IJFANS INTERNATIONAL JOURNAL OF FOOD AND NUTRITIONAL SCIENCES

ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11,S Iss 3, Dec 2022

Fuzzy Logic Model to Estimate the Success Rate of a Nutritional Supplement in a particular region

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Abstract To answer the questions like "is the supplement safe", "is the nutrient supplement is effective", etc. A simple way to find the answers is to assess the success rate of the particular product in that zone. The aim of this article is to develop a fuzzy logic model to analyze the success rate of a nutritional supplement in a particular region.

Keywords: Nutritional supplement, Fuzzy Inference System, Mamdani model

Introduction

Consciousness towards health and usage of health supplements in this fast moving generation is vital. Supplements for Vitamins and minerals are essential to fill the deficiency which one lacks in attaining from food directly. But there is a challenge for common man to identify the suitable supplements other than a doctor's suggestion, especially in the case of very common vitamin and minerals supplements.

In 2013, Joshua etal., proposed a fuzzy logic diet journaling system based on the premise that food intake with food recommendations from a user's perspective. In 2018, Sivamani etal, proposed a novel method in the decision support system for the nutritional management of livestock using the Bayesian model based on fuzzy rules, to determine the total digestible nutrient of the cow over the period of time to get the rate of probability, and the fuzzy rule is applied to determine the health status of the cow, to predict the nutritional intake in the livestock. In the same year, Johanna etal, summarized some of the challenges in supplement science and provided a case study of research at the Office of Dietary Supplements at the National Institutes of Health, USA, along with some resources available. In 2019, Regan etal., said that the use of dietary supplements is pervasive and can provide substantial amounts of micronutrients to those who use them. Estimated the usual intake to handle Supplement level. In 2021, George etal., introduced a novel framework titled *PIN* for Personalized Intelligent Nutrition based on the fuzzy logic paradigm to simulate human expert health assessment capabilities, including weight, caloric intake, and exercise recommendations as well as progress evaluation and recommendation adjustments. No much work is done for identifying the success rate frequency of usage of any nutrient supplement.

The authors have published different applications of fuzzy logic system. In this article, we designed a fuzzy controller system, in which the fuzzy model presents the success rate of a nutrient supplement based on the number of persons using it and the rate of change e in the number using the supplement.

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Materials and Methods

In this article, the author designed a Fuzzy control System by defining a set of Input variables, applied Mamdani Fuzzy Model to obtain the output. The Fuzzy Inference System involves the following steps: 1) Define the input, output variables, Linguistic Variables and their range, 2) Define the Input/output variables Membership Functions, 3) Construction of the fuzzy rule base, 4) Fuzzification, 5) Fuzzy Inference Engine, 6) Defuzzification.

Fuzzification, the process of decomposing a systems input and/or output variables into fuzzy sets mostly using a triangular or trapezoidal-shaped membership functions. The membership function of a Fuzzy set is associated with linguistic term. Using the rule base the, the inference engine combines the measurements of input variables with relevant fuzzy information rules and makes inferences regarding the output variable, as a Fuzzy set. Then by defuzzification, the fuzzy output obtained by inference engine, is converted to a single real number, the crisp output.

A Fuzzy Inference System (FIS) involves input and output membership functions, fuzzification, fuzzy inference engine, Fuzzy rule base and defuzzification, illustrated in Fig. 1:

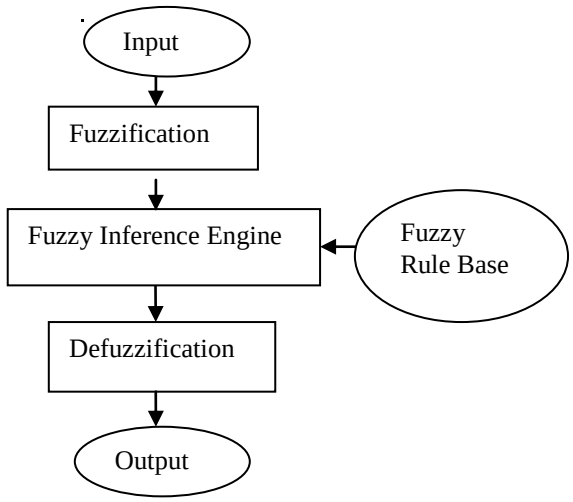

Fig.1: Fuzzy Inference System

To present the model with an example, we consider the input values are $x1 = 125$ and $x2 = -6$ using Mamdani model, as below:

Step1: Define the input, output variables, Linguistic Variables and their range:

Assume that the inputs to the system are x1 measuring the number of persons use the supplement S, and x2 is measuring the rate of change in the number of persons using the supplement S, . While the output variable which represents the control value CV to the success rate of a nutraceutical, S.

Consider the following assumption:

Assume that x1 can be Low (L), Medium (M), and High (H) and its range between 120 and 220, with three trapezoidal membership functions: D(110, 120, 130, 150), M(130, 150 190, 210), and D(190, 210, 220, 230). x2 ranges between -10 and +10 and is divided into Negative-Small(NS), Zero (ZE), and Positive-Small (PS), with three triangular membership functions: NS(-20, -10, 0), ZE(-10, 0, 10), and PS(0,10,20).

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The output CV ranges between 0 and 10 and is divided into Very small(VS),Small (S), Big(B), and Very-big (VB), with four membership functions: VS(-1,0, 2,4), S(2,4,6), B(4,6,8), and VB(6,8,10,12) for VS, S, B, and VB respectively.

Step-2: Define the Input/output variables Membership Functions:

The membership functions for all the input and output variables are defined as follows:

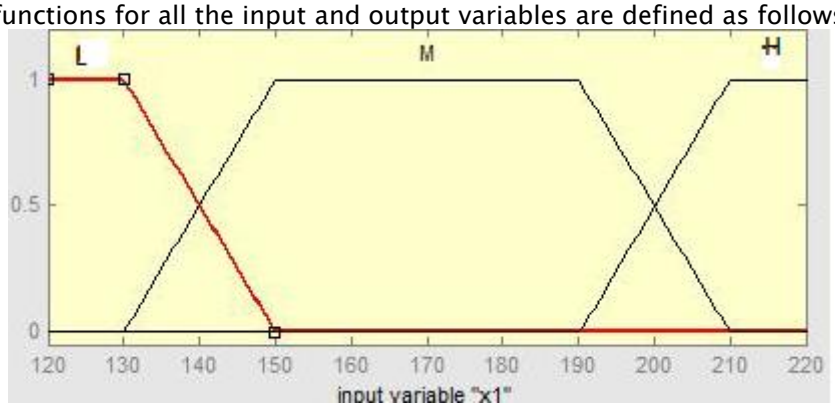

Fig.2: Membership functions for input variables X_1.

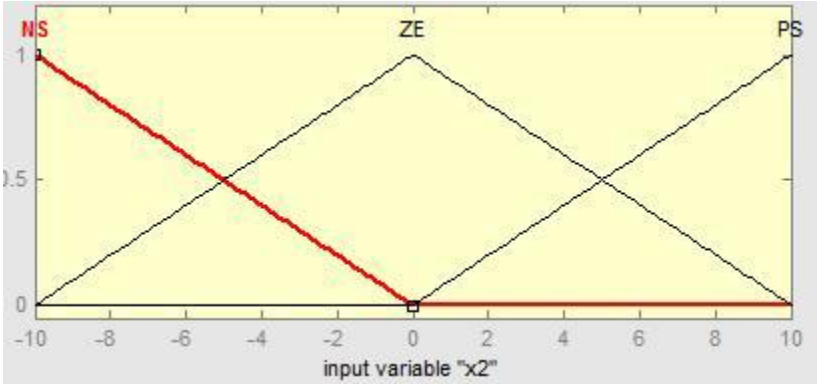

Fig.3: Membership functions for input variables X_2.

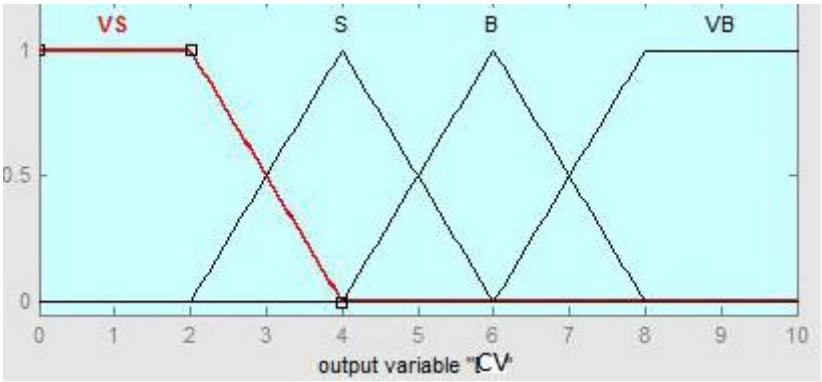

Fig.4: Membership functions for the output variable O.

Step-3: **Construction of Fuzzy Rule Base:**

Here we consider the following fuzzy rule base based on the linguistic variablesdefined for the input and output variables.

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X1 / X2	L	M	H
PS	B	S	VS
ZE	B	B	S
NS	VB	B	B

Step-4: Fuzzification:

Fuzzification, the process of decomposing a systems input variables into fuzzy sets. From the diagram we get for X1=125 then it is corresponding to membership function is Low (L).For X2= -6 then it is corresponding to the membership functions zero (ZE) and negatively small (NS).

Step 5: Fuzzy Inference Engine:

The fuzzy inference engine identifies the suitable rules from the Rule base for the fuzzy inputs. Therefore two rules will be fired:

IF X1 IS L AND X2 is ZE THEN CV is B

IF X1 IS L AND X2 is NS THEN CV is VB

For the first rule μ(X1) = 1 and μ(X2) = 0.4 thus, μ(CV) = 0.4 and for the second rule μ (X1) = 1 and μ (X2) = 0.6 thus, μ (CV) = 0.6

Now, the control value CV will be based on the rules fired as shown in fig 5.

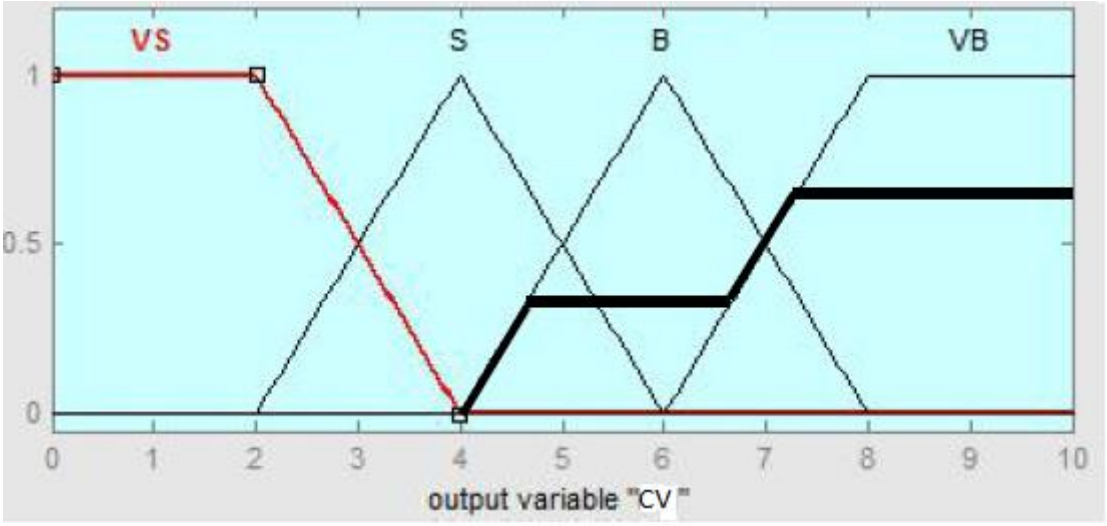

Fig.5: Fired Rules for output variable O.

Step 6: Defuzzification: The Fuzzy output obtained from the Mamdani Fuzzy Model is required to be converted to crisp output using the Defuzzification process by using Centroid Method. In Centroid method, the defuzzified value is defined as the value within the range of the output variable O for which the area under the graph of membership function obtained by truncating the fuzzy output. It is

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divided into sub-areas, Centroid method derives the output value as the centre of the area occupied by the Fuzzy set 'C' of the output variable O, given by

Area Segment No.	$\mu_A(x_i)$/Area (A)	x_i (Centroid)	$A_i x_i$
1	0.96	5.6	5.376
2	0.2	7	1.4
3	1.68	8.6	14.45
	Total Area = 2.84		$\sum A\bar{x}$ =21.226

By Centroid method, the defuzzified value

$$x^* = \frac{\sum A\bar{x}}{\sum A} = \frac{21.226}{2.84} = 7.47.$$

Therefore the control value for the success rate of a supplement S in a particular area is 7.47.

Results and Discussion

The model is explained thoroghly with the help of an example with the input variable as $X_1 = 125$, $X_2 = -6$, then membership functions that are characterizing the corresponding fuzzy sets of the input variables are Low(L), NS(Negatively Small) and ZE(Zero). The relevant rules are identified from the fuzzy rule base and the corresponding fuzzy output is obtained using Mamdani model. The defuzzified output using Centroid Method is eual to 7.47 on the 10 point scale implying a big (B) control value for a 70% success rate of the supplement S.

Conclusions

Nutrient supplements were essential in case of a pregnant women, elder people above 50 age, or people suffering from some chronic desease. We may not require a supplement if we are healthy adult and consume all variety of foods like vegetables, grains, legumes, dairy products, meat, fish, fruits and many more. But there is a drastic change in the eating habits of all the age groups leading to usage of food or nutrient supplements, either suggested by a doctor or expert. More commonly to take precaution, today many of us are using the supplements for a healthy life without recommmendation of a doctor or once suggested long years back. Without having a medical prescription we purchase some basic bnutrient supplements and here we can check for the success rate of a particular supplement and choose for ourself.

Acknowledgement

The authors acknowledge the support and encouragement provided by the management of Aditya institute of Technology and Management, Tekkali.

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