Fuzzy model for inventory control under uncertainty

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Abstract**—** Modern enterprise faces the huge stream of rapidly changing information. Thereby competitive advantage is fast response of changing external environment by tactical decision making. Decision making problems concern a lot of present science. Many decisions are making under uncertainty or risk. It becomes necessary from faithful deterministic representation goes to sphere of associative fuzzy thinking. These steps give you guidelines for developing decision support system with neuro-fuzzy.

Keywords**—** Inventory control, fuzzy set, decision support system, linguistic variables, uncertainty.

I. Introduction

A successful business relies on many factors, one of which is a reliable inventory management system. Inventory control is interesting not just for manufacturing enterprises but for telecommunication company. Huge material supplies freeze cash assets.

A major challenge in supply chain inventory optimization is handling uncertainty, as not all the data required for making decisions are available with certainty at the time of making the decision. This problem of design, analysis, and optimization under uncertainty is central to decision support systems. It becomes necessary from faithful deterministic representation goes to sphere of associative fuzzy thinking.

In decision making we deal with linguistic, not numerical, variables. The concept of linguistic variables is an alternative approach to modeling human thinking – an approach that, in an approximate manner, serves to summarize information and express it in terms of fuzzy seta instead of crisp numbers.

II. Creating fuzzy model

Society and industry are becoming knowledge-oriented and relying on different experts' decision – making ability to solve problems. Computer-based systems are capable of understanding the information being processed and can make a decision based on it, whereas the traditional computer systems do not know or understand the date/information they process Fuzzy logic, a flexible machine-learning technique, is an attempt at mimicking the logic of human thoughts. Human logic is flexible and less rigid when compared to crisp logic [1].

Fuzzy sets were originally introduced in 1965. [2] As was pointed out by Zadeh, conventional techniques for system analysis are intrinsically unsuited for dealing with humanistic systems, whose behavior is strongly influenced by human judgment, perception, and emotions. Fuzzy set theory provides a systematic calculus to deal with such information linguistically. And it performs numerical computation by using linguistic labels stipulated by membership function. Moreover, a selection of fuzzy if-then rules forms the key component of fuzzy inference system that can effectively model human expertise in a specific application. [3]

The fuzzy inference system (fuzzy model) is a popular computing framework based on the concept of fuzzy set theory, fuzzy if-then rules, and fuzzy reasoning. It has found successful applications in a wide variety of fields, such as automatic control, data classification, decision

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making, expert systems, time series prediction, robotics, and pattern recognition. Typical structure of fuzzy model can be shown on figure 2.

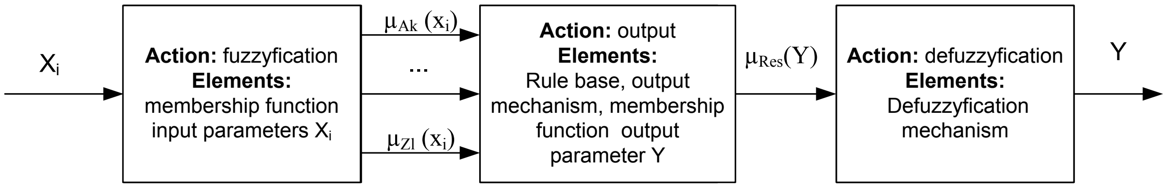

Fig. 1 Typical structure of fuzzy model

Block *«fuzzification»* calculates the membership degree of clear numerical values X_i fuzzy sets A_k, …. Z_l. Fuzzification unit must have access to a well-defined membership function inputs.

Block *«output»* at the entrance gets a membership degree and the output calculates the resulting so-called membership function of the output value of the model. It consists of rule base, output mechanism, membership function, output parameter.

Block *«defuzzification»* on the basis of the resulting membership function calculates the precise numerical value of the output parameter Y, which is the result for the output of numerical values X_i. [4, 10]

III. CONSTRUCTION OF KNOWLEDGE BASE

A procedure embeds fuzzy logic in the form of fuzzy rules containing linguistic terms with multiple values. There are fuzzy membership functions that map the linguistic values to crisp values, which then can be understood by machines, which can then interpret and execute commands. [1]

Creating a knowledge base follows the five-steps:

1) Identify the inputs and their ranges and name them.
2) Identify the output and its ranges and name it.
3) Create the fuzzy membership function for each input and output.
4) Translate the interaction of the inputs and outputs into IF–Then rules.
5) Decide defuzzified output. [5]

We will analyze inventory management system for a telecommunications company. [6, 7, 8] At the present time our company uses two technologies with absolute different types of cable: fiber-optic and copper. Fiber-optic cable has priority importance. Fiber-optic cable has different capacitance and divided to main cable, distribution cable and subscriber's cable.

Figure 2 shows structure of capacitance of main cable. The most popular capacitances are 8 and 16. The more the capacitance of main cable the more cost of project. The cable with high capacitance has low demand. As result this type of cable will stay at storehouse. At the same time some projects cannot be implemented without such cable. Time of purchase is once in three month.

For clarity, General Cable demand consists of cable demand calculated by project needs, emergency reserve, demand for scheduled repairs and unexpected demand.

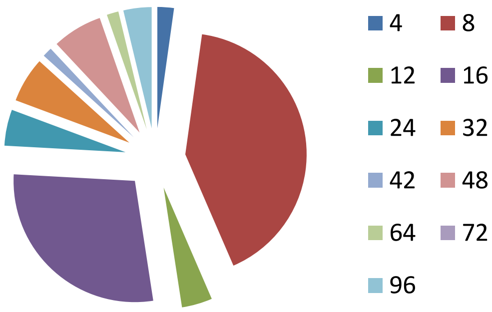

Fig. 2 Structure of capacitance of main

First three demands are crisp values which can be properly calculated. Unexpected demand depends on design error and additional requirements. Design error is linguistic variable. Terms {high, middle, low}.

Design error depends on project complexity. If project has big quantity of consumers for crossing xPON technology then it uses cables with different capacities and different length of the cable. The main design error is inaccurate length of the cable. If the length of the cable is smaller than in reality it led to rise in the cost of project (putting additional cable box) or increase period of construction (pull the cable with right length). If the length of the cable is bigger than in reality it led to rise in the cost of project (waste of the cable). Project author must realize project quickly as there a lot of consumers for crossing xPON technology.

Rule 1: If project quantity is big and time is limited then design error is high.

Rule 2: If project quantity is small and time is limited then design error is middle.

Rule 3: If project quantity is small and time is unlimited then design error is low.

Rule 4: If project quantity is big and time is unlimited then design error is middle.

TABLE I
DEPENDENCY MISTAKES QUANTITY ON PROJECT QUANTITY PER WEEK

Project quantity	2	4	6	10	12	14	16	18	20
Number mistakes	0	1	4	5	7	9	11	13	14

IV. TAKAGI SUGENO

The Sugeno fuzzy model (also known as the TSK fuzzy model) was proposed by Takagi, Sugeno, and Kang in an effort to develop a systematic approach to generate fuzzy rules from a given input-output data set.

Typical view rule of Takagi Sugeno model are

IF $(x_1=A_{11})$ and $(x_2=A_{21})$ and …$(x_p=A_{p1})$

Else $(x_1=A_{12})$ and $(x_2=A_{22})$ and …$(x_p=A_{p12})$

Else …

…

Then $(y=b_{i0}+b_{i1}x_1+\ldots+b_{ip}x_{pi})$,

where i – number of rule

V. SELF-TUNING OF PARAMETERS FUZZY MODEL

The best results can be achieved when structure of optimization model is combined with the optimization of its parameters.

Self-tuning algorithm:
1) Determination of the basic system model.
2) Tuning the basic model by measurement of input and output parameters.
3) Checking the accuracy of the basic model.
4) Error detection of the basic model.
5) Identifying maximum and minimum errors of the basic model.
6) Construction the model error.
7) Tuning the parameters of the membership functions of the model error.
8) Adding error model to the basic model.
9) Step three.

VI. Results

Using rules for self-tuning algorithm we receive results of error model which are presented in table 2. Average squared error is 0.052.

TABLE II
RESULTS OF ERROR MODEL

x1	10	13	15	10	15	17
x2	1	1	2	2	3	3
e0	0,32	0,1	-0,1	0,2	-0,23	-0,4
eM0	0,3	-0,041	-0,182	0,192	-0,41	-0,3
e1	0	0,141	0,082	0,008	0,18	-0,1

Neuro-fuzzy network, representing the model constructed on maximum error of the method is similar to the type of neural network RBF [8, 10].

VII. Conclusions

In this paper was shown approach creating fuzzy model for inventory management system under uncertainty. The main steps consist of description of the company on the outside and inside. Then using this knowledge you can develop decision support system with modern strategies of inventory control.

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Co-funded by the Tempus Programme of the European Union

This publication is the result of the project implementation:
TEMPUS CERES: Centers of Excellence for young RESearchers.
Reg.no.544137-TEMPUS-1-2013-1-SK-TEMPUS-JPHES

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