CMP9132M

Advanced Artificial Intelligence

Lecture 1: “Introduction”

Nicola Bellotto & Heriberto Cuayahuitl

Who am I?

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PADUA

Who am I

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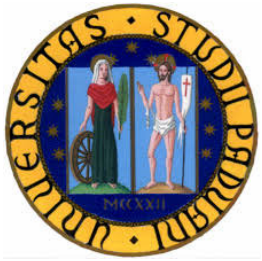
- Degree in Electronic Engineering (University of Padua)



- PhD in Computer Science and Robotics (University of Essex)

- Post-doc on Computer Vision (University of Oxford)

Who am I

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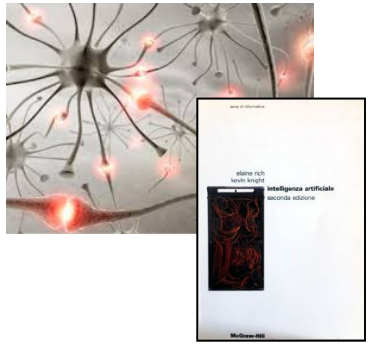
- Got interested in AI in my 20s



- Participated to RoboCup during university

- Worked with several robots and cameras for my Master, PhD, post-doc etc.

Who am I?

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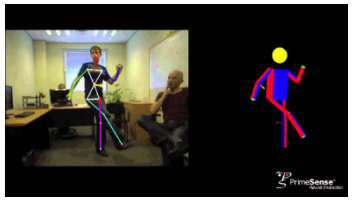
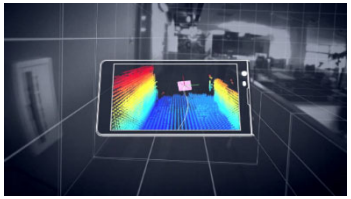
- Currently doing research on AI applied to mobile robots in human environments

- Also smart applications for mobile devices and intelligent environments




- See also http://webpages.lincoln.ac.uk/nbellotto/

Contact Information

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- Surgery hours

  (see Blackboard)

Who are YOU?

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Course Overview

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- This module covers the theoretical fundamentals and practical applications of decision-making, problem-solving and learning abilities in software agents.

- Final learning outcomes are three:

  1. Critically appraise a range of AI techniques for decision-making, problem solving and learning, identifying their strengths and weaknesses, and selecting appropriate methods to serve particular roles;

  2. Analyse the “state of the art” in AI, including an understanding of current applications;

  3. Design and develop an AI-based software program for solving complex search problems in an application domain of interest.

Assessment

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- Assignment (worth 50% of the final mark)
- In-class test (worth 50% of the final mark)
- More details on Blackboard and in the coming weeks

Topics

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- Quantifying uncertainty
  - Intro to probability etc.
- Probabilistic reasoning
  - Bayesian networks etc.
- Reasoning over time
  - Hidden Markov Models, Kalman filter, etc.
- Making complex decisions
  - Markov Decision Processes etc.

Links to Machine Learning

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- Reasoning over time
  - Hidden Markov Models, Kalman filter, etc.
  - Recurrent Neural Networks (RNNs)

- Making complex decisions
  - Markov Decision Processes etc.
  - Deep Reinforcement Learning (DRL)

Recommended Reading

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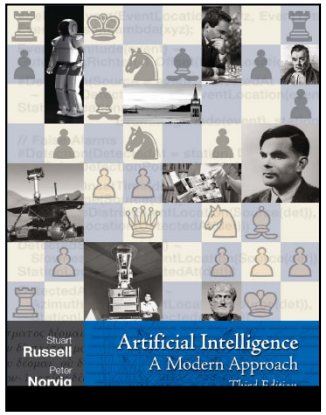
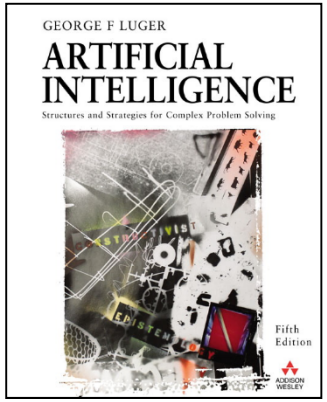
- Main book
  - S. Russell & P. Norvig, “Artificial Intelligence – A Modern Approach” (any edition)



- Further reading:
  - G. F. Luger, “Artificial Intelligence – Structures and Strategies for Complex Problem Solving” (any edition)



Basic Rules

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- Check frequently Blackboard and your email for updates and communications
- Remember to sign the register form
- Switch off your mobile, please!
- If something is not clear, just raise your hand

Outline

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- What is AI?
- A brief history
- Rational agents

What is AI?

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Views of AI fall into four categories:

Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

We adopt this view

Acting humanly

Turing Test

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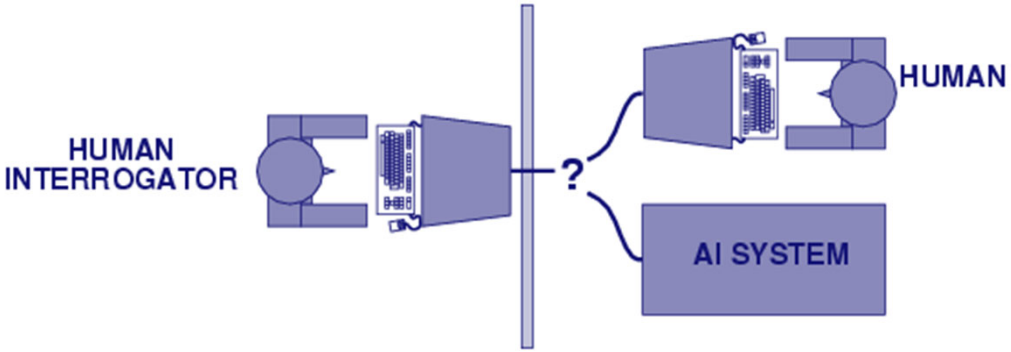
- Turing (1950) “Computing machinery and intelligence”:
- “Can machines think?” → “Can machines behave intelligently?”
- Operational test for intelligent behavior: the Imitation Game



- Suggested major components of AI: knowledge, reasoning, language understanding, learning

Thinking humanly
Cognitive modeling

- 1960s “cognitive revolution”: information-processing & psychology
- Requires scientific theories of internal activities of the brain
- How to validate? Requires

  1) Predicting and testing behavior of human (top-down)

  or…

  2) Direct identification from neurological data (bottom-up)

- Both approaches – 1) Cognitive Science and 2) Cognitive Neuroscience – are now distinct from AI

Thinking rationally

"Laws of thought"

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- Aristotle: what are correct arguments/thought processes?
- Several Greek schools developed various forms of *logic*: notation and rules of derivation for thoughts
- Direct line through mathematics and philosophy to modern AI
- Problems:
  1. Not all intelligent behavior is mediated by logical deliberation (e.g. reflex action)
  2. What is the purpose of thinking? Which thoughts should I have?

Acting rationally
Rational agent

- Rational behavior: doing the right thing!
- The right thing: that which is expected to maximize goal achievement, given the available information
- Doesn't necessarily involve thinking – e.g. blinking reflex – but thinking should be in the service of rational action

AI roots

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- **Philosophy** — Logic, methods of reasoning, mind as physical system foundations of learning, language, rationality
- **Mathematics** — Formal representation and proof algorithms, computation, (un)decidability, (in)tractability, probability
- **Economics** — utility, decision theory
- **Neuroscience** — physical substrate for mental activity
- **Psychology** — phenomena of perception and motor control, experimental techniques
- **Computer engineering** — building fast computers
- **Control theory** — design systems that maximize an objective function over time
- **Linguistics** — knowledge representation, grammar

AI history

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• 1943	McCulloch & Pitts: Boolean circuit model of brain
• 1950	Turing's "Computing Machinery and Intelligence"
• 1956	Dartmouth meeting: "Artificial Intelligence" adopted
• 1952-69	Look, Ma, no hands!
• 1950s	Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
• 1965	Robinson's complete algorithm for logical reasoning
• 1966-73	AI discovers computational complexity Neural network research almost disappears
• 1969-79	Early development of knowledge-based systems
• 1980-	AI becomes an industry
• 1986-	Neural networks return to popularity
• 1987-	AI becomes a science
• 1995-	The emergence of intelligent agents

State of the art

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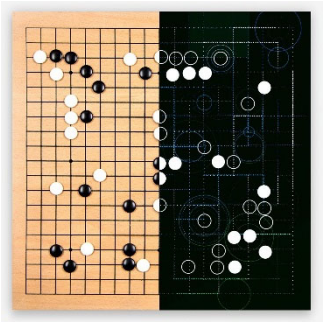
- IBM Deep Blue defeated world chess champion Garry Kasparov in **1997**
- IBM Watson won Jeopardy! in **2011**
- Google's AlphaGo beats #1 player in **2017**
- Autonomous vehicles
- SIRI, Amazon Echo, Google Home
- … and more!



AI history

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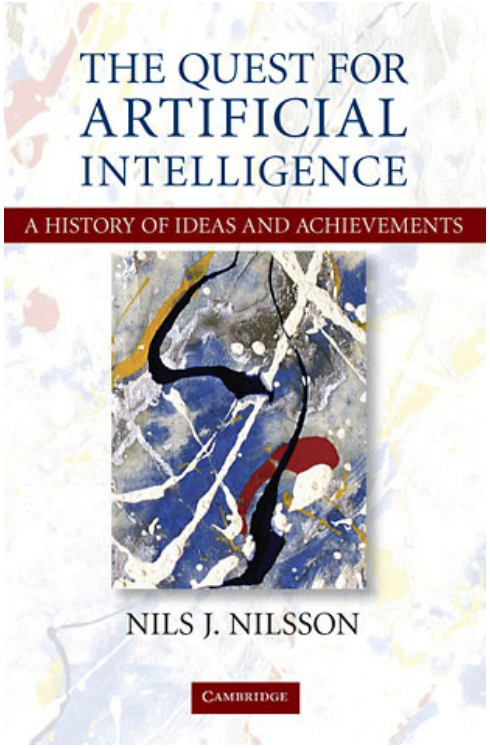
https://ai.stanford.edu/~nilsson/



Rational agents

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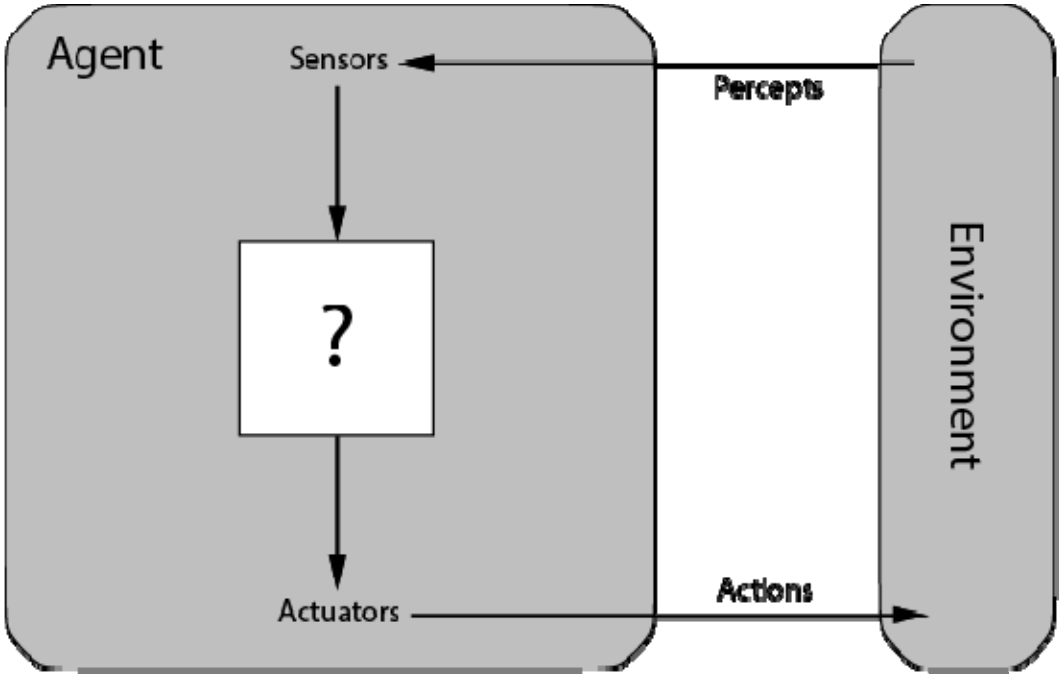
- An agent is an entity that perceives and acts



Rational agents

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- Abstractly, an agent is a function from percept histories to actions:

$$[f: \mathcal{P}^{\star} \rightarrow \mathcal{A}]$$

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
- The agent's rationality depends on
  - Metric to measure performance
  - Prior knowledge of the environment
  - Possible agent's actions
  - (Sequence of) agent's percepts

Task Environment

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- Task environment = problem to which the rational agent tries to provide a solution
- Different properties
  - **Fully** or **Partially Observable**
  - **Deterministic** or **Stochastic**
  - **Episodic** or **Sequential**
  - **Static** or **Dynamic**
  - **Discrete** or **Continuous**
  - **Single-** or **Multi-Agent**

In conclusion…

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- Problem: uncertainty and computational limitations make perfect rational agent(s) unachievable

  → design best program given the available information and machine resources!

Conclusions

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- Suggested reading
  - Chapter 1 and 2 of Russell & Norvig
- Next week
  - Intro to probability (Heriberto)
- Workshops start next week
- Any question?