Artificial Intelligence course

6th Semester

Bachelor in Informatics and Computer Engineering

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Intended learning outcomes

Students who successfully complete this course will be able to:

1. Knowing algorithms for search, progressive improvement, automated planning, and machine learning with neural networks
2. Understand the areas of application of search, progressive improvement, automated planning, and neural networks
3. Apply search, progressive improvement, and automated planning in problem solving; Apply neural networks in machine learning tasks

Intended learning outcomes

4. Compare results of the application of search, progressive improvement algorithms, automated planning, and neural networks
5. Writing reports analyzing the performance of different algorithms

Syllabus

- Introduction to Artificial Intelligence: motivation, type of problems that can be solved
- Search Algorithms: blind and guided searches in state space, progressive improvement algorithms in solutions' space, adversary search algorithms; Simulating Annealing and Hill Climbing as optimizers; Genetic Algorithms
- Automatic Planning: Total order and partial order planners
- Neural Networks

Assessment

- The assessment is based on two components with a weight of 50% each:
  1. Elaboration of three practical works carried out in groups and a final discussion;
  2. Final test carried out at the time of exams. At the time of appeal, the final test may be repeated.
- To be approved in the course, the student must have: final test score greater than or equal to 10 points; final discussion grade greater than or equal to 10 points.

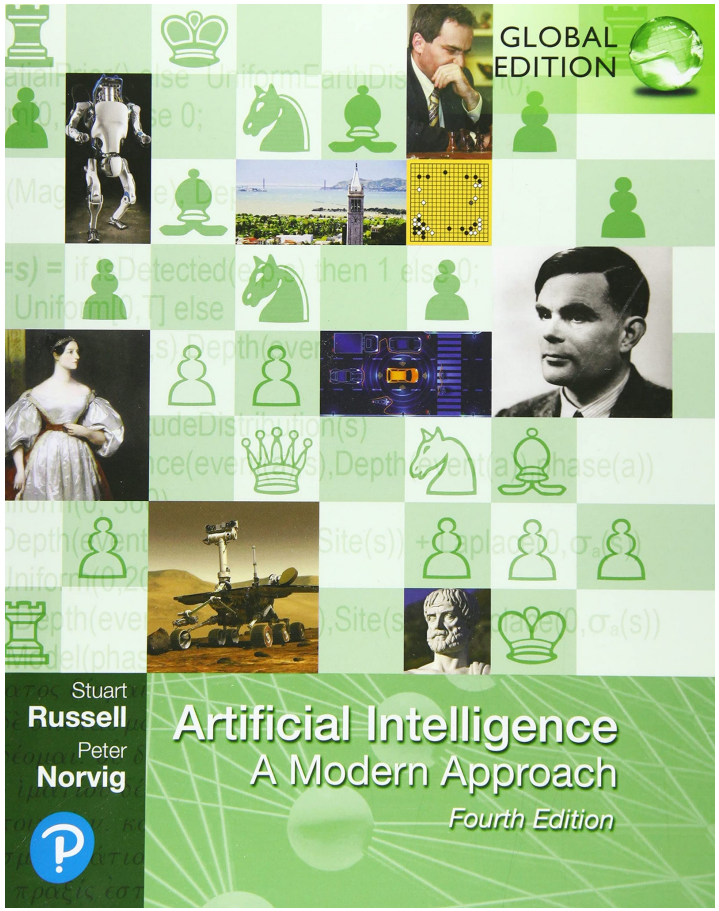
Practical projects

- Dates:
  - 1th project: publication on 14/March/22, due on 11/April/22
  - 2nd project: publication on 12/April/22, due on 16/May/22
  - 3rd project: publication on 17/May/22, due on 19/June/22
- Languages and software used: Prolog language and Java (or other); SWI-Prolog (`https://www.swi-prolog.org`)

Practical projects

- Practical projects, and their associated reports, are submitted into MOODLE platform:
  - AI Moodle URL:
    `https://2122moodle.isel.pt/course/view.php?id=5543`
  - In Moodle, you can: see classe's summaries, subscribe to Students' Practical Groups, see links to resources (on GitHub)

Bibliography I



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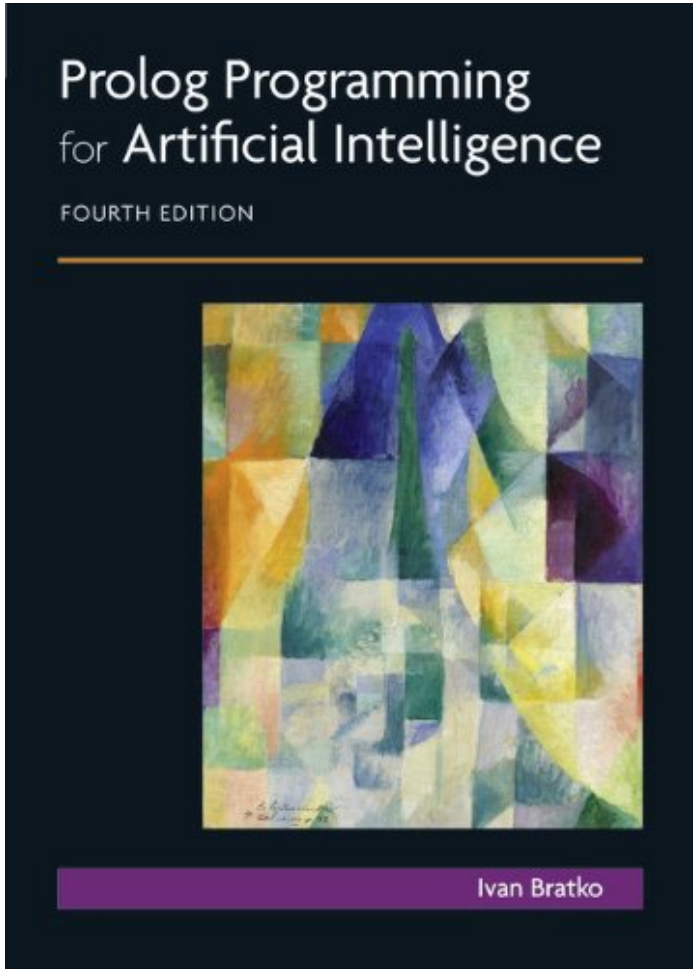
Bibliography II



Ivan Bratko,
Prolog Programming for Artificial Intelligence,
4th edition, Pearson Education Canada, 2011,
ISBN-10: 0321417461,
ISBN-13: 978-0321417466

Introduction to AI

- The following material was adapted from the book:
  - Wolfgang Ertel. “Introduction to Artificial Intelligence”
  - Undergraduate Topics in Computer Science
  - DOI: `https://doi.org/10.1007/978-3-319-58487-4`
  - Springer International Publishing AG 2017

What is AI?

- The central question for the engineer, especially for the computer scientist, is the question of the intelligent machine that behaves like a person, showing intelligent behavior
- One of the first definitions:
  - 1955, John McCarthy: *The goal of AI is to develop machines that behave as though they were intelligent.*

What is AI?

- Example:
  - 15 small robotic vehicles are moving on an enclosed 4 by 4 meter square surface
  - Some vehicles form small groups with relatively little movement
  - Others move peacefully through the space and gracefully avoid any collision
  - Still others appear to follow a leader
  - Aggressive behaviors are also observable
  - Is what we are seeing intelligent behavior?

- Psychologist Valentin Braitenberg has shown that this seemingly complex behavior can be produced by very simple electrical circuits
- Braitenberg vehicles have two wheels, each of which is driven by an independent electric motor. The speed of each motor is influenced by a light sensor on the front of the vehicle

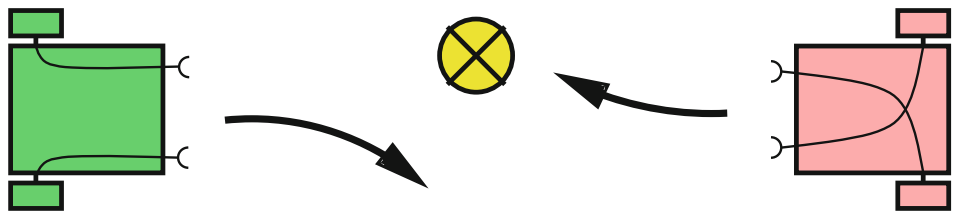


Fig. 1.1 Two very simple Braitenberg vehicles and their reactions to a light source

Introduction to AI

- The Encyclopedia Britannica's definition:
  AI is the ability of digital computers or computer controlled robots to solve problems that are normally associated with the higher intellectual processing capabilities of humans ...

Introduction to AI

- Definition by Elaine Rich:
  Artificial Intelligence is the study of how to make computers do things at which, at the moment, people are better.

Introduction to AI

- Example:
  - A person entering an unfamiliar room will recognize the surroundings within fractions of a second and, if necessary, just as swiftly make decisions and plan actions
  - To date, this task is too demanding for autonomous robots

Introduction to AI

- Intelligent systems cannot be built without a deep understanding of human reasoning and intelligent action in general, because of which neuroscience is of great importance to AI
- A particular strength of human intelligence is *adaptivity*
  - We are capable of adjusting to various environmental conditions and change our behavior accordingly through *learning*
  - Human's learning ability is vastly superior to that of computers
  - *Machine learning* is now a central subfield of AI

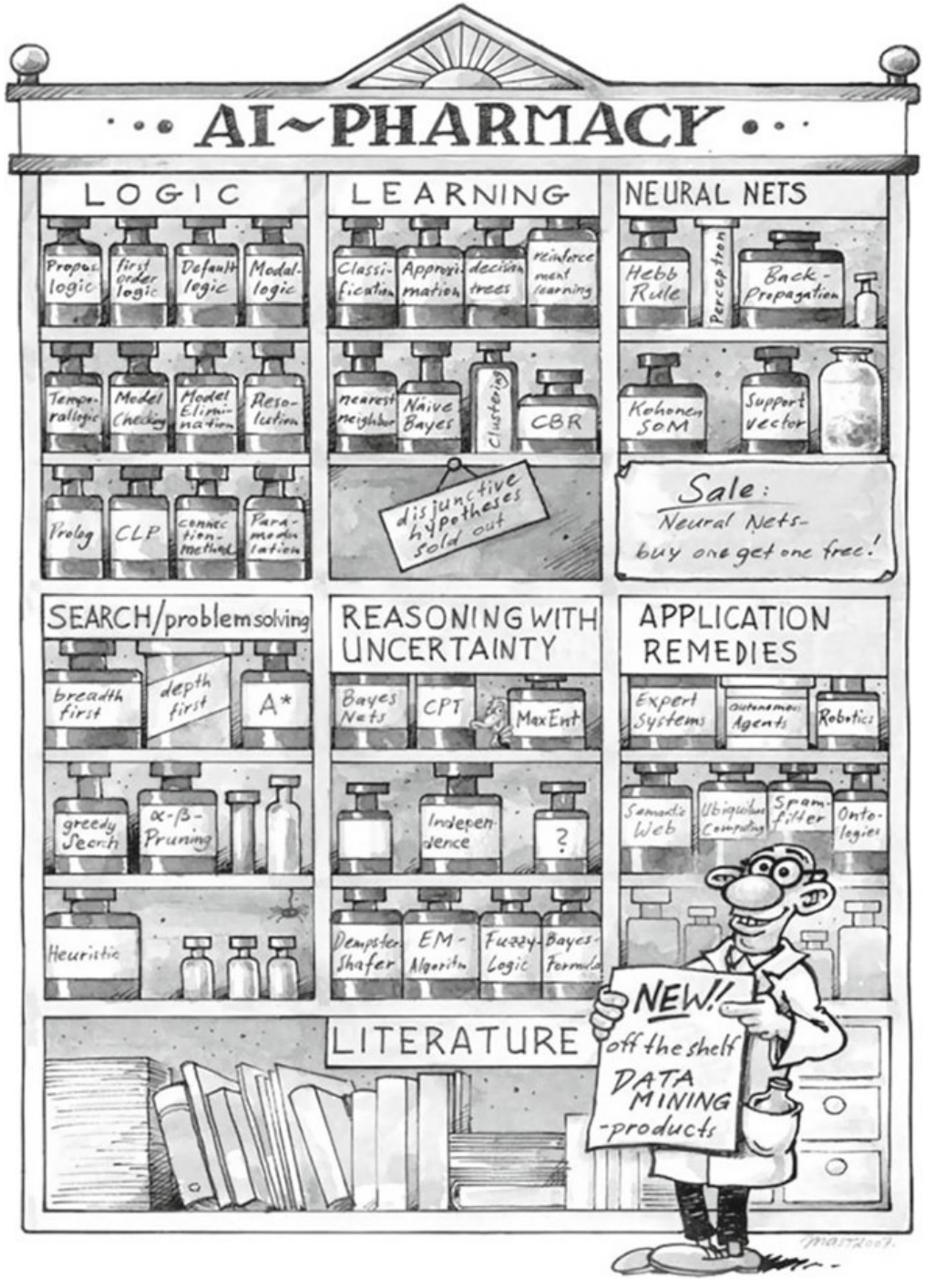


Fig. 1.2 A small sample of the solutions offered by AI

Table 1.1 Milestones in the development of AI from Gödel to today

1931	The Austrian Kurt Gödel shows that in first-order predicate logic all true statements are derivable. In higher-order logics, on the other hand, there are true statements that are unprovable.
1937	Alan Turing points out the limits of intelligent machines with the halting problem.
1943	McCulloch and Pitts model neural networks and make the connection to propositional logic.
1950	Alan Turing defines machine intelligence with the Turing test and writes about learning machines and genetic algorithms.
1951	Marvin Minsky develops a neural network machine. With 3000 vacuum tubes he simulates 40 neurons.
1955	Arthur Samuel (IBM) builds a learning checkers program that plays better than its developer.
1956	McCarthy organizes a conference in Dartmouth College. Here the name Artificial Intelligence was first introduced.
	Newell and Simon of Carnegie Mellon University (CMU) present the Logic Theorist, the first symbol-processing computer program.
1958	McCarthy invents at MIT (Massachusetts Institute of Technology) the high-level language LISP. He writes programs that are capable of modifying themselves.
1959	Gelernter (IBM) builds the Geometry Theorem Prover.
1961	The General Problem Solver (GPS) by Newell and Simon imitates human thought.
1963	McCarthy founds the AI Lab at Stanford University.
1965	Robinson invents the resolution calculus for predicate logic.
1966	Weizenbaum's program Eliza carries out dialog with people in natural language.
1969	Minsky and Papert show in their book Perceptrons that the perceptron, a very simple neural network, can only represent linear functions.
1972	French scientist Alain Colmerauer invents the logic programming language PROLOG.
	British physician de Dombal develops an expert system for diagnosis of acute abdominal pain. It goes unnoticed in the mainstream AI community of the time.
1976	Shortliffe and Buchanan develop MYCIN, an expert system for diagnosis of infectious diseases, which is capable of dealing with uncertainty.
1981	Japan begins, at great expense, the "Fifth Generation Project" with the goal of building a powerful PROLOG machine.
1982	R1, the expert system for configuring computers, saves Digital Equipment Corporation 40 million dollars per year.
1986	Renaissance of neural networks through, among others, Rumelhart, Hinton and Sejnowski. The system Nettalk learns to read texts aloud.
1990	Pearl, Cheeseman, Whittaker, Spiegelhalter bring probability theory into AI with Bayesian networks. Multi-agent systems become popular.

(continued)

Table 1.1 (continued)

1992	Tesauros TD-gammon program demonstrates the advantages of reinforcement learning.
1993	Worldwide RoboCup initiative to build soccer-playing autonomous robots.
1995	From statistical learning theory, Vapnik develops support vector machines, which are very important today.
1997	IBM’s chess computer Deep Blue defeats the chess world champion Gary Kasparov.
	First international RoboCup competition in Japan.
2003	The robots in RoboCup demonstrate impressively what AI and robotics are capable of achieving.
2006	Service robotics becomes a major AI research area.
2009	First Google self-driving car drives on the California freeway.
2010	Autonomous robots begin to improve their behavior through learning.
2011	IBM’s “Watson” beats two human champions on the television game show “Jeopardy!”. Watson understands natural language and can answer difficult questions very quickly.
2015	Daimler premiers the first autonomous truck on the Autobahn.
	Google self-driving cars have driven over one million miles and operate within cities.
	Deep learning enables very good image classification.
	Paintings in the style of the Old Masters can be automatically generated with deep learning. AI becomes creative!
2016	The Go program AlphaGo by Google DeepMind beats the European champion 5:0 in January and Korean Lee Sedol, one of the world’s best Go players, 4:1 in March. Deep learning techniques applied to pattern recognition, as well as reinforcement learning and Monte Carlo tree search lead to this success.

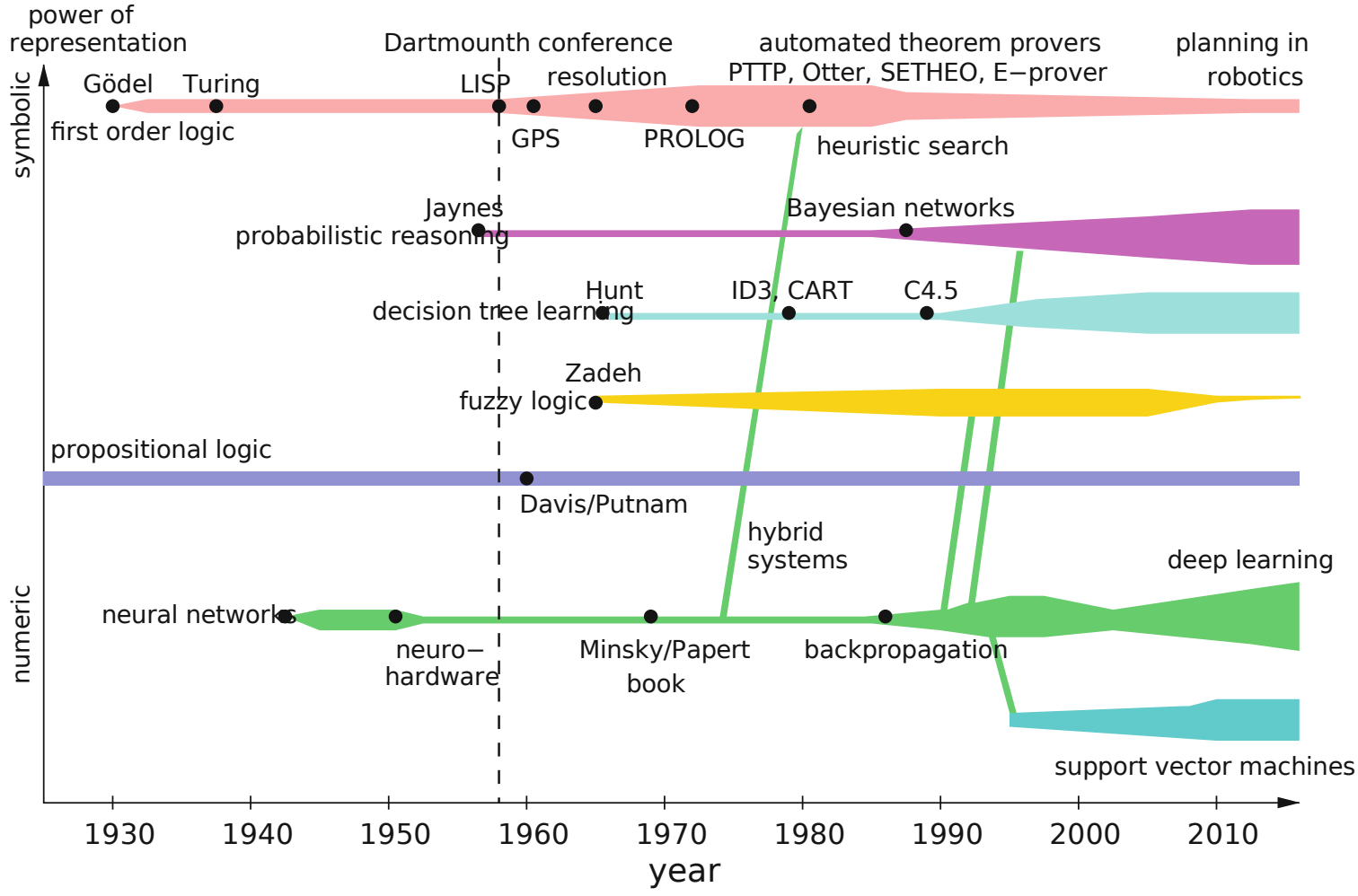


Fig. 1.3 History of the various AI areas. The width of the bars indicates prevalence of the method's use

Fig. 1.4 The assistance robot Marvin, deployed in the AsRoBe research project

- Boston Dynamics' humanoid robot Atlas:
  `https://youtu.be/rVlhMGQgDkY`