CS3243 INTRODUCTION TO ARTIFICIAL INTELLIGENCE

INTELLIGENT AGENTS

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ABOUT ME!

- Nicholas Teh
- Year 4 DDP Math/CS
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- Game Theory & Algorithmic Mechanism Design

OVERVIEW OF TOPICS

INTELLIGENT AGENTS

UNINFORMED SEARCH

INFORMED SEARCH & LOCAL SEARCH

ADVERSARIAL SEARCH

CONSTRAINT SATISFACTION PROBLEMS (CSP)

STRUCTURED CSP

LOGICAL AGENTS

INFERENCE IN FOL

UNCERTAINTY IN BAYESIAN NETWORKS

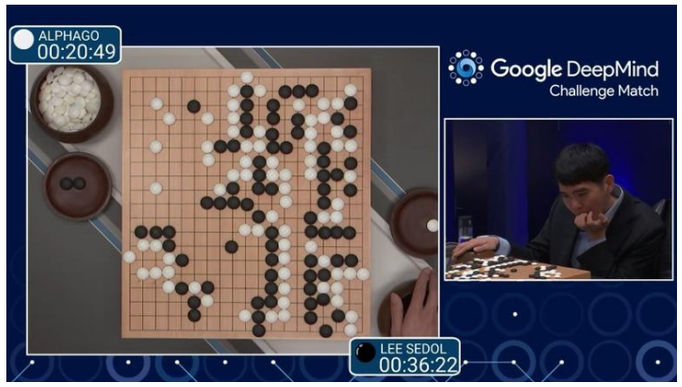
A VAST FIELD

VISION & ROBOTICS

- Autonomous vehicles
- Robot assistants
- Image classification

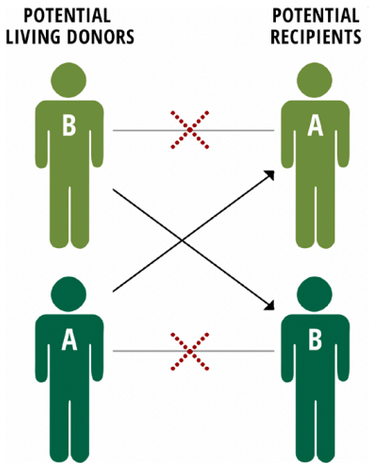
NATURAL LANGUAGE PROCESSING

- Robot PA
- Translation



MACHINE LEARNING

- Deep Learning
- Reinforcement Learning
- Graphical Models



GAME THEORY

- Mechanism Design
- Game-Playing AI
- Security Games
- AI for Social Good

ALSO RECENTLY

Fair

Accountable

Transparent

Ethical

IN THIS COURSE

- Expressing complex real-world problems in a (structured) form/a common “language” such that our AI can solve.
  - Search problem
  - Constraint satisfaction problem
  - First-order logic
  - Bayesian networks

TOPIC SCHEDULE

- Midterms (tentatively) will test you on:
  - Intelligent Agents
  - Uninformed Search
  - Informed Search & Local Search
  - Adversarial Search

WHAT TO EXPECT FROM TUTORIALS

- Conceptual understanding & review
- Selected diagnostic questions
- Tutorial questions (mostly application questions)
  - I will skip certain questions at times to make way for more interesting and useful ones (e-exam style)
- Some e-exam type questions & ways to solve them

SUBMISSIONS

- Please submit tutorial assignments into the correct folder on time before the deadline.

ATTENDANCE TAKING (ONLY FOR CONTACT TRACING PURPOSES)

- Scan QR code
- No attendance/tutorial attendance marks

TELEGRAM GROUP

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CONTENT SUMMARY

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KEY CONCEPTS

- **Intelligent Agents**
  - Key definitions and terms
  - Rationality
  - Task environments

RATIONALITY

- Concept of *rationality*: Doing the best I can given what I know
  "A rational agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome."

- *Rational mechanism: selects an action that is expected to maximise its **performance measure** for each possible percept sequence, given the evidence provided by the percept sequence and the agent's built-in knowledge.*

rationality is about syncing with the environment, not with the inner model

cause no point saying you are rational by maximising your internal model, when your internal model could be bad. Like to an insane person, they probably ARE OPTIMISING their internal model (utility), but we certainly don't consider that rational

AGENT FUNCTION VS AGENT PROGRAM

- *Think about what is the definition of a FUNCTION (in mathematics), and a PROGRAM (in computer science)*

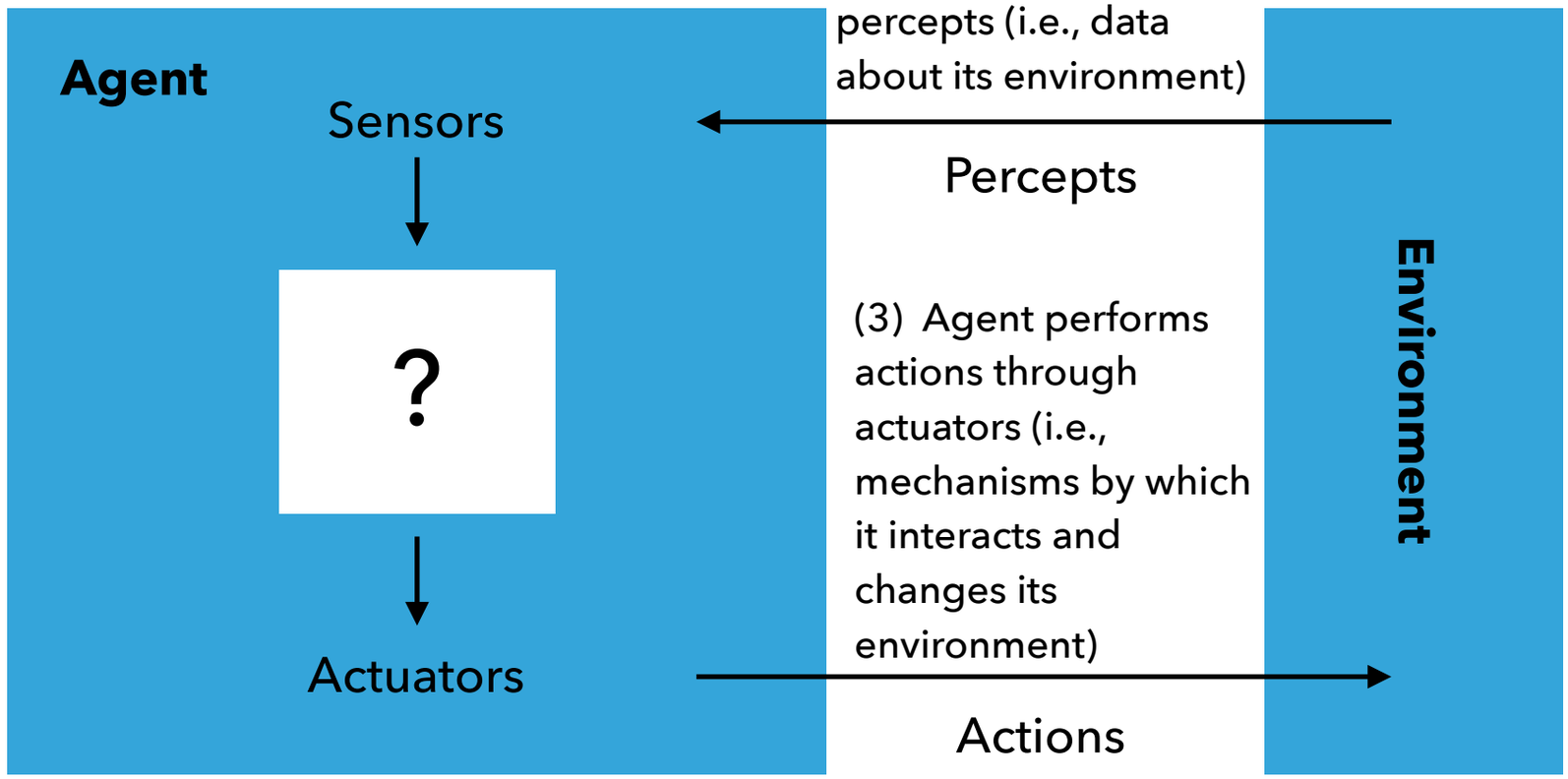
- An agent **function** maps every possible percept sequence to a possible action.

- An agent **program** is a concrete implementation, running within some physical system.

STRUCTURE OF AN INTELLIGENT AGENT

(1) Agents collects information about its environment via percepts (i.e., data about its environment)

(2) Agent function uses percepts (current, and sometimes also historical) as input data to generate an output (i.e., an action)



TYPES OF AGENTS

(i) reflex (conditions trigger corresponding actions)

(ii) model-based (keeps internal model of the environment)

(iii) goal-based (model-based + each state equal an objective) - can be used when have possibly subjective goals, e.g. fairness

(iv) utility-based (model-based + each state has a utility)

(v) learning (learn by exploration + past experiences)

PERFORMANCE MEASURE VS UTILITY FUNCTION

- Performance Measure: **External** estimate of an agent's capability (an "examiner" assess the ability of the agent objectively)
- Utility Function: **Internal** measure of how well the agent is doing (self-assessment)

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TUTORIAL 1 QUESTION 1

- **What determines the rationality of an agent?**

TUTORIAL 1 QUESTION 1

- **What determines the rationality of an agent?**

ANSWER:

- **Performance measure**
- Prior knowledge
- Percept sequence to date
- Actions available

a rational agent is typically one that maximizes the performance measure, given its current knowledge.

TUTORIAL 1 QUESTION 2 (TASK ENVIRONMENTS)

- **Define the task environment properties of Tic-Tac-Toe.**
- Fully/Partially Observable (can I see all elements of the game?)
- Single/Multi-Agent (how many players? – simple interpretation!)
- Deterministic/Stochastic (any random elements?)
- Episodic/Sequential (current move depends on previous move or affects future moves?)
- Static/Dynamic (things change while agent deliberating? Ignore time)
- Discrete/Continuous (are there continuous variables involved?)

TUTORIAL 1 QUESTION 2 (TASK ENVIRONMENTS)

- **Deterministic (vs Stochastic)**
  - **Deterministic**: Next state is completely determined by current state + action taken by agent. Taking a particular action at the same state will ALWAYS yield the same result.
- **Sequential (vs Episodic)**
  - **Sequential:** Current decision can affect all future decisions (agent needs to think ahead). Current decision depends on all past decisions

TUTORIAL 1 QUESTION 2 (TASK ENVIRONMENTS)

- **Static (vs Dynamic)**
  - **Static**: Task environment does not change *while agent is deliberating* (ignore timer). Agents need not keep looking at the environment while deciding.
- **Continuous (vs Discrete)**
  - **Continuous**: Possibly infinite set of actions. Examples: Space for an autonomous vehicle, Money (where we are not restricted by cents). Again, do not care about time.

TUTORIAL 1 QUESTION 2 (TASK ENVIRONMENTS)

- **Define the task environment properties of Sudoku.**

ANSWER

- **Fully**/Partially Observable (can see all elements of the game)
- **Single**/Multi-Agent (obvious)
- **Deterministic**/Stochastic (same state, take action, always same result)
- Episodic/**Sequential** (current available moves depend on previous moves)
- **Static**/Dynamic (when I make my decision, nothing changes)
- **Discrete**/Continuous (no continuous variables involved)

TUTORIAL 1 QUESTION 2 (TASK ENVIRONMENTS)

- **Define the task environment properties of Hanabi.**
- Fully/Partially Observable
- Single/Multi-Agent
- Deterministic/Stochastic
- Episodic/Sequential
- Static/Dynamic
- Discrete/Continuous

Cooperative game with imperfect information

TUTORIAL 1 QUESTION 2 (TASK ENVIRONMENTS)

- **Define the task environment properties of Hanabi.**

ANSWER

- Fully/**Partially** Observable (Can't see the drawing cards deck)
- Single/**Multi**-Agent (Multiple players)
- Deterministic/**Stochastic** ('Drawing a card' can result in different transitions)
- Episodic/**Sequential** (Current moves heavily depend on previous moves)
- **Static**/Dynamic (Nothing changes while agent is deliberating, besides time)
- **Discrete**/Continuous (no continuous variables involved)

TUTORIAL 1 QUESTION 3

- **Define an agent program for a Tic-Tac-Toe reflex agent that will always either win or draw.**

TUTORIAL 1 QUESTION 3

- **Define an agent program for a Tic-Tac-Toe reflex agent that will always either win or draw.**

ANSWER

- Simply a table of percepts/conditions and actions to take (defining a strategy for playing tic-tac-toe)
- Percepts/conditions are all possible configurations (note that tic-tac-toe grid is symmetric by flipping/rotation, so there are not that many cases)
- https://en.wikipedia.org/wiki/Tic-tac-toe#Strategy

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PRACTICE QUESTIONS

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QUESTION 1

- **True/False**: An agent that senses only partial information about the state cannot be perfectly rational.

- Think about what rational/perfectly rational means!

QUESTION 1

- **True/False**: An agent that senses only partial information about the state cannot be perfectly rational.

ANSWER

- FALSE!
- "A rational agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome."
- Perfect rationality refers to the ability to make good decisions given the information an agent has.
- It can do what's best given what it knows (best expected outcome).

QUESTION 2: AY19/20 ST 1 MIDTERM Q1

- **True/False**: It is possible for an agent to be perfectly rational in *k* distinct task environments.

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- **True/False**: It is possible for an agent to be perfectly rational in *k* distinct task environments.

ANSWER

- TRUE!
- Have a rational agent in one task environment playing some optimal policy.
- Duplicate this task environment and alter the parts of the environment unreachable/not important to the agent in its decision-making.
- Do this *k* times (choose a task environment complex enough so we can do this *k* times).

QUESTION 3: AY19/20 ST 1 MIDTERM Q2

- **True/False**: There exists a deterministic task environment where an agent that selects its actions uniformly at random (from a discrete set of possible actions), is rational.

In the rationale box: provide a rationale for your answer.

QUESTION 3: AY19/20 ST 1 MIDTERM Q2

- **True/False**: There exists a deterministic task environment where an agent that selects its actions uniformly at random (from a discrete set of possible actions), is rational.

ANSWER

- TRUE!
- It may be that all actions lead to the same outcome.
- If that's the case, selecting all actions uniformly at random will yield the same expected utility (trivially maximum), and is rational.

QUESTION 4: AY19/20 ST 1 MIDTERM Q3

- **True/False**: Every agent is rational in an unobservable environment.

  In the rationale box: provide a rationale for your answer.

QUESTION 4: AY19/20 ST 1 MIDTERM Q3

- **True/False**: Every agent is rational in an unobservable environment.

ANSWER

- FALSE!
- Being rational and the environment being observable are independent considerations/concepts.
- You can have a stupid agent in an unobservable environment, you can also have a smart, rational agent in the same environment.

QUESTION 5

- **True/False**: There exists a task environment in which every agent is rational.

QUESTION 5

- **True/False**: There exists a task environment in which every agent is rational.

ANSWER

- TRUE!
- In an environment with a single state, and all actions have the same reward, it doesn't matter which action is taken by each agent, each of them will get the same (trivially maximum) reward; and are hence maximising their expected utility, so they're rational!