

INTRODUCTION TO ARTIFICIAL INTELLIGENCE

in Python LANGUAGE

Chapter 1: Introduction to AI

Introduction to AI

Outline

1. What is AI: Definitions & History
2. Introduction to Machine Learning & Data Mining
3. Overview of Machine learning models

[CS 221 - Reflex-based Models Cheatsheet \(stanford.edu\)](https://stanford.edu/~cs221/refs/lex-reflex-cheatsheet.pdf)

1.1. AI: Definitions & History

- **Definitions:**

4 categories: Systems that **think like humans**, systems that **act like humans**, system that **think rationally**, systems that **acts rationally**.

“Effort to make computers think ... *machines with minds*” (Haugeland, 1985)

“The automation of activities such as decision-making, problem solving, learning, ...” (Bellman, 1978)

“The art of creating machines the perform functions that require intelligence” (Kurzewil, 1990)

“The study of how to make computers do things at which, at the moment, human are better” (Bellman, 1978)

“The study of mental faculties through computer models” (*Charniak et al., 1985*)

“The study of the computations that make it possible to perceive, reason and act” (Winston, 1992)

“A field of study that seek to explain and to emulate intelligence behavior in term of computational processes” (*Schalkoff et al., 1990*)

“The branch of computer science that is concerned with the automation of intelligent behavior” (Luger et al., 1993)

Source: Russell et al. , Artificial Intelligence, a Modern Approach

1.1. AI: Definitions & History

• Definitions:

Acting humanly: The **Turing test (1950)** was proposed to determine if a computer can be qualified to be intelligent or not. The authors define intelligence as the ability to achieve human – level performance in cognitive tasks. The test consists of having a computer interrogated by a human subject via teletype. The computer passes the test if the interrogator cannot identify if the other end is a computer or a human that is having the conversation with him/her. In order to pass this test, the computer must be equipped following capabilities:

- Natural language processing
- Knowledge representation
- Automated reasoning
- Machine learning

1.1. AI: Definitions & History

• Definitions:

Thinking humanly: The cognitive modelling approach:

- Defining human thinking process (introspection, psychological experiments) → Cognitive Science
→ Theory of working principles of human mind.
- Cognitive Science: Experiments on human / animals
- AI: Experiments on Computer

AI – Cognitive Science → Synergy: Several applications (Computer Vision, Natural Language Processing, Machine Learning),

1.1. AI: Definitions & History

• Definitions:

Systems that think rationally:

- Law of thought approach (Aristotle): Socrates is a man, a man is mortal \rightarrow Socrates is mortal.
- Law of thought is supposed to govern the operation of the mind \rightarrow **Logic**.
- 3 traditional laws (Bertrand Russell, 1912): The *law of identity*, the *law of non-contradiction*, the *law of excluded middle*
- 4th law: The *law of sufficient reason* (Of everything that is, there should be a reason or a cause).
- Creation of intelligent systems using computer: Statements, time, memory, algorithms searching the solution to problems (described in logical notation).

1.1. AI: Definitions & History

• Definitions:

Systems that act rationally:

- A system that act in order to achieve one's **goal**, given one's **beliefs**.
- The rational agent approach (intelligent agent): **perceives** and **acts**.
- The rational agent is capable of making correct **inferences**.
- Systems capable of acting rationally: Ability to represent knowledge and reason in order to make good decisions within a wide variety of situations.
- An **intelligent rational agents** should be able to:
 - Generate comprehensive sentences to communicate with users.
 - Learn and acquired new knowledge.
 - Visually perceive allowing a precise perception of the external environment.

1.1. AI: Definitions & History

• Foundations of AI:

Since the beginning of Computer Sciences (1940 - today):

- 1st computer: Built in 1940s by the team of Alan Turing.
- Colossus computer built by vacuum tube (1943).
- 1st programmable computer (Z-3 machine): Built by Konrad Zuse in 1941 in Germany.
- In US, different versions of computers were developed during 1940s:
 - ABC developed by J. Atanasoff & C. Berry (1940-1942) at Iowa Univ.
 - Mark I, II, III (military research) by H. Aiken at Harvard.
 - ENIAC by J. Mauchly & J. Eckert at Univ. of Pennsylvania (First Electronic, Digital Computer developed for artillery firing table).
 - EDVAC by J. V. Neumann (ability to store program)
 - IBM 701 built in 1952 by N. Rochester and his team → one of the world largest corporation.

1.1. AI: Definitions & History

- **History of AI:**

Beginning of AI (1943 - 1956):

- 1st recognized AI work: W. McCulloch & W. Pitts (1943):
 - Knowledge of the basic physiology and function of neurons in the brain.
 - Propositional logic (Boolean logic) by Russell and Whitehead.
 - Turing theory of computation.
- Propose a model of artificial neurons that can be activated by stimulation of neighboring neurons.
- McCulloch & Pitts suggested that suitable defined networks could learn. Hebb (1949) demonstrated that using simple updating rule for modifying the connection strengths could allow learning to take place.

1.1. AI: Definitions & History

- **History of AI:**

Gestation of AI (1943 - 1956):

- Chess program: 1953 (Alan Turing) for Von Neumann style computer.
- 1st Neural Network computer developed in 1951 by M. Minsky and D. Edmonds.
- Dartmouth (1956): Workshop regrouping influencing researchers in the field (McCarthy, Minsky, Shannon, Rochester, More (Princeton), Samuel (IBM), Solomonoff (MIT), Selfridge (MIT)) to discuss on related subjects such as: automata theory, neural net, intelligence → Birthplace of the notion **artificial intelligence**.

1.1. AI: Definitions & History

- **History of AI:**

Beginning of the development AI (1952 - 1969):

- Development of the General Problem Solver (GPS) that imitates human problem solving protocol.
- Researchers at IBM developed Geometry Theorem Prover that helps demonstrate theorems using explicitly represented axioms.
- Samuel (1952) wrote checker program capable to learn and improve its game and that could participate in tournaments.
- 1958: McCarthy defined the language **Lisp**, dominant high-level AI programming language, still in used today.
- Minsky worked on limited problems that requires intelligence to solve (micro-worlds): Closed form integrations, geometric analogy problem, ...

1.1. AI: Definitions & History

- **History of AI:**

Challenges & Difficulties (1966 - 1974):

- Researchers were too optimistic at the beginning (for ex: predicting a computer to become World Chess champion within 10 years, being able to create new mathematical theorem, ...)
- Early AI programs contain little or no knowledge.
- The early programs were feasible only because the micro-worlds contained very few objects.
- Failure of genetic algorithms (based on random mutations & preservation of mutations that seem to improve behaviors).

1.1. AI: Definitions & History

- **History of AI:**

Knowledge based system (1969 - 1979):

- Development of **experts systems**. The expertise derives from a large numbers of special purpose rules. Systems later incorporated McCarthy's Advice Taker approach: the **separation** of **Knowledge** (Set of Rules) and **Reasoning** Components.
- “To solve a hard problem, you almost have to know the answer already”.
- Examples: MYCIN to diagnose blood infections.

1.1. AI: Definitions & History

• History of AI:

Booming of AI Industry (1980 - 1988):

- 1st commercialization of Expert Systems (R1) at Digital Equipment Corporation: Help configure orders for new computer systems.
- Full scale natural language understanding system (1981): Fifth Generation Project (Japan).
- Software tools developed by several companies such as: Canergie Group, Inference, Intellicorp, Teknowledge → Tools to develop expert systems.
- Workstations proposed by hardware companies such as: Lisp Machine, Texas Instrument, Symbolics, Xeros, ...
- Development of Robotic Vision Systems by hundreds of companies.
- Sales: few millions of USD in 1980 → 2 billions of USD in 1988.

1.1. AI: Definitions & History

• History of AI:

Recently (1986 - today):

- After being neglected by the AI research community, Neural network returned.
- 1st work: Perceptrons (Minsky & Papert)
- Hopfield (1982), physicist that studied the storage and optimization properties of networks.
- D. Rumelhart & G. Hinton studied the neural net models of memory.
- Mid – 80s: Re-focus on back propagation algorithm first found by Bryson and Ho (1969).
- Rivalry between Neural Network System & Expert System.
- Today (from 1987 - now): Focusing on building on existing theory rather than proposing new one.
- Recent new techniques: HMMs (Hidden Markov Models), belief networks, planning
- New advances in robotics, computer vision, machine learning, knowledge representation, ...

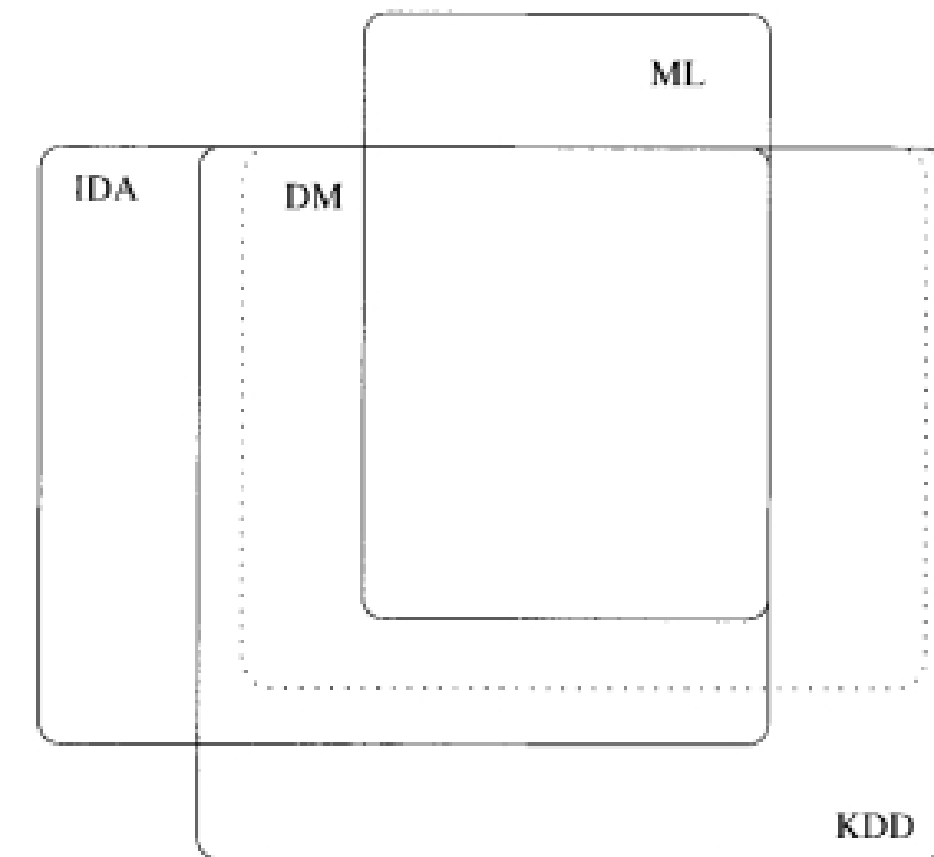
1.2. Introduction to Machine Learning & Data Mining

- **Machine learning (ML)** is a subfield of artificial intelligence
- Tremendous improvements in the last 20 years: numerous commercial and open source systems for machine learning
- Various applications in industry, medicine, economics, natural and technical sciences, ecology, finance, ...
- ML is used for data analysis and knowledge discovery in databases (**data mining**), automatic generation of knowledge bases for **expert systems**, learning to plan, game playing, construction of numerical and qualitative models, text classification and text mining (e.g., on the www), for automatic knowledge acquisition to **control dynamic processes**, automatic **recognition of speech, handwriting, and images**, etc. . *(Source: Machine learning & Data Mining – Kononenko et al.)*

1.2. Introduction to Machine Learning & Data Mining

- Today data analysis: Enormous amount of data.
- New interdisciplinary field emerged: pattern recognition, machine learning, visualization tools to analyze data & to discover the hidden principle within the data.
- ✓ Knowledge discovery in database (KDD)
- ✓ Data mining (DM)
- ✓ Intelligent Data Analysis

ML also covers other fields such as computational learning theory, reinforcement learning, dynamic control ...



(Source: Machine learning & Data Mining – Kononenko et al.)

1.2. Introduction to Machine Learning & Data Mining

- **Machine learning:**

- **Def 1:** “Machine learning (ML) is a branch of [artificial intelligence \(AI\)](#) and computer science that focuses on the using data and algorithms to enable AI to imitate the way that humans learn, gradually improving its accuracy.” — *Source:* [What Is Machine Learning \(ML\)? | IBM](#)
- **Def 2:** “Machine learning is the kind of programming which gives computers the capability to automatically learn from data without being explicitly programmed. This means in other words that these programs change their behavior by learning from data”. *Source:* [Intro to Machine Learning with Python | Machine Learning \(python-course.eu\)](#).
- **Def 3:** Machine learning is the way of programming a computer to automatically recognize features (classify) or solve a particular problem without explicitly giving it the formulas (predict). The computer is capable of learning by experience, i.e. using data and output errors for optimization.

1.2. Introduction to Machine Learning & Data Mining

- **How does it works ?**

A typical machine learning program can be divided in 3 parts:

- A Decision Process: Giving Prediction / classification based on data (labeled / unlabeled).
- An Error Function: Evaluate the prediction/classification and calculate the accuracy if training data is available.
- A Model Optimization Process: An iterative process allowing the update of parameters in order to improve the accuracy and make it converge to acceptable threshold.

Source: [What Is Machine Learning \(ML\)? | IBM](#)

1.2. Introduction to Machine Learning & Data Mining

- **ML categories:**

Supervised learning

Each input data has the corresponding labelling. This means that the training data has to be labelled by the programmer. Ex: KNN, SVM (Support vector machine)

Unsupervised learning

No training data are provided to the learning algorithm → no label. The program determines by itself the input data clustering. Ex: K-means, PCA, SVD (Singular values decomposition)

Reinforcement learning

The computer program receiving positive and/or negative feedback from the environment (no label data) and improve its performance by optimizing the learning parameters.

- *Source:* [Intro to Machine Learning with Python | Machine Learning \(python-course.eu\)](https://python-course.eu/).

1.3. Overview of Machine learning models

- **ML topics:**

- Data representations & visualization of data, splitting data set.
- Regression
- K- Nearest neighbors classifier.
- Neural Network
- Naive Bayes classifier.
- Decision trees, regression trees, Random forest
- Others methods (PCA, LDA, SVM, ...)

◦ *Source:* [Intro to Machine Learning with Python | Machine Learning \(python-course.eu\)](https://python-course.eu/).

Introduction to Artificial Intelligence

END OF CHAPTER 1