Artificial Intelligence[1]

Introduction

[1]The slides have been prepared using the textbook material available on the web, and the slides of the previous editions of the course by Prof. Luigia Carlucci Aiello

Summary

- ♢ What is AI?
- ♢ A short history
- ♢ The state of the art

What is AI?

"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem-solving, learning ..." (Bellman 1978)	"The study of mental faculties through the use of computational models" (Charniak McDermott 1985)
"The study of how to make computers do things at which, at the moment, people are better" (Rich Knight 1991)	"AI ... is concerned with intelligent behaviour in artifacts" (Nilsson, 1998)

What is AI?

Systems that think like humans	**Systems that think rationally**
Systems that act like humans	**Systems that act rationally**

Acting humanly: The Turing test

Turing (1950) "Computing machinery and intelligence":

♢ "Can machines think?" $\longrightarrow$ "Can machines behave intelligently?"

♢ Operational test for intelligent behavior: the Imitation Game

♢ Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes

♢ Anticipated all major arguments against AI in following 50 years

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

Problem: Turing test is not reproducible, constructive, or amenable to mathematical analysis

Thinking humanly: Cognitive Science

1960s "cognitive revolution": information-processing psychology replaced prevailing orthodoxy of behaviorism

Requires scientific theories of internal activities of the brain

– What level of abstraction? "Knowledge" or "circuits"?

– How to validate? Requires

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

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

Both approaches (roughly Cognitive Science and Cognitive NeuroScience are now distinct.

Thinking rationally: Laws of Thought

Normative (or prescriptive) rather than descriptive

Aristotle: what are correct arguments/thought processes?

Several Greek schools developed various forms of logic:
notation and rules of derivation for thoughts;
may or may not have proceeded to the idea of mechanization

Direct line through mathematics and philosophy to modern AI

Problems:
1) Not all intelligent behavior is mediated by logical deliberation
2) What is the purpose of thinking? What thoughts should I have?

Acting rationally

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

Aristotle (Nicomachean Ethics):

> *Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good*

Rational agents

An agent is an entity that perceives and acts

This course is about designing rational agents

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

$$f : \mathcal{P}^* \rightarrow \mathcal{A}$$

For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

Caveat: *computational limitations make perfect rationality unachievable*

$\rightarrow$ design best program for given machine resources

AI and other disciplines

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
Psychology	adaptation
	phenomena of perception and motor control
	experimental techniques (psychophysics, etc.)
Economics	formal theory of rational decisions
Linguistics	knowledge representation
	grammar
Neuroscience	plastic physical substrate for mental activity
Control theory	homeostatic systems, stability
	simple optimal agent designs

History of AI

1931

The Austrian Kurt Goedel 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

History of AI

1955

Arthur Samuel (IBM) builds a learning chess 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 the Massachusettes Institute of Technology (MIT) 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

History of AI

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 dialogue 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

History of AI

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

The last 20 years of AI

1997 Deep Blue wins against Kasparov

2011 Watson wins Jeopardy champions

2016 Deepmind wins against GO champions

The state of the art: Competitions/Challenges

1997 First RoboCup in Nagoya

- DARPA Grand Challenges
- Everywhere (ICAPS, ... Angry bird)

The state of the art: topics

- Speech understanding and NLP
- Robotics
- Vision
- Big Data

Big data and Deep Learning

The state of the art: keywords

Agent-based and Multi-agent Systems, Distributed AI, E-Commerce, Game Theory, Social Choice, Constraints, Satisfiability, and Search Knowledge Representation, Reasoning and Logic, Automated Reasoning and Theorem Proving, Description Logics and Ontologies, Diagnosis and Abductive Reasoning, Geometric, Spatial, and Temporal Reasoning, Machine Learning, Data Mining, Deep Learning, Evolutionary Computation, Neural Networks, Planning and Scheduling, Uncertainty in AI

The state of the art: Keywords

AI and Natural Sciences, AI and Social Sciences, Art and Music, AI and Ubiquitous Computing Systems, Autonomic Computing, Brain Sciences, Cognitive Modeling, Computational Biology and e-Health, Computational Sustainability, Computer Games, Computer-Aided Education, Human-Computer Interaction, Intelligent Database Systems, Intelligent User Interfaces, Interactive Entertainment, Knowledge-based Systems, Knowledge-based Software Engineering, Personalization and User Modeling, Real-Time Systems, Security and Privacy, Validation and Verification,

Web and Knowledge-based Information Systems, Semantic Web, Social Networks, Web Mining, Web Search,

The state of the art: Keywords

Natural-Language Processing, Information Extraction, Information Retrieval, Machine Translation, Psycholinguistics, Question Answering, Speech Recognition and Understanding, Text Classification,

Robotics and Vision Behavior and Control Cognitive Robotics Human Robot Interaction Localization, Mapping, State Estimation Manipulation Motion and Path Planning Multi-Robot Systems

Sensor Networks Vision and Perception

Philosophical and Ethical Issues

Philosophical questions

- Can a machine **think** ?
- Can a machine have an **intelligent behaviour** ?
- Can a machine have **consciousness** ?
- Can a machine have **self-consciousness** ?
- Can a machine have **emotions, ...** ?

Ethical issues

- Advantages and disadvantages of **automation**
- Increase or decrease **human intelligence**?
- **Privacy**
- **Legal Issues**
- **Ethics**