decision support, investment planning, fuzzy neural system

Marcin RELICH*

THE SUPPORT OF ALTERNATIVE PROJECT CHOICE WITH USING INTELLIGENCE SYSTEMS

Abstract

This paper aims to make an approach that supports the process of taking investment decision in case if the primary project cannot be completed. The factors, which occur in investment decision-making, often have an imprecise and uncertain form. In this case may be used a fuzzy neural system that supports the choice of alternative project by improvement in the estimates precision for requested resources. The paper contains an example with the using of different approaches in the estimation of time for project critical tasks that commit the substantial enterprise resources.

1. INTRODUCTION

In dynamic surroundings, the great importance for the obtained profits has the quality of taking decisions in the enterprise. In this case, the particular significance has the decision that involves the considerable resources of the firm. In this kind of decision may be involved, for example, the investment choice that absorbs substantial means. The wrong decision may worsen the liquidity of firm or even lead towards a bankruptcy. In this case, it seems very important to support the decision-maker by taking decision process.

Last years the information and communication technologies have become one of the most important factors, conditions and chances of the firm development. These technologies enable the collection, presentation, transfer, access and using of enormous amount of data. The data are a potential source of information that in connection with manager skills and experience may influence on the choice of the correct decision. On taking decision also influence the trends in economy in micro- and macro scale, the situation on the market and in sector, social and political situation, as well as manager intuition that comes from years of experience in this profession.

From among the successive stages of the science development, two seem to be especially significant. First is the development such a mathematics fields as theory of probability, theory of optimization and theory of games that took place mainly in previous century. Second important stage was a formation of computer science field that regards an artificial intelligence, and above all a computational intelligence [3, 8].

* Ph. D. Marcin Relich, Faculty of Economics and Management, University of Zielona Góra, ul. Podgórna 50, 65-246 Zielona Góra, Poland, m.relich@wez.uz.zgora.pl

Among the support decision methods, in field of computational intelligence are universally applied: artificial neural networks, decision trees, fuzzy systems, as well as expert systems using different structure and methods of knowledge representation [2, 11]. Each approach finds place in a specific applications, taking into consideration their properties [1, 6, 14]. Neural networks enable to construct the classifiers on the base the correct classification case. However, the knowledge using in decision process is located in the entire network and difficult in processing. As fuzzy systems as other rules systems use knowledge in a clear form for a knowledge engineer. The using in rules a fuzzy description lead to create the systems with less amount of rules and wider activity range. This kind of systems is also functional in indirect cases that occur in non-fuzzy rules. The particular case of fuzzy systems is fuzzy neural system [4, 7, 11].

The essential problem for large group of decision systems is acting in case of inaccurate and incomplete input data. With data, that are described in imprecise way, is connected the fuzzy set theory. The difficult of gaining knowledge from experts has led to automatic knowledge discovery from databases of organization. In this case may use a fuzzy-neural system that joins advantages these techniques: the learning of system and processing inaccurate data.

In activity of present organizations more and more importance regards the unique activities, so-called a project [1, 15]. On account of this, the demand arises for new knowledge that enable to solve the problems occur in realization of unique project. In this case, the particular significance has knowledge that regards project management and that uses the special methods and techniques.

In literature, an insufficient note is dedicated the data quality for project planning and saving of project that is at risk of unfeasibility. In article was focused the presentation of making alternative variants of project, in the case as the primary project cannot be completed. Moreover, there is indicated the using of intelligence systems in improvement of precision for the estimates of requested resources.

2. PROBLEM FORMULATION

The enterprises distinguish oneself by a notable complexity and diversity. In this case, the build an efficient and universal method of making alternative project, for all kinds of enterprise, is pointless. However, it may be the correct results for selected enterprise classes. In this paper is taken into consideration the enterprises that make the project for client. It is assumed, the enterprise has an information system that register the data regard the business processes, as well as the past projects. The tool for the project management supports a preparation and controlling of project. Each project has basic plan and its next modifications that contain the data regarding e.g. cost and time of investment tasks.

The decision is taken on the base of (un)certain and (in)accurate information. The volumes of fixed costs or sale guaranteed by contracts constitute certain information, whereas the planned sales volume and a related level of variable costs may be regarded as uncertain. The preciseness depends on the accuracy of economic measurements, which leads to the issue of data quality.

It is assumed, the client orders may be taken and begun in each time (possibility adding the new projects to a set of just making projects). The budget of project is set with cash flow budget in investment period. The client order is chosen by the profitability analysis (NPV) and technical realizability. In case the lack of possibility to continue the primary project, for constraints is sought a set of alternative variants of project.

The decisive variables contain the data concerning the enterprise (e.g. from information system), as well as its surroundings (e.g. macroeconomic rates, situation in sector). For project, the variable contain e.g.:

- resources of enterprise (financial, personal, logistic etc.),
- quantity and range the present and past projects,
- tasks of project,
- date of beginning project,
- time of realization task,
- cost of realization task.

The constraints contain:

- permissible quantity of resources in the enterprise,
- the sequence of tasks in project,
- horizon of project realization.

The problem comes down to an answer to following question: is there, and if yes, what is a schedule of alternative project realization that will be completed in required time and by new constraints?

Above question may be supplemented as followed:

Is possibility to reallocate the resources from primary project to alternative one, and if yes, what is the cost?

Which elements should be added to data base in the enterprise to ensure a required accuracy of identification for correctness making decision?

The answers to above questions let to support a decision-maker on two fields: more exact estimation of required resources values for project realization and taking a decision concerning the resignation or modification of project.

3. METHOD OF SUPPORT ALTERNATIVE PROJECT CHOICE WITH USING INTELLIGENCE TECHNIQUES

The problem that was described in previous chapter may be presented in two points of view regarding knowledge: description and prediction. In first case, the result of taking investment decisions are conditional rules that complement knowledge base, and in consequence – the accuracy of required resources estimation. In case of prediction, the relations are the result that often base on time series analysis. The knowledge discovery process may be supported by using of artificial intelligence techniques. The place of using these techniques, as well as successive stages of proposed method were presented in Fig. 1.

If the investment was begun and the client took a decision about change in budget of project, then there is made a set of alternative projects variants. For each variant is estimated as criteria as: a level of involving means using (similarity of finished and in progress tasks) and cost concerning the adaptation of a new project to the realization. These criteria are presented for decision-maker (client), who considers non-financial criteria (e.g. a need of alternative project realization) and takes a decision.

The presenting approach may be also used to improve the accuracy of required resources estimation (see Fig. 1). In this case, the variables are added successively, till the required value will be exceeded. After supplement a variable, the relationship is tested between a new set of variables and dependent variable. If the relationship is reduced, then a variable is not added into model. The choice of potential variable is made according to subjective criteria concerning e.g. the logical relation between added variable and dependent variable or an access to data.

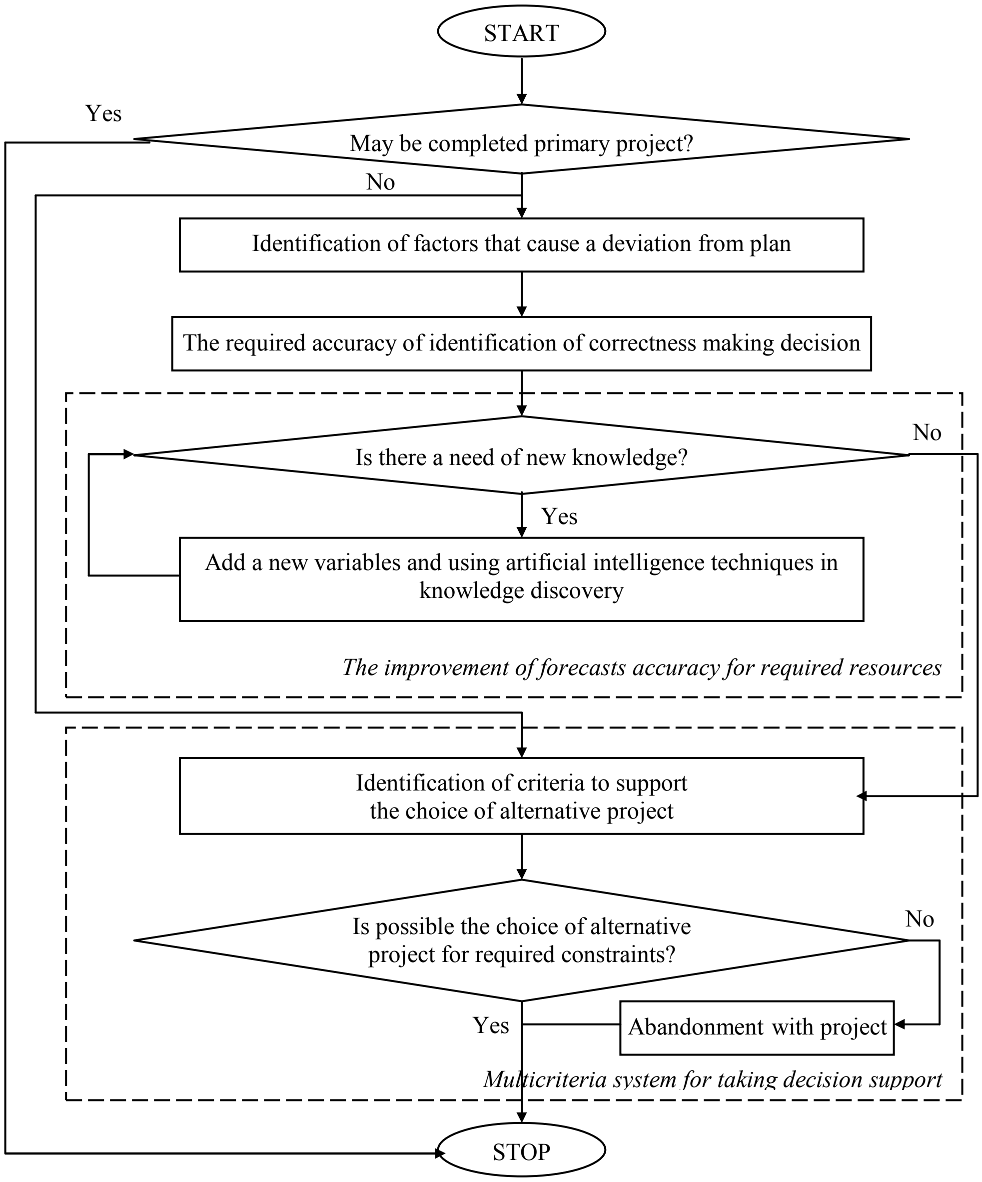

Fig. 1. The procedure of proposed approach

The difficulties with gaining knowledge from expert have led to the increase of interest in an automatic knowledge discovery [12]. One of the successful technique in this field is the hybrid fuzzy neural system. Both neural network and fuzzy systems are trainable dynamic systems that estimate input-output functions. They estimate a function without any mathematical model and learn from experience with sample data. A fuzzy system adaptively infers and modifies its fuzzy associations from representative numerical samples. Neural networks, on the other hand, can blindly generate and refine fuzzy rules from training data [13]. Fuzzy systems and neural networks are established as universal approximators. This implies that fuzzy systems and neural networks can approximate each other. This leads to a symbiotic relationship, in which fuzzy systems provide a powerful framework for knowledge representation, while neural networks provide learning capabilities and exceptional suitability for computationally efficient hardware implementations [10, 11].

The procedure of rules base determination includes following stages [4, 11]:

- the choice the structure and initial parameters of fuzzy neural system (e.g. by using one of the classification method),
- the learning the parameters of fuzzy neural system,
- the evaluation of the obtained rules base and the use it.

In next chapter was presented an example concerning the using of above described method.

4. EXAMPLE

The example regards a project that was taken as the client order and concerning the building of a shop floor. The example was divided in three parts:

- the description of primary project,
- the using of intelligence systems to estimate the time of task,
- the multicriteria system to support the alternative project choice.

4.1 The description of primary project

It is assumed, the building of a shop floor contains 8 tasks. In Table 1 was presented task description, as well as time, earliest and latest start (finish), and slack time of task.

In example was assumed the enterprise has enough personal and material resources to make investment. The critical path regards tasks 2-3-4-6-7-8. The planned finish time was estimated at 75 day, by the cost equals 1.5 million zł. After finishing the tasks in Table 1, there is bought and installed the production devices in cost equals 1.05 million zł.

During realization task number 4 and 5, the client encountered the financial difficulties that made it impossible to complete a project in primary form. The expenses concerning the beginning of investment equal 30% of entire investment (0.45 million zł), that influence on a decision about completing of project in other form. In this case, the enterprise that realizes a project should make a few alternative variants of primary project.

Each project is unique, however, a part of projects may be included in the same class, for as reasons as the required resources and network of tasks. In this case, the required resources may be estimated with using the past experiences the enterprise that made projects. In this way might try to replace the subjective expert opinion concerning e.g. time of task, and to estimate the probability of completed task in definite time.

The enterprise has got the data concerning 52 past projects. Next the task 4 and 5 are carefully considered, because their realization regards a notable part of resources in the project. The arithmetic average equals 34.7 day for task 4 and 22.4 day for task 5. However, the average is not too useful in case a significant dispersion. In considered class of projects, coefficient of variation equals 28% for task 4 and 33% for task 5. These values show a significant dispersion for considered tasks. In this case, it seems reasonable to be the making an approach that enables to estimate the task time in an accurate way. In next subsection was presented an approach that uses intelligent systems to estimate the task time in project.

Tab. 1. The data for a shop floor project

No task	Task description	Time (days)	Earliest start (days)	Latest start (days)	Earliest finish (days)	Latest finish (days)	Slack time (days)	Cost (millions zł)
1	To dig a drainage ditch	1	0	4	1	5	4	0.03
2	To dig a ditch for foundations	5	0	0	5	5	0	0.09
3	To lay the foundations	10	5	5	15	15	0	0.23
4	To build the load-bearing walls	35	15	15	50	50	0	0.5
5	To lay a concrete floor	22	15	28	37	50	13	0.2
6	To build a roof structure	10	50	50	60	60	0	0.15
7	Roofing	5	60	60	65	65	0	0.12
8	To fit in the windows and doors	10	65	65	75	75	0	0.18
Sum								1.5

4.2. The using of intelligence systems to estimate the time of task

In proposed approach (see Fig. 1) for tasks, that have an essential dispersion, are sought the relationships that should estimate the value of resource more exact than traditional approaches. In example this resource is time of task (Y). The traditional approach means that the forecasts are based on average or linear models. As example of intelligent systems were chosen a multilayer feedforward neural network and fuzzy neural system. It is assumed, the accuracy of estimation should improve about 15% in comparison with estimates from linear model.

In example as the decisive variables were chosen the cost of task (X_1) and month of task realization (X_2). To compare the quality of forecasts is determined the error separate for each variable, and also for combination of the variable. The amount of combination is calculated according the formula 2^m-1, where m is the number of independent variables. In case of two independent variables, there are three combination: $\{X_1\}$, $\{X_2\}$, $\{X_1,X_2\}$. The root mean square error is calculated as followed:

$$RMSE = \sqrt{\frac{1}{I}\sum_{i=1}^{I}(y_i - \hat{y}_i)^2} \tag{1}$$

where:

$\hat{y}_i$ – forecast of task time in *i* project,
y_i – real task time in *i* project,
I – set of data (past project with considered tasks).

In Table 2 was presented RMSE for task 4 and 5, for all three combinations of independent variable and different forecasting models. In case of fuzzy neural system, error was determined with using ANFIS tool that is Matlab® software. The estimation quality is usually made on learning and testing set. In this way may be sought a function with suitable approximation grade that is not too adjusted to learning data. The data set (52 samples) was divided into two sets: learning (L) – 42 samples and testing (T) – 10 samples.

Tab. 2. RMSE for task 4-5

	Task 4					
	X_1		X_2		X_1,X_2	
	L	T	L	T	L	T
Linear model	3.54	2.94	4.69	4.88	3.52	2.77
Neural network	3.27	2.71	2.84	2.43	2.87	2.61
ANFIS	1.81	1.72	1.86	1.84	1.74	1.57
	Task 5					
Linear model	2.55	1.74	4.09	3.28	2.48	1.91
Neural network	2.52	2.04	2.27	2.58	2.06	1.93
ANFIS	1.59	1.39	1.73	1.35	1.46	1.58

May note, the least error was generated in learning set by using ANFIS with two input variables. For comparison, RMSE for arithmetic average for learning and testing set equals 9.55 and 9.64 (task 4), and 7.38 and 7.15 (task 5). May also note, an essential difference in the forecasts quality between arithmetic average and other models. The using ANFIS, in testing set by {X1,X2} combination, improves the quality of forecasts in comparison with linear model about 43% ((2.77-1.57)/2.77) for task 4, and about 17% ((1.91-1.58)/1.91) for task 5.

In studies was used a multilayer feedforward neural network that was learnt with using the backpropagation algorithm, by optimisation weights according to Levenberg-Marquardt algorithm. The neural network structure was determined in experimental way, by comparison RMSE for the different number of layers and hidden neurons. The minimal value of RMSE was determined by neural network with 5 hidden neurons. Also the using of fuzzy-neural system requires the declaration of a few parameters concerning e.g. the system structure, type of membership function or defuzzification method.

Before learning the intelligent system usually takes place the identification of a class number. The identification of class (decisive rules) and the initial parameters of membership function of fuzzy sets may be made e.g. by grid partition, fuzzy c-mean or subtractive clustering [5]. The last mentioned method is not as complexity as other methods and it does not require to declare the number of class.

The creation of fuzzy-neural system requires the declaration of the input variables number, defuzzification method or operator of conjunction for antecedents in the rule (Fig. 2).

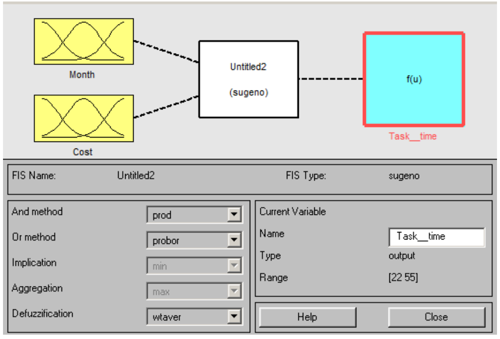

Fig. 2. Declaration of parameters in fuzzy-neural system

For considered data set, the subtractive clustering method estimated three classes and their initial parameters of membership functions of fuzzy sets. In Fig. 3 was presented the structure of fuzzy-neural system. The abbreviations ‘inputmf’ and ‘outputmf’ regard the membership function for input and output variables.

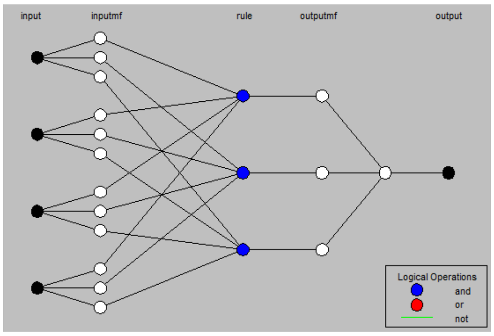

Fig. 3. Structure of fuzzy-neural system

Next stage regards the learning of fuzzy-neural system. In this case may be used e.g. backpropagation algorithm. In this way, the shape of membership function is determined (Fig. 4).

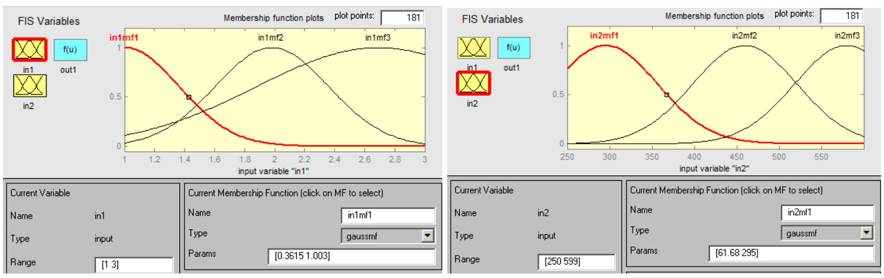

Fig. 4. Membership function of fuzzy sets for input variables

The rules may be presented for decision-maker in descriptive form (Fig. 5). The expression ‘Cost is in2mf1’, that occurs in first rule, regards first membership function for variable Cost (X2), with two parameters that describe function: vertex of gaussion function (0.295 million zł) and standard deviation (0.0617 million zł, see Fig. 4). The months were classified into three group. There is also possibility to add the new rules by user.

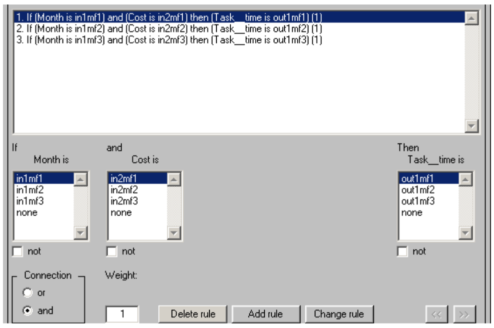

Fig. 5. Rules editor

The learning stage requires the declaration of optimisation weights method (e.g. backpropagation algorithm), and stop criterion: error value or the number of iteration. After learning phase may be led the testing data to input of system to compare the results with target. The parameters and results for learning and testing phase were presented in Fig. 6.

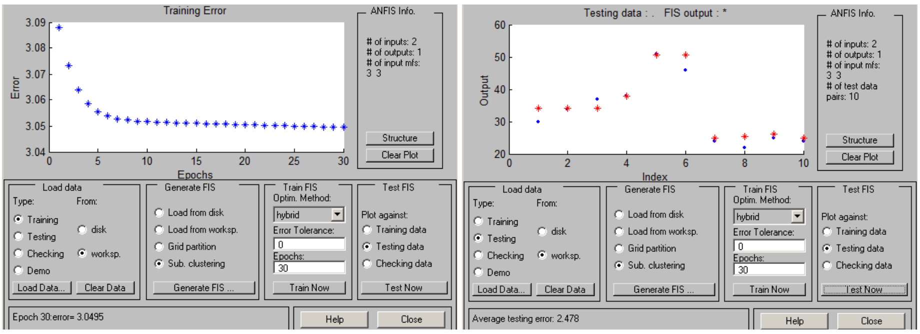

Fig. 6. Declaration of parameters for learning and testing phase

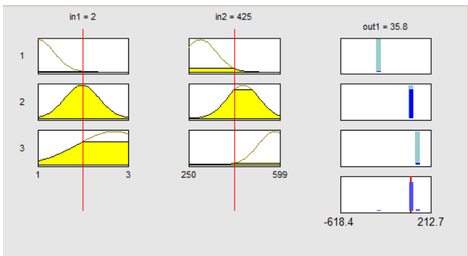

Fig. 7. The estimation of output variable

The value of output variable is calculated according to a defuzzification method, e.g. average centre defuzzification (Fig. 7).

The estimates may be next used to support the taking of the investment decision (see Fig. 1). In next subsection was presented an example of alternative project choice.

4.3. The multicriteria system to support the alternative project choice

With using the base of past projects were sought three variants of primary project. The seeking these variants took place by conformity verification of initial task sequence in primary and alternative project.

Variant A – the adjustment of investment to social rooms (e.g. canteen),
Variant B – the adjustment of investment to storehouse,
Variant C – the adjustment of investment to delivery track garage.

The task network for each variant is similar with structure of primary project (see Table 1). However, the adjustment a primary variant to new variant is connected with additional expenses regard the type of modification.

Tab. 4. The data for variant B of alternative project

No task	Task description	Task status	Critical task	Time (days)		Cost (million zł)
				Average	ANFIS	
1	To dig a drainage ditch	completed	X	X	X	X
2	To dig a ditch for foundations	completed	X	X	X	X
3	To lay the foundations	completed	X	X	X	X
4	To build the load-bearing walls	in progress	yes	25	32	0.2
4a	To adjust primary variant to alternative one	in expectation	yes	2	2	0.02
5	To lay a concrete floor	in progress	no	10	15	0.1
6	To build a roof structure	in expectation	yes	10	14	0.15
7	Roofing	in expectation	yes	5	5	0.12
8	To fit in the windows and doors	in expectation	yes	2	2	0.05
Sum				44	55	0.64

For example, the adjustment to canteen requires installing sanitary devices. In Table 4 was presented the task network for variant B. There is selected the additional task 4a concerning adjustment primary variant to alternative one. In variant B, the adjustment regards an adoption of door and windows to a new dimension.

The range of some tasks of primary project (e.g. roofing) is not also changed in alternative project. In this case may be used fuzzy neural system to estimate the time for critical task that required notable resources. More accuracy in required resources identification may be interpreted as the improvement of certainty in task realization.

In Table 5 was presented the planned cost and time concerning each alternative variant. The client reduced project budget from 1.5 million zł to 1.2 million zł. The cost of three initial tasks and partial realization of task 4-5 equals 0.45 million zł. So for realization of alternative variant remains 0.75 million zł.

Tab. 5. The criteria of alternative projects

Variant	Cost of completed investment (mio zł)	The estimated time of project (days)	
		Average	ANFIS
A	0.71	55	61
B	0.64	44	55
C	0.67	46	59

In Table 5 were presented variants of investment only with two criteria. However, these variants may be also considered with criterion concerning e.g. significance of investment for organisation (client).

5. CONCLUSION

In article was presented the possibility of using the intelligence systems to supplement a knowledge base and to improve of precision for the estimates of requested resources. In case an essential variation of used resources, the traditional methods do not ensure satisfied results. If in enterprise is data base of past project, then there is possibility to gain additional information in form of conditional rules. It enables more exact estimation e.g. time of task realisation. The additional advantages of knowledge base may be using its in support decision system concerning a choice of alternative project. In this case, the improvement of forecasts quality for required resources may be interpreted as an increase in certainty for project realisation.

The lack of a uniform rules that regard the projecting of intelligent (e.g. fuzzy neural) system may cause the acceptance problem by decision-makers. Moreover in this type of systems appears the problem with preprocessing, repeatability experiments and convergence. The fuzzy neural system is like 'black box' for users. The user cannot perceive the relationships and the influence input data on results. This feature may lead to the lack of acceptance for the intelligence techniques. It seems that the users acceptance may increase by a comparison of generated forecasts errors for different approaches (in described case: traditional and proposed approach based on intelligence systems). In case more precise the forecasts, the user can accept the tool without its reasoning.

The further research contain among other things a build of tool that seeks alternative variants of project, and estimates the correctness of initial task sequences, a required modification and resources. Moreover, it seems to be important to give additional criteria to support a choice of alternative variant. The criterion may regard e.g. the description of required resources in form of fuzzy sets. In addition to this, further research may concern a criterion of choice/removal variable to/from model and analysis possibility of using data from outside the information systems of the enterprise.

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