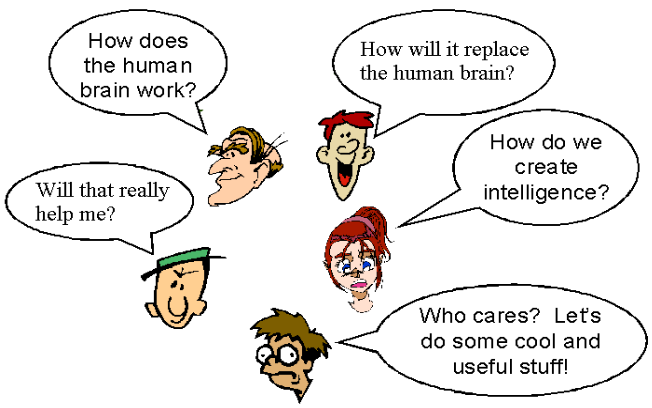
Intelligent Systems in Business
Introduction

Iulian Nastac

1. Introduction
What is an intelligent system?



Intelligent system

- Can interpret information.
- Comprehends the relations between phenomena or objects.
- Applies the acquired information to new conditions.

History

- 1943 - Warren McCulloch & Walter Pitts publish “A Logical Calculus of the Ideas Immanent in Nervous Activity”
  - **Artificial Neuron**
- Arturo Rosenblueth, Norbert Wiener & Julian Bigelow coin the term "cybernetics" in a 1943 paper
- 1945 - Vannevar Bush published “As we may think”
- 1950 A.M. Turing published "Computing Machinery and Intelligence“
  - Turing’s Test - a test of intelligent behavior
- 1950 Claude Shannon published detailed analysis of chess playing as search

History (cont.)

- **1955 - A PROPOSAL FOR THE DARTMOUTH SUMMER RESEARCH PROJECT ON ARTIFICIAL INTELLIGENCE**

  J. McCarthy, Dartmouth College
  M. L. Minsky, Harvard University
  N. Rochester, I.B.M. Corporation
  C.E. Shannon, Bell Telephone Laboratories

- **1956 - Demonstration of the first running AI program, the Logic Theorist (LT) written by Allen Newell, J.C. Shaw and Herbert Simon (Carnegie Institute of Technology, now Carnegie Mellon University)**

History (cont.)

- 1964 Prof. Lotfi Zadeh started wondering, if there wasn't a better logic to use in machinery
  - Fuzzy Set Theory
  - Fuzzification
  - Fuzzy Quantification
  - Fuzzy Events
- 1975 John Holland
  - the beginning of the research of **genetic algorithms**

History (cont.)

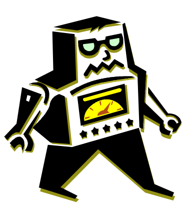
- .... Many years elapsed with successes and failures ....
- 1997 - IBM's Deep Blue Super computer played a fascinating game against Gary Kasparov in chess and won
  - The secret behind Deep Blue was a turbo expert system with very powerful search algorithms

2. Human/Artificial Intelligence

What is Human Intelligence?

- **Not easy to define**
- **It is an open term**
- **It can include everything from logic ability and mathematical thinking to word understanding and creativity**

What is Artificial Intelligence (AI)?

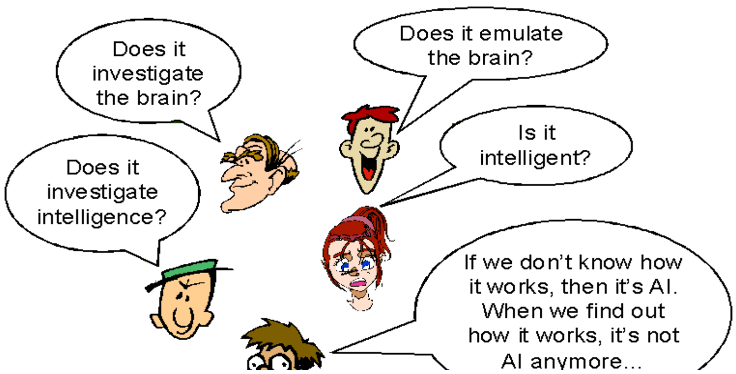


We can look at it from different perspectives:

- Research perspective
- Business perspective
- Domain perspective
- Intelligence perspective
- Programming perspective

Research perspective

- How do we classify research as AI?



Research perspective (cont.)

- "Artificial intelligence is the study of how to make computers do things which at the moment people do better" (Rich & Knight)

Business perspective

- AI is a set of very powerful tools, and methodologies that can solve difficult business problems

Domain perspective

- **Formal tasks**
  - mathematics
  - games
- **Communications**
  - perception
  - natural language
  - common sense reasoning
- **Expert tasks**
  - financial analysis
  - medical diagnostics
  - robotics (movement)
  - engineering
  - scientific analysis etc.

Intelligence perspective

- Intelligence requires knowledge

- Expert problem solving
  - restricting domain to allow relevant knowledge

Programming perspective

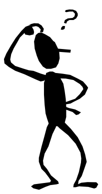
- A study of symbolic programming, problem solving and search:
  - Symbols and numeric processing
  - Problem solving - achieve goals
  - Search - seldom access a solution directly
- Soft Computing
  - programming is replaced by learning

Man-Machine Interaction

Machine-centeredness ➡ Human-centeredness

- A human-in-the-loop system (**HiLS**) (Bien 2003)
- The **soft computing (SC) techniques** play an important roles

Soft computing (SC) ~ Adaptive & Intelligent Systems



- Fuzzy systems
- Neural networks
- Evolutionary computing
- Probabilistic reasoning

3. Computational Intelligence

Computational intelligence refers to several computing paradigms within computer science:

- expert systems (ES)
- neural networks (NN)
- genetic algorithms (GA)
- fuzzy logic (FL)
- machine learning (ML)

Expert Systems

- Intelligence within expert systems is embodied in their knowledge base, for example in the form of rules and facts.
- Expert systems have proved their worth as assisting systems in diagnostics, planning and scheduling tasks in different disciplines.

Neural Networks

- Neural networks receive their intelligence through a learning procedure in which the network learns by examples.

- The method has proved its worth in several real-world problems where classification, pattern recognition, and forecasting is needed.

Genetic Algorithms

- Genetic algorithms refer to a family of computational models inspired by evolution.
- They receive their intelligence through selection, reproduction and mutation.
- Genetic algorithms have been successfully used in many difficult optimization problems.
- They can also be used as aid in building the rule base of an expert system and to find optimal neural networks.

Fuzzy Logic

- Fuzzy logic is a method of reasoning that allows for partial description of rules.
- The power of fuzzy logic resides in the capacity for evaluation of uncertain, conflicting and hazardous information, using a small number of very flexible rules.
- Knowledge in a fuzzy system is carried both in its rules and in fuzzy sets, which hold general descriptions of the properties of phenomena.

Machine Learning Algorithms

- Create rules and rule-trees by searching through data for statistical patterns and relationships
- Use information about the distribution of data to try to cluster records into specific categories
- Prove good models for prediction and classification
- Abstract clear rules from data
- Can explain the process that generated the data

4. Expert systems

An application that contains a knowledge base and a set of algorithms or rules that infer new facts from knowledge and from incoming data.

- **Functional components**
  - What the system does (rather than how)
- **Structural components**
  - How the system works
- **A mix of both**

Functional Components

- Problem area
  - narrow problem area
- Problem difficulty
  - difficult enough to require expert knowledge
- Performance requirement
  - at a human level
- Explain reasoning
  - justify its own line of reasoning

Structural Components

- Use AI techniques
- Knowledge component
- Separate knowledge and control
- Inference procedures
- Model human expert

5. Human / Computer Reasoning

How do people reason?

- They create categories
  - Cash is a current asset
  - A current asset is an asset
- They use specific rules
  - If A then B
  - If B then C
- They use heuristics
  - If the meal includes meat ... Red wine
- They use past experience
  - Law cases
- They use expectations

Artificial Intelligence limitations

- AI is affected by errors (noise)
- Ex: an expert system language translator

"The flesh is weak, but the spirit is strong"

Proverb

→ Translation to Russian

→ Translate back to English

"The food was lousy, but the vodka was great"

How do computers reason?

- Translation problem → program
  - Description of the problem
  - Encoding the knowledge
- Problem context
- Dimension of the problem
- Software tools
  - Classical programming
  - Soft computing
- Hardware tool

6. Intelligence density

- A measure of organizational intelligence and productivity
- A heuristic measure of the *army type* of intelligence
- How much of the chart, status report, financial statement or computer output do you have to examine before you can make a decision of a specified quality?
- Conceptually: ID = Quality / time

(Dhar & Stein, 1997)

System Quality

- Accuracy
  - how close the outputs of a system are to the correct or best decision
- Explainability
  - the description of the process by which a conclusion was reached
- Response speed
  - the time it takes for a system to complete analysis at the desired level of accuracy

How well is the system engineered?

- Scalability
  - the number of variables to the problem or the range of values that variables can take
- Compactness
  - how small the system can be made
- Flexibility
  - how easy it is to change the variables or modify the goals of the systems
- Embeddability
  - how easy it is to couple the system with … or incorporate into the infrastructure of an organization
- Ease to use

Quality of available resources

- Tolerance for noise in data
  - the degree of the accuracy/ quality of the response when data are affected by noise
- Tolerance for data sparseness
  - incomplete or lack of data
- Tolerance for complexity
  - interactions among various components
- Learning curve requirements
  - become sufficiently competent at solving a problem or using a technique

Logistical Constraints

- Independence from experts
- Computational ease
- Development speed

7. Encoding the knowledge

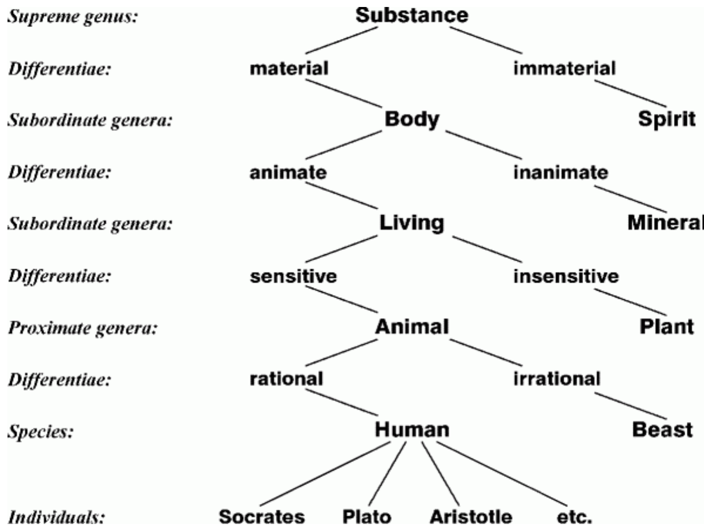
- Production rules
  - Auditing , tax
  - The set of rules is called knowledge base or rule base
- Semantic Networks (cases)
  - Tax cases
  - The set of cases is called case base
- Frames
  - frame attributes called slots
  - each frame is a node

Production rules

- Building systems based on heuristic methods
- ”if-then” rules
  - Empirical consequence of a given condition
  - The action that should be taken in a given situation

Semantic Networks

- A graphic notation for representing knowledge in patterns of interconnected nodes and arcs
  - philosophy
  - psychology
  - linguistics
  - computer implementations
  - artificial intelligence
  - machine translation



Frames

- *Nodes* in *Semantic networks*
- Attributes called *slots*
- Value can be stated explicitly
- Each frame is a node in a hierarchy
  - higher levels → general concepts
  - lower levels → specific aspects
  - unspecified value can be *inherited* from the more general node

8. Rule-based reasoning

Maybe the most common form of expert system

- User Interface
- Databases
- Inference machine
- Knowledge Base
- Uncertainty

User Interface

- Friendly
- Knowledge of how to present information
- Knowledge of user preferences ...possibly accumulate with use

Databases

- Contain some of the data of interest to the system
- maybe connected to online company or public database
- Human user may be considered a database

Inference engine

- General problem solving knowledge or methods
- Interpreter analyzes and processes the rules
- Scheduler determines which rule to look at next
- The search portion of a rule based system
  - takes advantage of heuristic information

Inference strategies

- Forward chaining
- Backward chaining

Example of rule base

If: Tax bracket = 50%
and liquidity is greater than 100 000
Then: A tax shelter is indicated
If: A tax shelter is indicated
and risk tolerance is low
Then: Recommend pulp and paper investments
If: A tax shelter is indicated
and risk tolerance is high
Then: Recommend IT investments

Example (cont)

- Assume we know that the current client's tax bracket is 50%, his liquidity is greater than 100 000 and he has a high tolerance for risk

Example of rule base (forward chaining)

If: *Tax bracket = 50*
and liquidity is greater than 100 000
Then: *A tax shelter is indicated*
If: *A tax shelter is indicated*
and risk tolerance is low
Then: Recommend pulp and paper investments
If: *A tax shelter is indicated*
and risk tolerance is high
Then: *Recommend IT investments*

Example (cont.)

- Assume we only want to know whether IT investments are appropriate for the same client as before

Example backward chaining

If: Tax bracket = 50% (4)
and liquidity is greater than 100 000 (5)
Then: A tax shelter is indicated (3)
If: A tax shelter is indicated
and risk tolerance is low
Then: Recommend pulp and paper investments
If: A tax shelter is indicated (2)
and risk tolerance is high (6)
Then: Recommend IT investments (1)

Knowledge Base

- A collection of knowledge expressed using some formal knowledge representation language

- Rules are of the form **IF *condition* THEN *action***
  - Condition portion of the rule is usually a fact – (If some particular fact is in the database then perform this action)
  - Action portion of the rule can include
    - actions that affect the outside world (print a message on the printer)
    - test another rule
    - add a new fact

Knowledge Base (cont.)

- Rules can be specific
- Rules can be heuristics
- Rules can be chained

Uncertainty

- Mathematical expression of uncertainty is applied to data that cannot be assessed with high precision.
- Certainty factors
- Probabilities
- Fuzzy logic

9. Case-based reasoning

- A technique for problem solving which looks for previous examples which are similar to the current problem.

- This is useful where heuristic knowledge is not available.

Case-based reasoning (cont.)

- Uses past experiences
- Based on the premise that human beings use analogical reasoning or experimental reasoning to learn and solve complex problems
- Particularly evident in precedence-based reasoning
  - tax law or choice of accounting principles
- Useful when little evidence or information is available or incomplete
- Learning

Case-based reasoning (cont.)

- Cases consist of
  - information about the situation
  - the solution
  - the results of using the solution
  - key attributes that can be used for quickly searching for similar patterns or attributes

Case-based reasoning (cont.)

Elements in case-based reasoning:

- the case base
  - set of cases
- the index library
  - used to efficiently search and quickly retrieve cases that are most appropriate or similar to the current problem
- similarity metrics
  - used to measure how similar the current problem is to the past cases selected by searching the index library
  - how to use temporal information
- the adoption module
  - creates a solution for the current problem by either modifying the solution or creating a new solution using the same process as was used in the similar past case

10. Knowledge engineering

The discipline of building expert systems

- Knowledge acquisition
  - the process of acquiring the knowledge from human experts or other sources (e.g. books , manuals)
  - can involve developing knowledge to solve the problem
- Knowledge representation

Why business is interested in intelligent systems?

Although intelligent systems applications are much more limited than human intelligence they are of interest to business for the following reasons:

- to preserve expertise
- to create organizational knowledge
- to create a mechanism that is not subject to human feelings
- to eliminate routine and unsatisfying job tasks
- to enhance the organizational knowledge

Areas where used

- Security
- Routing applications
- Retail Packing
- Failure Analysis
- Data Analysis
- Customer Service
- Management
- Manufacturing
- Finance (almost 20% of all applications)

Drawbacks

- Costly and time consuming to develop
- Difficult to obtain knowledge
- Lack of common sense

References

- Back, B., 2002, Course on ”Intelligent Systems in Business”, Lecture 2/19.9.02
- Bien, Z., 2003, Presentation on “Soft Computing Techniques are essential for Human-friendly Man-Machine Interaction”, IAMSR, August 2003
- Brown, Carol E. and O’Leary, Daniel E., 1993, Introduction to Artificial Intelligence and Expert Systems. Lecture Notes
- Dhar, V. and Stein, R., 1997, Intelligent Decision Support Systems, Prentice Hall
- Luconi, F.L. & Malone, T.W. and Scott Morton, M.S., 1993, Expert Systems: The next challenge for managers, In Decision Support Systems, Putting Theory into Practice, ed. by Sprague, R.H. and Watson, H.J., Prentice Hall
- Rich, E. and Knight, K. 1991, Artificial Intelligence, NY:McGraw-Hill