

Fuzzy Logic Analysis Based on Inventory Considering Demand and Stock Quantity on Hand

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Abstract

The approach is based on fuzzy logic analysis as it does not require the statement and solutions of complex problems of mathematical equations. Here consideration is inventory control problem solutions, for which demand values for the stock and it quantity-on-hand in store is proposed. Expert decisions are considered for developing the fuzzy models, and the approach is based on method of nonlinear dependencies identifications by fuzzy knowledge. The linguistic variables are considered for the membership functions. Simple IF-Then rules are used with expert advices.

Keywords:- Inventory control, Fuzzy logic, Membership Function, Defuzzification.

1. Introduction

The most important problem for the management is the minimization of the inventory storage cost in enterprises and trade stocks including raw materials, stuff, supplies, spare parts and products. The models of this theory are built according to the classical scheme of mathematical programming: goal function is storage cost; controllable variables are time moments needed to order (or distribute) corresponding quantity of the needed stocks. Construction of such models requires definite assumptions, for example, of orders flows, time distribution laws and others.

On the other hand, experienced managers very often make effective administrative decisions on the common sense and practical reasoning level. Therefore, the approach based on fuzzy logic can be considered as a good alternative to the classical inventory control models. This approach elaborated in works requires neither complex mathematical models construction no search of optimal solutions on the base of such models. It is based on simple comparison of the demand for the stock of the given brand at the actual time moment with the quantity of the stock available in the warehouse. Depending upon it inventory action is formed consisting in increasing or decreasing corresponding stocks and materials.

"Quality" of control fuzzy model strongly depends on "quality" of fuzzy rules and "quality" of membership functions describing fuzzy terms. The more successfully the fuzzy rules and membership functions are selected, the more adequate the control action will be.

However, no one can guarantee that the result of fuzzy logical inference will coincide with the correct (i.e. the most rational) control. Therefore, the problem of the adequate fuzzy rules and membership functions construction should be considered as the most actual one while developing control systems on fuzzy logic. In this article it is suggested to build the fuzzy model of stocks and materials control on the ground of the general method of nonlinear dependencies identification by means of fuzzy knowledge bases. The grounding for the expediency to use this fuzzy approach relative to inventory control is given in the first section of the article. The main principles of the identification method applied for modeling are brought forward. The inventory control model is constructed on the basis of fuzzy knowledge base. The problems of fuzzy model tuning and numerical example illustrating application of training data in tuning problem are described. Formulation of conclusions and directions for further research are defined in the final section.

2. Method of identification

The method of nonlinear objects identification by fuzzy knowledge bases serves as the theoretical basis for the definition of the dependency between control actions and the current state of the control system. Originally this method was suggested for medical diagnosis problems solution, and then it was spread on arbitrary "inputs – output" dependencies.

The method is based on the principle of fuzzy knowledge bases two-stage tuning. According to this principle the construction of the "inputs – output" object model can be performed in two stages, which, in analogy with classical methods, can be considered as stages of structural and parametrical identification. The first stage is traditional for fuzzy expert systems. Formation and rough tuning of the object model by knowledge base construction using available expert information is accomplished at this stage. However, as it was mentioned in the introduction, no one can guarantee the coincidence of the results of fuzzy logic inference and correct practical decisions. Therefore, the second stage is needed, at which fine tuning of the model is done by way of training it using experimental data. The essence of the fine tuning stage consists in finding such fuzzy IF-THEN rules weights and such fuzzy terms membership functions parameters which minimize the difference between desired (experimental) and model (theoretical) behavior of the object.

3. Fuzzy model of control

Let us present the inventory control system in the form of the object with two inputs ($x1(t)$, $x2(t)$) and single output ($y(t)$), where: $x1(t)$ is *demand*, i.e. the number of units of the stocks of the given brand, which is needed at time moment *t;* $x2(t)$ is *stock quantity-on-hand*, i.e. the number of units of the stocks of the given brand which is available in the warehouse at moment *t*; $y(t)$ – *inventory action* at moment *t*, consisting in increasing decreasing the stocks of the given brand.[5] System state parameters $x1(t)$, $x2(t)$ and inventory action $y(t)$ are considered as linguistic variables[1], which are estimated with the help of verbal terms on five and seven levels:

$x1(t)$ = Falling(F), Decreased(D), Steady(S), Increased(I) and Rise up(R)

x2 (t) = Minimal(M), Low(L), adequately sufficient (A), high (H) and excessive (*E*)

$y(t)$ = *T*o decrease the stock sharply (D1), To decrease the stock moderately (D2),

To decrease the stock poorly (D3), do nothing (D4), To increase the stock poorly (D5)

To increase the stock moderately (D6), To increase the stock sharply (D7)

Let us note that term "adequately sufficient" in variable x2(t) estimation depicts the rational quantity of the stock on the common sense level and does not pretend to the mathematically strong concept of optimality which envisages the presence of goal function, controllable variables and area of constraints. The Figure (1) is defined by expert way and depicts the complete sorting out of the $(5\times 5 = 25)$ terms combinations in the triplets $x1(t)$, $x2(t)$, $y(t)$. Grouping these triplets by inventory actions types, we shall form fuzzy knowledge base system in following figure (2).

This fuzzy knowledge base defines fuzzy model of the object in the form of the following rules:

IF demand is falling AND stock is excessive, OR demand is falling AND stock is high, OR demand is decreased AND stock is excessive, THEN it is necessary to decrease the stock sharply;

IF demand is falling AND stock is adequately sufficient, OR demand is decreased AND stock is high, OR demand is steady AND stock is excessive, THEN it is necessary to decrease the stock moderately;

IF demand is falling AND stock is low, OR demand is decreased AND stock is adequately sufficient, OR demand is steady AND stock is high, OR demand is increased AND stock is excessive, THEN it is necessary to decrease the stock poorly;

IF demand is falling AND stock is minimal, OR demand is decreased AND stock is low, OR demand is steady AND stock is adequately sufficient, OR demand is increased AND stock is high, OR demand is rising up AND stock is excessive, THEN do nothing;

IF demand is decreased AND stock is minimal, OR demand is steady AND stock is low, OR demand is increased AND stock is adequately sufficient, OR demand is rising up AND stock is high, THEN it is necessary to increase the stock poorly;

IF demand is steady AND stock is minimal, OR demand is increased AND stock is low, OR demand is rising up AND stock is adequately sufficient, THEN it is necessary to increase the stock moderately;
IF demand is increased AND stock is minimal, OR demand is rising up AND stock is minimal, OR demand is rising up AND stock is low, THEN it is necessary to increase the stock sharply.
By definition membership function μ *T* (*u*) characterizes the subjective measure (in range of [0,1]) of the expert confidence in crisp value *u* corresponding to a fuzzy term T**.**

4. Fuzzy membership functions

For simplification MATLAB is used as tool as consideration of Input membership function as Demand (x1(t)) and In stock Quantity on Hand(x2(t)) and output as (y(t)) for this various linguistic variables are taken into consideration and for that Gaussian bell shaped (Gaussian) membership functions, which parameters allow to change the form of the function, are the most widely practiced.
For Defuzzification i.e. to convert the linguistic value into the crisp output the Centroid method is used with Mamdani approach.

5. Results

The fuzzy logic approach to the above model give the most appropriate result in term of inventory as we can get the value for any input in the system to optimize the inventory mentioned in the Table no 9 which provide the rule viewer for inventory control as one value mentioned in the rule viewer is as input 1 is 41.5 and input 2 is 160 the output i.e inventory should be 0.38 for these values.

6. Conclusion

The approach to inventory control problems solution, which uses the available information about current demand values for the given brand of stock and it quantity-on-hand in store, is proposed. The approach is based on the method of nonlinear dependencies identification by fuzzy knowledge bases. It was shown that fuzzy model data sample allows approximating model control to the experienced expert decisions.
The advantage of the approach proposed consists in the fact that it does not require the statement and solution of the complex problems of mathematical programming. Expert IFTHEN rules are used instead which are formalized by fuzzy logic and tuned with the help of data.
Further development of this approach can be done in the direction of the adaptive (neuro fuzzy) inventory control models creation, which are tuned with the acquisition of new experimental data about successful decisions. Besides that with the help of supplementary fuzzy knowledge bases factors influencing the demand and quantity-on-hand values (seasonal prevalence, purchase and selling praises, delivery cost, plant-supplier power and others) can be taken into account.
The approach proposed can find application in the automated management systems of enterprises and trade firms. It can also be spread on the wide class of the optimal control problems in reliability and complex systems maintenance.

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Functional dependency

$$y(t) = f(x1(t), x2(t))$$

x2(t)

E	D1	D1	D2	D3	D4
H	D1	D2	D3	D4	D5
A	D2	D3	D4	D5	D6
L	D3	D4	D5	D6	D7
M	D4	D5	D6	D7	D7
	F	D	S	I	R

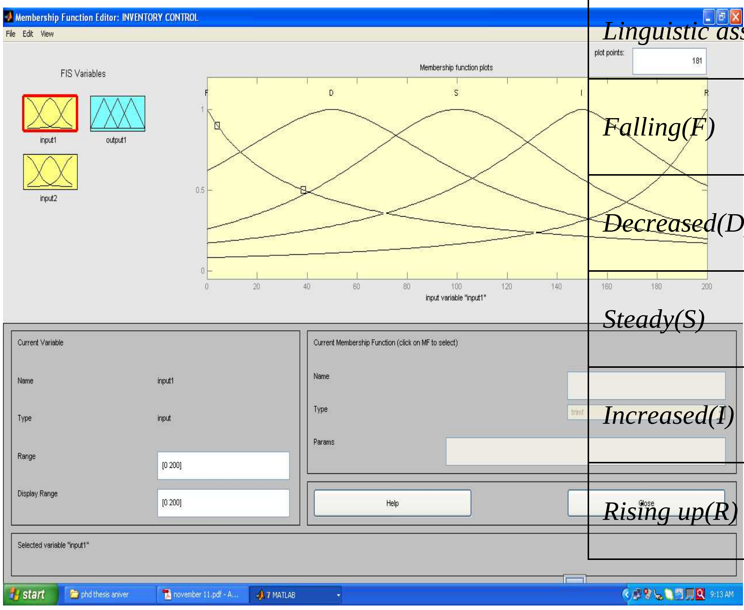
x 1(t)

Fig (1) Dependencies between parameters and inventory actions

IF		Then
Demand x1 (t)	*Stock quantity-on-hand x2(t)*	*Inventory action y(t)*
F F D	E H E	D1
F D S	A H E	D2
F *D* *S* *I*	*L* *A* *H* *E*	D3
F *D* *S* *I* *R*	*M* *L* *A* *H* *E*	D4
D *S* *I* *R*	*M* *L* *A* *H*	D5

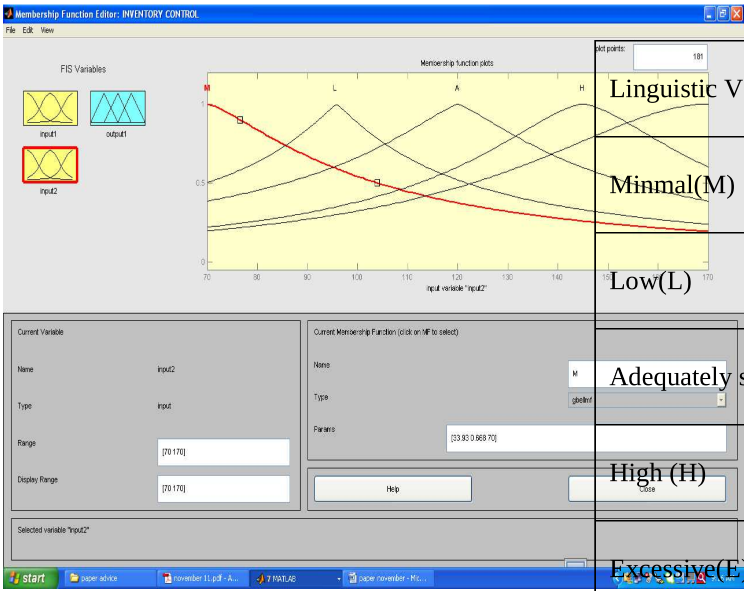
S *I* *R*	M L A	D6
I *R* *R*	*M* *M* *L*	D7

Figure (2) Grouping of Triplet as fuzzy Knowledge base system



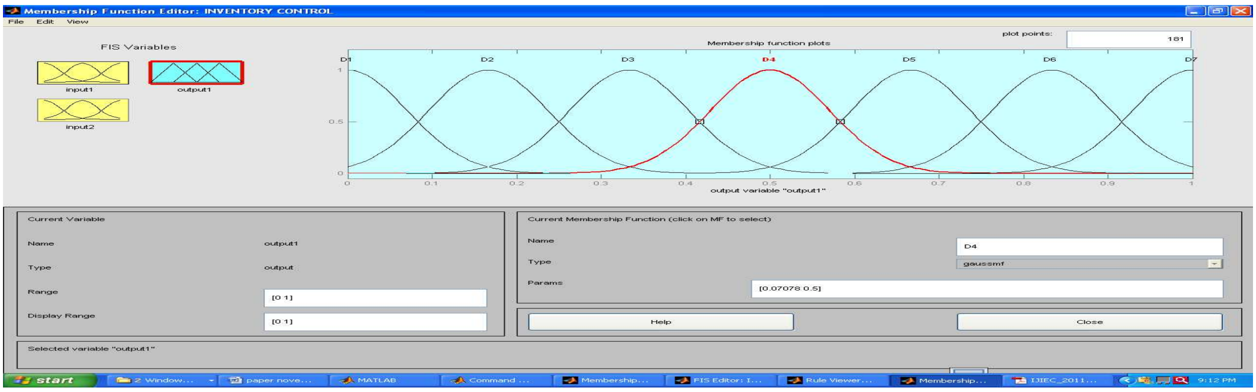
Linguistic assessment	*Parameter*
Falling(F)	*1.15*
Decreased(D)	*34.51*
Steady(S)	*105*
Increased(I)	*170.1*
Rising up(R)	*199.1*

Figure (3) Input membership function parameter of variable x1(t) Demand

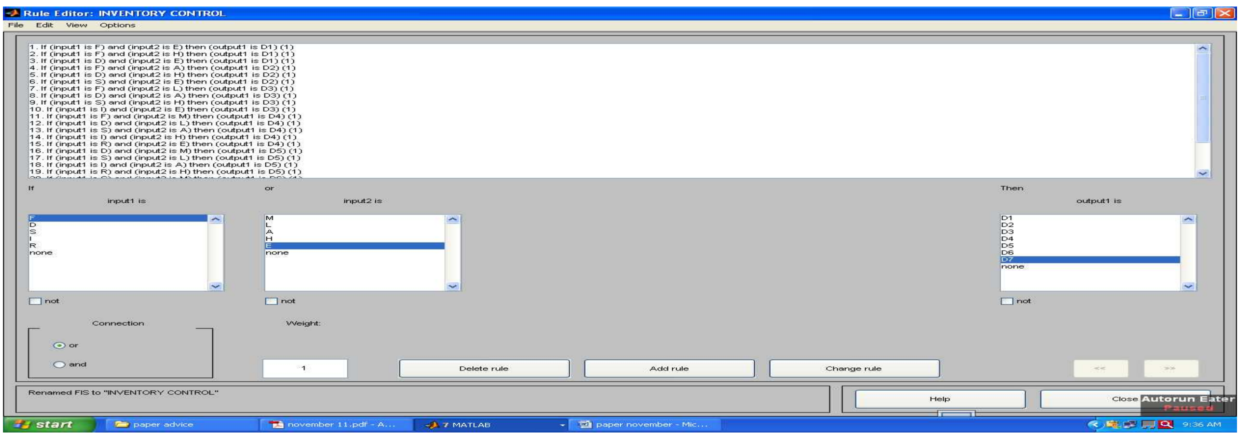


Linguistic Variable	Parameter
Minmal(M)	75.09
Low(L)	88.12
Adequately sufficient(A)	125
High (H)	157
Excessive(E)	168

Figure (4) Input Membership Functions for In stock quantity on hand



Figure(5) Output Membership Functions for Inventory Models



Figure(6) Rule base editor for inventory control

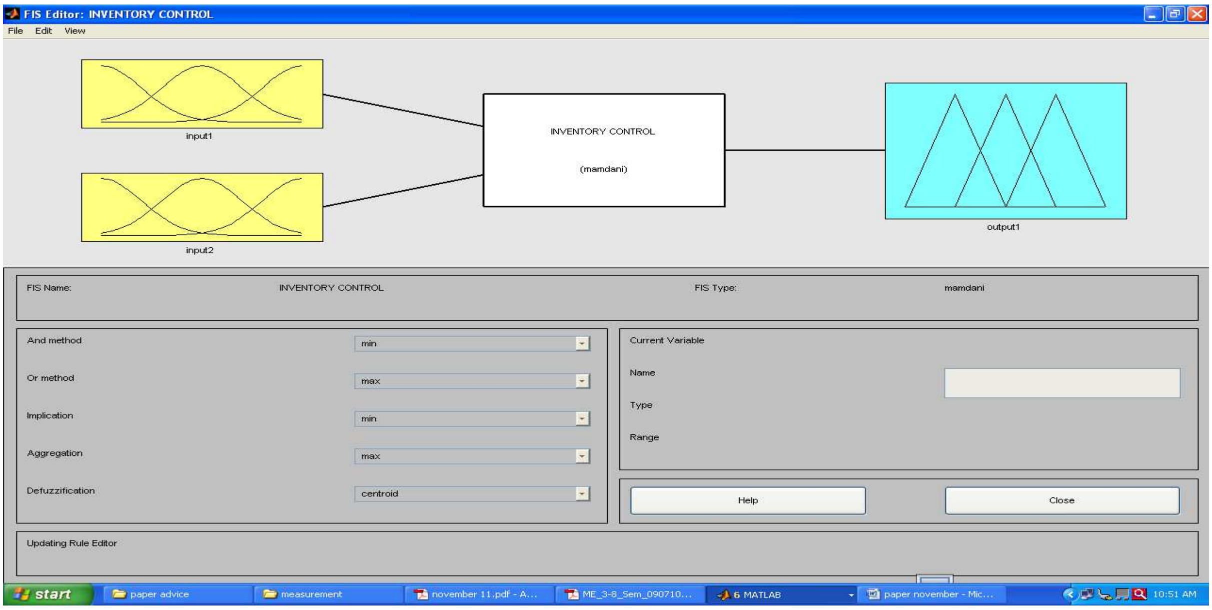


Figure (7) Defuzzfication Apporach

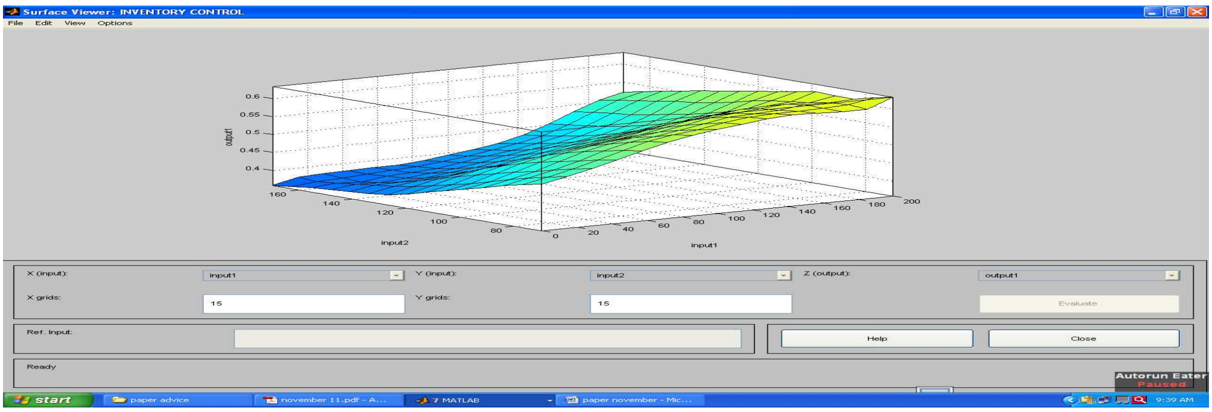


Figure (8) Surface Viewer for inventory control

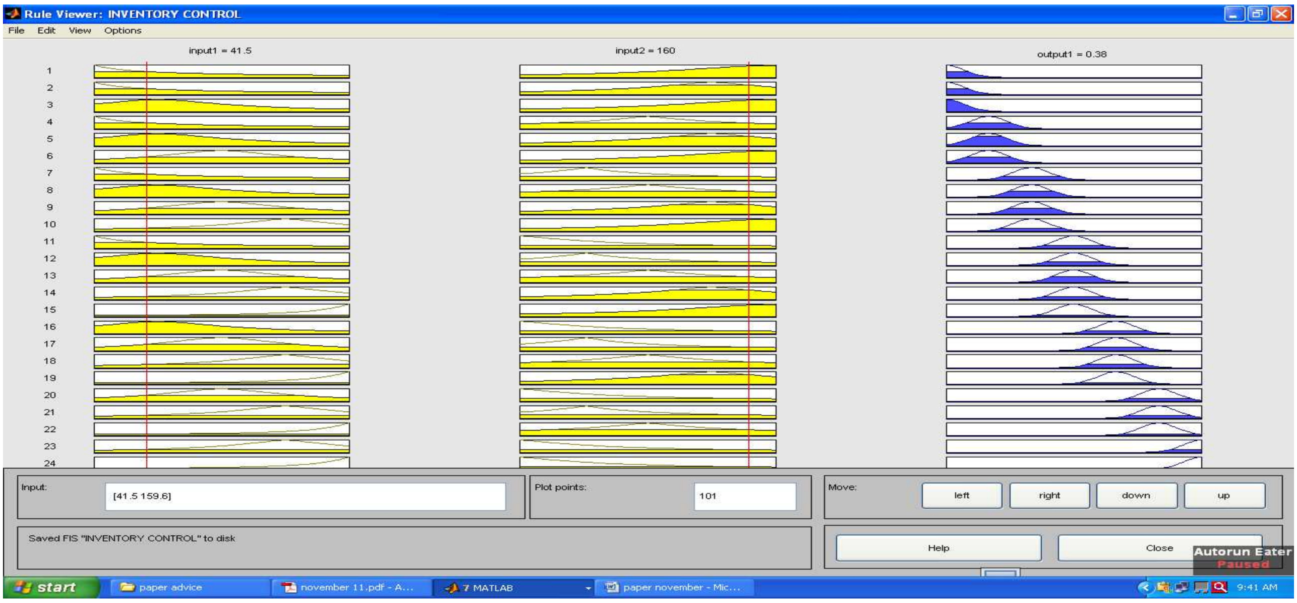


Figure (9) Rule Viewer for Inventory Control