Intelligens Számítási Módszerek Tudás alapú intelligens rendszerek

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Aaron Sloman:

" A számítógéptudomány egy alkalmazott részterülete. A mesterséges intelligencia egy nagyon általános kutatási irány, mely az intelligencia természetének kiismerésére és megértésére, valamint a megértéséhez és lemásolásához szükséges alapelvek és mechanizmusok feltárására irányul."



Yoshiaki Shirai¹ – Jun-ichi Tsuji:

 "A mesterséges intelligencia kutatásának célja az, hogy a számítógépeket alkalmassá tegyük az emberi intelligenciával megoldható feladatok ellátására."





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Sántáné Tóth Edit:

"A mesterséges intelligencia a számítástudomány azon részterülete, amely intelligens számítógépes rendszerek kifejlesztésével foglalkozik. Ezek pedig olyan hardver/szoftver rendszerek, amelyek képesek 'emberi módon' bonyolult problémákat megoldani: az emberi gondolkodásmódra jellemző következtetések* révén bonyolult problémákra adnak megoldást, a problémamegoldást teljesen önállóan végzik, vagy közben kommunikálnak környezetükkel, tapasztalataikból tanulnak, stb."



Fábry Sándor (2005):

"... a legutóbbi "Legyen ön is milliomos" játékot egy intelligens mosópor nyerte."



Intelligent machines

- *Intelligence* is their ability to understand and learn things.
- *Intelligence* is the ability to think and understand instead of doing things by instinct or automatically.
 - (Essential English Dictionary, Collins, London, 1990)
- Intelligence as the ability
 - to learn and understand,
 - to solve problems and
 - to make decisions.



The goal of artificial intelligence (AI)

- To make machines do things that would require intelligence if done by humans.
- AI is an applied sub-field of computer science, which is a combination of
 - computer science,
 - physiology, and
 - philosophy
- AI is a very general investigation of the nature of intelligence and the principles and mechanisms required for understanding or replicating it.



Main goals in AI research

- Empirical:
 - Empirical modelling of existing intelligent systems work done in close collaboration with work in psychology, linguistics, philosophy
- Theoretical:
 - Theoretical analysis and exploration of possible intelligent systems
- Practical:
 - Solving practical problems in the light of the above two goals, namely: designing useful new intelligent or semi-intelligent machines



Turing Test

- *"Computing Machinery and Intelligence"*, was written by the British mathematician *Alan Turing* (1950)
- It stands up well under the test of time, and the Turing's approach remains universal.
- The questions asked:
 - Is there thought without experience?
 - Is there mind without communication?
 - Is there language without living?
 - Is there intelligence without life? (Is there life with intelligence?:-)
- The fundamental questions of artificial intelligence:
 - Can Machine Think? MIQ (Machine Intelligence Quotient)



Turing Imitation Game: Phase 1

- The interrogator, a man and a woman are each placed in separate rooms.
- The interrogator's objective is to work out who is the man and who is the woman by questioning them.
- The man should attempt to deceive the interrogator that he is the woman, while the woman has to convince the interrogator that she is the woman.





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Turing Imitation Game: Phase 2

- The man is replaced by a computer programmed to deceive the interrogator as the man did.
- It would even be programmed to make mistakes and provide fuzzy answers in the way a human would.
- If the computer can fool the interrogator as often as the man did, we may say this computer has passed the intelligent behaviour test.





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Universality of the Turing Test

- Neutral medium communication via terminals
 objective standard view on intelligence.
- The test is quite independent from the details of the experiment.
 - It can be conducted as a two-phase game, or even as a single-phase game when the interrogator needs to choose between the human and the machine from the beginning of the test.
- A program thought intelligent in some narrow area of expertise is evaluated by comparing its performance with the performance of a human expert.



Turing teszt – egyfázisú változat

- A vizsgáló személy csak a terminálokon keresztül tartja a kapcsolatot az emberrel és a számítógéppel.
- A vizsgáló személy kérdéseket tesz fel, melyekre az ember, ill. a számítógép válaszol.
- Ha a válaszokból nem tudja eldönteni, hogy mely válaszok származtak a géptől és melyek az embertől, akkor a számítógép (igazi) mesterséges intelligenciával rendelkezik.



vizsgáló személy



Intelligent Systems

- A system thought intelligent in some narrow area of expertise is evaluated by comparing its performance with the performance of a human expert. *MIQ* (*Machine Intelligence Quotient*)
- To build an intelligent system, we have to capture, organise and use human expert knowledge in some narrow area of expertise.
- Intelligent system:
 - human knowledge representation, implementation
 - Turing believed that by the end of the 20th century, it would be possible to program a digital computer to play the imitation game. Although modern computers still cannot pass the Turing test, it provides a basis for the verification and validation of knowledge-based



systems.

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Intelligent Systems - Classification

Classical Artificial Intelligence:

- Artificial Intelligence (knowledge-sparse "Weak Methods")
- Knowledge-based Systems / Expert Systems (domain-specific, knowledge-intensive techniques)

Computational Intelligence:

- Artificial Neural Networks
- Fuzzy Set Theory / Fuzzy Logic
- Evolutionary Computation / Genetic Algorithms



Classical Artificial Intelligence

• Artificial Intelligence

(knowledge-sparse "Weak Methods")

- A set of information technologies which exhibit some ability for intelligent behaviour via artificial means.
- Knowledge-Based Systems/Expert Systems (domain-specific, knowledge-intensive techniques)
 - An information technology based on the application of rules derived from expert knowledge which can imitate some intelligent behaviour.



Computational Intelligence

- Artificial Neural Networks / Connectionism
 - An information technology based on the way neurons in the brain collectively process information.
- Fuzzy Set Theory/Fuzzy Logic
 - An information technology based on the use of approximate information and uncertainty to generate decisions in a manner similar to human reasoning.
- Genetic Algorithms
 - An information technology which mimics the processes of biological evolution with its ideas of natural selection and survival of the fittest to provide effective solutions for optimization problems.



Intelligent Systems – Knowledge

Much knowledge and expertise

- Physical models
 - Rule-based expert systems
 - Fuzzy systems
 - Neuro-fuzzy systems
 - Artificial Neural Networks
- Statistical methods Much empirical data



I

History - The birth of AI (1943 – 1956)

- The first work recognised in the field of AI was presented by **Warren McCulloch** (degree in philosophy and medicine) and **Walter Pitts** (mathematician) in **1943.** They proposed a model of an *artificial neural network and demonstrated that simple network structures could learn.*
- McCulloch, the second "founding father" of AI after Alan Turing, had created the corner stones of neural computing and artificial neural networks (ANN).
- The third founder of AI was **Neumann János**:
 - He was an adviser for the **Electronic Numerical Integrator and Calculator** (**ENIAC**) project at the University of Pennsylvania and helped to design the Electronic Discrete Variable Calculator.
 - He encouraged and supported two of his graduate students (Marvin Minsky and Dean Edmonds) in the Princeton mathematics department to build the *first neural network computer* in 1951.



History - The birth of AI (1943 – 1956)

- Claude Shannon shared Alan Turing's ideas on the possibility of machine intelligence. In 1950, he published a paper on chess-playing machines, which pointed out that a typical chess game involved about 10¹²⁰ possible moves. Even if the new von Neumann-type computer could examine one move per microsecond, it would take 3 * 10¹⁰⁶ years to make its first move. Thus Shannon demonstrated the need to use heuristics in the search for the solution.
- In 1956, John McCarthy, Martin Minsky and Claude Shannon organised a summer workshop to brought together researchers interested in the study of machine intelligence, artificial neural nets and automata theory. Although there were 10 researchers, this workshop gave birth to a new science called Artificial Intelligence (AI).



History - The rise of AI (1956 - late 1960s)

- Works on neural computing and ANN started by McCulloch and Pitts were continued. Learning methods were improved and Frank Rosenblatt proved the perceptron convergence theorem, demonstrating that his learning algorithm could adjust the connection strengths of a perceptron.
- One of the most ambitious projects of the era of great expectations was the *General Problem Solver (GPS)*. Allen Newell and Herbert Simon developed a generalpurpose program to simulate human-solving methods. They make use of *state space search* to determine the solution plan.



History - The rise of AI (1956 - late 1960s)

- However, GPS failed to solve complex problems. The program was based on formal logic and could generate an infinite number of possible operators. The amount of computer time and memory that GPS required to solve real-world problems led to the project being abandoned.
- In the 60s, AI researchers attempted to simulate the thinking process by inventing *general methods for solving broad classes of problems*.
- They used the general-purpose search mechanism to find a solution to the problem. Such approaches now referred to as *weak methods*.



Unfulfilled promises, or the impact of reality (late 1960s - early 1970s)

- By 1970, it is the downfall of AI.
- Most government funding for AI projects was cancelled. AI was still a relatively new field, academic in nature, with few practical applications apart from playing games. So to the outsider, the achieved results would be seen as toys, as no AI system at that time could manage real-world problems.
- Because AI researchers were developed general methods for broad classes of problems, early programs contained little or even no knowledge about a problem domain.



Unfulfilled promises, or the impact of reality (late 1960s - early 1970s)

- In 1971, the British government also suspended support for AI research.
- Sir James Lighthill had been commissioned by the Science Research Council of Great Britain to review the current state of AI.
- He did not find any major or even significant results from AI research, and therefore saw no need to have a separate science called "artificial intelligence".



Unfulfilled promises, or the impact of reality

The main difficulties for AI in the late 1960s were:

- Because AI researchers were developing general methods for broad classes of problems, early programs contained little or even no knowledge about a problem domain.
- To solve problems, programs applied a search strategy by trying out different combinations of small steps, until the right one was found.
- This approach was quite feasible for simple toy problems, so it seemed reasonable that, if the programs could be "scaled up" to solve large problems, they would finally succeed.
- But even if the searching has logarithmic complexity, the space has exponential size related to the number of its dimensions (number of symbols)

(Tractable problems can be solved in polynomial time, i.e. for a problem of size n, the time or number of steps needed to fund the solution is a polynomial function of n.



History - expert systems - the key to success

(early 1970s – mid 1980s)

- Important development in the **70s realisation that** *the domain for intelligent machines had to be sufficiently restricted*.
- When weak methods failed the only way to deliver practical results was to solve typical cases in narrow areas of expertise, making large reasoning steps.
- NASA supported the *DENDRAL* project (Stanford University) to determine the molecular structure of Martian soil, based on the mass spectral data provided by a mass spectrometer.
- The project focuses on incorporating the expertise of an expert into a computer program to make it perform at a human expert level. Such programs were later called *expert system*.
- DENDRAL marked a major "paradigm shift" in AI: a shift from general-purpose, knowledge-sparse weak methods to domain-specific, knowledge-intensive techniques.



History - expert systems - the key to success (early 1970s – mid 1980s)

- The DENDRAL project originated the fundamental idea of expert systems knowledge engineering, which encompassed techniques of capturing, analysing and expressing in rules an expert's "know-how".
- In **1986**, in **Waterman's** survey reported a remarkable number of successful **expert system applications** in different areas: **chemistry, electronics, engineering, geology, management, medicine, process control and military science.**
- Although **Waterman** found nearly **200 expert systems**, most of the applications were in the field of **medical diagnosis**.



History - expert systems - difficulties

- Expert systems are **restricted to a very narrow domain of expertise**.
- Expert systems **can show the sequence of the rules they applied** to reach a solution, **but cannot relate accumulated, heuristic knowledge** to any deeper understanding of the problem domain.
- Expert systems have **difficulty in recognising domain boundaries**. When given a task different from typical problem, an expert system might attempt to solve it and fail in rather unpredictable ways.
- Heuristic rules represent knowledge in abstract form and lack even basic understanding of the domain area. It makes **the task of identifying incorrect, incomplete or inconsistent knowledge difficult**.
- Expert systems, especially the first generation, have little or no ability to learn from their experience.

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History -"Learning" machines - the rebirth of neural networks (mid 1980s –)

- In mid-80s, researchers found that building an expert system required much more than putting enough rules in it. They decided to have a new look at neural networks.
- By the late 60s, most of the basic ideas and concept necessary for neural computing had already been formulated. But the solution only start to emerge in mid-80s. The major reason was technological: there were no powerful workstations to model and experiment with ANN.



History -"Learning" machines - the rebirth of neural networks (mid 1980s –)

- In **1980**, **Grossberg** provided the basis for a new class of neural networks established using a new **self-organisation theory** (*adaptive resonance theory*).
- In 1982, Hopfield introduced neural networks with feedback
 Hopfield networks (much attention in the 1980s).
- In 1982, Kohonen introduced the *self-organising map*.
- In **1983, Barto, Sutton** and **Anderson** introduced *reinforcement learning* and its application in control.
- The real breakthrough came in **1986** when the *back-propagation* learning algorithm, first introduced by Bryson and Ho in 1969, was reinvented by Rumelhart and McClelland.



History - neural networks

- Neural network technology offers more natural interaction with the real world than do systems based on symbolic reasoning.
- ANN can learn, adapt to changes in a problem's environment, and establish patterns in situations where rules are not known.
- However, they lack explanation facilities and usually act as black box.
- The process of training neural networks with current technologies is slow, and frequent retraining can cause serious difficulties.



History -"Computing with words" (late 1980s –)

- Another branch of research that attracts attention is *fuzzy logic*.
- This technology can deal with vague, imprecise and uncertain knowledge and data, it performs much better compare to classical expert system.
- Fuzzy Logic or fuzzy set theory was introduced by Professor Lotfi Zadeh (Berkeley's electrical engineering department chairman) in 1965.
- Part of the problem was the provocative name "fuzzy" it seemed too light-hearted to be taken seriously.
- Eventually, fuzzy theory, ignored in the West, was taken seriously in the East – by the Japanese. It has been used successfully since 1987 in Japanese-designed dishwashers, washing machines, air conditioners, television sets, copiers, and even cars.



History – Fuzzy Logic – main benefits

- Improved computational power: Fuzzy rulebased systems perform faster than conventional expert systems and require fewer rules. A fuzzy expert system merges the rules, making them more powerful.
- Improved cognitive modelling: Fuzzy expert systems model imprecise information, capturing expertise similar to the way it is represented in the expert mind, and thus improve cognitive modelling of the problem. E.g. in imprecise terms as *high and low, fast and slow, heavy and light.*



History – Fuzzy Logic – difficulties

- Although fuzzy systems allow expression of expert knowledge in a more natural way, they still depend on the rules extracted from the experts, and thus might be smart or dumb.
- Some experts can provide very clever fuzzy rules

 but some just guess and may even get them wrong. Therefore, all rules must be tested and tuned, which can be a prolonged and tedious process.
- For example, it took Hitachi engineers several years to test and tune only 54 fuzzy rules to guide the Sendal Subway System.



Period	Key Events
The birth of Artificial Intelligence (1943–1956)	McCulloch and Pitts, A Logical Calculus of the Ideas Immanent in Nervous Activity, 1943
	Turing, Computing Machinery and Intelligence, 1950
	The Electronic Numerical Integrator and Calculator project (von Neumann)
	Shannon, <i>Programming a Computer for Playing Chess</i> , 1950
	The Dartmouth College summer workshop on machine intelligence, artificial neural nets and automata theory, 1956

• From the AI book of Negnevitsky



Period	Key Events
The rise of artificial intelligence (1956–late 1960s)	 <i>LISP</i> (McCarthy) The General Problem Solver (GPR) project (Newell and Simon) Newell and Simon, <i>Human Problem Solving</i>, 1972 Minsky, <i>A Framework for Representing Knowledge</i>, 1975
The disillusionment in artificial intelligence (late 1960s–early 1970s)	Cook, <i>The Complexity of Theorem Proving Procedures</i> , 1971 Karp, <i>Reducibility Among Combinatorial Problems</i> , 1972 The Lighthill Report, 1971

• From the AI book of Negnevitsky



Period	Key Events
The discovery of expert systems (early 1970s–mid-1980s)	DENDRAL (Feigenbaum, Buchanan and Lederberg, Stanford University)
	MYCIN (Feigenbaum and Shortliffe, Stanford University)
	PROSPECTOR (Stanford Research Institute)
	PROLOG - <i>a logic programming language</i> (Colmerauer, Roussel and Kowalski, France)
	EMYCIN (Stanford University)
	Waterman, A Guide to Expert Systems, 1986

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Period	Key Events
The rebirth of artificial neural networks (1965–onwards)	Hopfield, Neural Networks and Physical Systems with Emergent Collective Computational Abilities, 1982
	Kohonen, Self-Organized Formation of Topologically Correct Feature Maps, 1982
	Rumelhart and McClelland, <i>Parallel Distributed</i> <i>Processing</i> , 1986
	The First IEEE International Conference on Neural Networks, 1987
	Haykin, Neural Networks, 1994
	Neural Network, MATLAB Application Toolbox (The MathWork, Inc.)

• From the AI book of Negnevitsky



Period	Key Events
Evolutionary computation (early 1970s–onwards)	Rechenberg, Evolutionsstrategien - Optimierung Technischer Systeme Nach Prinzipien der Biologischen Information, 1973
	Holland, Adaptation in Natural and Artificial Systems, 1975.
	Koza, Genetic Programming: On the Programming of the Computers by Means of Natural Selection, 1992.
	Schwefel, Evolution and Optimum Seeking, 1995
	Fogel, Evolutionary Computation – Towards a New Philosophy of Machine Intelligence, 1995.

• From the AI book of Negnevitsky



Period	Key Events
Computing with Words (late 1980s-onwards)	Zadeh, Fuzzy Sets, 1965
	Zadeh, Fuzzy Algorithms, 1969
	Mamdani, Application of Fuzzy Logic to Approximate Reasoning Using Linguistic Synthesis, 1977
	Sugeno, Fuzzy Theory, 1983
	Japanese "fuzzy" consumer products (dishwashers, washing machines, air conditioners, television sets, copiers)
	Sendai Subway System (Hitachi, Japan), 1986
	The First IEEE International Conference on Fuzzy Systems, 1992
	Kosko, Neural Networks and Fuzzy Systems, 1992
	Kosko, Fuzzy Thinking, 1993
	Cox, The Fuzzy Systems Handbook, 1994
	Zadeh, Computing with Words - A Paradigm Shift, 1996
	Fuzzy Logic, MATLAB Application Toolbox (The MathWork, Inc.)

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The "wish list" of an Intelligent System

- A truly intelligent system is characterised as one that can:
- exhibit adaptive goal-oriented behaviour
- learn from experience
- use vast amounts of knowledge
- exhibit self awareness (öntudat)
- interact with humans using language
- tolerate error and ambiguity in communication
- respond in real time



• Home appliances

Company: BPL Product : washing machine ABS 50F Fuzzy system decides the type of Program & amount of water and washing ingredients

Company : BPL Product : washing machine

ABS 60 NF

Neuro-fuzzy system detects a type of material in the machine and decides the type of the program and amunt of water and washing ingredients.

(collected by Prof. Péter Sinčák)





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• Home appliances

(collected by Prof. Péter Sinčák)

Company : Videocon-international Product : washing machine – V-NA- 45 FDX

The same as before - just 996 different cycle to choose from . Which on is decided By neuro-fuzzy system

Company: Videocon-internetional **Product**: Washing machine Fuzzy control of the machine







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• Home appliances

(collected by Prof. Péter Sinčák)

Company : Sanyo Product : washing machine ASW-F60T

The same concept - made by company

Company : LG Product : Refrigerator

Neural fuzzy system controls the freezing procedures in the refrigirator





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• Home appliances

(collected by Prof. Péter Sinčák)

Company Sanyo Cook , owen - rice cooker ECJ-5205SN

According to the senszors of infra, thermal senzor a huminity senzor it estimate a meal quality and determine A time of cooking.





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• Electronics

(collected by Prof. Péter Sinčák)

Company: Sharp Product : microwave owen

Accoding to the analysis of the inside air the lenght of the cooking is controlled. The analysis of the Food smell during cooking is matter of interest.

Company: Videocon Product : air-conditioner

Neuro-fuzzy control of air-conditioner to keep equal temperature within the room



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• Electronics

(collected by Prof. Péter Sinčák)

Company : Cannon

Product : videocamera

Canon uses fuzzy system with 13 rules to focus the objectives based on the information in the image characteristics

Company : Mitsubishi

Product : TV set

Make a neural controller to adjust the image contrast according to the broadcast image. This adaptive approach produce a very good User feeling while seeing TV program.





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• Electronics

(collected by Prof. Péter Sinčák)

Company : Samsung **Product** : Blod pressure measurement Fuzzy system controls the overall process of Blood measurement



Company: Samsung Product : Camera

Fuzzy control of image focusing & sharpening





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• Electronics

(collected by Prof. Péter Sinčák)

Company: JVC

porduct: car-radio

Using neural networks it is able to control car radio with high reliability and adapt to the voice of the speaker.



Company: IntelaVoice

Product : switcher controled by voice

Using neural networks it is able to control the switch with high reliability and adapt to the voice of the speaker.





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• Copy machines

(collected by Prof. Péter Sinčák)

Company: Canon **Product : Copy Machine** Series of CLC700 a CLC800 have a fuzzy control of the toner to achieve the best results



Company: Panasonic

Product : Copy machine

In the series FP-1680 up to FP-4080 is implemented a neuro-fuzzy system to control various parameters to get the best copy results as possible





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• Car industry

(collected by Prof. Péter Sinčák)

Companies : Mercedes & Hyundai

Mercedes in model CLK use Automatics transmission based on Highly adaptive technology to adapt to the style of the driver. Similar approach is in XG Hyundai model.





Company : BMW

BMW uses long time a fuzzy approach in ABS brake system which adapts the braking process with the aim to avoid blocking phase. Also in other advance systems these technologies are used.





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• Car industry

(collected by Prof. Péter Sinčák)

Company : Siemens AG Product : Smart Airbag

Smart airbags - for persons safety uses some parts of intelligent technologies including adapting safety measures to the people.





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Ajánlott irodalom

• The slides of this lecture are partially based on the book:

Michael Negnevitsky: *Artificial Intelligence: A Guide to Intelligent Systems*, Addison Wesley, Pearson Education Limited, 2002. ISBN 0201-71159-1



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