Learning objectives

At the end of the class you should be able to:

- characterize simplifying assumptions made in building AI systems
- determine what simplifying assumptions particular AI systems are making
- suggest what assumptions to lift to build a more intelligent system than an existing one

Dimensions

- Research proceeds by making simplifying assumptions, and gradually reducing them.
- Each simplifying assumption gives a dimension of complexity
  - multiple values in a dimension: from simple to complex
  - simplifying assumptions can be relaxed in various combinations

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- Example: Planning a trip from here to a see the Mona Lisa in Paris.
- Flat representations are adequate for simple systems.
- Complex biological systems, computer systems, organizations are all hierarchical
- A flat description is either continuous or discrete. Hierarchical reasoning is often a hybrid of continuous and discrete.

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- Infinite stage: the agent plans for going on forever (process oriented)

Representation

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  - 30 binary features can represent $2^{30} = 1,073,741,824$ states.
- Individuals and relations
  - There is a feature for each relationship on each tuple of individuals.
  - Often an agent can reason without knowing the individuals or when there are infinitely many individuals.

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- Bounded rationality: the agent must make good decisions based on its perceptual, computational and memory limitations.

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- Learning is impossible without prior knowledge (bias).

Uncertainty

There are two dimensions for uncertainty. In each dimension an agent can have

- No uncertainty: the agent knows what is true
- Disjunctive uncertainty: there is a set of states that are possible
- Probabilistic uncertainty: a probability distribution over the worlds.

Why probability?

- Agents need to act even if they are uncertain.
- Predictions are needed to decide what to do:
  - definitive predictions: you will be run over tomorrow
  - disjunctions: be careful or you will be run over
  - point probabilities: probability you will be run over tomorrow is 0.002 if you are careful and 0.05 if you are not careful

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- Acting is gambling: agents who don't use probabilities will lose to those who do.
- Probabilities can be learned from data and prior knowledge.

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Whether an agent can determine the state from its stimuli:

- Fully-observable: the agent can observe the state of the world.
- Partially-observable: there can be a number states that are possible given the agent's stimuli.

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The dynamics can be:

- Deterministic: the resulting state is determined from the action and the state
- Stochastic: there is uncertainty about the resulting state.

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Examples: coffee delivery robot, medical doctor

Number of agents

Are there multiple reasoning agents that need to be taken into account?

- Single agent reasoning: any other agents are part of the environment.
- Multiple agent reasoning: an agent reasons strategically about the reasoning of other agents.

Agents can have their own goals: cooperative, competitive, or goals can be independent of each other

Interaction

When does the agent reason to determine what to do?

- reason offline: before acting
- reason online: while interacting with environment

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State-space search

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Deterministic planning

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Decision networks

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Markov decision processes (MDPs)

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Decision-theoretic planning

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Reinforcement learning

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Classical game theory

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Humans

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The dimensions interact in complex ways

- Partial observability makes multi-agent and indefinite horizon reasoning more complex
- Modularity interacts with uncertainty and succinctness: some levels may be fully observable, some may be partially observable
- Three values of dimensions promise to make reasoning simpler for the agent:
  - Hierarchical reasoning
  - Individuals and relations
  - Bounded rationality