Paradigms of Intelligent Systems

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This paper approaches the subject of paradigms for the categories of intelligent systems. First we can look at the term paradigm in its scientific meaning and then we make acquaintance with the main categories of intelligent systems (expert systems, intelligent systems based on genetic algorithms, artificial neuronal systems, fuzzy systems, hybrid intelligent systems). We will see that every system has one or more paradigms, but hybrid intelligent systems combine paradigms because they are made of different technologies.
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1 Introduction

Intelligent systems [3] form that high level information technology, capable of identifying "something important for business, maybe even fundamental for the organization's development, structures and relations that might transform management and business practices". They have specific artificial intelligence techniques.

Intelligent systems are classified as: expert systems, intelligent systems based on genetic algorithms, artificial neuronal systems, fuzzy systems, hybrid intelligent systems.

Philosopher of science [7] Thomas Kuhn gave the word *paradigm* its contemporary meaning. When he adopted this term, he refers to the set of practices that define a scientific discipline during a particular period of time. Kuhn defines a scientific paradigm as:

- what is to be observed and scrutinized,
- the kind of questions that are supposed to be asked and probed for answers in relation to this subject,
- how these questions are to be structured,
- how the results of scientific investigations should be interpreted.

Alternatively, the Oxford English Dictionary defines paradigm as „a pattern or model, an exemplar". Thus an additional component of Kuhn's definition of paradigm is: how an experiment is conducted, and what equipment is available to conduct the experiment. The prevailing paradigm often represents a more specific way of viewing reality, or limitations on acceptable programs for future research, than the much more general scientific method.

2. Expert Systems

According to Edward Feigenbaum [3], expert systems are „software made for judgement in order to solve problems that usually require considerable human expertise" or "an expert system is an intelligent program for the computer, which uses knowledge and inference procedures for problems solving that are difficult enough for using important human expertise".

Expert systems [6] are excellent for diagnostic and prescriptive problems. Diagnostic problems are those requiring an answer to the question "What's wrong?" and correspond to the intelligence phase of decision making. Prescriptive problems are those that require an answer to the question "What to do?" and correspond to the choice phase of decision making.

An expert system is usually built for a specific application area called a domain. We can find exert systems in the following domains: accounting, medicine, process control, human resource management, financial management, production, forestry management.

An expert system uses IT to capture and apply human expertise. An expert system can:

handle massive amounts of information, reduce errors, aggregate information from various sources, improve customer service, provide consistency in decision making, provide new information, decrease personnel time spent on tasks, reduce costs.

Knowledge paradigm [12] for expert systems means the representation of large amounts of knowledge which would ensure their integrity, consistency, and effective exploitation is one of the main issues of artificial intelligence.

For this purpose expert systems have been proposed to manage knowledge processing. It is based on the idea of taking on the knowledge from a specialist and expressing it in an appropriate representation to exploit the knowledge in the same way as the human expert does and above all with the same result.

There can be identified [14] several types of knowledge:

- declarative knowledge, for example sorting algorithms classification, concepts of a programming language and the relations between them;
- procedural knowledge, the way a problem can be solved (for example, interchanges of two elements);
- generic schemes (patterns) for problem solving and the way they are classified for a certain problem.

Looking at the taxonomy of the represented knowledge, expert systems have a *procedural knowledge paradigm* and a *declarative knowledge paradigm.*

An expert system [6], like any IT system, combines information, people, and IT components:

- Information types: domain expertise, “why?” information, problem facts;
- People: domain expert, knowledge engineer, knowledge worker;
- IT components: knowledge base, knowledge acquisition, inference engine, user interface, explanation module.

What is specific to achievement methodologies of the expert systems is the fact that they are based on *progressive achievement paradigm* [5] of software systems, that differ from the linear model, of passing just once through several stages, phases, activities, etc. The content of different stages and the way of taking them again represent specific elements for each methodology.

Achievement of each expert system involves several successive activities: investigation – with the purpose of detailed knowing of the domain for which the system is made; analysis – mostly for identifying and formalizing knowledge; design - for the entire or detailed expert system; system components programming; expert system evaluation and/or its components; setting working activities; exploitation and maintenance.

Progressive achievement paradigm [16] made itself known in the domain of intelligent systems because, on one hand is a reasonable method, and on the other hand, it is the only approach that allows handling of the unstructured requests of the final users, and knowledge acquisition difficulties exceeding.

Intelligent agent paradigm is new, standing at the confluence of artificial intelligence and networking and computer science. Intelligent agents, in fact they are expert systems with artificial intelligence, used for data mining and even for formal knowledge discovery.

“An intelligent agent [10] is a real or abstract entity capable of acting on its own and on its environment, has a partial representation on this environment. In a multi-agent environment it can communicate with other agents and its behaviour is the consequence of its observations, its knowledge and interaction with other agents.”

Agents [14] can also be called as program entities (Shoham, 1993), which work autonomic, fulfil certain goals and communicate with other agents or people. Autonomic functioning assumes an environment in which the agents act. In order to accustom to the outside environment changes, intelligent agents must have a model of the surrounding environment, or ontology to use for choosing between different ways of acting.

The most common approach [13] is to see the agents as a particular type of knowledge-based system. This is the *symbolic artificial* *intelligence paradigm*. This paradigm is based on the physical-symbol system hypothesis formulated by Newell and Simon: “a physical symbol system is defined to be a physically realizable set of physical entities (symbols) that can be combined to form structures, and which is capable of running processes that operate on those symbols according to symbolically coded sets of instructions. The physical-symbol system hypothesis then says that such a system is capable of general intelligent action”.

3. Genetic Algorithms

Genetic/progressive algorithms are computing models of evolution, based on generating simulations; they have an important role in artificial life models. Close to the theory of chaos and complexity, they accelerate and develop the rhythm of evolution for thousand of generations on the computer, and billions of phases in just a few hours or days. They don’t program directly a solution, but let “freely” to appear, after flexible simulation of progressing dynamics.

By progressive process [6] (*progressive paradigm*) – referring to Darwin’s evolution theory – using instruction and computer science algorithms, researchers try to imitate intelligence associated with problem solving capabilities, specific to progressive process. This type of continuum adjustment, like in the real life, creates robust organisms. The entire process continues for many “generations”, with the best genes that are transmitted, with the help of genetic algorithms, to the next generations.

The main idea of a genetic algorithm consists in beginning with a solution population for a certain problem and to produce new solution generations, each one with much more performance than the previous.

The phases of the cycle [3] of this type of algorithm are: creation of a population of “members” (possible solutions for problem solving); member selection that have adjusted best for the needs of the problem to be solved; reproduction (genetic operators are used for mutating and interbreeding, to obtain new members); evaluation of the way in which the new members correspond better to problem solving; renouncing the old population by replacing it with the new one from the new generations.

The mechanism [4] specific of these algorithms is inspired by the functioning of the biologic systems (*biologic or biologic-progressive paradigm*), that means it supports the candidate solutions for solving a problem and punishes the solutions without success. This way, after many generations, very good solutions for complex optimization problems are obtained, with a big number of parameters.

4. Artificial Neuronal Systems

Artificial neuronal systems are based on neuronal network knowledge representation method. Artificial neuronal networks learn how to solve a certain problem, developing a memory capable of associating a large number of input data sets to those sets responsible for results or effects. They have the ability to learn from examples that are showed to them, without knowing anything about the mathematical model and the resolving algorithm of this model. Even though the practical problem is so complex that doesn’t allow expressing a coherent mathematical model, an artificial neuronal network built in a good manner can resolve in a good way the problem with the only condition of existence of enough examples of input-output data to use in instruction.

Widely, artificial neuronal network can be integrated in “artificial intelligence” calculation structures to call for other recent techniques like genetic algorithms, progressive programming and fuzzy system theory. Their paradigm is called *connexionism*, because they design the problem’s solutions by instructing the artificial neurons connected in networks configured with the help of specific development environments.

Connexionism paradigm [11] introduces the neuronal calculus concept and generated the making of artificial neuronal networks - models inspired by the human brain structure. In the connexionist [15] approach, it is believed that intelligence is owed only to the existence of a large number of neurons highly interconnected. Intelligence [14] is owed to complex neuronal networks, which include a big number of simple processing units – neurons – bind together by a large number of connexions – synapses.

(Neo)connexionism [9] paradigm, known also as distributed parallel processing paradigm or neuronal modelling starts from the idea that cognitive activity can be explained based on neuronal inspiration models. This neuronal networks approach represents the parallel nature of neuronal processing and distributed nature of neuronal representations. Distributed parallel processing offers a mathematical model which researchers could use. The model comprises: a set of processing units, activation for each unit, an output function, a connectivity template between units, propagation rule for activating through connections, an activation rule for combining inputs in a unit and for obtaining the new activation, a learning rule for modifying connections based on experience, an environment that offers the needed experience to the system. These eight components are the base for all connexionist models.

We could also remember the *neuronal-biologic paradigm.* A neuronal network [2] is a reasoning model based on the structure and functionality of the human brain. The equivalent of the human neuron in artificial intelligence is made of input, output and load.

5. Fuzzy Systems

Intelligent systems based on fuzzy logic have a great flexibility and proved to have performance in a variety of industrial control applications and structure recognition, starting with handwriting and ending with credit evaluation. Fuzzy logic [2] refers to what humans think and its main goal is to design the sense of the terms used in a certain context or another, the way they make decisions and use knowledge. Thus, it helps artificial systems to become more human, intelligent systems. Essential for intelligent systems' flexibility, based on fuzzy logic is the notion fuzzy set.

Fuzzy reasoning is the process of conclusions inferring (derivation) form a fuzzy rule set that acts on fuzzy knowledge. This aggregate action of fuzzy rules is the main principle that stands at the base of intelligent systems' flexibility.

In comparison with the neuronal systems [1], the main advantage of these systems is that their knowledge base use production rules structures, very easy to examine, understand and modify. Because member functions and rules must be established on manual way, by expert and knowledge engineers with great experience, results a big time consume and the possibility of making mistakes. These systems are not easy to adapt to the operational environment changes; new needed rules must be made manual when environment's conditions change.

Fuzzy systems, use, like artificial neuronal systems, connexionist paradigm, and we may state that of distributed parallel processing.

6. Hybrid Intelligent Systems

Hybrid intelligent systems [3] are made at least of two technologies like: expert systems, artificial neuronal networks, fuzzy systems, intelligent agents and genetic algorithms. Integration of these technologies determines the apparition of so called hybrid systems, and the collection of techniques used to integrate them is known under the name of fusion technology. The most used combinations for applications are:

- artificial neuronal networks for fuzzy systems design;
- fuzzy systems for neuronal networks design;
- genetic algorithms for fuzzy systems design;
- genetic algorithms for automated instruction and generation of artificial neuronal networks;
- intelligent agents for different tasks.

These hybrid systems have the characteristics of the technologies they are made of, that is why we get the conclusion that they have the same paradigms as these but combined in order to compensate the disadvantages of a certain technology with the advantages of another.

We can recall here, symbolic logic paradigm. Symbolic approach [3] begins at the highest knowledge level: symbolic manipulation and language. The fundamental hypothesis of this approach is that the human brain is not only a material support capable of producing thinking processes. Symbolic models offer a complementary profile, which means they obtain performance in doing the reasoning process, inferences and deductions, natural symbolic manipulation and their justification. Their representations are localized and explicit, very easy to understand.

1980 years' researches on artificial neuronal networks, fuzzy systems and genetic algorithms, are framed under *soft computing paradigm* or intelligent computing. Soft computing refers to program products or software, between which can be inserted models that develop in time, adding useful information step by step that allows a better flexibility. Here we can appoint progressive computing, fuzzy systems, artificial neuronal networks and any other artificial intelligence techniques. Progressive computing means imitation of surrounding environment's processes; it also can be met at the others systems remembered in this paper.

7. Conclusion

This paper is a restrictive approach of the paradigms mentioned. We must not resume only to these paradigms, every system has many more. If the reader has a minimum of knowledge in the artificial intelligence field, he could say that the intelligent systems mentioned are themselves paradigms and he wouldn't be wrong. Intelligent systems are used in different domains such as: accounting, investments, insurance, human resources, medicine, control and monitoring.

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