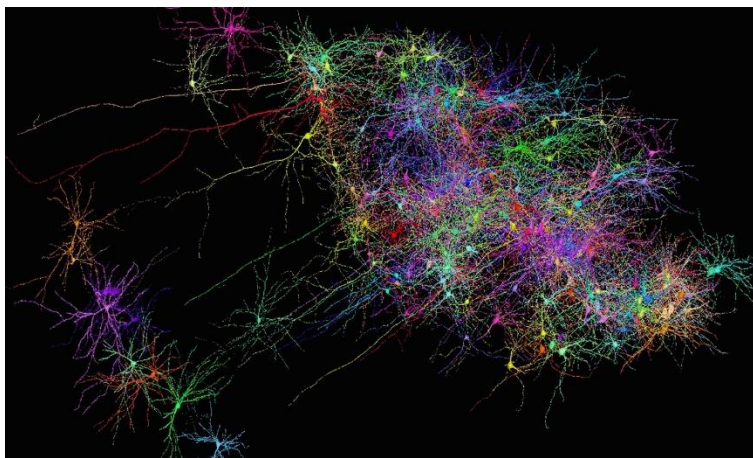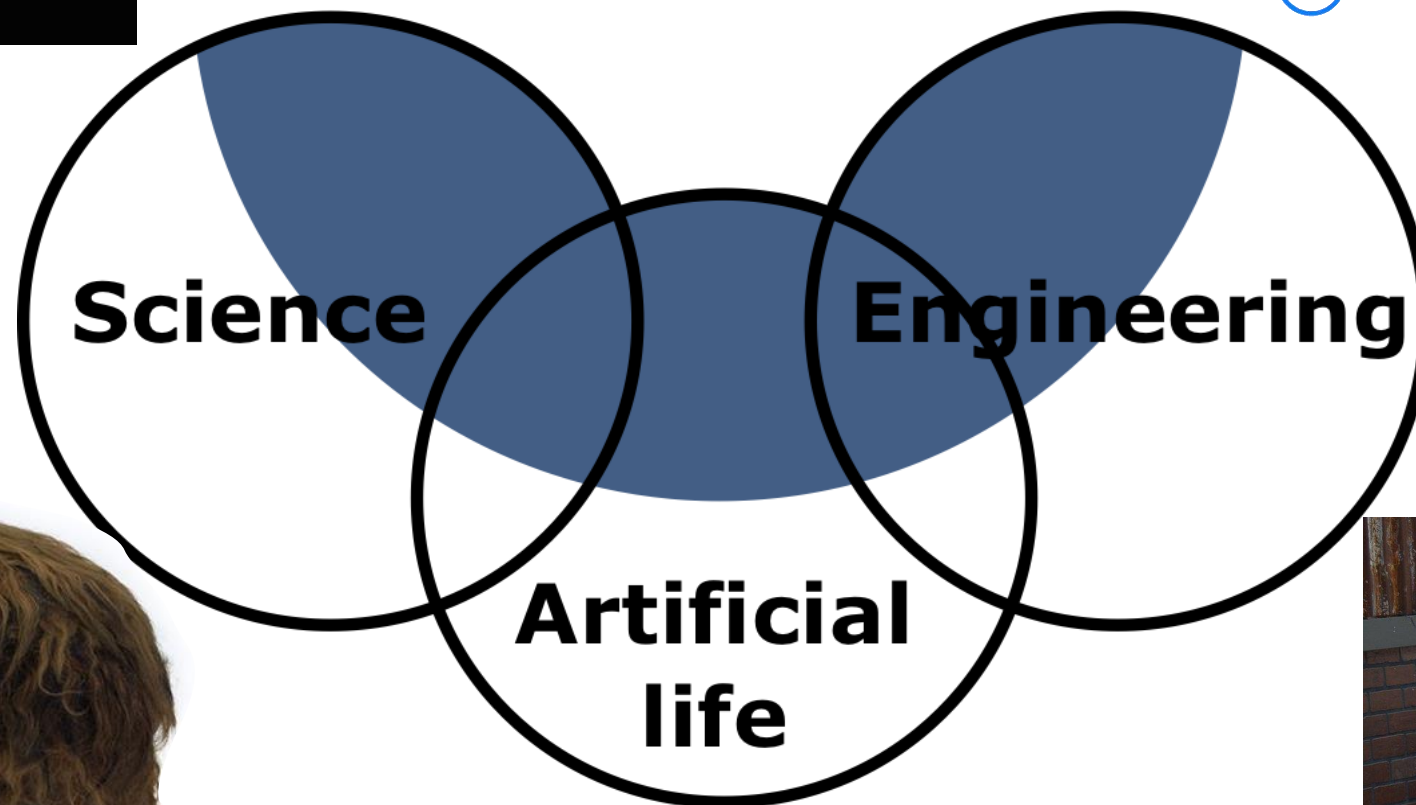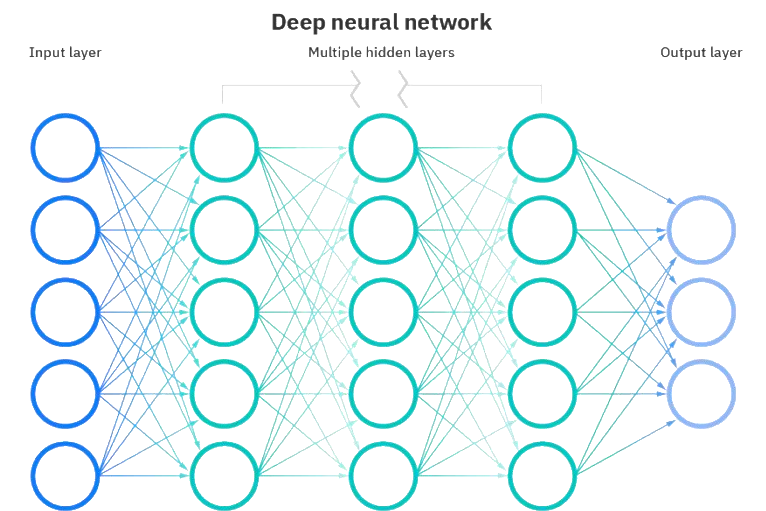
2. Module structure

   1. Classes

   2. Assessments

[1]

Introduction to adaptive systems

Why study adaptive systems?

- **Broadly speaking, there are two reasons:**

  1. **The pursuit of knowledge (scientific) - e.g. to understand and model natural adaptive systems**

  2. **Technological (engineering) - so that we can make useful artificial adaptive systems (e.g. software systems & robots)**

- **Many researchers are actively involved in both of these research programmes - studying *either* one can help to understand the other**

- **So, whether our main interests are scientific or technological, we should study both natural and artificial adaptive systems**

  - **As we will on this module**

Why study natural adaptive systems?

- **In general, they are superior to our own creations**

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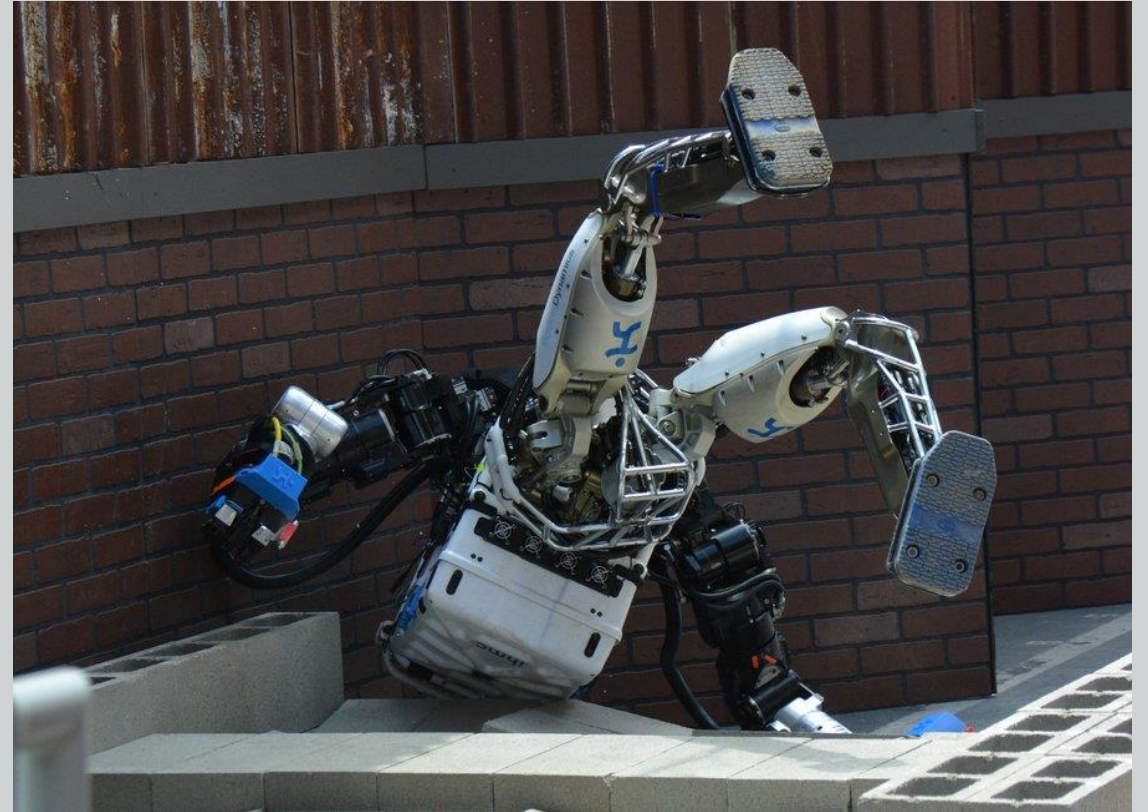
[12]

- **They are smarter, more agile, and more dextrous**

Also, we _are_ natural adaptive systems

Why study natural adaptive systems?

- **Because they can inspire our own designs**

(a) Single CPG controller   (b) Multiple CPGs controller
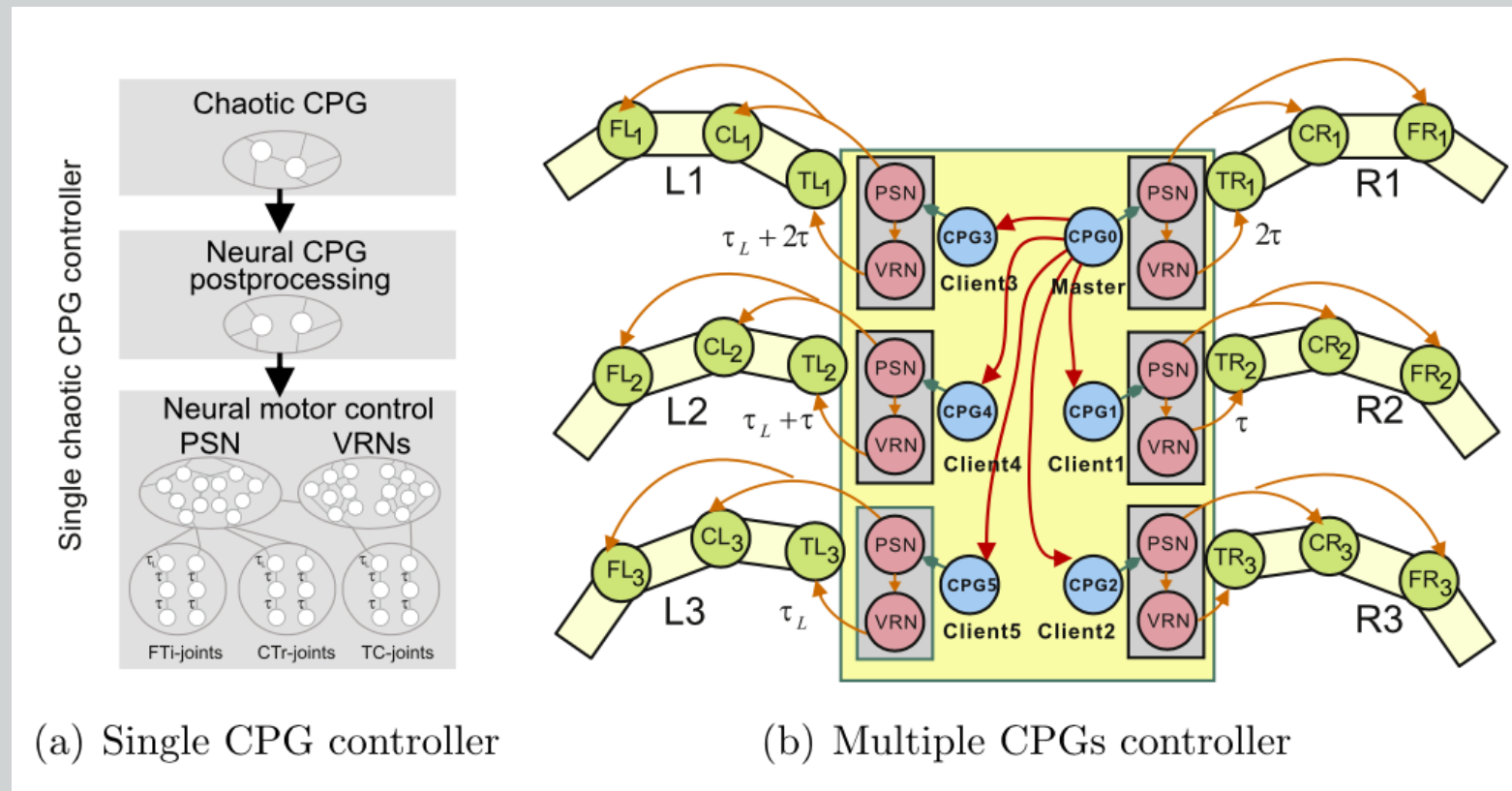
[1]

- **In this single example from robotics we see:**

  - **Hexapod body (insect-inspired)**

  - **Artificial neural network (inspired by animal nervous systems)**

  - **Central pattern generators for locomotion (inspired by specific circuits in animal nervous systems)**

  - **Neural circuits with chaotic dynamics**

Why study artificial adaptive systems?

- **We study artificial adaptive systems because:**

    1. **We can experiment with them easily**

        - **For example, in a simulation we can keep a complete record of all variables for analysis (as we will in our labs)**
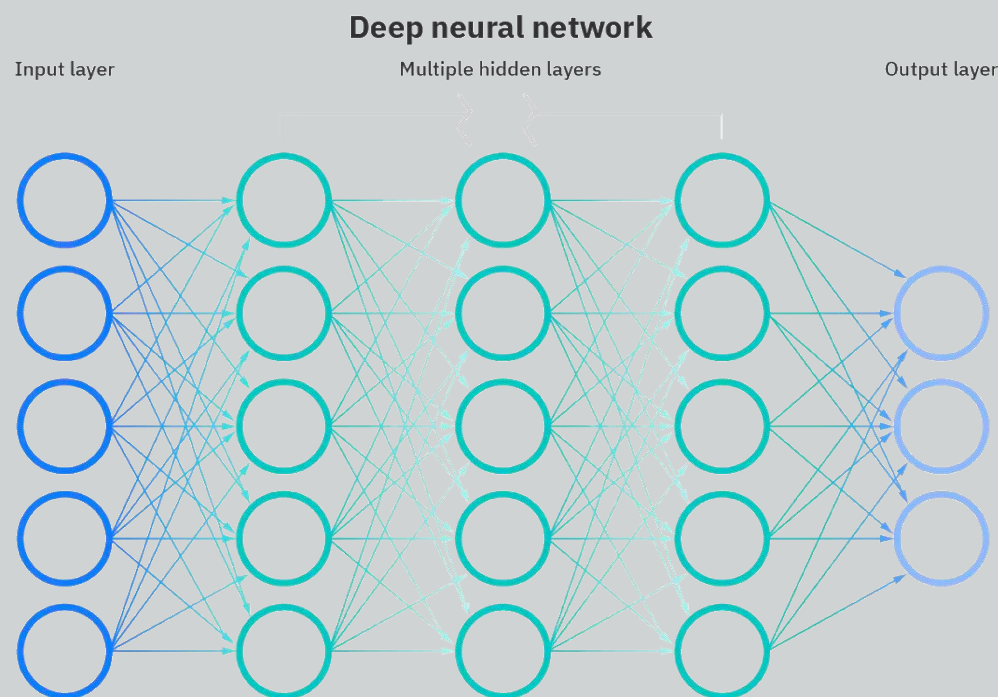
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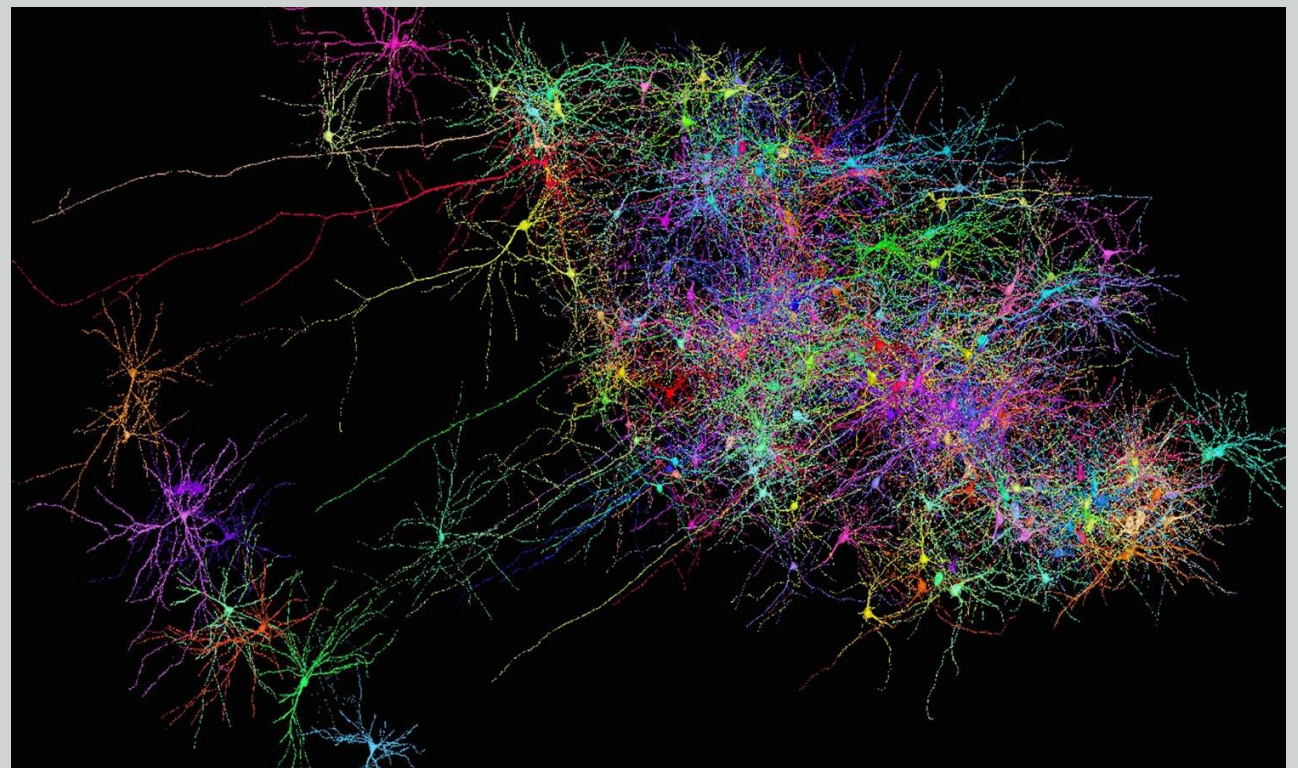
[21]

Why study artificial adaptive systems?

- We study artificial adaptive systems because:

    2. We may discover principles which also apply to natural systems

    3. We can copy their designs for our own applications

Deep neural network

Input layer   Multiple hidden layers   Output layer
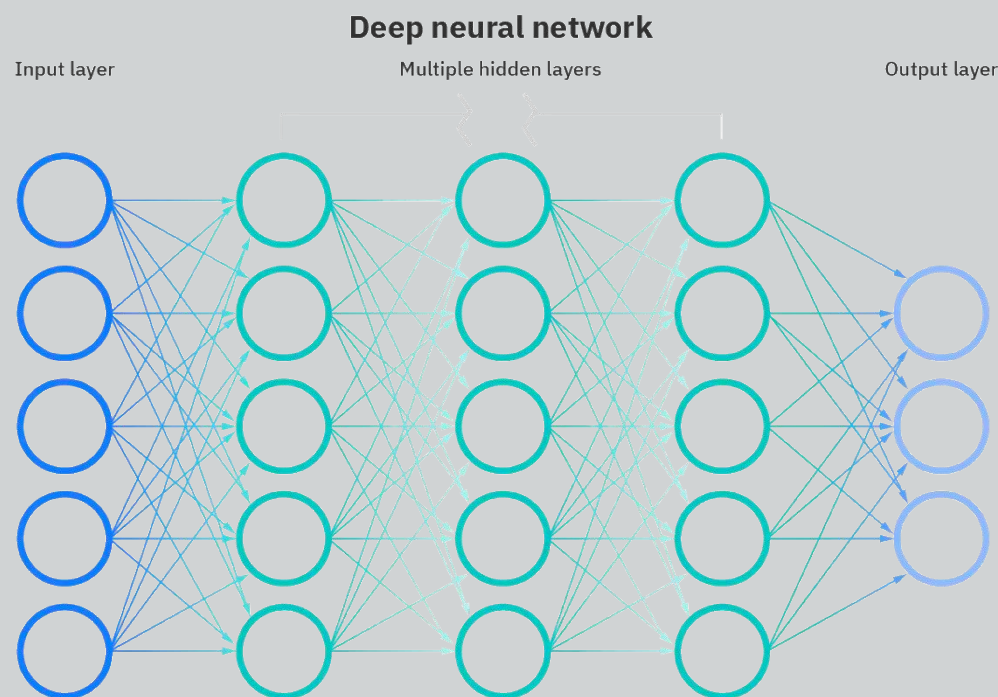
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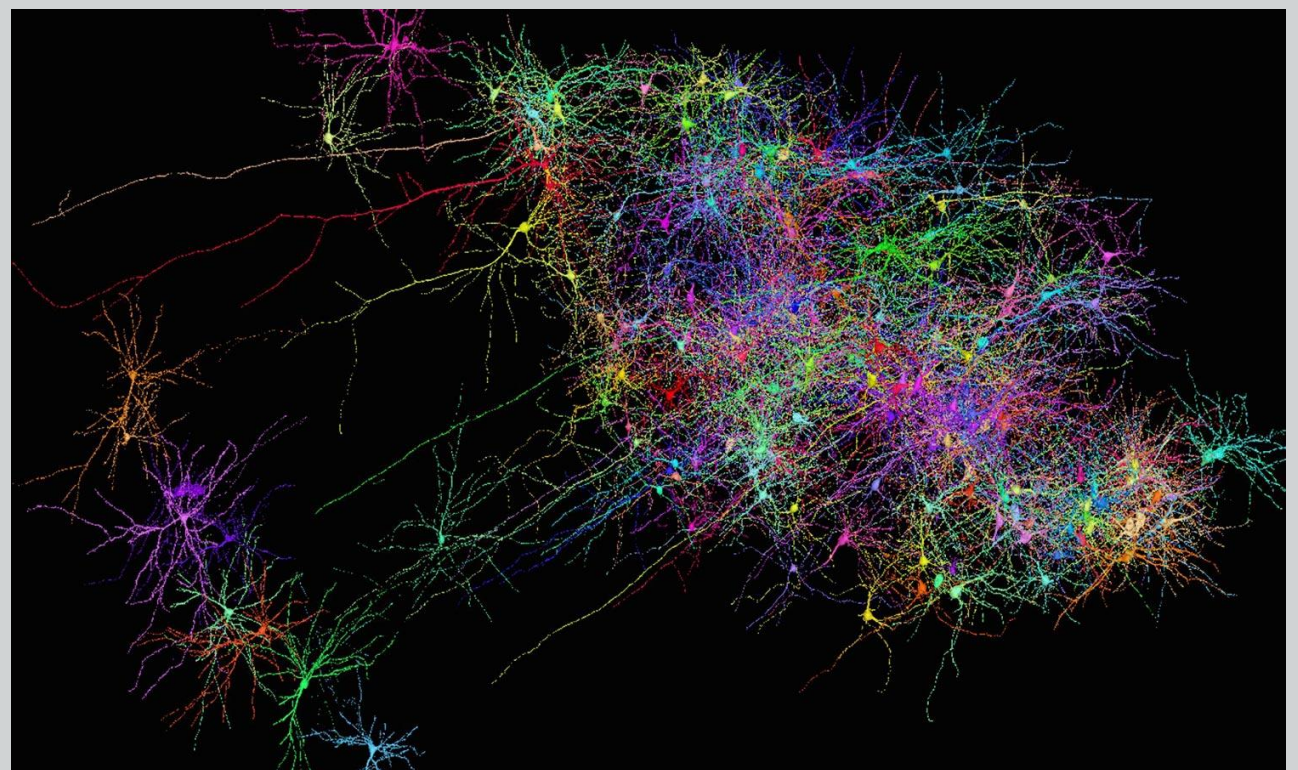
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Module structure

Module structure

Lectures

- **A series of 10 Lectures, on adaptive systems theory.**

Lab classes

- **5 lab classes, where you will apply adaptive systems theory to experiments with simulated systems.**

Seminar classes

- **6 seminars, for discussion of (adaptive) systems theory and report writing.**

Module structure

Lectures – provisional schedule

1. An introduction to Adaptive Systems (now!)

2. Systems theory

3. Cybernetics and the importance of negative feedback

4. Positive feedback: stigmergy and chaos

5. Ashby part 1: state-determined systems

6. Ashby part 2: ultrastable systems

7. Sensorimotor systems

8. Evolution and evolutionary robotics

9. Self-organising systems

10. Living systems

Module structure

Assessments

Acceptable use of Artificial Intelligence (AI) for these assignments

Generative AI tools must not be used to generate any materials or content for assessments in this module. In this module, you must not use generative artificial intelligence (AI) to generate any materials or content for your assessment submissions.

Note that:

- The baseline position at the University is Sussex is that the use of generative AI material in assessment submissions is prohibited, unless explicitly permitted by the module convenor.
- Students registered with the Disability Advice team and in receipt of reasonable adjustments are still permitted to use other assistive technology as required. If in any doubt about what is permissible, students should check with the module convenor.

Academic integrity

It is compulsory to be familiar with the University's Academic Integrity Values, and with the Academic Misconduct guidelines. Please ensure you have read and understood these, if you have any questions contact the module convener.

Guide to referencing

You can use any of the referencing styles described on this page:

Link to guide on different referencing styles.

Choose one, stick to it, and use it properly. Don't mix styles, and please make sure you provide *full details* of all sources of information, quotes, code, and images in your list of references.

Module structure

Assessments

- A 1000 word report on an adaptive systems experiment

  - Word count does not include methods, captions, etc.

  - Some coding required

  - Due in week 8

  - Worth 20% of your final mark

- A 3000 word report on an adaptive systems experiment

  - Word count does not include methods, captions, etc.

  - A significant amount of coding required

  - Due in the Spring assessment period

  - Worth 80% of your final mark

Module structure
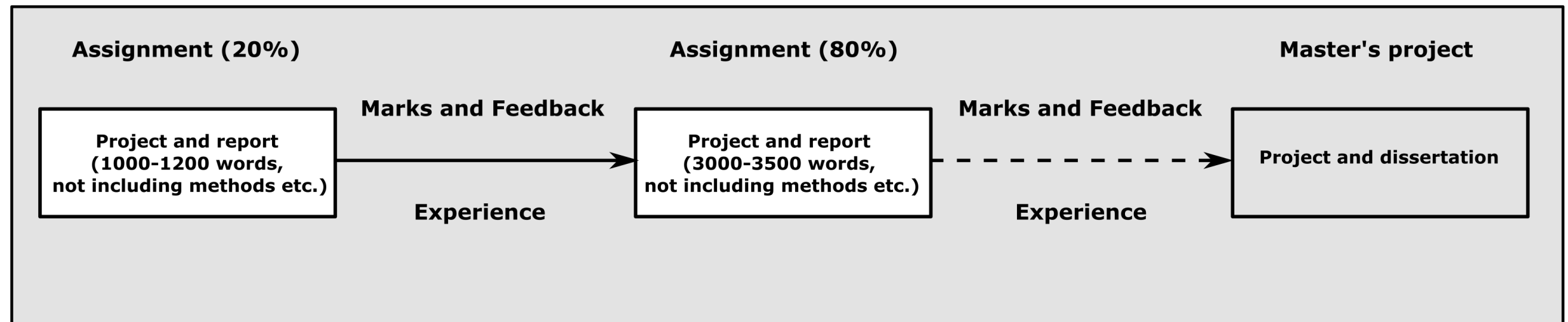
- **Assignment 1 is an opportunity to get some practice and feedback which will help with assignment 2**

- **Assignment 2 *can be* an opportunity to get some practice and feedback which will help with your dissertations**

Module structure

Assessment 2

- **A 3000 word (not including methods etc.) report on an adaptive systems experiment**

- **Must involve some kind of learning or evolution**

  - **There are 3 main directions you can take:**

    1. **Scientific: e.g. simulating and analysing a model of a biological adaptive system**

    2. **Engineering: e.g. designing, implementing and testing your own adaptive system**

    3. **Artificial life: investigating and explaining theoretical adaptive systems**

Bibliography

Recommended articles and books

[1] Ren, G., Chen, W., Dasgupta, S., Kolodziejski, C., Wörgötter, F., & Manoonpong, P. (2015). Multiple chaotic central pattern generators with learning for legged locomotion and malfunction compensation. Information Sciences, 294, 666–682. https://doi.org/10.1016/j.ins.2014.05.001

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[3] Koos, S., Cully, A., & Mouret, J. B. (2013). Fast damage recovery in robotics with the t-resilience algorithm. The International Journal of Robotics Research, 32(14), 1700-1723.

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[6] https://news.sky.com/story/red-and-grey-squirrels-go-head-to-head-in-nut-iq-test-11258591

[7] https://www.wildlifetrusts.org/saving-species/red-squirrels

[8] https://theconversation.com/is-it-too-late-to-bring-the-red-fox-under-control-11299

[9] https://cheetah.org/canada/2020/08/09/how-is-the-cheetah-skeleton-different-from-other-cats/

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[31] Spencer, H. (1866). The Principles of Biology

[32] Bateson, G. (2000). Steps to an ecology of mind: Collected essays in anthropology, psychiatry, evolution, and epistemology. University of Chicago Press.

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[12] https://www.wowamazing.com/trending/new-tech/funny-video-of-robots-falling-down/

[13] https://www.wallpaperflare.com/cats-acrobatics-indoors-one-animal-mammal-focus-on-foreground-wallpaper-sduey

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[15] https://www.nationalgeographic.com/travel/article/photography-jordan-desert

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[16] https://www.ibm.com/cloud/learn/neural-networks

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[18] https://thecityfix.com/blog/india-worst-road-safety-record-world-new-law-aims-change-amit-bhatt/

[19] https://commons.wikimedia.org/wiki/File:Fossa_River_and_Waterfall_2.jpg

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[28] https://www.internetgeography.net/topics/what-is-continental-drift/

[29] https://www.researchgate.net/figure/shows-the-predicted-environmental-temperatures-and-core-temperature-for-the-desert-iguana_fig11_225258595