INNOVATION IN MANAGEMENT THROUGH THE USE OF SOME TOOLS ARTIFICIAL INTELLIGENCE

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Abstract: The article presents some of the tools of artificial intelligence and their use in the management of innovation, especially in its essential element, which is the decision-making process. Contemporary innovative economy based on the transfer of new technologies, understood as the process of transfer of original ideas - the results of research into the company for their practical application, it forces the use in the management of the use of tools, and today, in the era of the twenty-first century, a special tool is the artificial intelligence, and in it such systems as expert and scattered. In modern management, particularly in countries with highly developed communication technologies, these systems are commonplace in Polish enterprises enter on this path, through the development of appropriate relationships between science - business. Artificial Intelligence /AI/, for machine with the ability to inference and learning , giving people the prospect of release from the simple, strenuous work, but also from those that require a lot of knowledge and innovation in the management element. In a world of rapidly developing information technology decision-making process cannot be left solely intuitive. Artificial intelligence, expert systems, data warehouses, evolutionary programming - are only examples of the most important trials in order to enhance the intellectual and procedural possibilities of man, so they are one of the essential elements of innovation.

Key words: Artificial Intelligence, Fuzzy Logic, Expert System

1. Introduction

We currently live in the era of technical achievements. Such achievements lead to informational revolution on the ground of decision-making processes. One may characterize this revolution by an emergence of large and complex organizational structures utilizing advanced technologies of information processing and by mutual penetration of human activities by machines, on the ground of production processes. The word “depersonalization” is often called to describe process of dehumanization of peoples’ decisions. From the organization’s economical point of view, the clue is to possess highly processed information, gain it in a short time, and skillfully utilize it to make a decision. Such a conduct increases chances to successfully fulfill particular tasks of an organization, but requires specific tools of Artificial Intelligence to support decision processes.

The Artificial Intelligence systems encompass Expert Systems, Fuzzy Logic Systems and Distributed ones. Although one often includes issues of evolutionary systems, such as neural networks, into AI systems, the paper concentrates on basic tools of Artificial Intelligence, i.e.: Fuzzy Logic Systems, Expert Systems and Distributed Systems.

2. Fuzzy Logic Systems

Conditions that determine possibilities of making decision are characterized as three distinct states: certainty, risk and uncertainty. Certainty is a situation, when decision-maker knows, with large probability, available choices and their conditions. Risk is a situation, when decision-maker knows benefits and costs of possible choices only with little (estimated) probability. Finally, uncertainty is a situation, when decision-maker knows neither all the possible choices, nor risks connected with them. Decision-makers should gain possibly most useful information referring to their future decision, to make a right choice under uncertainty circumstances; they should be able to "filter out" information that is not useful, as well as get suggestions leading to the choice of the most favorable variant. The vital part in such cases is played by informatics and various decision support systems.

Significant feature of decision-making process is uncertainty of premises, the decision is based on, as well as uncertainty of final decision made, as an effect of conclusions drawing. Therefore, the most important issue of decision support systems operation, is effective processing of uncertain and inaccurate information. For such a purposes, numerical methods based on calculus of probability are used. These include: certainty factors, fuzzy sets and fuzzy logic, non-monotonic logic etc. From among mentioned, the one that is very convenient is a method based on fuzzy systems, where uncertainty is encoded in fuzzy statements and rules, and is conveniently processed in accordance with generalized (fuzzy) logic (e.g. *Modus Ponendo Ponens*).

Artificial intelligence methods try to describe real world in a way that imitates human reasoning. Their aim is to overcome shortcomings of traditional computer algorithms that fail in situations, where human is able to solve the problem with no difficulty. Lots of phenomenon of real world are very imprecise – they may be connected, for example, with shape, location, color, surface or just description semantics of the real world objects. Consider, for example, words like: considerably, lots of, majority etc. in a sentences like: *Repair cost* ***considerably*** *exceeded 50€. Stocks are* ***nearly*** *zero*. Although such a statements are very difficult to define, peoples are able to interpret them and use, so formulated knowledge to solve decisive problems. Uncertainty lays in a difficulty to sufficiently and precisely define values of all the variables. The problem is to define, what does "considerably" or "nearly" really mean. Such a luck of precision is usually called fuzziness, and leads to the notion of fuzzy sets.

The notion of fuzzy set was introduced in 1965 by professor Lotfi A. Zadeh, as an extension of the classical notion of set. Fuzzy sets are sets whose elements have degrees of membership. In classical set theory, the membership of elements in a set is assessed in binary terms, according to a bivalent condition — an element either belongs or does not belong to the set. By contrast, fuzzy sets permit the gradual assessment of the membership of elements in a set – this is described with the aid of a membership function valued in the real unit interval [0, 1].

Fuzzy sets generalize classical sets, since the indicator functions of classical sets are special cases of the membership functions of fuzzy sets, if the membership function only takes values 0 or 1. In opposition to classical sets, which are only an approximation of the real world, the fuzzy sets define the real world phenomenon more precisely and truly.

An element mapping to the value 0 means that the member is not included in the fuzzy set, while 1 describes a fully included member. Values strictly between 0 and 1 characterize the fuzzy members. Transition from membership to non – membership is smooth, and borders of sets are fuzzy (not sharp).

A special case of a convex fuzzy set is a fuzzy number. A fuzzy number is an extension of a regular number in the sense that it does not refer to one single value but rather to a connected set of possible values, where each possible value has its own weight between 0 and 1. This weight is called the membership function. Membership functions on *A* represent fuzzy subsets of *A*. The membership function which represents a fuzzy set *A* is usually denoted by μ_A. For an element *x* of *X*, the value $\mu_A(x)$ is called the membership degree of *x* in the fuzzy set *A*. The membership degree $\mu_A(x)$ quantifies the grade of membership of the element *x* to the fuzzy set *A*. The value 0 means that *x* is not a member of the fuzzy set; the value 1 means that *x* is fully a member of the fuzzy set. The values between 0 and 1 characterize fuzzy members, which belong to the fuzzy set only partially.
Another way of creating fuzzy number and its function is to use mean value taken from several measurements, in case when available number of such measurements does not allow to define parameters of distribution of the variable.

The knowledge in fuzzy systems is represented as fuzzy statements (fuzzy facts) and fuzzy rules, also called unconditional fuzzy rules and conditional ones, respectively. Consecutively, linguistic variables occur in fuzzy rules, with their values expressed with words (linguistically). They are also represented as fuzzy sets.
Values of fuzzy sets, in opposition to classical ones, do not change sharply when transiting between neighboring ones, but overlap (diffuse) one another. Membership of a given element of variable *x* in a set *A* is defined by a value of membership function $\mu_A(x)$ calculated for that element.

Traditional computer programs require precise decisions: turn something on – turn something off, yes – no, good – bad. However, phenomenon of the real word are not definable in such a simple way. Therefore, there is a place to incorporate decision support systems based on fuzzy systems. Fuzzy systems consist of multiple concepts and techniques that allow the best representation of information that is imprecise, indeterminate or unclear. Fuzzy systems create their own rules based on approximations or subjective valuation, as well as on incomplete or ambiguous data. For example, information like "hot" or "expensive" are not suitable to utilize by traditional algorithms. Fuzzy systems are tools, that allow to define such an information with logical expressions that contain certain inexactnesses. Contrary to traditional programs, that use simple "if – then" rules, fuzzy systems are based on comparisons that model human way of thinking, which may be interpreted both by computers and professional experts.

Although fuzzy systems found their utilitarian value mainly in automated devices, they are also used in other branches of science and economy, e.g.: to support decision making, automation of data mining, objects classification, patterns recognition etc. Classical sample of decision support system that uses fuzzy rules is a simple system, which advices house purchase while required to fulfill several, often contrary, conditions like: acceptable, not excessive price, small annual real estate tax, close distance to workplace or school.

3. Expert Systems

Development of theories and applications of Artificial Intelligence tools is connected with their incorporation into intelligent informatics systems such as Expert Systems. They are capable of solving complicated problems, that require professional expertise and solve them equivalently to human experts of a certain discipline. On the ground of knowledge contained in a knowledge database, the Expert System draws conclusions and suggests making specific decisions. It stands in for human experts, competently emulating their train of thought without a need of human presence during system operation.

The notion Expert System, like the notion Artificial Intelligence, does not have uniform and concise definition, and may be described with multiple descriptive statements slightly differing, accordingly to various points of view. The principles of Expert System operation, i.e. knowledge gaining, processing and delivering it to the user, are depicted in Figure 1.

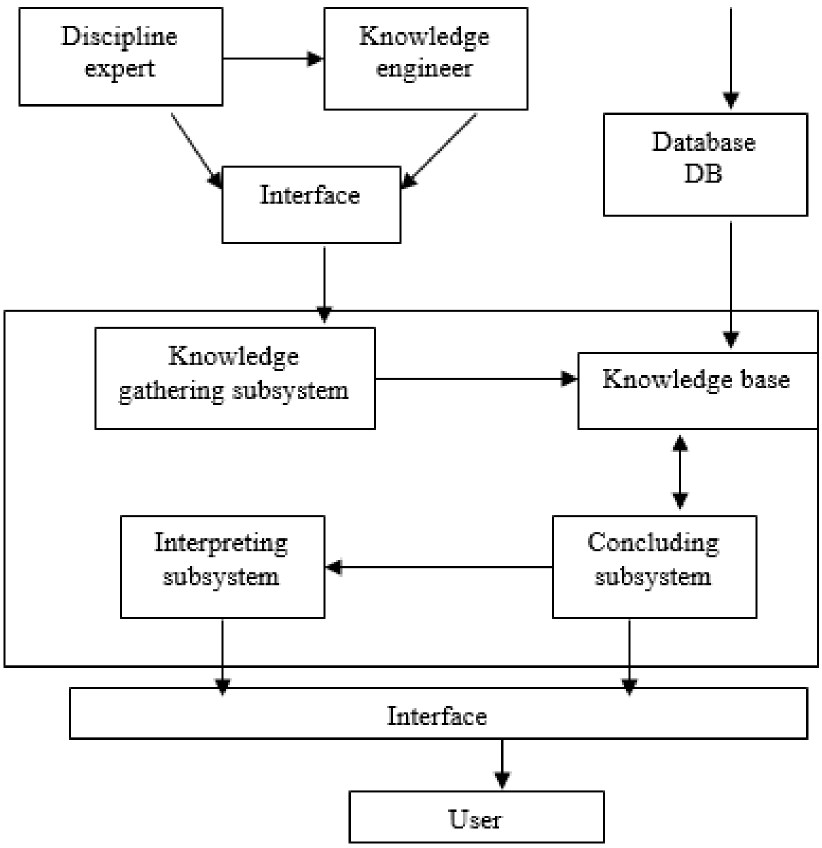

Fig. 1. The principles of Expert System operation

Sample notions of Expert System may be cited here, without graduating their significance:

– Expert system is a complex computer program (programmed system) intended and designed to emulate (simulate) behavior of human expert in a relatively narrow discipline of science to solve problems on the ground of that discipline.
– Expert system is a computer program, that helps solve problems solvable by human experts, who have specialist knowledge gained as a result of long-lasting experience and studies in disciplines that are poorly formalized (have no algorithmically described theory).
– Expert system is an “intelligent” computer program using knowledge and reasoning (inference) procedures to solve problems, that require human (human expert) experience gained as a result of long-lasting activity in a given discipline.

Vital feature of Expert Systems is their ability to communicate with users in language convenient for users and similar to their native language. Expert systems are able to improve themselves on the ground of knowledge contained in knowledge base, which makes them self-learning systems. Knowledge gaining into knowledge base is a long-lasting and laborious process, therefore development of expert system makes sense only when it is supposed to be used over long time and by multiple users. Method of knowledge gaining into knowledge base is depicted in Figure 2.

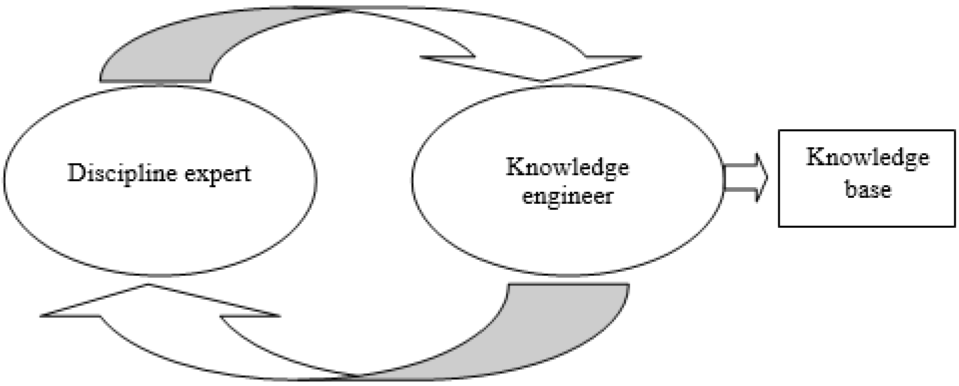

Fig. 2. Knowledge gaining into knowledge base of Expert System

Knowledge (essential to assure appropriate level of expertise), along with inference procedures, may be considered as an expertise model, usually possessed only by specialists of given discipline. Knowledge of Expert System consists usually of facts and heuristics. Facts are fundaments of knowledge base of the system – information, that is widely available and commonly acceptable by specialists of a given discipline. Heuristics are usually more subjective information, that characterizes evaluation process and problem solving by specific expert. Exemplary heuristics are: intuitive conjectures, assumptions, common sense rules of action. The level of expertise, offered by a specific expert system is, in the first place, function of extent and quality of knowledge base of that system.

Expert Systems entered nearly into every domain of creative human activity. Demand for experts' knowledge is large and growing. Development of microprocessors led to creation of Expert Systems that operate on a cheap and widely available computer hardware, therefore further practical utilization of Expert Systems is possible in more and more disciplines. Development process of Expert Systems became very dynamic and, apart from sociological problems (some human expert felt threatened), continues. Main virtues to develop this particular domain of AI are: rising expertise quality and gaining higher qualifications by human experts, possibility to process knowledge and draw conclusions in case of quitting the job by human expert, increase of experts' number in the world, which results in easier access to knowledge, elevation of humans' life quality and reduction of knowledge costs. Another, not less important, are: persons, who are not experts, may solve very complicated problems with support of Expert Systems, time to solve problems decreases, multiple solutions are generated over a short time, cost of problem solving is low, monotonous and laborious operations are eliminated etc.

Expert Systems may be divided, based upon multiple criteria. One of available classifications has been collected in Table 1.

Tab. 1. Types of Expert Systems

Category	Tasks fulfilled by Expert System
Interpretative	They deduce situation descriptions by observing sensors' states, e.g.: voice recognition, image recognition, data structures recognition.
Predictive	They make conclusions to predict future on the ground of current situation, e.g.: weather forecasting, disease development predictions.
Diagnostic	They determine system faults on the ground of observations, e.g.: medicine, electronics, mechanics.
Collective	They configure objects under limited circumstances, e.g.: configuration of computer system.
Planning	They take actions to reach defined goal, e.g.: robots' movements.
Monitoring	They compare observations with defined restrictions, e.g.: power plant monitoring, medicine, traffic control.
Steering	They drive system's behavior; they encompass interpreting, prediction, improvement and monitoring of object's behavior.
Improving	They suggest actions to be taken in case of faulty functioning o an object.
Service	They schedule actions taken to repair damaged objects.
Instructing	In-service training systems for students.

Development of decision support systems is tightly related to development of methods of processing of large amount of data. Data warehouses, multidimensional data bases, reporting tools – all have become essential components of applications described as *Business Intelligence*. Wider and wider application of extended *BI* applications brings another view to decisive problems, searching for new ways of problems solving, that results in a demand for new tools and technologies. The new thesis is developed, according to which the current position of *Data Mining* tools among analytical controlling applications may be threatened by Expert Systems that use formalized notation of analysis methodology of knowledge stored in the knowledge bases. Conclusions and explanations drawn by Expert Systems reveal reasons of negative phenomenon occurrence in the observed area of an organization's functioning. They define area and scope of available decisive variants allowing, at the same time, to evaluate the most probable effects of each variant (Expert System fulfills its projection functions in this case).

Decisive processes support requires application of wide spectrum of tools and technologies and encompasses most parts of information system existing in an organization. It indicates that design, implementation, exploitation and development of every single informatics solution should take deployment of decisive information processed by the system, under consideration. Types of processing conducted by Expert Systems are:

- optimization, including solution of linear and non-linear equations;
- classification, conducted by division of initial set into classes and categories associated with available features;
- steering, conducted without a need of model development, based only on experience;

– recognition, understood as a classification of initial set, even if the set does not match any of stored patterns,
– estimation, conducted as a sequence of approximation, interpolation, filtering, prediction and forecasting.

Exemplary application areas of Expert Systems are: diagnostic of diseases, identification of molecular structures, legal advising, problem diagnosing (e.g. faulty operation of a device), assessment and calculation of vehicles' repair costs be insurance companies.

4. Distributed Systems

Desire for effective application of computer systems in various domains of management (steering) leads to development of new and new classes of distributed, utilitarian programs of a large scale. Systems, we talk about, are not only individual capabilities of computer exploitation, but informatics services with high level of integration and reliability, available for users, located miles away and using various computer hardware.

Issues of comprehensive computerization are visible wherever problems are to be solved repeatedly, e.g. on different steering levels. Solution for such a situations is brought by Distributed Operating Systems.

Contemporary Distributed Systems consist of distinct computers connected by a computer network. One may notice, that computer systems created recently tend to split computations among multiple processors. In comparison with individual systems, these processors do not split their memory and clocks. Each processor has its own local memory. Processors communicate one with another by various means of communication, e.g. Ethernet network, wireless networks etc. Such a systems are usually called *loosely coupled systems* or *diffused systems*.

Processors creating diffused system may vary by power and intended use. There may be small microprocessors, workstations, minicomputers, large computer systems of general purpose among them. Designation of individual processors is done by describing them as *sites*, *nodes*, *computers* etc. – depending on the context they are described in. Distributed systems are created for multiple, following reasons:

1. Resources sharing – after connecting individual workstations (with various configurations), the user of one station gets access to resources available on the other one. For example, the user of node A may use printer installed at node B. At the same time user B may access files stored on A's hard drive. Generally speaking, resources sharing in distributed system creates mechanisms of access to files shared by a remote nodes, processing information collected in a diffused databases, printing files at remote nodes, using specialized, remote devices (e.g. arrays of processors, distinguished by high speed computations).
2. Computations acceleration – if it is possible to split computation into a set of partial computations, that may be computed concurrently, distributed system may assign these computations to particular workstations and order their concurrent execution. Furthermore, if a particular workstation is overloaded with computations, part of them may be shifted to another, not loaded workstation. Such a shift of tasks is called *load sharing*.
3. Reliability – in case of malfunction of a particular workstation in the distributed system, other station will continue operation. If the system consists of a large, autonomous installations (i.e. general purpose computers), malfunction of one of

them does not effect operation of remaining ones. Whereas, in case of the system consisting of small machines, with each of them having specific tasks assigned (e.g. read – write operations on a file system), malfunction of one station results in holding down all the system. Generally speaking, existence of sufficient redundancy (both hardware and data) in a system makes it operational, even with multiple nodes malfunctioned.

4. Communication – there are various situations, when programs have to exchange data one with another within individual system. Connecting the nodes one with another by a network allows to exchange information among them. Network users may send files or share information not only within one node, but also with users of another nodes.

There are six fundamental properties that determine distributed systems usability:

1. Sharing – common resources usage, i.e. resources, that may be useful for multiple users. Such a resources encompass both hardware and software, e.g. drives, printers or files, databases, data units.
2. Openness – ability of expansion; the system may be opened or closed for hardware expansions (e.g. addition of a new external device, memory, interface) or software expansion (e.g. addition of a new functional modules).
3. Concurrency – if one processor has to compute multiple processes, they are computed concurrently. In case of single core processors, concurrency is achieved by partial execution of each process and queuing these parts.
4. Scalability – the smallest distributed system may consist of only two workstations and a fileserver, whereas distributed system based on a local network may contain hundreds of workstations and multiple fileservers, print servers and servers of special purpose. Local networks may be further connected to create wide area networks.
5. Malfunctions tolerance – as a result of hardware of software malfunctions, programs may generate faulty results or just "hang up". To overcome possible malfunctions there are two approaches: hardware redundancy – usage of redundant components, and software regeneration – designing programs capable of cancelling effects of faulty computations. Hardware redundancy is often achieved by running two workstations, one of which plays a back-up role. Distributed systems are designed with multiplication of crucial servers (i.e. the most important ones), while remaining servers are used for "non-crucial" tasks. If server malfunction is detected, clients are redirected to another server. Software regeneration requires programs to be designed with capability to restore persistent data after malfunction to the state saved before certain program started its execution. Distributed systems assure high level of availability after hardware malfunction. Always, after malfunction of a workstation, the user may shift to another workstation and resume server process he had started on a previous station. Taking full advantage of concurrency and malfunctions tolerance in a client – server systems requires however, more complicated programs design.
6. Transparency – means hiding from the user and application programmer separate parts of distributed system, so the system is seen rather as a whole, than as a collection of independent components. Components separation is a natural feature of distributed systems which results in a demand for communication, openness of system administration and integration. It facilitates real concurrency, faults tolerance and removal of malfunction effects, without interfering the whole system.

5. Conclusion

Artificial Intelligence, in other words machines with ability of inference and learning, create perspective of relieving humans from simple, burdensome works, but also complicate ones, that require certain knowledge. In the world of rapid development of technology, information process of making decisions cannot be an intuitive operation. Artificial Intelligence, data warehouses, evolutional programming are just samples of the most important actions taken to support human intellectual and procedural abilities. Exposure of the essence of decisive process is not easy, although modeling of elementary decisive acts or even more complicated decisive processes seems to be within arm's reach.

Artificial intelligence supports people in decision-making in multiple domains of their lives. Human, when making a decision, undergoes emotions, while computer acts in accordance with a specific algorithm. Contemporary psychology learns the ropes of human and does not separate thinking from emotions, that influence each other. Machines may turn out to be better in making decisions, where "cold blood" is needed, without impact of emotions.

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