COMP 532
Machine Learning and Bioinspired Optimisation

Lecture 1

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Welcome to COMP532

- Overview of the module
- Introduction to bio-inspired learning
- Applications

Overview

- Module delivery
  - Lecturer: Meng Fang (Meng.Fang@liverpool.ac.uk)
  - Demonstrators
- Module Website
  - https://liverpool.instructure.com/courses/67579
  - All lecture materials are available on Canvas:
    - Slides
    - Assignments
    - Tutorials and Coding Solutions
    - Papers and Notes

Overview

- Delivery of Lectures
  - 30 one-hour lectures in total
  - 3 lectures each week (on campus)
- Delivery of Tutorials
  - One-hour each week (on campus)
  - Tools
    - Python
    - Google Colab: https://colab.research.google.com/

Overview

- Lectures will be recorded and uploaded to Canvas each week
  - stream.liv.ac.uk
  - Canvas module - COMP532
- MS Teams
- Meeting hours
  - Monday, 1:00 pm – 2:00 pm

Module Aims and Objectives

- We focus on **learning agents** that **interact** with an initially unknown world. Since the world is **dynamic** this module will put strong emphasis on learning to deal with sequential data unlike many other machine learning courses.

Module Aims and Objectives

- Introduce and give an overview to the state-of-the-art **bio-inspired self-adapting** methods.
- Enable students to not only learn to build models with reactive input/output mappings but also **build computer programs** that sense and perceive their environment, plan, and make optimal decisions.
- Familiarise students with **reinforcement learning**, **multi-agent learning**, **swarm intelligence**, **deep neural networks**, **evolutionary game theory**.
- Demonstrate **principles of bio-inspired methods**, provide indicative examples, develop problem-solving abilities and provide students with experience to apply the learnt methods in real-world problems.

Learning Outcomes

- A systematic understanding of bio-inspired algorithms
- In depth insight in the mathematics of biologically inspired machine learning and optimisation methods
- A comprehensive understanding of the benefits and drawbacks of the various methods
- Demonstrate knowledge of using the methods in real-world applications
- Practical assignments will lead to hands on experience

Module Topics

- Problem solving from Nature
- Reinforcement learning
- Deep learning
- Multi-agent systems

Module Syllabus (approximate)

- Problem Solving from Nature (2)
- Math and Programming Basics (1)
- Reinforcement Learning (7)
- Deep Learning (7)
- Revision (1)
- Multi-Agent System (7)
- Swarm Intelligence (4)
- Revision (1)

Module Assessments

- Written exam: 70%
- Two course projects: Each 15%
  - Will be available in Canvas – Module COMP532 Assignments
  - Pen & Paper, Programming tasks
  - Groups of 3 (or more)

Assessment Projects

- Task 1 on reinforcement learning, some programming and pen/paper exercises (15%)

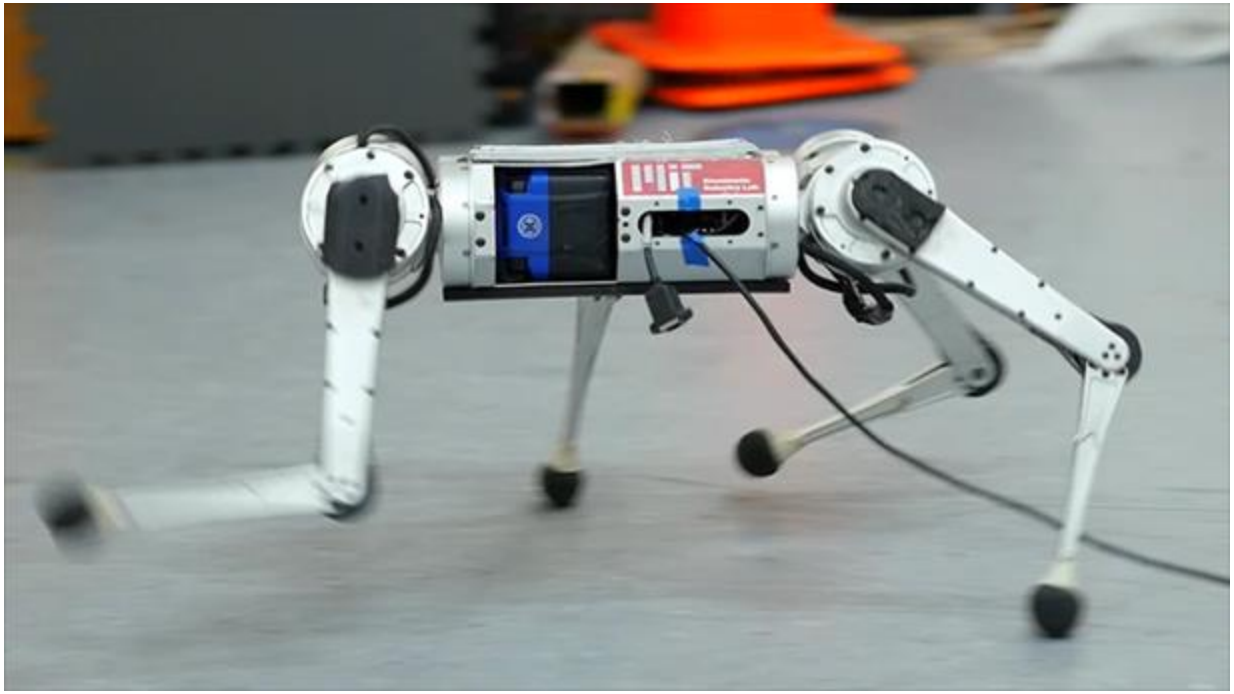
- Task 2 on deep reinforcement learning implementation and pen/paper exercises (15%)

Useful Resources

- Reinforcement learning
  - Courses
    - UCL Course on RL, https://www.davidsilver.uk/teaching/
    - Reinforcement Learning: A Graduate Course, https://www.it.uu.se/research/systems_and_control/education/2017/relearn
  - Book
    - Reinforcement Learning: An Introduction, by Richard S. Sutton and Andrew G. Barto, https://web.stanford.edu/class/psych209/Readings/SuttonBartoIPRLBook2ndEd.pdf
- Machine learning
  - Stanford, CS229 Machine Learning, https://cs229.stanford.edu/
- Deep learning
  - MIT, Introduction to Deep Learning, http://introtodeeplearning.com/
  - Stanford, CS230 Deep Learning, https://cs230.stanford.edu/
  - Book
    - Deep Learning, by Ian Goodfellow and Yoshua Bengio and Aaron Courville, https://www.deeplearningbook.org/

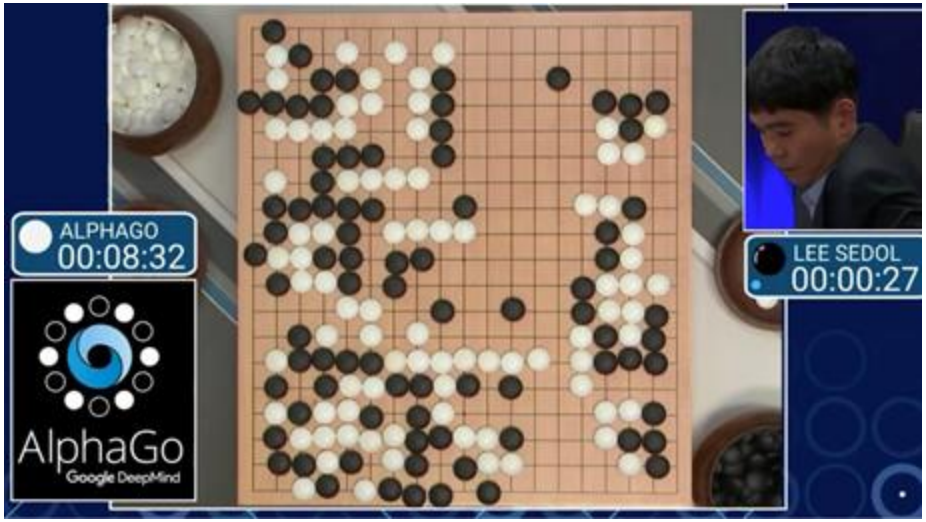
Introduction to Bio-inspired Learning

- Bioinspired Robotics
  - Bioinspired Robotics: Smarter, Softer, Safer
  - Bioinspired robots walk, swim, slither and fly, https://www.nature.com/articles/d41586-022-03014-x



Nature or Bio-inspired Learning

- How a robot/computer/agent makes decisions?



Nature or Bio-inspired Learning

- Bio-inspired computing
  - Solve computer science problems using models of biology
  - In computer science, bio-inspired computing relates to artificial intelligence and machine learning
- Examples:
  - Reinforcement Learning
  - Evolutionary Game Theory
  - Evolutionary Computation – Swarm Intelligence
  - …

- What is Machine Learning?
- What is Agent?

Nature or Bio-inspired Learning

- Machine Learning
  - “A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as measured by P, improves with experience E.” –Tom M. Mitchell

- Agent
  - An independent program or entity that interacts with its environment by perceiving its surroundings via sensors, then acting through actuators or effectors.

Nature or Bio-inspired Learning

- Bio-inspired Machine Learning
  - To optimise its products, nature exploits genetic operators: selection, mutation, crossover
  - There are those mechanisms we can “easily” mimic
  - Can we model emergent collective intelligence from local simple interactions at level of:
    - Cells
    - Neurons
    - Insects
  - How do simple creatures like ants/bees organise themselves to show great intelligence at a group level?

Nature or Bio-inspired Learning

- This course is NOT about Advanced Machine Learning or Data Mining for its Applications

- But it is about **agents** situated in a (potentially) unknown **environment**, learning **how to behave and optimize** its action in order to achieve its goals, taking **inspirations from nature**.

Nature or Bio-inspired Learning

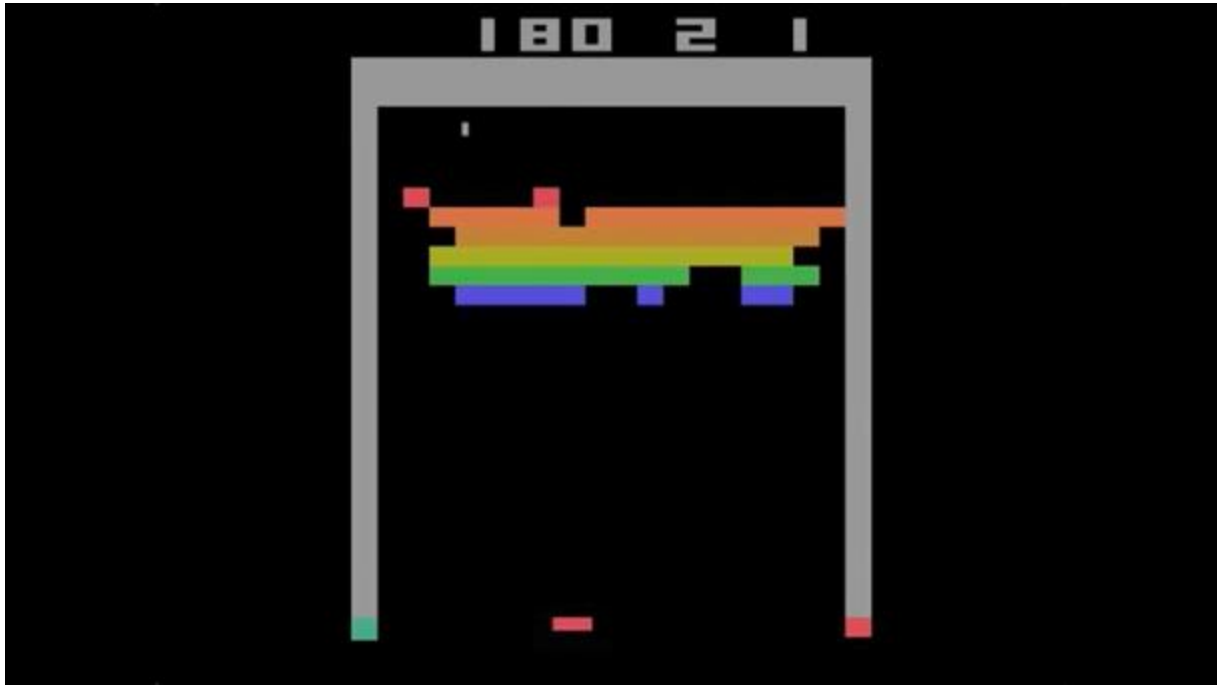
- Some important notes:
  - We are not necessarily mimicking nature
  - Inspirational

Nature or Bio-inspired Learning

- Single agent reinforcement learning
  - Application example: [Mobile ALOHA: Your Housekeeping Robot]

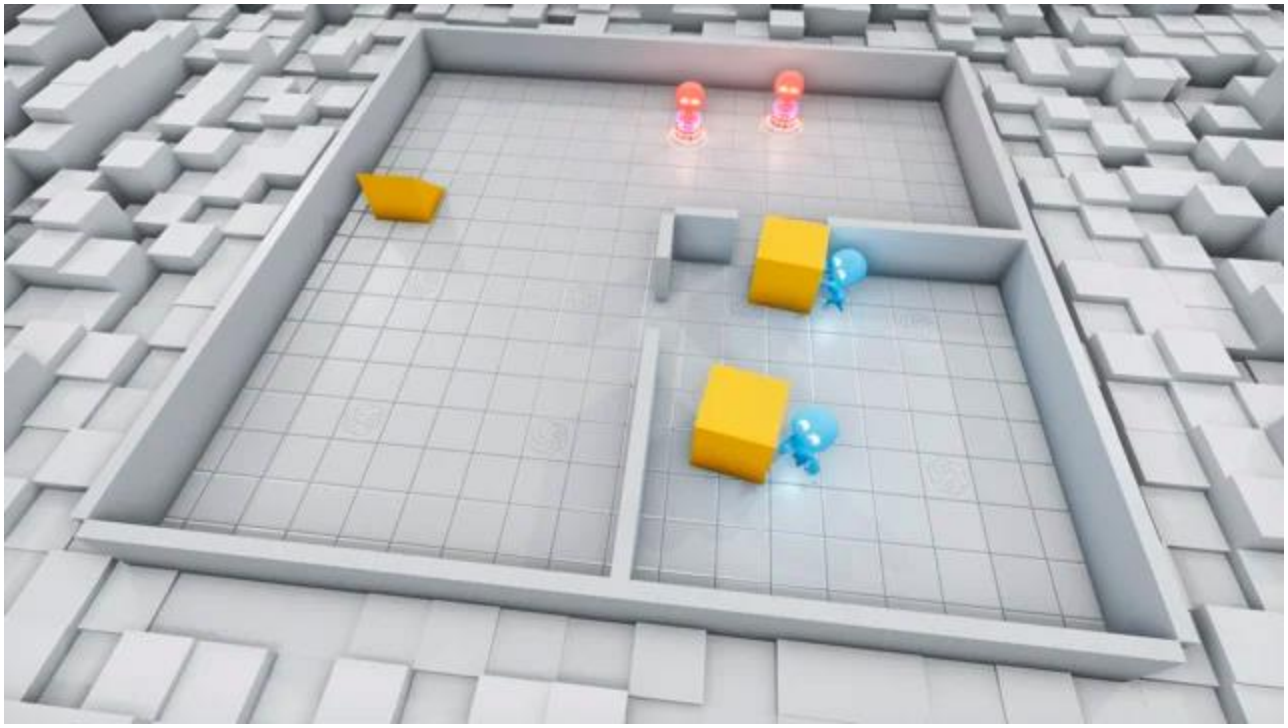
Nature or Bio-inspired Learning

- Deep reinforcement learning
  - Application example: DQN Breakout



Nature or Bio-inspired Learning

- Multi-agent learning
  - Application example: Multi-Agent Hide and Seek



Nature or Bio-inspired Learning

- Swarm intelligence
  - Application example: Teaching groups of drones to fly in formation

Nature or Bio-inspired Learning

- Other applications
  - Portfolio optimisation
  - Playing games better than humans
  - Search engines
  - … …

Summary

- Introduction to the course
- Topics of the course
- Introductory applications/examples