Agent-Based Systems

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Paolo Turrini

www.dcs.warwick.ac.uk/~pturrini p.turrini@warwick.ac.uk

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Introduction

Timetable

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Asynchronous Videos here

Synchronous Wed 9:00 am

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Seminars (f2f) Wed (group dependent)

Seminars (online) Wed from 10:00 am (group dependent)

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The module

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Seminars nine in total, every week, starting form the next

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Coursework 50% of the mark (deadline week 12)

Exam 50% of the mark

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Lectures

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Location	Available online. It changes.
Description	Syllabus, notes and material on the course webpage
Slides	**Available** (but I would also attend the lectures)
Homepage	`https://warwick.ac.uk/fac/sci/dcs/teaching/modules/cs404/`

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Seminars/Labs

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Exercises	Questions on explained material
Labs	Programming-based exercises
Previous Papers	Some exercises are previous exam papers of mine
Solutions	Key exercises will come with model answers

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Tip 1: go to the seminars/labs and do all the exercises.
Tip 2: write everything down, even when you think it's trivial.

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Tutors

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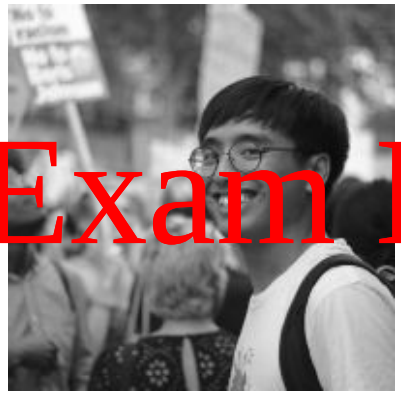

Jack

jack.bara@warwick.ac.uk

https://powcoder.com

Stas

s.zhydkov@warwick.ac.uk

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Charlie

charlie.pilgrim@warwick.ac.uk

Coursework

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- The coursework will be a Python-based implementation of a strategic agent, participating in an auction. The goal is to make money.
- You are going to be playing against one other.

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- It's not a programming exercise, although it involves programming. The focus is on the strategic behaviour itself.
- There will be a coursework handout lecture (week 3), where everything will be explained in details, and a coursework hints lecture (week 10), to discuss some basics, in case you are lost.

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Exam

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- Questions on the material explained.
- Focus will be on precise applications of learnt techniques.
  - This means no questions like:
    "What's your view on Artificial Intelligence?"
  - But rather:
    "This is the problem: calculate the solution"
- It won't be a memory game.
  The goal is to reward the 'understanding' of the subject.
- Everything I explain is examinable.

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Interaction

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- This is a course on multi-agent interaction, and I like interaction.
- The vast majority of the slides will be available before the lecture, but some will not, because I want you to think on the spot.
- All the slides will be available after the lecture.
- Don't be scared of saying wrong things (before the exam).

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Questions

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1. Ask them in class
2. Ask them during seminars
3. Send me an email (p.turrini@warwick.ac.uk)

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The toolbox for the design of interactive decision-makers

Artificial Intelligence with many agents

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AlphaGo
Defeats the World Champion 4-1
(March 2016)

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The toolbox for the design of interactive decision-makers

Artificial Intelligence with many agents

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Libratus
Wins 1.7M dollars from top players
(January 2017)

AlphaGo
Defeats the World Champion 4-1
(March 2016)

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The toolbox for the design of interactive decision-makers

Artificial Intelligence with many agents

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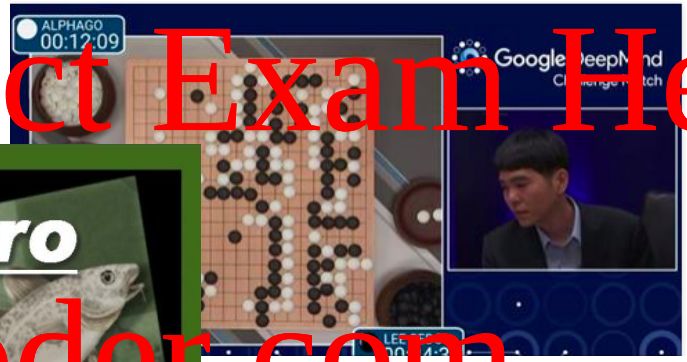
Libratus
Wins 1.7M dollars fro
(January 20

AlphaZero
Defeats the best open source engine
28-0, after 9 hours of self-training
(December 2017)



AlphaGo
e World Champion 4-1
(March 2016)

The toolbox for the design of interactive decision-makers

Connections

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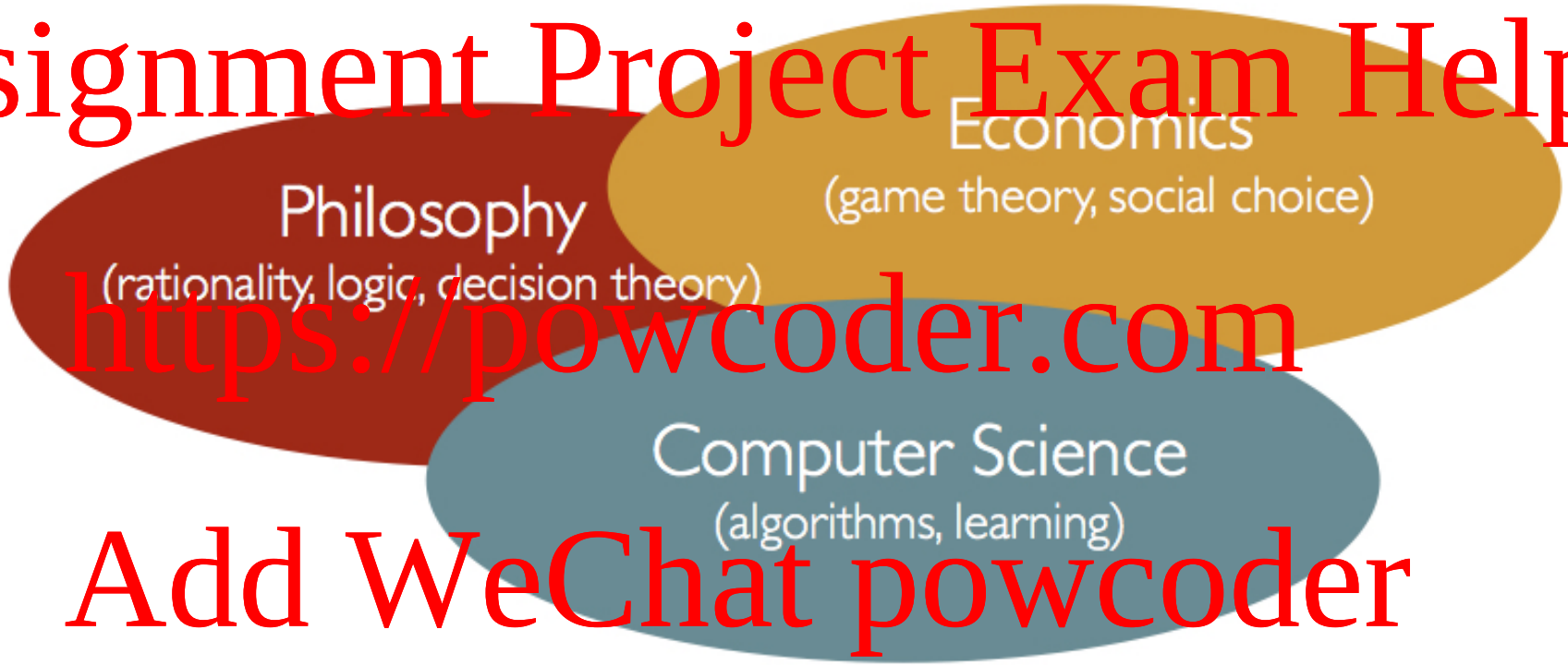

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Important private investments: Google DeepMind

The starting kit

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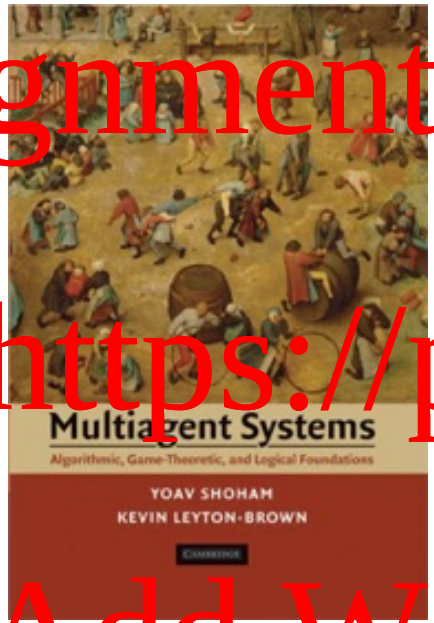

Y. Shoham and K. Leyton-Brown
Multiagent Systems: Algorithmic, Game-Theoretic and Logical Foundations
www.masfoundations.org

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Helpful background basics

Discrete mathematics, probabilities, algorithms, logic.

Other important references

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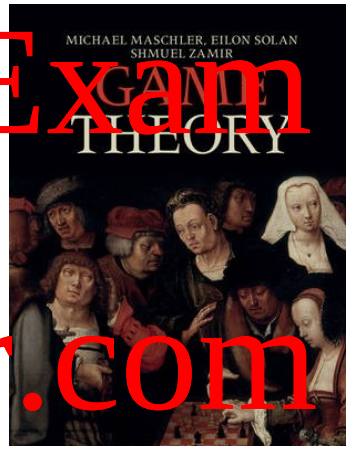
- M. Maschler, E. Solan and S. Zamir
  Game Theory
- Y. Shoham and K. Leyton-Brown
  Essentials of Game Theory
- S. Russel and P. Norvig
  Artificial intelligence: a modern approach



One of the greatest books ever written

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It's very useful to look at different ways of presenting the same topic!

Acknowledgments

This module would not have been possible without:

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Ulle Endriss
Institute for Logic, Language and Computation
University of Amsterdam

Agents

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An **agent** is a formal model of decision-maker which:

- lives in a world, made of states
- is goal-oriented (wants to achieve some states, or sequences of states)
- has a view-point on the world
- can take actions to change the world into a different state

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AlphaGo is an agent,
You are an agent,
Pretty much everything interesting is an agent.

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An abstract comprehensive theory of (rational) decision-making

Humans can be rational

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Robert J. Aumann
Nobel Prize in Economics

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'A person's behaviour is **rational** *if it is in their best interests, given their information.'*

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Agents (not only humans) can be rational!

Agents can be rational

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Robert J. Aumann
Nobel Prize in Economics

'An **agent***'s behaviour is* **rational** *if it is in their best interests, given their information.'*

Agents (not only humans) can be rational!

Multi-agent Systems

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A **multi-agent system** is any situation with more than one agent.

- their goals might be interdependent (one against the other, or they need one another to achieve them)
- each have view points on the world, the other agents, and view points about the other agents' viewpoints!
- their choices are interdependent, too: the world state changes as a function of what all agents do.

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Kuhn Poker

Two players, Ann and Bob, are dealt one of the following cards: $\{A, K, Q\}$.

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Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+1 to Ann
bet	bet		+ 2 to higher card

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- Players take turns in starting. So each player can be playing two different games: the one when they start, and the one when they don't start.
- Each of these games is an extensive game of imperfect information.
- Although Poker is more complicated, it's not that much more complicated really.

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Harold E. Kuhn

Simplified two-person poker

Contributions to the Theory of Games, 1950

Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob.

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Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q.

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Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q. Ann bets.

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Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q. Ann bets. What do you do?

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Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q. Ann bets. What do you do?

Scenario 2:

You are Bob.

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Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q. Ann bets. What do you do?

Scenario 2:

You are Bob. You are dealt Q.

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Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q. Ann bets. What do you do?

Scenario 2:

You are Bob. You are dealt Q. Ann passes.

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Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q. Ann bets. What do you do?

Scenario 2:

You are Bob. You are dealt Q. Ann passes. What do you do?

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Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q. Ann bets. What do you do?

Scenario 2:

You are Bob. You are dealt Q. Ann passes. What do you do?

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Scenario 3

You are Ann.

Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q. Ann bets. What do you do?

Scenario 2:

You are Bob. You are dealt Q. Ann passes. What do you do?

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Scenario 3

You are Ann. You are dealt A.

Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q. Ann bets. What do you do?

Scenario 2:

You are Bob. You are dealt Q. Ann passes. What do you do?

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Scenario 3

You are Ann. You are dealt A. What do you do?

Let's Play!: Kuhn Poker

Ann	Bob	Ann	outcome
pass	pass		+1 to higher card
pass	bet	pass	+1 to Bob
pass	bet	bet	+ 2 to higher card
bet	pass		+ 1 to Ann
bet	bet		+ 2 to higher card

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Scenario 1:

You are Bob. You are dealt Q. Ann bets. What do you do?

Scenario 2:

You are Bob. You are dealt Q. Ann passes. What do you do?

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Scenario 3

You are Ann. You are dealt A. What do you do?

Question: What are the objectively bad choices? The good ones?

In a slogan...

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Agent-based systems is Artificial Intelligence with many agents.

where...

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- **Artificial** means done by a computer.
- **Intelligence** means rational.
- **many agents** means many agents.

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No magic, no singularity, no spelling the end of the human race.
Just computational modelling.

The plan

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- **Logical Agents [Week 1-2]**
  - Knowledge, Preferences, Strategies and how to reason.
- **Decision-Making Agents [Week 3]**
  - Probabilistic Beliefs and Expected Utility
- **Strategic Agents [Week 4-5]**
  - Games, Equilibria, Opponent Modelling.
- **Learning Agents [Week 6-7-8]**
  - Opponent Modeling and (Multi-Agent) Learning.
- **Social Agents [Week 8-9]**
  - Groups and Networks

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- Coursework hints for those who are hopelessly lost
- Revision Lectures 1 and 2 (your input matters!)

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What we have seen

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- The course plan
- Agents: first definition
- Agents and multi-agent systems
- Rationality

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Coming next

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- Modelling actions, plays and wins
- Strategies

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