Intelligens Számítási Módszerek
Tudás alapú intelligens rendszerek

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Mesterséges intelligencia definíciók

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."

Mesterséges intelligencia definíciók

Yoshiaki Shirai[1] – Jun-ichi Tsuji:

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

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Mesterséges intelligencia definíciók

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."**

*** (???)**

Mesterséges intelligencia definíciók

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

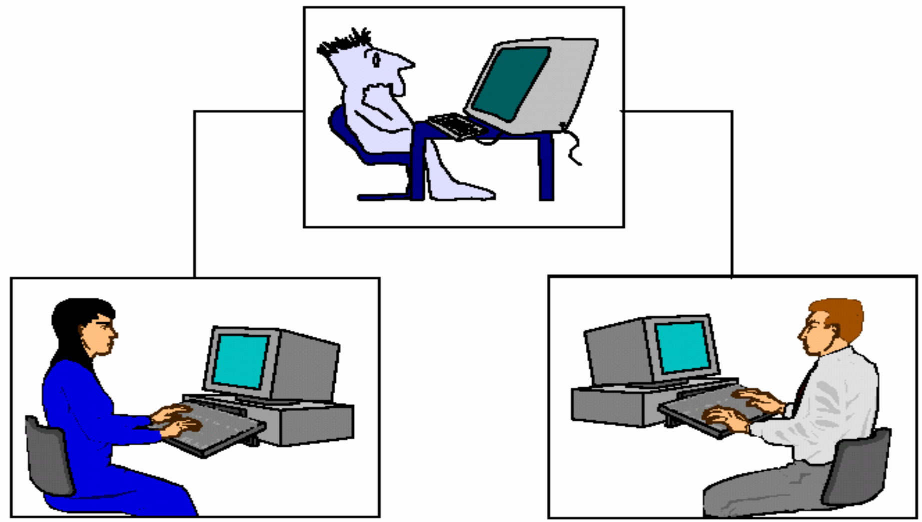
- **Empirical:**
  - **Empirical modelling of existing intelligent systems - work done in close collaboration with work in psychology, linguistics, philosophy**
- **Theoretical:**
  - **Theoretical analysis and exploration of possible intelligent systems**
- **Practical:**
  - **Solving practical problems 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)*

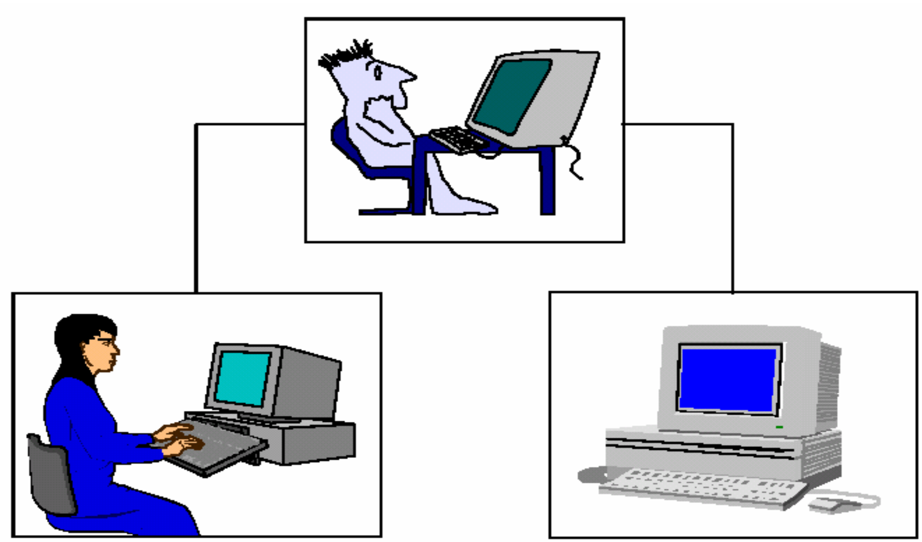
Turing Imitation Game: Phase 1

- 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.



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.

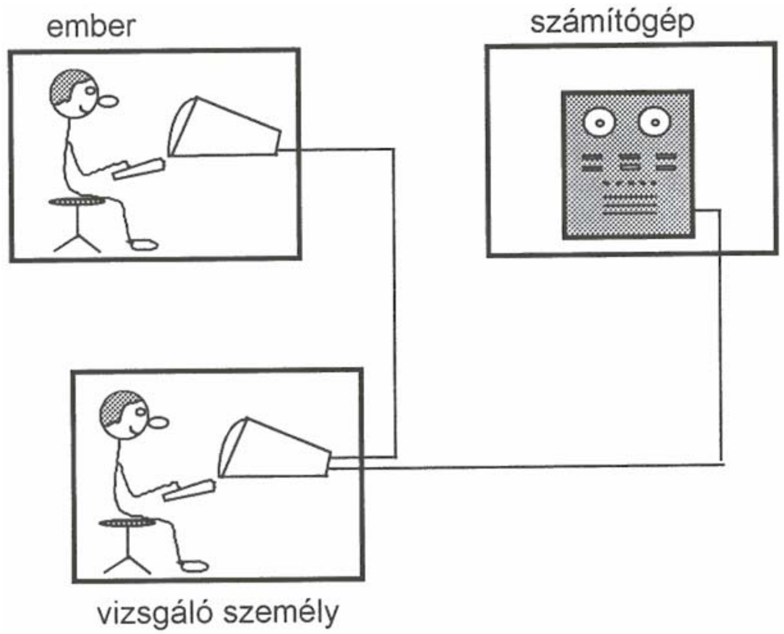


Universality of the Turing Test

- **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.**



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.

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

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 10^{120} possible moves**. Even if the new von Neumann-type computer could examine **one move per microsecond**, it would take **$3 * 10^{106}$ 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 **general-purpose 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**.

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 rule-based 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.

History – key events

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, *Programming a Computer for Playing Chess*, 1950 The Dartmouth College summer workshop on machine intelligence, artificial neural nets and automata theory, 1956

- From the AI book of Negnevitsky

History – key events

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

- From the AI book of Negnevitsky

History – key events

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 - *a logic programming language* (Colmerauer, Roussel and Kowalski, France) EMYCIN (Stanford University) Waterman, *A Guide to Expert Systems*, 1986

- From the AI book of Negnevitsky

History – key events

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, *Parallel Distributed Processing*, 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

History – key events

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

History – key events

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.)

- From the AI book of Negnevitsky

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

Intelligent System Applications

- **Home appliances**

(collected by Prof. Péter Sinčák)

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.

Intelligent System Applications

- ## 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

Intelligent System Applications

- **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

Intelligent System Applications

- **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.

Intelligent System Applications

- **Electronics**

(collected by Prof. Péter Sinčák)

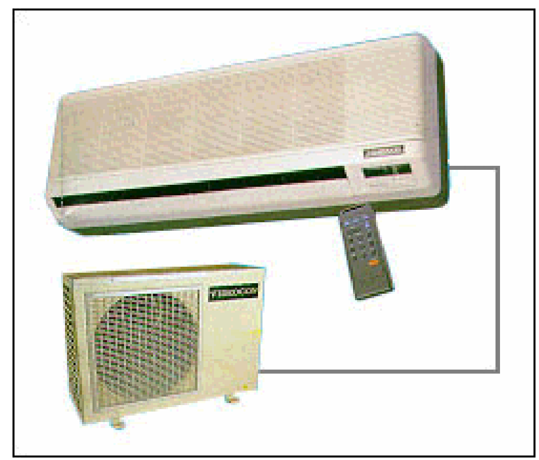
Company: Sharp

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

Intelligent System Applications

- ## 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.

Intelligent System Applications

- ## 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

Intelligent System Applications

- **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.

Intelligent System Applications

- **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

Intelligent System Applications

- ## 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.

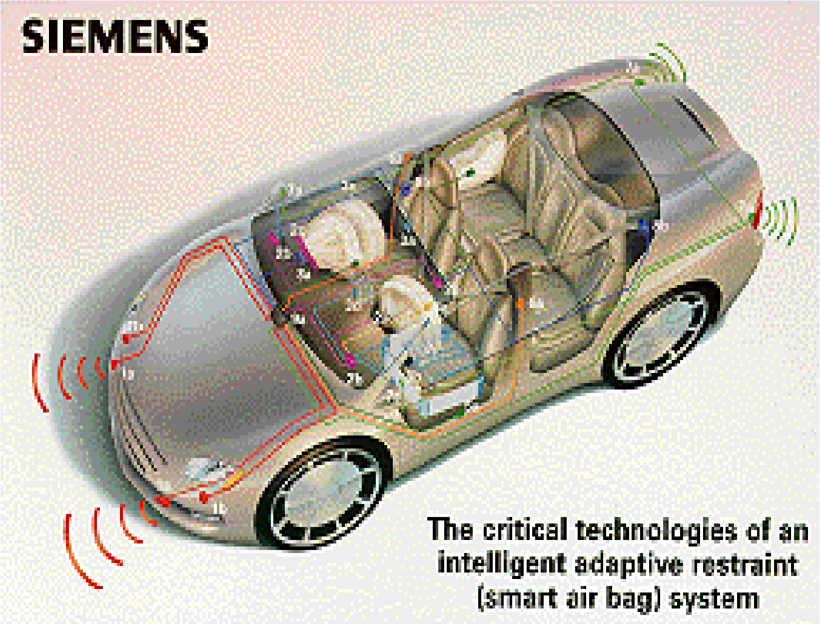
Intelligent System Applications

- ## 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.



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