Fuzzy Logic Techniques used in Manufacturing Processes Reengineering

LUCIAN IONEL CIOCA, RADU EUGEN BREAZ, GABRIEL SEVER RACZ
Engineering Faculty
"Lucian Blaga" University of Sibiu
Emil Cioran Street 4, 550025 Sibiu
ROMANIA

Abstract: - Reengineering is quite a new research subject and methods for applying it are developed very fast. One of the main problems is to take the decision if a process needs to be reengineered or not. This work presents a method for taking this decision, based upon fuzzy techniques. The main advantage of this method is, after authors' opinion, the ease of its implementation together with the reduced time for gathering data and processing it. Multi-variable decision systems are usually based upon complicated mathematical methods and involved a large amount of data to be processed. The fuzzy approach presented here is based only on five input variables and one output variable. The data for the model are gathered by simple queries and quizzes. Human perception, the main point of fuzzy logic, is widely used here for gathering input data for the decision model.

Key-Words: - decision, fuzzy logic, manufacturing, mathematical models, reengineering

1 Introduction

The objective of the theoretical and applicative researches described in this paper is to implement a method that allows the managerial decision-making regarding business process reengineering [2], [4]. With time as a limiting factor, the decision must be made in the shortest possible time based on information gathered through the most rapid and intuitive means, such as query forms.

The process analysis must be as precise as possible and, given the current speed of evolution of business processes, as fast as possible. However, the two conditions are contradictory, a precise analysis can be made only based on precise information, which cannot be gathered rapidly. On the other hand, given the speed of the process evolution, it is possible that at the moment of extracting the conclusions resulted from an analysis based on precise information, these do no longer reflect the reality from the process.

Nowadays, the development of the data processing means, of the computer technology in general, offers the support for a rapid and direct application of efficient logical and mathematical algorithms, whose application was so far limited by the rudimentary data processing equipment. The method proposed will fundament the managerial decision-making on reengineering based on running mathematical models with a high degree of generality, the results of which will indicate whether applying reengineering is necessary for the analysed process or not.

2. The generalized fuzzy model

The research proposes the use of the methods of fuzzy logics for the elaboration of a decisional model regarding the implementation of the reengineering process, bringing forward following arguments:

- fuzzy logics is one of the methods which allows the extraction of precise conclusions, based on vague, imprecise input data;
- when elaborating the model of fuzzy-type multicriterial analysis, especially the fuzzy-type rules base, one can benefit from the experience of specialists in this domain, experience which can successfully replace the usage of complex mathematical algorithms;
- the fuzzy model has a great flexibility, its modification and refining being done with great easiness;
- the collection of data needed for the applying of the fuzzy model for multicriterial decision and its unfolding can be done in very short time, so that it can be even regarded as a real-time decision;
- currently there are several software programs which make possible the easy implementing of models based on fuzzy logics, without requiring advanced programming knowledge.

Based on the above-mentioned arguments, a generalized fuzzy model referring to the decision of starting process reengineering has been implemented.

A structural scheme of the fuzzy model is presented in fig. 1.

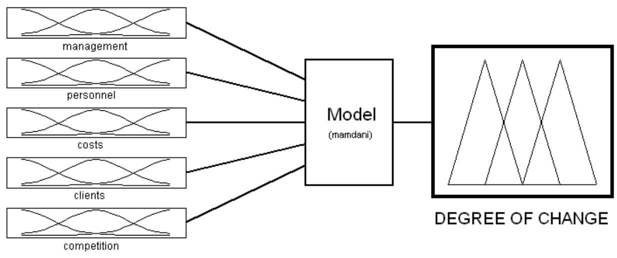

Fig. 1. The fuzzy model

From the bibliographical study carried out, from the theoretical and practical research and after discussions with various experts in the domain, following input variables were chosen:

- management quality;
- level of personnel training;
- costs related to the unfolding of the process;
- degree of clients satisfaction;
- competition in the domain.

The complexity of defining synthetic indicators for the measurement of the five variables is high. On the other hand, for someone from within the process, it is easy to "feel" whether its management is good or bad. The degree of subjectivity is, of course, high, if we take into account only one person, but when the "final grade" results as a statistical mean value, the confidence level of the results gains, in the context of fuzzy logics, character of law.

The construction of the model requires the elaboration of query forms, distributed both to those involved in the analysed process and to outside persons (customers). These query forms request the granting of grades, from 1 to 10, for each of the 5 input variables. Regarding the evaluation of the level of personnel training, the grades can be obtained, for a higher objectivity, directly by unfolding some tests.

The output variable of the generalized model was defined as "necessary degree of change" and varies percent between 0 and 100%. According to the literature, the reengineering of the process is needed when the necessary degree of change is greater than 80% [1], [2], [6]. When approaching the change management, we must start from the concept of change in general, and of organizational change in particular.

Figure 2 shows the steps which have to be done when performing a decision making process upon reengineering a manufacturing system or an assembly system. If the degree of change is smaller than 80%, one should try to optimise or automate the process rather than reengineering it [5].

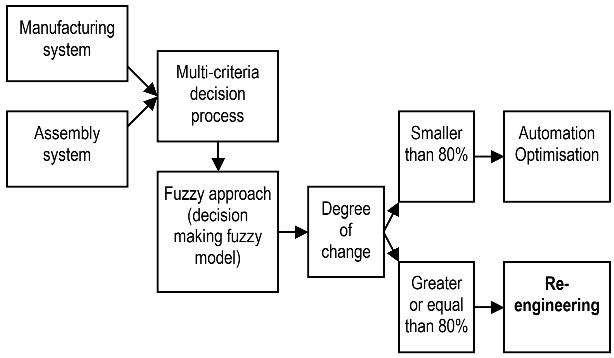

Fig. 2. Steps taken in the decision making process

For the construction of the fuzzy model, the integrated software environment MATLAB was used, with the module "Fuzzy Logic Toolbox". The construction of the model (the membership functions for each variable, the fuzzy rules etc.) is presented in the figures shown below.

The authors have been opted for a graphical-interface-type work environment (instead of the command-line-type), because it allows the user to focus on realizing and refining the model. The main qualities of the model are is realization in an "open" variant, offering the possibility to rapidly and easily modify it and to visualize the results in real time.

The membership functions for all five input variables and for the output variable are presented in fig. 3 to fig 8.

There are 5 input variables, each of which could be grouped in one, two or even three value domains. The total number of rules that determine the dependence of each variable of all other variables, and the way in which they influence the output, is extremely large. Using the methods of fuzzy logic, they were restrained to nine fundamental rules, considered as necessary and sufficient:

Rule 1: If the management is excellent, the costs are acceptable and the clients are pleased, then the change is reduced.

Rule 2: If the management is good, the costs are small and the clients are pleased, then the change is reduced.

Rule 3: If the management is good, the customers are pleased and the competition is reduced, then the change is reduced.

Rule 4: If the management is inadequate and the costs are great, then the change is radical.

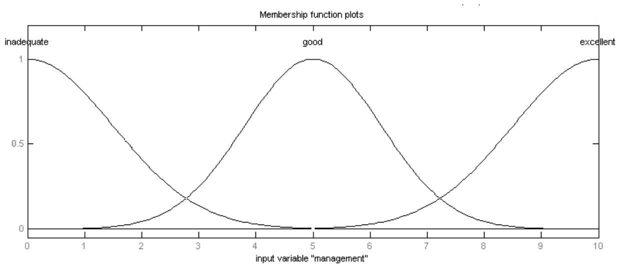

Fig. 3

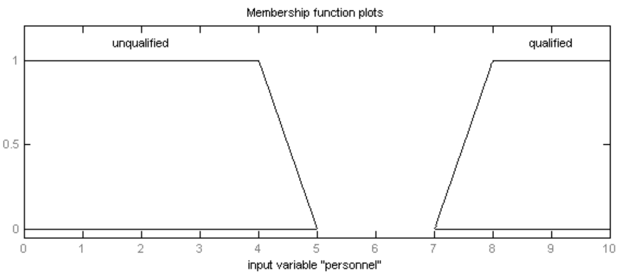

Fig. 4. Membership function for “management”

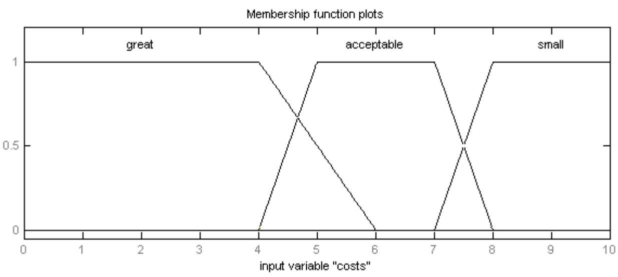

Fig. 5. Membership function for “personnel”

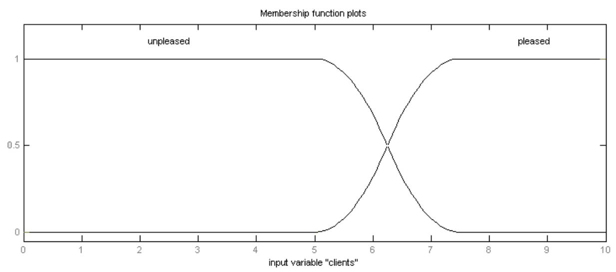

Fig. 6. Membership function for “costs”

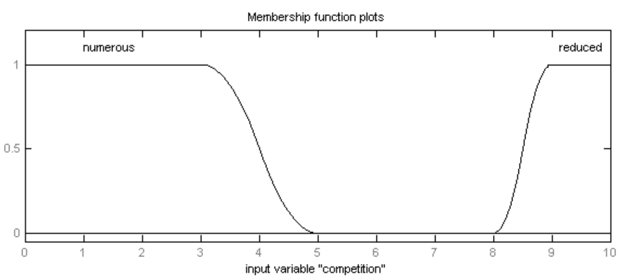

Fig. 7. Membership function for “competition”

Rule 5: If the personnel is unqualified, the costs are great and there is a numerous competition, then the change is radical.

Rule 6: If the customers are unpleased and there is a numerous competition, then the change is radical.

Rule 7: If the management is inadequate, the personnel is unqualified and there is a numerous competition, then the change is radical.

Rule 8: If the management is good, the costs are small, the clients are unpleased and the competition is reduced, then the change is moderate.

Rule 9: If the personnel is qualified, the costs are acceptable and the competition is reduced, then the change is moderate.

The defuzzyfication method used was the centroid.

It can be remarked that the "management" variable has a special importance in the elaboration of the rules base for the fuzzy model, it appearing in 6 of the nine rules and indicating the interdependence between management and reengineering.

In the case of rule 5, for example, high costs and high competition indicate a very precarious situation of the process, and the untrained personnel does not offer the premises for a possible improvement. In this case, it has been considered that the "management" variable can no longer influence the situation positively, not even in the case of an excellent management, so that its influence was not taken into account [3]. In the case of rule 6, customers which are not satisfied and a numerous competition (thus the customers can easily change over to the competition) also indicate an unacceptable situation, which the other input variables cannot influence positively.

3 The fuzzy model for manufacturing processes

In order to apply the proposed method on specific processes, such as manufacturing and/or assembly processes, a particular model was developed. The input 2 to 5 parameters where kept the same, while the input parameter “management” has been replaced with “productivity” [3].

While the evaluation of the input parameters 2 to 5 was performed by means of queries (specific queries were designed to obtain accurate results for each input), the productivity of the process was evaluated differently. The maximum productivity achievable by using the highest manufacturing and/or assembling rate (which may not be however the best choice with regards of the system's reliability) was graded with 10, and the lowest productivity achieved during a year was graded with 1. After that pre-evaluation process, the productivity input was fuzzyfied using Gauss shaped membership functions and three value domains (or linguistic variables): inadequate, good and excellent productivity.

The proposed models (both the general and particular) and methods were implemented and tested successfully for testing the necessity of applying reengineering in a number of automotive parts plants within the industrial area of Sibiu, the city in which authors live.

4 CONCLUSION

The main contribution of this work was intended to be the building of a mathematical model in support of reengineering decision based on fuzzy techniques. Because of the great complexity of defining crisp mathematical relationships regarding reengineering, the fuzzy approach is believed as a reliable alternative.

Another purpose of this research was to implement the above-mentioned model in a software environment that allows graphical user interface programming (GUI), in order to relieve the researcher from having complex programming skills. The input data, the membership functions and the fuzzy rules can be changed "on the fly" by modifying data within the GUI interface, without the requirement of writing complex program code.

The open structure of the model, together with its ease of implementation is intended to be another strength of this approach.

Further research will be performed in order to refine the model, mainly by trying to define more comprehensive methods to evaluate the inputs.

The stability of the reengineered process will be studied by dynamic simulation, but this approach depends on finding some rules for modelling the inputs variation.

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