Investigation of the Possibilities for Interdisciplinary Co-operation by the Use of Knowledge-based System

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Abstract: Each problem always originates from constraints. The decision is a response to the challenges by the environment. In order to chose appropriate decision support techniques the structural complexity of the problem has to be determined. The aim of the application of knowledge based systems is to obtain decision support. In this paper the application of the system 'Doctus' is illustrated and exemplified in connection with processing the problem of the potential co-operation between the industrial companies and institutes of higher education. The analysis was carried out by the application of inductive and deductive inference procedures taking into account the requirements of the companies and the abilities and skills of the higher educational institutions. The assessment of the results obtained may generate further dilemmas for the solution of which appropriate knowledge bases can be brought about or the already existing ones have to be refined.

Keywords: Knowledge-based Systems, Knowledge-based Technologies, Deductive Graph, Deductive Reasoning, Model Graph, Inductive Reasoning, Interdisciplinary Co-operation

1 Introduction

To what extent can human thinking be substituted by computers?

By seriously establishing the idea of automating abstract mathematical proofs rather than merely arithmetic, Turing greatly stimulated the development of general purpose information processing only in 1936. Previously, Hilbert had emphasized between the 1890s and 1930s the importance of asking fundamental questions about the nature of mathematics. Instead of asking 'is this mathematical proposition true?' Hilbert wanted to ask 'is it the case that every mathematical proposition can in principle be proved or disproved?' This was unknown, but Hilbert's feeling, and that of most mathematicians, was that mathematics was indeed complete. Gödel destroyed this hope by establishing the existence of mathematical propositions which were undecidable, meaning that they could be neither proved nor disproved.

The next interesting question was whether it would be easy to identify such propositions. After Gödel, Hilbert's problem was re-phrased into that of establishing decidability rather than truth, and this is what Turing sought to address. In the search for an automatic process by which mathematical questions could be decided, Turing envisaged a thoroughly mechanical device, the Turing machine (1936), in fact a kind of 'glorified typewriter'. Its significance arises from the fact that it is sufficiently complicated to address highly sophisticated mathematical questions, but sufficiently simple to be subject to detailed analysis [1]. Turing's universal computer can simulate the action of any other, in certain sense. This is the fundamental result of computer science. Indeed, the power of the Turing machine and its cousins is so great that Church [2] and Turing [3] framed the 'Church-Turing thesis,' to the effect that "*Every function 'which would naturally be regarded as computable' can be computed by the universal Turing machine.*" This thesis is unproven, but has survived many attempts to find a counterexample, making it a very powerful result.

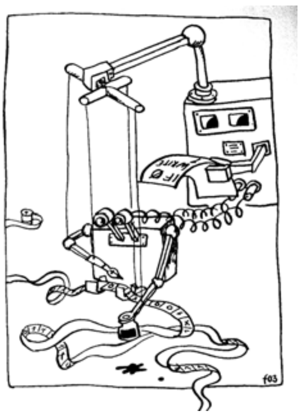

Figure 1
Turing's 'glorified typewriter', the Turing Machine

In the possession of the idea of Turing Machine the computational complexity of a problem can be determined by the number of steps a Turing machine must make in order to complete any algorithmic method to solve the problem. If an algorithm exists with the number of steps given by any polynomial function of the amount of information given to the computer in order to specify the problem then the problem is deemed tractable and is placed in the complexity class 'P'. If the number of the necessary steps in solving a task rises exponentially with this information, then the problem is hard and is in another complexity class. There is an even stronger way in which a task may be impossible for a computer. Such problems are termed uncomputable. The most important example is the 'halting problem'. A feature of computers familiar to programmers is that they may sometimes be thrown into a never-ending loop.

According to the above outlined situation it can be stated that recent development of Information Technology made it possible the partial or in certain very special cases even the full automation of the process of human thinking, more formally speaking, at least in the realm of '*P class problems*'. In our days the decision supporting systems embodied in expert systems as software running on common computers are indispensable requisites for managers. Normally these decision supporting systems are used for managing decision dilemmas at the strategic level of decision making [4]. Their application can be extended for the rather 'soft' fields of application as social sciences as well as for the rather 'hard' subject areas of natural and technical sciences. In this paper, as an application example of the knowledge based technologies, analysis of the possible co-operation between the industrial companies and the higher educational institutions is presented.

The role and position of the higher educations seems considerably vary worldwide in these years. The situation of the Hungarian educational institutions is even more dubious: its staff frequently has to cope with often controversial demands that also vary in time. The basic knowledge obtained at the educational institutions has to be further developed in the practice. By our days this knowledge became of strongly technological nature, and it is expanded and enriched mainly by the research carried out by private companies. As a consequence its key elements ceased to be 'public properties', and became 'private' ones. The great majority of this technological knowledge does not even reach the educational institutions, and it is hopeless to acquire them by separate research conducted in these institutions. The employees of the industrial companies are provided with up-to-date technological knowledge in special education carried out within the companies. This situation automatically devalues the output of the traditional educational institutions that is the student who is provided with certain particular lexical knowledge that cannot be fresh and really up-to-date. The costs and time requirements of the post-education within the companies that is needed for obtaining really useful labor force also mean some burden to the industry that naturally wish to reduce them.

The education that is specific to the needs of the various companies can be brought about via the co-operation of the industrialists and the educational institutes by harmonizing the appropriate goals and conditions of the education. This harmonization has to result in the reduction of the financial burden of the postgraduate training, in the production of more marketable graduate students, and more popular institutional organizations of widely recognized reputation. It can also be expected that increasing proportions of the financial resources of the higher education will be covered directly by the students in Hungary.

The burden of the post education mainly can be reduced by deliberately providing the students rather with skills than with particular lexical knowledge in the education. On the basis of these skills the graduated students become able to learn in fast and efficient manner so the duration and the costs of the post-education can be reduced. For the development of these skills the higher educational institutions have to operate as intellectual training camps the actual program of which also corresponds to the daily activities conducted in the industrial companies. In our view this practical demand is the key element on the basis of which the working connection between the educational institutes and the industry can be revitalized.

The up-to-date lexical part of the common, public knowledge to be acquired by the students during the education obtains special emphasis in this phase. The industrial development is accompanied by intensive standardization. The crystallization of the industrial standards is a long process in which various, often concurrent, competing companies take part simultaneously. It is much more expedient and advantageous for the educational institutions to take part in this process than only compiling the already existing, well crystallized standards. In this manner the graduate students can obtain knowledge and skills that are immediately marketable in the industry.

2 The Role of Computers in Decision Making

Management decision making level	Information required for	Type of CIS support
Top Strategic	Planning long-term policy decision and planning	Decision Support System (DSS)
Middle Tactical	Controlling comparing results of operations with plans and adjusting plans or operations accordingly	Management Information System (MIS)
Lower Operational	Operating maintaining business records and facilitating the flow of work in a project	Data Processing System

Table 1
The role of computers in decision making [8]

2.1 Data Processing Systems

A Data Processing System contains a series of procedures that deal with one or more types of relevant business transactions. Examples for the processed transactions are the payrolls, making out bills, acceptable bills, payable bills, stock control, purchase and others. Each data processing system is typically named as an application. Within the organization these systems support a wide scale of transactions. The required decision contains an individual transaction.

The data processing systems can be described as managers of many transactions, in turn they provide plenty of data and it is possible to have access to the required information. It is a fact that the data can increase as an avalanche. Here is arising the problem in the decision making of the management concerning the possible application of the systems data files namely the data volumes are too large. It is impossible to reach a general interpretation as the details are too much. Accordingly the capacity of the computers is applied to data summarizing and interpretation of reports and information [8].

2.2 Management Information Systems

A management information system summarizes and selects data from a large volume of data file and in such a way it makes a report to the system outputs. This process is often quoted as 'lock out reporting' or 'managing with lock out'. In the system the managers insert data selection criteria within the computer program on the basis of the content. Management information systems help especially in handling of problems with known structures soluble on the basis of the past experiences. Problem solving of such type is often associated with the tactical level of the management. The 'tactical' term refers to such starting operations within which the decisions can be made on the basis of known relations, rules, laws, that is as in the case of structured problems. There are reliable precedents applicable in decision making. In effect the knowledge and experience of the manager qualifies the problem as structured and the managing area as tactical. The nature of problems and the suitable solving method often depends on the situation, on the experience and knowledge on the given area of the problem solver [8].

2.3 Knowledge-based Systems (Decision Support Systems)

The purpose of the application of knowledge based systems is rather decision making than information processing. For solving problem the degree of an existent structure represents the dividing criterion for the application of decision support techniques. A knowledge based systems is most effective in the managing of semi-structured problems. The abilities of such systems are usually applied on the managing level of strategic planning. The tactical and strategic planning is unfortunately often defined with the term time range instead of its relative duties. The tactical planning deals with the starting situation including the application of know principles, rules, and laws. The strategic planning deals with situations including certain elements of the undoubtedly not predictable unknown. Strategic planning includes the future but not necessarily the long range future. The identifying characteristic can be catched rather in the semi-structured nature of the problem to be solved and in the uncertainty of the future [8].

The structurality of a problem is determined by that person who perceives and solves the problem. Therefore it is impossible to define the structurality of a problem in an absolutely correct manner. The degree of structurality of a problem is function of the knowledge, experience of the problem solver. The principle of the definition of problem structure is especially important in understanding of the knowledge based systems.

A knowledge based system is such a computer tool that is used by the manager in connection with his/her problem solving and decision making activity, helping him/her in decision making. A person has to define the problem structure and the criteria in connection with the problem evaluation. The manager makes certainly the decisions and solves the problems. Creation of alternative possible solutions is the duty of human creativity. The knowledge based system can be regarded as a problem solving tool kit that can be used in the 'valuation of alternatives' phase of the problem solving process [9].

Application of knowledge based systems requires 'new technology' in the sense that knowledge-based technology is qualitatively different to, and does not fall under the technological development trends of programming. It came about during the researches of the artificial intelligence in connection with human problem solving [10]. The aim of the artificial intelligence researches is the development of intelligent computer system. This is an artificial intelligence program that solves the problems such a way, and behaves so, as persons. On this basis it could be named as 'intelligent behavior'. It tries to create systems that imitate thinking and acting habits of persons. An artificial intelligence program must have attributes characteristic of the human problem solving behavior, that is in case of complicated problems having alternative possibilities with effective problem solving ability, with communication ability, with ability to handle uncertain situations, with ability to handle exceptions and with learning talent.

On the basis of the above ideas it can be stated that the knowledge based systems are artificial intelligence programs with new program structure appropriate to processing symbolical information. The information are processed with reasoning, with application of heuristics. The quality of problem solution depends on the quantity and quality of information available on the relevant area. The programming style is declarative [11]. Accordingly, the task of a knowledge based system operating on the knowledge based technology is not the realization of some mapping between the input and output domains and obtaining data adequate to the given conditions. Instead of that, its task is generation of statements on expert level on basis of the given data proposal [12]. That is the decision support system does not want replace the decision maker. It is satisfied by accelerating and supporting the process of human thinking. Further it can be said that it alloys the advantageous attributes of the human person (human knowledge) and the computer (artificial knowledge) [4].

Its advantages are listed as follows:

- Integration of knowledge of more experts, so it can make more perfect decision, can give better-founded proposal than any individual expert.
- Quick operation, the more hours for human decision can be shortened to a few minutes.
- In problem solving it comes always to identical solutions in contrast to the human decisions that normally are motivated by external conditions, atmosphere, and other effects.
- It can switch over flexibly from a problem to other one.
- Its application has no limits neither in time nor in space. Human expert can be found at definite date at definite place. He/she is not always available. He can step out taking away his knowledge.
- Its amortization is a gradual process while the costs in connection with human experts does not decrease.
- The expertise is summarized and stored on highest level.
- Knowledge Based Systems (KBS) are continuously developable open systems.
- They have modeling ability.
- They are especially efficient in the area of education/teaching.

Limits of the application of KBSs:

- Their unjustified application, forcing can lead to faults.
- They are always only able to solve problems of a narrow, mainly special field. The human person is all-round.
- They follow only given rules, cannot think with common sense.
- The human expert is ready to admit his/her incapability to give a real answer to a problem. In contrast, the system does not sense the limits of its applicability, so in situations not defined by rules it can come to incorrect solutions.
- In case of a system including too much rules it is difficult to check the success of relevant rules, the process of the program can slow down. In case of too few rules it can come to unreasonable conclusions.

The structure of the knowledge based system is custom-built. The knowledge basis includes in explicit form, separated from the other system components, the knowledge and terms describing the special field. The separated knowledge is easily available also for others.

The knowledge collection and arranging is a process describing the expert knowledge [10].

First step of building the knowledge basis is the determination of the decision dilemma [4].

3 Simulation Examination and Simulation Results

Problems always arise from difficult situations. The decision is an answer to the challenge of the environment. A decision maker can be able to make decisions only when he has recognized the difficult situation, has looked for the solution and has power and authorization to make decisions. For the decision maker the real difficulty arises when the decision attributes, their values and the relations between the decision attributes are uncertain [4]. Situations in which the object of decision is a great stake do not mean such difficulties.

In this particular case the decision dilemma is following:

What chances have the higher educational institutions to cooperate with companies? In this paper this problem field and the relevant decision possibilities, alternatives are examined via applying the 'Doctus' knowledge based shell system by deductive and inductive reasoning.

3.1 Reasoning on Basis of Rules (Deductive Reasoning)

3.1.1 Knowledge Base

The knowledge base building denotes the decision preparing and the decision support denotes the decision proposal [4]. The decision attributes are shown in the first column of Table 2. The values pertaining to the decision attributes are given on nominal or ordinal scale. They are discrete terms. Their formulation and quantity is a delicate task, as at determining the rules of the depending attribute not suitable formulation and excessive refining of the values can cause problems. In such case it is necessary a subsequent refinement, and correction [4]. The situation could be made easier by presenting on interval scale, while the application of fuzzy sets should eliminate all difficulties as the fuzzy logics deals with the mathematical handling of the uncertainty of the linguistic terms. Fuzzy systems can successfully be used for various purposes e.g. in motion control of wheeled systems [5], identification of various physical systems [6], and control of test devices [7]. Handling of the uncertainty will be realized most effectively in the fuzzy expert systems [13].

Result	**No**	**promising**	**Yes**
Competence	Confuse	clear	
Partner relationship	Subordinate	equal	
References	of dubious origin	missing	convincing
Communication ability	Weak	convincing	
Communication possibility	Clumsy	just acceptable	good
Personal relationships	Problematic	acceptable	good
Cultural differences	Great	soluble	small
Capacity	Weak	to be extended	satisfactory
Infrastructure	Problematic	acceptable	
Technical background	to be developed	acceptable	
Human resources	to be developed	acceptable	
Professional teachers	weak	acceptable	excellent
Motivation of teachers	Burden	accepts	challenge
Flexibility	Inflexible	flexible	
Confidence	Missing	partial	exists
Financial possibilities	Critical	promising tendencies	good
Separable resources	Hopeless	possible	already solved
Sponsors	Missing	little	considerable
Manager’s attitudes	Burden	passive	active support
Manager’s motivation	Prestige	self-realization	
Manager’s skills	Burden	passive	active
Manager’s social commitments	Little	much	
Investment costs	Little	just acceptable	much
Image	Bad	acceptable	good
Controllability	Casually	posteriorly	continuous
Number of competitors	Missing	little	much
Strength of competitors	Small	middle	great
Economic advantage	Little	uncertain	considerable
Available knowledge	Negligible	useful	
Experience	Beginner	experienced	
Attitude	Constrained	accepted	readily
Activation of results	in a single field	in various fields	
Problem identification	not real	suspicious	real
Way of realization	False	acceptable	
Solution	Disquieting	just acceptable	excellent
Position in competition	Difficult	advantageous	

Table 2
Decision criteria and typical ‘values’

3.1.2 Deductive Graph

It is an empirical fact that the expert is not able draw together more than 3-4 decision attributes with 'if..then' rules. Therefore it is practical to classify the attributes in graph form, arranging them in a hierarchy. The deductive graph presents the dependence conditions of the attributes [4].

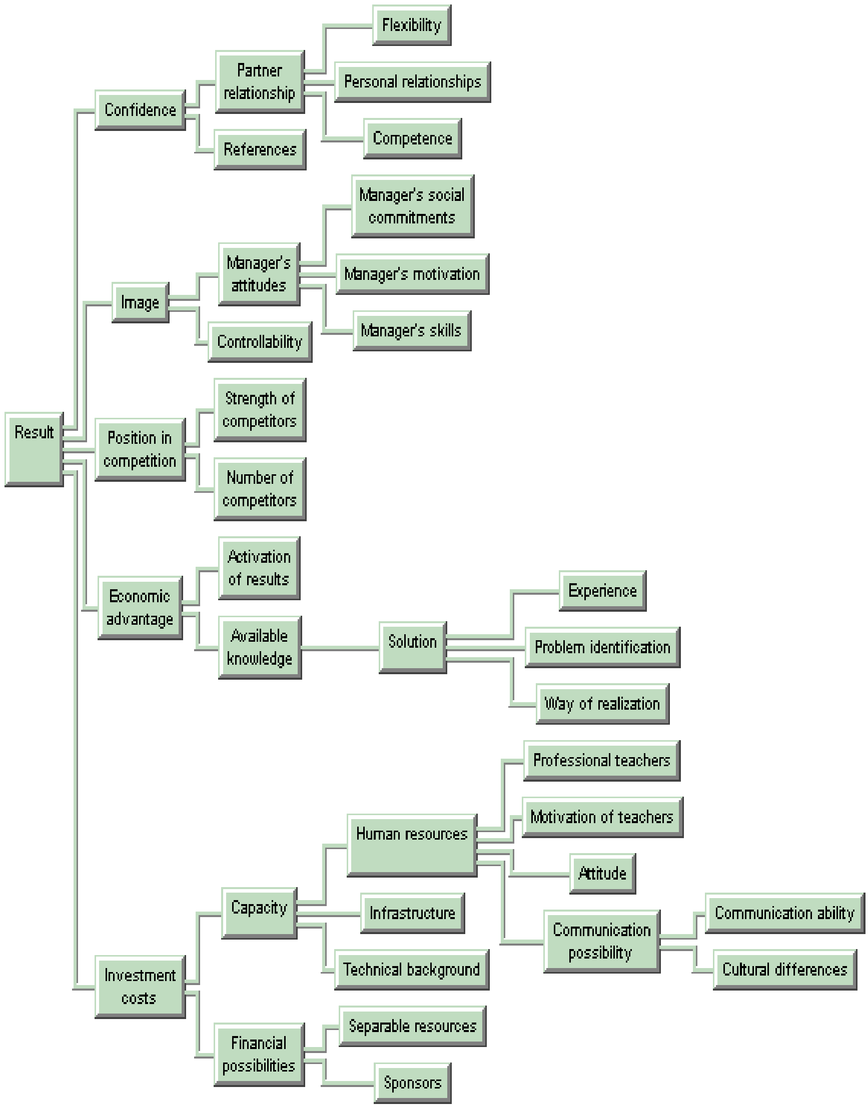

Figure 2
Deductive graph

3.1.3 Rules

The conclusion runs along the graph upwards from below, from the input attributes through the depending medians to the top of the decision tree, to the final decision [4].

3.1.4 Cases

Next step is presenting the cases.

	Partner relationships	References	Communication ability	Communication possibility	Personal relationships	➔
A	subordinate	missing	convincing	just acceptable	problematic	➔
B	equal	dubious origin	weak	clumsy	acceptable	➔
C	equal	missing	convincing	just acceptable	good	➔
D	equal	convincing	weak	just acceptable	problematic	➔
E	subordinate	dubious origin	convincing	just acceptable	acceptable	➔
F	equal	missing	weak	clumsy	good	➔
G	subordinate	convincing	convincing	good	problematic	➔
H	equal	dubious origin	weak	clumsy	acceptable	➔
I	equal	missing	convincing	just acceptable	good	➔
BMF	subordinate	convincing	convincing	good	acceptable	➔

Table 3

Cases and their values (excerpt)

As the aim of this study is to present the applicability and operation of the knowledge based systems, and since no authentic input data for the real higher educational institutions are available, the institutions denoted with are fictitious institutions. The values of input attributes are casually chosen. The final BMF is included as a real institution.

Reasoning consists in the activation of rules. The shell is reasoning on basis of the input rules through the depending attributes on the output attributes, in the present case on the ‘result’.

	Result
A	promising
B	promising
C	no
D	yes
E	no
F	no

G	promising
H	yes
I	yes
BMF	promising

Table 4
Results of the deductive reasoning

3.2 Reasoning on the Basis of Cases (Inductive Reasoning)

On the basis of known cases it is possible to come to general conclusion regarding the decision rules.

The knowledge base includes the decision attributes and their values (Table 2).

3.2.1 Model Graph

The system generates the model graph, using the inputs of the cases.

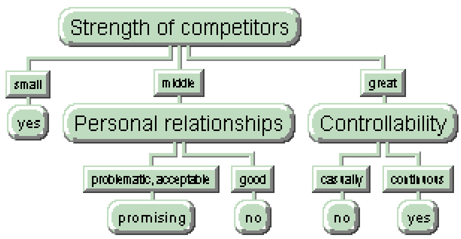

Figure 3
Model graph

The 'if..then' rules constituting the base of decision making are readable from the model graph. It also is visible that the qualifying attributes influence the decision.

Through the application of the inductive method it is visible that in reality the weight of decision attributes is different. With regarded to this the informativy degree gives a numerical value that reflects the gain originating from the given information. The informativy degree can have a value from '0' to '1'.

Conclusions

With regard to the possibilities of interdisciplinary cooperation the conclusion is more reliable if more experts take part in building up the knowledge base, in the creation of the rules.

Deductive Reasoning

On the basis of the performed analysis regarding the BMF, the 'Doctus' knowledge based system gives the 'promising' result in the case of the rule based reasoning. This means the possibility of cooperation for the realization of which there are still tasks to be done. With full knowledge of these, not striving for completeness, further decision dilemmas can arise as follows (it is possible to repeatedly build up the knowledge based on them):

- What steps are to be made for the necessary realization?
- Are these capable to be realized?
- Is it worth to realize them?
- To what extent are they compatible with the strategic plans of BMF?
- Etc…

Inductive Reasoning

Parameters of particular cases were not available. Supposing that the conclusions determined by the deductive method are acceptable, they were considered as cases. On the basis of the model graph the determining attribute is the 'Strength of competitors'.

The companies can choose from the supply of the market, so the market position of the higher educational institutes effects mostly the realization of the cooperation.

The 'strength of competitors' compared to the given educational institution influences the conclusions as follows:

- If small, the cooperation will be realized.
- If middle, a further attribute will be the quality of 'personal relationships'.
- If great, a further attribute the decision will be influenced by the 'controllability' of the higher educational institutions.

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