Task

Conduct a mini research project on a question of your choosing in the field of multi-agent Artificial Intelligence (AI). The goal is not necessarily to produce original research, and students will not be graded on this, however it is to show good general research acumen. Students will be graded on their ability to formulate a well-defined research question, perform a thorough literature review, design a suitable method for answering the research question, complete reasonable experiments to answer the research question, and finally their ability to critically analyse their method / results in light of the research question.

Components

1. **Project Proposal** - A short (max 1 page) document outlining the project that the group intends to do. The document should present a research question, a short introduction to how the research question will be answered, and a short literature review outlining the key works in the area.
2. **Project Presentation** - A 10-minute presentation of the research project (problem statements, related work, ideas, preliminary results if any etc) to the rest of the class, Prof. Wang and the TAs.
3. **Research Paper** - A research paper (main body 4-8 pages max latex format https://neurips.cc/Conferences/2023/PaperInformation/StyleFiles) on the research project that is proposed. The minimum expectation is for the research paper to contain the following sections: Introduction, Literature Review, Method, Experiment Results, Discussion. For some reference papers, please refer below.

Grading (50% of total module grade)

1. **Project Proposal (5%)**
    a. Clarity of research question - is the research question clear in what it wants to achieve, and is it reasonably achievable?
    b. Initial literature review - does the research proposal successfully highlight the key papers in the area? Does it successfully highlight why they are important to this research question?
2. **Project Presentation (20%)**
    a. Is the research question clear /easy to understand? The target audience is the other students with less knowledge of the subject area.
    b. Is the proposed research method clear / easy to understand?
        i. Is there a clear framework? Is it suitably visualised? Is there any maths that is sufficiently explained?
    c. Are results presented clearly if any? If no results just yet, whether the proposed ideas/methods are sound or well justified? Explain why.
3. **Research Paper (25%)**
    a. Introduction
        i. Is the research question clear? Is the research question well-motivated? Is a high-level overview of the method presented? Is the structure of the research paper discussed?
    b. Literature Review

        i. Are the key pieces of literature in the area discussed and compared? How do they relate to the research question? How do they relate to the method? Are more esoteric pieces of literature reviewed?
    c. Method
        i. Is the method clearly explained? How well suited to addressing the research question is it? Are there any missing implementation details? Is it possible to visualise the method?
    d. Results
        i. Are the results clearly presented? Are they relevant to the research question? Are the figures / tables visually easy to read / understand? Are the details of the results well-described and clear?
    e. Discussion
        i. What do the results say about the research question? How do they fit in with the literature in the area? What are the limitations of the method / results in answering the research question? What are the opportunities for future work?
    f. Code
        i. The results must be reproducible so please provide the link of your code with clear readme.

Deadlines

1. **Research Proposal** - **February 16**
   Send to oliver.slumbers.19@ucl.ac.uk, titled MAAI-Group ID - Topics. Please talk to the assigned TAs (see below for your group) for the proposal before submission. Please use office hours to discuss your proposal as well if needed.
2. **Research Presentation** - **March 20 5-7pm** (online zoom presentation, 10 mins talk 2 mins questions each group)

   Join Zoom Meeting
   https://ucl.zoom.us/j/6884877070?omn=99175411961

   Meeting ID: 688 487 7070

3. **Research Paper** - **April 12 (moodle submission)**
   COMP0124 (Delivery: 2023, T2)(Sitting: 2023, Main) #002 Project (Group) - Task & Submission Link Assignment

Example Topics (but not limited to those listed below) + References

Investigating algorithms to establish coordination / cooperation in social dilemmas
Multi-agent Reinforcement Learning in Sequential Social Dilemmas - Leibo et al. 2017
Learning Dynamics in Social Dilemmas - Macy and Flache 2002
Multiagent Reinforcement Learning in the Iterated Prisoner's Dilemma - Sandholm and Crites 1996
Empirically Evaluating Multiagent Learning Algorithms - Zawadzki et al. 2014

Comparison of Nash learning techniques in competitive games

On Learning Algorithms for Nash Equilibria - Daskalakis et al. 2010
Learning and Equilibrium - Fudenberg and Levine 2009
On No-Regret Learning, Fictitious Play and Nash Equilibrium - Jafari et al. 2002

Understanding self-play and population learning in competitive games
Iterative Solution of Games by Fictitious Play - Brown 1951
Fictitious self-play in extensive-form games - Heinrich et al. 2015
Deep Reinforcement Learning from Self-Play in Imperfect-Information Games - Heinrich and Silver 2016
A Unified Game-Theoretic Approach to Multiagent Reinforcement Learning - Lanctot et al. 2017

Multi-agent reinforcement learning for simple autonomous driving scenarios
https://github.com/Farama-Foundation/HighwayEnv
Deep Reinforcement Learning and Imitation Learning for Autonomous Driving in a Minimalist Environment - Hourigan 2021
Multi-Agent Reinforcement Learning with Application on Traffic Flow Control - 2021

Exploring the price of anarchy and reduction methods in multi-agent systems
Selfish Routing and the Price of Anarchy - Roughgarden 2005
The Price of Anarchy of Finite Congestion Games - Christodoulou et al. 2005
D3C: Reducing the Price of Anarchy in Multi-agent Learning - Gemp et al. 2020

Some useful simulators that can be used
https://github.com/Farama-Foundation/HighwayEnv **-** Lightweight autonomous driving simulator.
https://pettingzoo.farama.org - Large collection of multi-agent reinforcement learning environments.
https://github.com/tianyu-z/pettingzoo_dilemma_envs - Iterated matrix games.
https://github.com/google-deepmind/open_spiel - Large collection of multi-agent games.

Group Staff Assignments

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Group 2 - Jun Wang
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