COMP9414/9814/3411: Artificial Intelligence

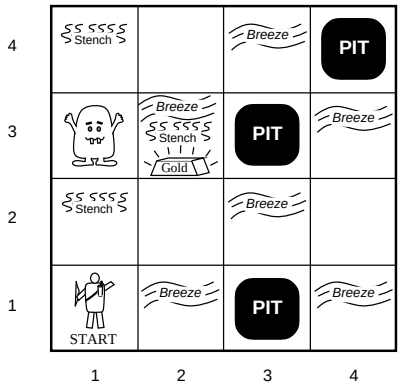
Week 2. Classifying AI Tasks

Russell & Norvig, Chapter 2.

Examples of AI Tasks

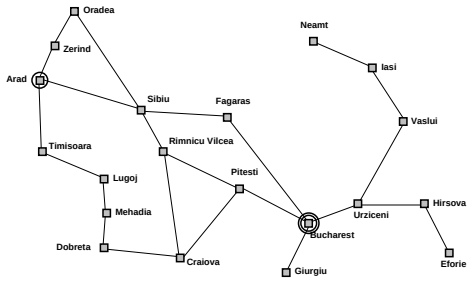
- Week 2: Wumpus World, Robocup Soccer
- Week 3: Path Planning (mazes, graph search)
- Week 4: Path Search Puzzles (8-puzzle, Rubik's cube)
- Week 5: Games (board games, dice games, card games)
- Week 6: Constraint Satisfaction (N-queens, Sudoku)

Wumpus World

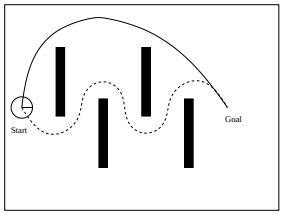


Robocup Soccer

Week 3: Path Planning

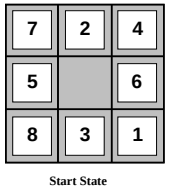


Traveling in Romania

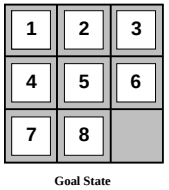


Trajectory Planning

Week 4: Path Search Puzzles

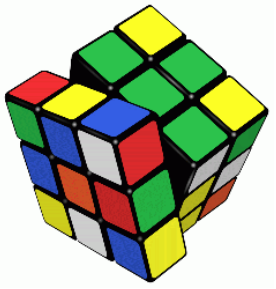


Start State



Goal State

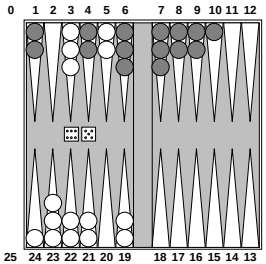
8-Puzzle



Rubik's Cube

Week 5: Games

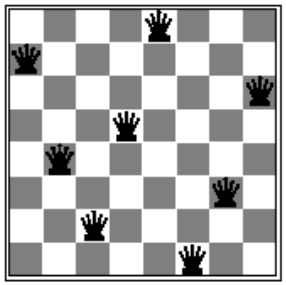
board games



dice games

card games

Week 6: Constraint Satisfaction Problems



N-queens

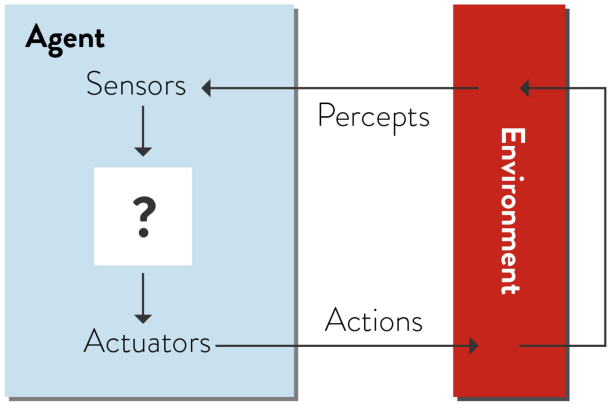
9				6				3
1		5		9	3	2		6
	4			5				9
8						4	7	1
		4	8	7				
7		2	6		1			8
2								
5				3	2		9	4
	8	7		1	6	3	5	

Sudoku

Specifying and Classifying Tasks

We want a unified framework that can be used to specify, characterize, compare and contrast different AI tasks.

Agent Model



Agents as functions

Agents can be evaluated empirically, sometimes analysed mathematically

Agent is a function from percept sequences to actions

Ideal rational agent would pick actions which are expected to maximise the performance measure.

The PEAS model of an Agent

- Performance measure
- Environment
- Actuators
- Sensors

Example: Playing Chess

Performance measure: +1 for a Win, $+\frac{1}{2}$ for a Draw, 0 for a Loss.

Environment: board, pieces

Actuators: move piece to new square

Sensors: which piece is on which square

Example: Automated Taxi

Performance measure: safety, reach destination, maximize profits, obey laws, passenger comfort, ...

Environment: city streets, freeways, traffic, pedestrians, weather, customers, ...

Actuators: steer, accelerate, brake, horn, speak/display, ...

Sensors: video, accelerometers, gauges, engine sensors, keyboard, GPS, ...

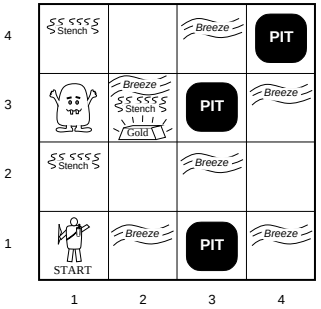
Robots

DARPA Grand Challenge

DARPA Grand Challenge

Example AI Environment - Wumpus World

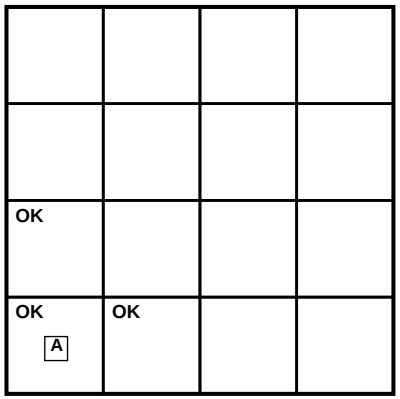
- Environment
  - Squares adjacent to Wumpus are Smelly
  - Squares adjacent to Pit are Breezy
  - Glitter iff Gold is in the same square
  - Shoot
    - kills Wumpus if you are facing it
    - uses up the only arrow
  - Grab
    - picks up Gold if in same square



Wumpus World PEAS description

- Performance measure
  - Return with Gold +1000, death -1000
  - -1 per step, -10 for using the arrow
- Actuators
  - Left, Right, Forward, Grab, Shoot
- Sensors
  - Breeze, Glitter, Stench

Exploring a Wumpus World



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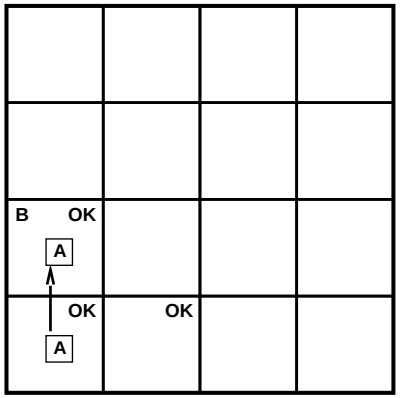

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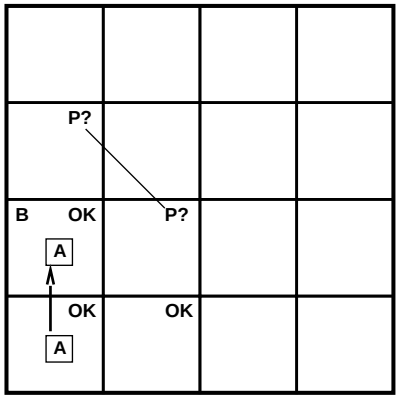

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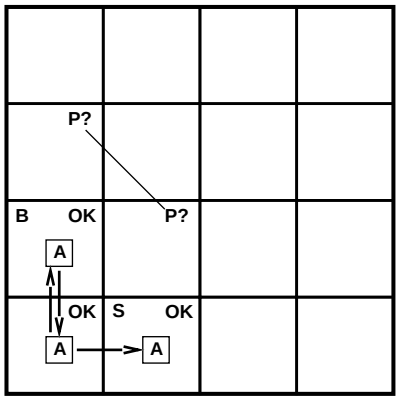
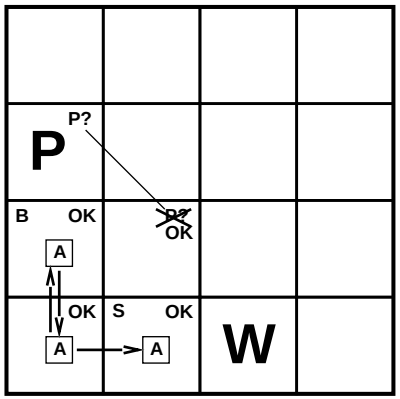


Exploring a Wumpus World



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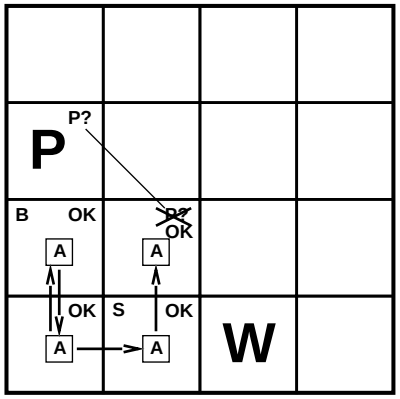

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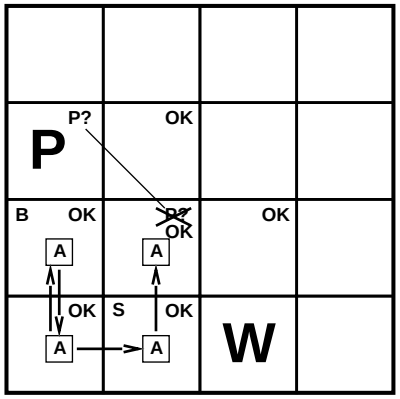

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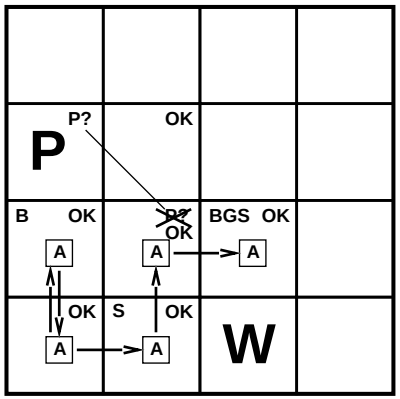


Classifying Tasks

Simulated	vs.	Situated or Embodied
Static	vs.	Dynamic
Discrete	vs.	Continuous
Fully Observable	vs.	Partially Observable
Deterministic	vs.	Stochastic
Episodic	vs.	Sequential
Known	vs.	Unknown
Single-Agent	vs.	Multi-Agent

Environment Types

Simulated: a separate program is used to simulate an environment, feed percepts to agents, evaluate performance, etc.

Static: environment doesn't change while the agent is deliberating

Discrete: finite (or countable) number of possible percepts/actions

Fully Observable: percept contains all relevant information about the world

Deterministic: current state of world uniquely determines the next

Episodic: every action by the agent is evaluated independently

Known: the rules of the game, or physics/dynamics of the environment are known to the agent

Single-Agent: only one agent acting in the environment

Chess vs. Robocup Soccer

Chess

Robocup Soccer

Simulated vs. Situated or Embodied

- Chess is Simulated, Robocup is Situated and Embodied

Simulated: a separate program is used to simulate an environment, feed percepts to agents, evaluate performance, etc.

Situated: the agent acts directly on the actual environment

Embodied: the agent has a physical body in the world

Question: If Chess is played on a physical board with actual pieces, would it become embodied?

Simulated vs. Situated or Embodied

- Chess is Simulated, Robocup is Situated and Embodied

Simulated: a separate program is used to simulate an environment, feed percepts to agents, evaluate performance, etc.

Situated: the agent acts directly on the actual environment

Embodied: the agent has a physical body in the world

Question: If Chess is played on a physical board with actual pieces, would it become embodied?

Answer: Yes it would; however, we normally "abstract" away the game itself (choice of moves), and treat the movement of the pieces as a separate task.

Static vs. Dynamic

- Chess is Simulated, Robocup is Situated and Embodied
- Chess is Static, Robocup is Dynamic

Static: the environment does not change while the agent is thinking

Dynamic: the environment may change while the agent is thinking

e.g. if the ball is in front of you but you take too long to act, another player may come in and kick it away

Notes:

1. In a multi-player game, Static environment will obviously change when the opponent moves, but cannot change once it is "our turn".
2. In tournament Chess, the clock will tick down while the player is thinking (thus making it slightly non-static).

Discrete vs. Continuous

- Chess is Simulated, Robocup is Situated and Embodied
- Chess is Static, Robocup is Dynamic
- Chess is Discrete, Robocup is Continuous

Discrete: only a finite (or countable) number of discrete percepts/actions

Continuous: states, percepts or actions can vary continuously

e.g. each piece must be on one square or the other, not half way in between.

Fully Observable vs. Partially Observable

- Chess is simulated, Robocup is Situated and Embodied
- Chess is Static, Robocup is Dynamic
- Chess is Discrete, Robocup is Continuous
- Chess is Fully Observable, Robocup (Legged) is Partially Observable

Fully Observable: agent percept contains all relevant information about the world

Partially Observable: some relevant information is hidden from the agent

[watch Dog's Eye View video] [watch Melbourne vs. Cornell video]

Note:

The Robocup F180 League is close to fully observable, because the robots have access to an external computer connected to an overhead camera.

Deterministic vs. Stochastic

- Chess is Simulated, Robocup is Situated and Embodied
- Chess is Static, Robocup is Dynamic
- Chess is Discrete, Robocup is Continuous
- Chess is fully observable, Robocup (Legged) is Partially Observable
- Chess is Deterministic, Robocup is Stochastic

Deterministic: the current state uniquely determines the next state

Stochastic: there is some random element involved

Note:

The non-determinisim partly arises because the physics can only be modeled with limited precision. But, even if it could be modeled perfectly, there would still be randomness due to quantum mechanical effects.

Episodic vs. Sequential

- Chess is Simulated, Robocup is Situated and Embodied
- Chess is Static, Robocup is Dynamic
- Chess is Discrete, Robocup is Continuous
- Chess is Fully Observable, Robocup (Legged) is Partially Observable
- Chess is Deterministic, Robocup is Stochastic
- Both Chess and Robocup are Sequential

Episodic: every action by the agent is evaluated independently

Sequential: the agent is evaluated based on a long sequence of actions

Both Chess and Robocup are considered Sequential, because evaluation only happens at the end of a game, and it is necessary to plan several steps ahead in order to play the game well.

Known vs. Unknown

- Chess is Simulated, Robocup is Situated and Embodied
- Chess is Static, Robocup is Dynamic
- Chess is Discrete, Robocup is Continuous
- Chess is Fully Observable, Robocup (Legged) is Partially Observable
- Chess is Deterministic, Robocup is Stochastic
- Both Chess and Robocup are Sequential
- Both Chess and Robocup are Known

Known: the rules of the game, or physics/dynamics of the environment, are known to the agent.

Note:

Video Games like Infinite Mario are sometimes set up in such a way that the dynamics of the environment are Unknown to the agent.

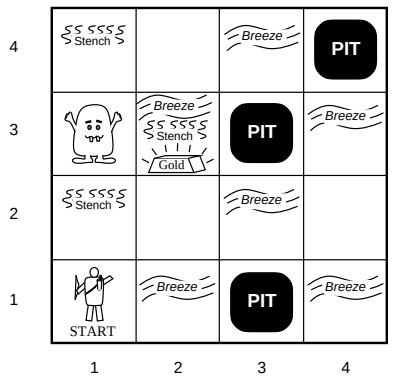
Single-Agent vs. Multi-Agent

- Chess is Simulated, Robocup is Situated and Embodied
- Chess is Static, Robocup is Dynamic
- Chess is Discrete, Robocup is Continuous
- Chess is Fully Observable, Robocup (Legged) is Partially Observable
- Chess is Deterministic, Robocup is Stochastic
- Both Chess and Robocup are Sequential
- Both Chess and Robocup are Known
- Both Chess and Robocup are Multi-Agent

Examples of Single-Agent tasks include:

- solving puzzles like Sudoku, or Rubik's cube
- Solitaire card games

Wumpus World



Simulated ?

Static ?

Discrete ?

Fully Observable ?

Deterministic ?

Episodic ?

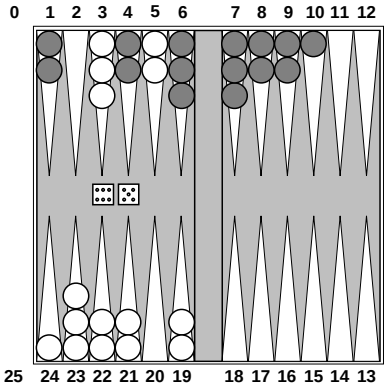
Known ?

Single-Agent ?

Wumpus World

- Like Chess, Wumpus World is Simulated, Static, Discrete, Sequential and Known.
- Wumpus World is Partially Observable – for example, you don't know where the Wumpus is.
- Wumpus World is normally considered Deterministic, because the location of the Wumpus, Gold and Pits are determined at the beginning and don't change after that.
- Wumpus World is Single-Agent. We consider the Wumpus as a "natural feature", because it doesn't move and can't make any choices.

Dice Games (Backgammon)



Simulated ?

Static ?

Discrete ?

Fully Observable ?

Deterministic ?

Episodic ?

Known ?

Single-Agent ?

Dice Games (Backgammon)

- Like Chess, Backgammon is Simulated, Static, Discrete, Sequential and Known and Multi-Agent.
- Normally, we consider Backgammon to be Fully Observable and Stochastic. The dice rolls are random, but all players can see them.
- If instead the dice rolls are generated by a computer using a pseudo-random number generator, with a specified seed, the game could be considered Deterministic but Partially Observable. In this case, the sequence of dice rolls is fully determined by the seed, but future dice rolls are not observable by the players.

Card Games (Poker, Rummy, Mahjong)

Simulated ?

Static ?

Discrete ?

Fully Observable ?

Deterministic ?

Episodic ?

Known ?

Single-Agent ?

Card Games (Poker, Rummy, Mahjong)

- Card Games like Poker, Rummy or Mahjong are Simulated, Static, Discrete, Sequential, Known and Multi-Agent.
- Card Games are Stochastic if the cards are shuffled during the game, but can be considered Deterministic if the cards are shuffled only once, before the game begins.
- Card Games are Partially Observable and involve Asymmetric Information in the sense that each player can see their own cards but not those of other players.

Robots

Situated and Embodied Cognition

Rodney Brooks 1991:

- Situatedness: The robots are situated in the world – they do not deal with abstract descriptions, but with the "here" and "now" of the environment which directly influences the behaviour of the system.
- Embodiment: The robots have bodies and experience the world directly – their actions are part of a dynamics with the world, and actions have immediate feedback on the robot's own sensations.

Situated vs. Embodied

- Situated but not Embodied: High frequency stock trading system:
  - it deals with thousands of buy/sell bids per second and its responses vary as its database changes.
  - but it interacts with the world only through sending and receiving messages.
- Embodied but not Situated: an industrial spray painting robot:
  - does not perceive any aspects of the shape of an object presented to it for painting; simply goes through a pre-programmed series of actions
  - but it has physical extent and its servo routines must correct for its interactions with gravity and noise present in the system.

Summary

- AI tasks or environments can be classified in terms of whether they are simulated, static, discrete, fully observable, deterministic, episodic, known, single- or multi- agent.
- The environment type strongly influences the agent design (discussed in the next section..)