DECISION MAKING IN MANAGEMENT: AN EXAMPLE OF IDSS FOR ALTERNATIVES CHOOSING IN UNSTRUCTURED ENVIRONMENT

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ABSTRACT: In the paper are given the authors research results about application of intelligent systems for decision making process in operation of mining method selection.

ВЗИМАНЕ НА УПРАВЛЕНСКО РЕШЕНИЕ: МОДЕЛ НА IDS СИСТЕМА ЗА АЛТЕРНАТИВЕН ИЗБОР В НЕУСТОЙЧИВА ОКОЛНА СРЕДА

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РЕЗЮМЕ: В доклада са представени резултатите от изследването на авторите относно използването на интелигентни системи в процеса на взимане на управленско решение при избора на минна технология.

INTRODUCTION

The choice of methods in weakly structured fields is often a complex problem whose solving requires the participation of domain specialists, that is, of their empirical knowledge.

IDSS is certainly one of contemporary approaches in solving problems in weakly structured fields, within which the choice of methods in weakly structured fields also belongs.

The thesis deals with the possibility of the creation and application of IDSS which can be applied with the aim of choosing a method in the underground excavation of ore deposits.

MAKING DECISIONS – THE PROCESS OF DECISION-MAKING

The importance of decision-making in managing business, organisational and other systems has been dealt with by many authors (Cupic et all, 2003). A number of them have also given their definitions regarding decision-making, that is, of the process of making decisions.

One of the most important definitions regarding decision-making is given by Mora (1980) who defines decision making as **a series of activities carried out with the aim of selecting one possibility to the exclusion of others.**

Based on the research conducted in the classical theory of decision-making so far, and respecting, at the same time, the opinions given by the majority of significant authors from this field, Cupic (2003) states that decision-making is a **choice** among available alternatives.

Mora (1980) and Kickret (1980) also point to the mutual connection which exists between decision-making and choices, while Kickret says that the **choice is the key element of decision-making**.

MAKING A CHOICE AMONG AVAILABLE ALTERNATIVES – THE CLASSIFICATION OF DIFFERENT TYPES OF DECISION-MAKING

Cupic (2003) emphasises three basic types of decision making in the classical theory of decison-making:

- Decision-making with CERTAINTY
- Decision-making with RISK, and
- Decision-making with UNCERTAINTY.

Decision-making with **uncertainty** can be selected as a characteristic (especially complex / complicated) case of making decisions, that is, the case when there are no precisely defined steps nor the precise information required for the application of the procedure of decision-making.

Simon (1960) has also given a well-known classification of decision-making, and he points to the difference between **programmable** and **non-programmable** decisions.

The former very often repeat themselves and it is therefore possible to define the procedures that should be used for their solving; the latter, on the other hand, possess certain specific characteristics which make it difficult to define the generally applicable procedures which can be used to solve them (Simon, 1960).

According to Cupic (2003), the **non-programmable** decisions could be classsified as unstructured at the same time.

STRUCTUREDNESS VS. UNSTRUCTUREDNESS

Structured problems, that is, fields refer to the cases where the procedure for decision-making is known as well as the information needed for the application of certain steps in the process of decision-making.

On the other hand, weakly structured fields have the following characteristics:

- the non-existence, that is, the impossibility of defining precise steps of decision-making, that is, of the choice of alternatives and especially generally applicable procedures
- imprecision of, or even unavailability to the information required for decision-making.

Important common characteristics of weakly structured fields are the following:

- in order to make decisions, empirical knowledge of proper domain specialists is very often necessary,
- decision-making models developed in the classical theory of decision-making are of no particular significance here, and
- it is impossible to define precise, especially generally applicable, procedures of decion-making.

If we take into account everything stated so far, we can identify two problems which are related to the decision-making process in weakly structured fields:

- the necessity of applying empirical knowledge in order to solve problems is certianly very significant when it comes to choosing the number of decision-makers capable of coming to right decisions, and
- the impossibility of formulating precise steps for decision-making considerably limits or even prevents the creation and application of computer programmes which would ease the job for decision-makers in weakly structured fields.

Decision Support Systems (DSS) can ease the process of decision-making in weakly structured fields for decision-makers, and here Model based DSS is of particular importance as it has in its data base a number of models which can be applied in order to generate the given suggestions.

Still, Model based DSS is much more applicable in making decisions in structured fields; its characteristics are such that its possibilities are greater as the structuredness grows.

THE USE OF IDSS WHEN CHOOSING A METHOD

During the developments of DSS and Expert Systems (ES) significant advantages which could be accomplished by their integration were spotted. Bonczek, Holsapple and Whinston (1981) provided the theoretical basis for Intelligent Decision Support Systems (IDSS) having noticed the possibilities and advantages which could be achieved by the application of the achievements reached in Artifical Intelligence and ES with the aim of developing the decision support system (Power, 2003).

The possibility of integrating DSS and ES has been dealt with by many authors, among whom the most prominent are certainly Turban (1990) and Cupic (1995). One of the possible ways of this integration is the forming of IDSS in which ES, that is, its components Knowledge Base and Inference Engine are used with the aim of generating the alternative solutions.

However, the practical realisation of a system conceived in this manner is not simple, especially when we are talking about weakly structured fields, where there are at least two groups of problems:

- Gathering necessary knowledge, and
- Creating a suitable model for showing indeterminacy, that is, imprecision of rules.

Besides that, in weakly structured fields it is quite natural to expect that the very information used when choosing alternatives possesses certain indeterminacy.

THE METHOD CHOICE OF UNDERGROUND EXCAVATION OF ORE DEPOSITS

The method choice of underground excavation of ore deposits is a **classical example** of decision-making in weakly structured fields.

The problem of the method choice in underground excavation of ore deposits is characteristic of the following:

- The existence of a number of methods for digging and excavation which could be applied (according to some authors, there are over 180 methods (Gluscevic, 1974))
- A large number of relevant factors whose influence should not be neglected when choosing a method, and
- Different influence, that is, significance these factors have when choosing a method.

The problem of the method choice in underground excavation of ore deposits, therefore, can be classified as a weakly structured problem.

What is also characteristic and significant here is that a decision-maker cannot have any influence on the circumstances which affect the choice of the method. This means that here we cannot talk about **the choice of the optimal solutions,** which is characteristic of the classical theory of decision-making, but about **the choice among available alternatives**, that is, the choice of an acceptable, applicable solution, that is, method.

DEFINING THE PROBLEM OF THE METHOD CHOICE IN UNDERGROUND EXCAVATION

The most imortant goal the chosen method is aimed at is primarily lower costs of exploitation of ore deposits and higher profits at the same time.

It is the chosen method which determines significant parametres of the exploitation of ore deposits, and these are: production rate, costs of ore excavation, ore losses and depletion, and the final profit.

From what has been said so far, it is clear that the choice of the method depends on the current conditions of the deposit itself. The choice of the method, that is, of the ore exploitation system, can be interpreted as a tendency towards maximum profit, but the decision regarding the choice of the method cannot be solely based on economic effects; other factors have to be taken into account as well.

Numerous authors have considered the problem of the method choice of underground excavation of ore deposits, among whom the most important are Bajkonurov (1969), Imenitov (1970), Popov (1970), Gluščević (1974). As common characteristics of steps these authors suggested when choosing the method for underground excavation of ore deposits, we can name the following:

- the preliminary choice of potentially applicable methods, which is based on geological and operating conditions in mines, and
- choosing the most acceptable method among all applicable methods.

PROBLEM FORMALISATION

If we take into consideration what has been said, we can conclude that the method choice in underground excavation of ore deposits is actually the elimination of methods for which it has been estimated that they cannot be applied in the given case or that their potential use would not lead to desirable effects. The application of the given procedure forms a set of applicable methods, after which techno-economic analyses and the method of analogy are applied to make a final choice of the method that will be used in excavation of ore deposits.

In order to make the right choice of the method, knowledge, that is, the empirical knowledge of domain specialists is of crucial importance.

It is not easy, especially in weakly structured fields, to present this knowledge by simple rules or definitions, e.g.

If *x* Then *y*, 1.0

whereby:

- *x* stands for a set of conditions which is necessary to fulfil so that the method can be said to be applicable, and
- *y* stands for a decision, that is, method which can be applicable in a concrete case.

The conditions referring to rules used to show the application of alternatives, represent the conjuction of simple statements, that is, the conjuction of relations of comparisons which are used to come to the required values of relevant factors important for showing whether an alternative is applicable or not. The unfulfilling of the conditions of any simple statement, that is, of the relation of comparison, leads to 'discarding' the rules and concluding that the considered alternative is not applicable.

Therefore we can conclude that the mere application of the above-mentioned rules in weakly structured fields is not justified.

Weakly structured fields are characteristic of a certain degree of indeterminacy, that is, the very relations within the system's domain are unreliable, which considerably limits the application of formula 1.0. In order to show the empirical knowledge required for the method choice, we can see that it is necessary to use the following rule: **If *x* Then *y***; in this way the level of reliability gets higher.

The rules of lower levels of reliability in weakly structured fields can be formulated in the following manner:

- neglecting the influence of certain, in most cases less influential relevant factors, and
- defining more flexibly the relations of comparison which are used to come to the required values of relevant factors.

The rules of lower levels of reliability of choice, as well as a growing number of rules used to show the possibility of applying certain alternatives, allow the more adequate presentation of the domain specialists' knowledge.

MODELLING THE METHOD CHOICE PROCEDURE IN WEAKLY STRUCTURED FIELDS

Analysing the way of making a choice, that is, the method choice procedure, which domain specialists use when solving problems in weakly structured fields, it has been noticed that domain specialists not only show the conditions at which they are 'absolutely' sure an alternative can be applied, but also they can more easily define the conditions at which they can see a certain possibility when an alternative can be applied.

Domain specialists' choice of an alternative is based on the available information, and they identify **the dominant alternative** among a series of available alternatives.

In case when they identify more than one alternative that can be viewed as approximately equal candidates when choosing the optimal solution, domain specialists can **recommend** the application of the identified alternatives, whereby the final choice is made by help of certian models paying attention to economic effects.

Also, domain specialists can **propose** the application of an alternative, whereby they show at the same time a lower level of reliability of the made choice.

Taking into account both the characteristics of relevant factors which domain specialists use when choosing alternatives and their joined intervals of allowed values, rules of various degree of reliability can be created, as well as corresponding factors of reliability, both qualitative and quantitative.

When the qualitative, descriptive factors of reliability are used, the number of levels of reliability depends on the characteristics of the (spoken) language domain specialists and a knowledge engineer (t.is., future users) use. In the Serbian language, beside the absolutely **correct** – **YES**, and the absolutely **incorrect** – **NO**, there are three more levels of reliability: **maybe**, **probably** and **certianly**.
We can attach the folowing meanings to the mentioned levels of reliability:

- The **maybe** level of reliability points only to the possibility of application, as there is no enough evidence to ensure the possibility of application.
- The **probably** level of reliability points out that the conditions needed or important for the application have been fulfilled, although not all the evidence has been ensured that the alternative can really be used.
- The **certainly** level of reliability points out that all the evidence necessary for the application of a particular alternative has been ensured, whereby it is possible, at the same time, to expect that the chosen alternatives are the candidates for the choice of the dominant alternative, or a set of candidates among which the most acceptable one will be chosen.
- The (absolutely) **correct** level of reliability in weakly structured fields can be considered a special case, especially when we are dealing with the fields in which the choice of altenatives is conditioned by a larger number of relevant factors of various levels of influence. In such cases, it is really difficult to create the conditions which will be respected when choosing an alternative that guarantees reaching the level of reliability that is called (absolutely) correct.

The maybe, probably and certainly levels of reliability have also similar meanings when showing the impossibility of the application of an alternative, since in weakly structured fields it is often easier to show that an alternative cannot be applied than to show the conditions which are necessary for the application of the alternative.

CHOOSING A METHOD WITH THE HELP OF IDSS

Taking into account all the above defined requirements, a system which possesses possibilities of choosing alternatives in weakly structured fields has been created.

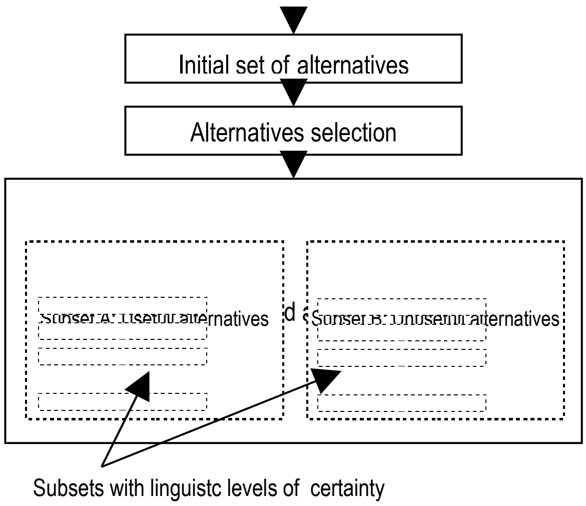

Figure 1: Transformation of initial set of alternatives into subsets of usable and unusable alternatives

Using as a base the rules regarding the choice of alternatives, that is, the results of testing the rules which are contained in its data base, IDSS groups the alternatives into usable and unusable ones, along with the corresponding factor which shows the reliability of the made choice.

The subset of coming to conclusions is conceived in such a way that it allows, at the same time, the appearance of an alternative within a set of applicable and a set of non-applicable alternatives. This characteristic of IDSS is perhaps illogical at first sight, but it is very important when IDSS is applied in weakly structured fields especially when there are various aspects of indeterminacy of knowledge, as well as possible incompleteness of the very knowledge base of the system.

In order to make a choice among alternatives, that is, to test the conditions of choosing, IDSS needs information which show characteristics in a concrete case.The system provides the information from the user via a particular interface. When a condition during the choosing of an alternative initiates a demand for some information, a subsystem of the dialogue formulates the following question: "**Charecteristic *K* of the relevant factor *R* Θ *V* ?**", whereby **Θ** stands for the comparison operator.

Depending on the reply of the system's user, that is, his conviction of the correctness or incorrectness of the assumption formulated in the above given question, the logical relevance of the condition which initiated a demand for the information is estimated, while the gathered information is temporarily kept, during the choosing of alternatives, in the system's working memory in case it may be used again.

When we are dealing with weakly structured fields, the user is very often expected not to be sure whether the particular information is correct or not, which will certainly make it more difficult for him to make a choice between Yes and No. Besides the choice between Yes and No, the system is conceived in such a manner as to ensure additional levels of showing indeterminacy of knowledge (maybe, probably, cetainly), which also reflects the reliability of the decision formed by the application of the information which alone possesses a certain level of indeterminacy.

At the end of the process, the method choice system determines the resulting reliability of the choice for every tested alternative and ranks them providing the decision-maker with the information needed for making a decision, that is, for choosing an alternative.

CONCLUSION

Up-to-date researches of authors indicate on possibility of application of intelligent systems for decision support in order to make adequate mining method selection.

Formed system prototype, i.e. method selection subsystem, allows efficient methods selection and also rates them according to level of method applicability, based on usage of rules for alternative selection, i.e. knowledge included in knowledge base of system and available informations.

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