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APPLYING A FUZZY LOGIC APPROACH TO EFFECTIVELY DESIGN AND MANAGE THE SUPPLY CHAIN

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ABSTRACT

Fuzzy inference systems, In order to account for uncertainty and imprecision in decision making, models like the Mamdani and Sugeno models are widely utilised. MATLAB is a well-known programming environment that offers the required tools and techniques for individuals interested in creating and deploying fuzzy inference systems. Supply Chain Management is all about making sure customers are happy while also keeping costs low. This paper talks about using fuzzy if-else statements or Fuzzy inference rules to figure out how to make customers happy and save money in the supply chain process. The plan we came up with gives managers a better idea of how their decisions affect everyone involved in the supply chain - like suppliers, manufacturers, warehouses, transporters, retailers, and customers. We focus on how our agent buys parts using a mix of long and short-term planning, and how it sets prices based on what's happening in the market.

INTRODUCTION

Fuzzy inference systems are like super smart computers that are really good at dealing with things that are kind of uncertain or fuzzy. They help make sense of all the information and data out there in the world. These systems are a big deal in today's technology because they can handle all the tricky stuff that comes with trying to understand and predict things. FISs find applications in diverse domains, such as information fusion, pattern recognition (Ejewa and Ahemen 2023], prediction (Sharma, R.P. and Dharavath , 2023), decision-making (Ragab and Ashary,2023) and control systems . Their ability to handle uncertain and imprecise information makes them particularly useful in these areas, where the input data often contain noise, errors, or missing values. FISs can help to identify patterns in complex datasets, make accurate predictions based on historical data, and make informed decisions in uncertain and dynamic environments (Liu and Huang, 2023). Furthermore, FISs can be integrated into control systems to regulate the behavior of complex systems, such as robots, vehicles, or industrial processes. Additionally, FISs play a pivotal role in financial applications by predicting stock prices and analyzing market trends. In medical diagnosis systems, they assist doctors in interpreting medical test results and making informed treatment decisions (Yolcu 2023). In light of their critical role and widespread utilization, there is a compelling need to enhance the design of FISs for greater efficiency and sustainability.

Supply chain management (SCM) is like a big game of hot potato, where products get passed from one player to the next until they reach the final destination - the consumer. SCM is all about making sure everyone works together smoothly, from the supplier to the manufacturer to the wholesaler to the retailer. The goal is to make sure products are always available when needed, while also keeping inventory levels low. It's like a well-oiled machine that keeps things moving efficiently.

A fuzzy inference system (FIS) is a sort of man-made reasoning innovation that utilizes fuzzy mental stability to talk over with another information. Because it can deal with uncertainty and erroneousness, fuzzy logic is a good analytical foundation for handling difficult questions about the real world. In a Fuzzy surmising framework, the information factors are portrayed as Fuzzy sets, that are depicted by participation works that assign a place of enlistment for each worth in the set. The rules that define how the recommendation variables influence the gain variables are represented using fuzzy sanity, and the crop variables are also depicted as fuzzy sets. The course of determination in a fuzzy surmising framework incorporates three primary advances: rule judgment, defuzzification, and fuzzification. Fuzzification changes over the new proposal values into Fuzzy sets using the cooperation capabilities. Rule judgment determines the degree of participation of the output variables by applying the fuzzy rules to the fuzzy inputs. Finally, defuzzification reverts the fuzzy production sets to new decision-

making principles. Fuzzy conclusion orders are frequently utilized in control techniques, where they can be used to model and control complex orders with ambiguous or changing dossier. They are more utilized in dossier thinking and example affirmation utilizes, place they can assist with recognizing complex companionships in bountiful dossier sets. Fuzzy end framework (FIS) is the method involved with arranging the arrangement from a logical proposal to a result using Fuzzy reasoning controllers and Fuzzy principles. Before, the plan provides a foundation from which one can draw inferences or identify a pattern. FIS is individual of extreme unbelievable purposes of Fuzzy sense and Fuzzy set conviction. In Fuzzy set hypothesis, a changing that enjoys a benefit is named semantic variable. The system is primarily distinguished by fuzzy philosophy manipulators of "or" and "and," enrolment functions of recommendation and crop semantic variables, and if-therefore rules. The types of fuzzy sets used to delineate recommendation variables and, furthermore, the configuration of fuzzy rules determine the optimality of the quantity variables. The substance of FIS is laid out their bifold personality of suggestion and benefit factors that they are clever to deal with phonetic thoughts. In light of this substance, FIS have upgrade whole approximates that ready to act non-undeviating weighing center from two focuses data sources and results. The Mamdani-type and the Sugeno-type FIS have been developed using these two FIS strengths. The principal parts of administration are fuzzification interface, derivation engine and Defuzzification.

Samavat 2023 et al. In order to introduce the ideal regulator for enhancing the output of a planetary group by utilising the two types and learning about their qualifications, the two classes for Mamdani and Sugeno are surveyed. Also considered is what the capacity for information enrolment entails for the regulator's suitability. Along these lines, each fuzzy system model is provided one of two optional information involvement capabilities. It is crucial to note that fuzzy system, a subset of man-made reasoning, was created by inherited calculations due to a human desire to automate certain jobs. On a planetary group, four distinct fuzzy system have thus been created and put to use. The discoveries were evaluated and grouped in MATLAB Simulink.

Sonia 2023 et al. uses a multi-layer neural network no-property method to create a novel system for classifying the three forms of diabetes mellitus. The two primary information system phases that the algorithm uses are the development phase and the testing phase. Type 1 diabetes comes first in each period, followed by normal and type 2 diabetes, and healthy pregnant women with diabetes come last. A multi-layer neural network is then trained separately using the pertinent traits that were chosen throughout the attribute selection procedure. The architecture of the multi-layer neural network improves classification performance. A confusion matrix is developed following an experiment to evaluate the sensitivity, specificity, and accuracy of diabetes diagnosis. Maximum specificity and sensitivity values of 0.95 and 0.97 were attained.

Sangeetha Devi, 2022. et al. put forward a new A Several fuzzy graph operations, including cycle, union, join, and products, are used to find the Sugeno-Type Fuzzy Graph of Groups. A figure that is representative depending on those vertices in all paths with those vertices as their starts and ends is the minimal number of shared edges chosen by those vertices in the formations that comprise all paths with those vertices as their starts and ends to compare with other paths. The Sugeno dominating path-colouring number, which exists in all sets of shared edges, allows for a range of methods because it exists in all sets of shared edges. With the aid of these new discoveries, several newly created chromatic number graphs are studied.

Kotiyal 2022 et al. Given that a substantial section of the population is affected, big data is relevant to this problem. Deep Learning can solve the issues that Big Data faces, notwithstanding these issues. Big data and deep learning are consequently particularly interesting to academics. In this study, we attempted to employ effective preprocessing and Deep Learning approaches to achieve binary classification of diabetic retinopathy. The experiment makes use of an Indian-sourced Kaggle dataset. The peculiarity of the research is that three models—InceptionV3, Xception, and VGG19—and the performance of the Logistic Regression classifier are contrasted on the Spark platform. The models' precision is compared as a comparison metric. The trial's results show that InceptionV3 is 95% accurate, Xception is 92.50% accurate, and VGG19 is 89.94% accurate. InceptionV3 outperforms the other two models as a result.

Srivastava 2022 et al. focuses on categorising the common kinds of arrhythmia in Southeast Asian populations. It has been carefully examined how medical information is applied in practise to enhance professional arrhythmia diagnosis. This system is tested to evaluate how well the inputs and outputs match using a satisfied factor.

2. BACKGROUND AND PRELIMINARIES

2.1. Supply Chain Management

Supply chain management is like a big puzzle that companies use to make sure they can get their products to customers in the best way possible. It's not just about making the product, but also about getting it to the store or to your doorstep. Companies that are really good at this are finding that they can beat their competition. The Supply Chain Management Program is a way for companies to learn how to do this puzzle well. It covers everything from making the product to getting it to the customer. When a company is good at supply chain management, it means they can make sure everything runs smoothly and all the different parts work together perfectly.

This program also teaches companies how to work with all the different people involved in getting the product to customers. This includes not just the people in the company, but also the suppliers, delivery companies, and even the computer systems that help keep everything organized.

So, in simple terms, supply chain management is all about making sure products are made and delivered in the right amounts, to the right places, and at the right times. This helps companies save money and make sure customers are happy.

2.2. Fuzzy Set Theory

Fuzzy logic is a derivative from classical Boolean logic and implements soft .linguistic variables on a continuous range of truth values to be defined between conventional binary. It can often be considered a suspect of conventional set theory. Since fuzzy logic handles approximate information in a systematic way, it is ideal for controlling non-linear systems and for modeling complex systems where an inexact model exists or systems where ambiguity or vagueness is common.

A typical fuzzy system consists of a rule base, membership functions and an inference procedure (Timothy J.Rose 1997]. Fuzzy logic is a super set of conventional Boolean logic that has been extended to handle the concept of partial truth-truth-values between “completely true” and “completely false”.

Fuzzy sets are an extension of the classical notion of a set, where each element has a degree of membership, enhancing its capability to handle uncertainty (Wang, Xiao,2022).

Definition 1. Let X be the universe of discourse. Then, a fuzzy set A on X is characterized by membership function $\mu A : X \rightarrow [0, 1]$.

Definition 2. Let A and B be two fuzzy sets defined on set X. The standard form of the set operations intersection and union calculate the membership of each $x \in X$ by Equations (1) and (2), respectively.

$$\mu A \cap B(x) = \min\{\mu A(x), \mu B(x)\}. \quad (1)$$

$$\mu A \cup B(x) = \max\{\mu A(x), \mu B(x)\}. \quad (2)$$

2.3. Structure of Fuzzy Rules

Examine fever on the basis of body temperature: Conventional model:–

If temperature>X,take paracetamol else, stop taking paracetamol

Fuzzy System:-

if temperature = hot, take paracetamol of high mg if temperature=warm, take paracetamol of low mg if temperature = normal, stop taking paracetamol

In fuzzy rules, the linguistic variable temperature also has the range (the universe of discourse)between 99and105, but this range includes fuzzy sets, such a shot, warm and normal.The universe of discourse of the linguistic variable take paracetamol can be between150and 500mgand may include such fuzzy sets as high, low and stop.

A fuzzy rule can be defined as a conditional statement in the form:

IF x is A

THEN y is B

Where x and y are linguistic variables; and A and B are linguistic values determined by fuzzy sets on the universe of discourses X and Y, respectively.

2.4. Fuzzy Inference System (FIS)

A FIS as a smart computer program that uses fuzzy logic to make decisions. It has three main parts: fuzzification, inference, and defuzzification.

Fuzzification is like translating regular numbers into fuzzy numbers that represent different possibilities. Inference is when the program uses rules to figure out what to do based on the fuzzy numbers. It's like following a recipe with "if this, then that" instructions. The program can combine different rules using max-min or max-product methods.

Defuzzification is the final step where the program turns the fuzzy answers into clear, numerical values. These values are then used to control a system, like adjusting the temperature in a room. There are different ways to do this, such as finding the center of the fuzzy values, using the highest or average values, or weighing the values to find an average.

3. PROPOSED MODEL

we're talking about a super cool water purifier that uses fancy technology called RO. In our plan, we have a special person called the customer agent who handles all the requests from customers who want this water purifier. When a customer asks for a certain amount of water purifiers to be delivered on a specific day, the customer agent is the one who takes care of it. Another important part of our plan is the component agent, who works with suppliers to make sure we always have enough parts to make the water purifiers. This way, we can keep up with the demand from customers who want to buy our awesome water purifiers.

3.1. Selecting Customer Request

We know that Water Purifier with RO is used for removing hardness from water. So the main task of Customer agent to find the areas where people are drinking hard water. As usual the demand for Water Purifier with RO in those areas will be more. If the demand is high then Customer agent may sell the product with high margin of profit and may increase the agent commission also. Customer agent commission depends on delivery date and hardness of water in the demanding areas.

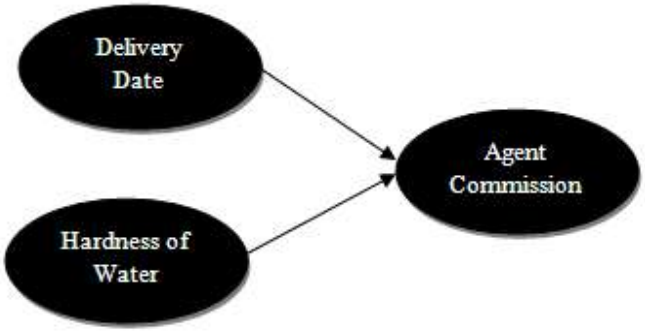

Fig 1: Agent Commission depends on Delivery Date and Hardness of Water

3.2 Measure Water Hardness - How is Water Hardness Measured?

Water hardness is measured in "grains" per gallon, in milligrams of calcium (Ca) per liter, or parts per million, and German Degrees of Hardness (dH) [which we drop here as this is for fish tanks]. we can take a water sample to a water test lab to have its hardness measures.

We can convert among water hardness measures. Water with hardness of 25 ppm = 25 mg. of hardness-causing minerals per liter of water.

Degrees of Water Hardness	
Soft water	0-17.1 mg/L of minerals
Slightly hard water	16.1-60 mg/L of minerals
Moderately hard water	61-120 mg/L of minerals
Hard water	121-180 mg/L of minerals
Very hard water	more than 180 mg/L of minerals

Table 1: Degrees of Water Hardness (Wikipedia, 2023)

3.3 Methodology

We are applying the Fuzzy logic if-else algorithm using the following rules and simulated it using available data. Here we define fuzzy rules and then revisited the rules for our goal. Here we can define the membership function which can calculate the degree of hardness of water, then another membership function which can calculate the delivery date then on the basis of linguistic variables we can decide the agent commission. According to Table. 1. we assume the degree of hardness as given below

0.0 if the hardness of water is between (0 -17.1mg/L) of minerals (soft water)

0.25 if the hardness of water is between (16.1 – 60mg/L) of minerals (slightly hard water)

0.50 if the hardness of water is between (61-120 mg/L) of minerals (moderate hard water)

0.75 if the hardness of water is between (121-180 mg/L) of minerals (hard water)

1.0 if hardness >180 mg/L of minerals (very hard water)

Now we can decide the degree of delivery

0.0 if RO installed after seven days of request

0.20 if RO installed after six days of request

0.40 if RO installed after five days of request

0.50 if RO installed after four days of request

0.65 if RO installed after three days of request

0.75 if RO installed after two days of request

delivery > 0.85 if RO installed on the day of request.

Linguistics variables used in the rules

Hardness	Degree of Hardness	Degree of Delivery	Agent Commission	
200	1.0	1.0	A1	1.0
130	0.75	0.20	A2	0.75
67	0.50	0.60	A3	0.60
500	1.0	0.70	A4	1.0
700	1.0	0.80	A5	1.0

Table 2: Agent Commission on the basis of degree of membership

3.4 Fuzzy Intersection Operation

The membership function of the Intersection of two fuzzy sets A and B with membership functions μA and μB respectively is defined as the minimum of the two individual membership functions. This is called the minimum criterion.

$\mu A \cap B = \min(\mu A, \mu B)$.

3.5 Fuzzy Rules for Customer Agent Commission

So according to Rules given below, we can decide the agent commission on the basis of degree of hardness and delivery date.

Rule1: If the hardness of water is very high and Customer agent installing the Water Purifier with RO on the request date then the agent commission is very high.

Rule2: If the water is soft and Customer agent installing the Water Purifier with RO after seven days of request then the agent commission is very low

3.6 Data Analysis and Discussion

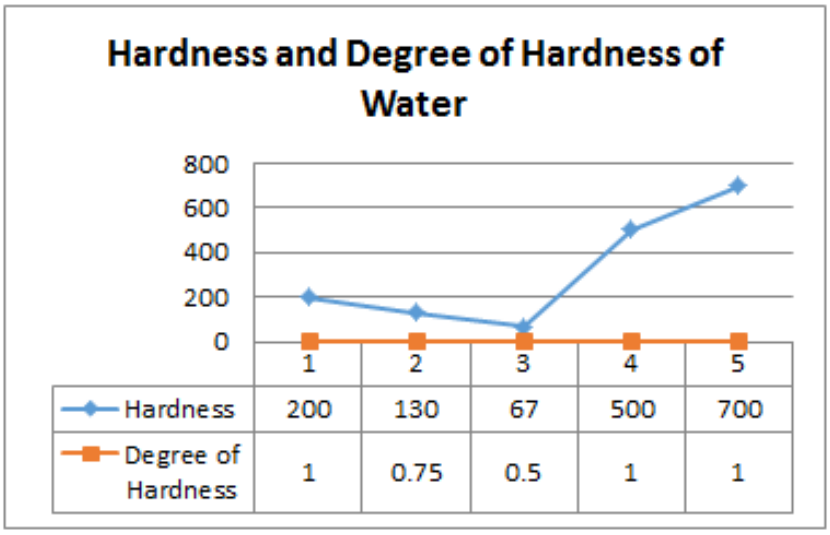

Fig 2: Degree of Hardness

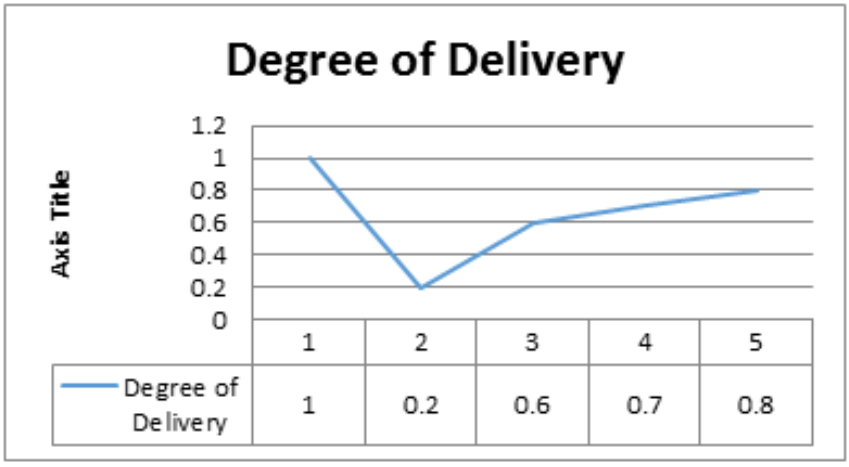

Fig 3: Degree of Delivery

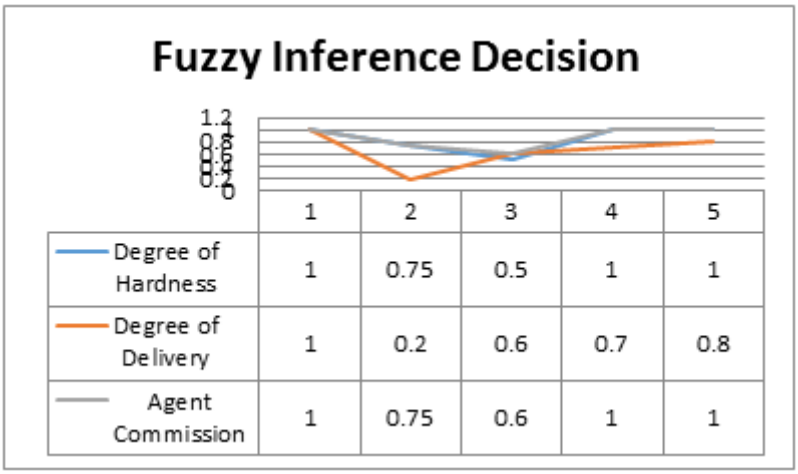

Fig 4: Fuzzy Inference Decision

The aim of this research is to analyze the supply chain management on the basis of Customer Agent performance, the sale of water purifier with RO is depends on the Hardness of water and delivery time, as the sale of water purifier with RO increased the profit of manufacturer, suppliers, distributors and most important the agent commission also increased. Fig 2, Fig 3 and Fig 4 are justifying above thought.

4. SIMULATED RESULTS

Hardness	Delivery Date	Agent Commission	
Soft water	After seven Days	A1	Very low
Slightly hard water	After five days	A2	Low
Moderately hard water	After three days	A3	High
Very Hard Water	Same Day	A4	Very high

Table 3: Simulated Result

Fuzzy linguistic terms also showing the same result, as the result coming from crisp data. We are getting the crisp data in terms of degree after the fuzzification of crisp data. Then using the fuzzy if- else algorithm, it is giving the same results.

5. CONCLUSION

This paper, intended to use fuzzy logic in decision making for the supply chain management. Here we focused on agent commission in supply chain management. For achieving it we have used the fuzzy approach. In the proposed scheme, customer agent commission depends on the harness of water and delivery timings.

REFERENCES

[1] Ejegwa, P.A.; Ahemen, S. Enhanced intuitionistic fuzzy similarity operators with applications in emergency management andpattern recognition. Granul. Comput. 2023, 8, 361–372.

[2] Sharma, R.P.; Dharavath, R.; Edla, D.R. IoFT-FIS: Internet of farm things based prediction for crop pest infestation using optimizedfuzzy inference system. Internet Things 2023, 21, 100658.

[3] Ragab, M.; Ashary, E.B.; Aljedaibi, W.H.; Alzahrani, I.R.; Kumar, A.; Gupta, D.; Mansour, R.F. A novel metaheuristics with adaptive neuro-fuzzy inference system for decision making on autonomous unmanned aerial vehicle systems. ISA Trans. 2023,132, 16–23.

[4] Liu, S.; Huang, S.; Xu, X.; Lloret, J.; Muhammad, K. Efficient Visual Tracking Based on Fuzzy Inference for Intelligent Transportation Systems. IEEE Trans. Intell. Transp. Syst. 2023, 24, 15795–15806.

[5] Yolcu, O.C.; Yolcu, U. A novel intuitionistic fuzzy time series prediction model with cascaded structure for financial time series. Expert Syst. Appl. 2023, 215, 119336

[6] Wang, Z.; Xiao, F.; Cao, Z. Uncertainty measurements for Pythagorean fuzzy set and their applications in multiple-criteriadecision making. Soft Comput. 2022, 26, 9937–9952.

[7] Timothy J.Rose, "FUZZY LOGIC WITH ENGINEERINGAPPLICATIONS,Mc–Graw Hill.Inc,Newyork,1997.

[8] Samavat*et al.*, "Research Article A Comparative Analysis of the Mamdani and Sugeno Fuzzy Inference Systems for MPPT of an Islanded PV System," vol. 2023, 2023.

[9] J. J. Sonia, P. Jayachandran, A. Q. Md, S. Mohan, A. K. Sivaraman, and K. F. Tee, "Machine-Learning-Based Diabetes Mellitus Risk Prediction Using Multi-Layer Neural Network No-Prop Algorithm," *Diagnostics*, vol. 13, no. 4, pp. 1–16, 2023, doi: 10.3390/diagnostics13040723.

[10] A. Sangeetha Devi, "An Extensive Study on Graph Colourings and Dominator Chromatic Number of Sugeno-Type Fuzzy Graphs," *Math. Probl. Eng.*, vol. 2022, 2022, doi: 10.1155/2022/3135201.

[11] Bk. Otiyal and H. Pathak, "Diabetic Retinopathy Binary Image Classification Using Pyspark," *Int. J. Math. Eng. Manag. Sci.*, vol. 7, no. 5, pp. 624–642, 2022, doi: 10.33889/IJMEMS.2022.7.5.041.

[12] P. Srivastava, N. Sharma, and C. S. Aparna, "Fuzzy Soft System and Arrhythmia Classification," *Chinese J. Math.*, vol. 2014, pp. 1–12, 2014, doi: 10.1155/2014/164781.