Application of Fuzzy Mathematics in Predicting Rainfall

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Abstract

Fuzzy Logic is a multiple valued logic, from which the truth values of variables might be any real numbers between 0 and 1. It has wide application in different fields of real life. We might face different challenges in our daily life to deal with vagueness and uncertianity. There are various criteria in the literature for decision-making under uncertainty in a crisp environment. In this paper, we address the relation between temperature, humidity and rainfall with the help of Mamdani fuzzy inference system.

Introduction

Traditionally, mathematics was limited in only two conclusion and they are true and false denoted by 1 and 0 respectively. According to traditional view, science should strive for certainty in all manifestation and uncertainty is regarded as unscientific (Zadeh, 1965). In real life, we encounter many situations in which the inclusion and non-inclusion asset are not really defined. To deal such problem, Prof. Lofti Zadeh introduced fuzzy logic and fuzzy set theory. Fuzzy logic deals with such problems having no clear answer with vague and unfocused information. Thus, fuzzy logic is method of reasoning that resembles human reasoning. Fuzzy set theory is aboard view of classical set theory. Specially, fuzzy logic may be viewed as an attempt at formation of two remarkable capabilities. First the capability to converse the reason and make rational decision in an environment of vagueness, uncertainty, incompleteness of information, conflicting information, partiality of truth and partiality of possibility. Second, the capability to perform a wide variety of physical and mental task without any measurement and any computation (Zadeh, 2008).

An outstanding contribution and plenty of works have been done in the field of fuzzy set and fuzzy logic in the last 50+ years. Several researchers have worked on fuzzy set and fuzzy logic with their application to real field. In the field of economic, medical, engineering, agriculture and much more, fuzzy logic is widely used. A model for evaluating the level of economic development of countries and region using fuzzy logic (Stojić, 2012). In 2013, Sami proposed a comprehensive index to measure sustainability in agriculture production system (Sami *et al.,* 2013). In 2015, how the method of fuzzy logic has been effectively used to solve a myriad of problems in the field of agricultural sciences (Philomine *et al.,* 2015). They proposed a framework build an expert system for managing crop crisis and exemplify proposed framework by taking an example of crop disease diagnostics (Prateek *et al.,* 2018). In 2019, they referred the way of organizing a group of agro-system (Rodríguez *et al.,* 2019). In 2022, they have used fuzzy max-min composition to address the difficulties in selecting the best candidate from the group of people in the same environment (Paudel *et al.,* 2022).

The objective of this study was to deal with the following problems:

- To study fundamental concept of fuzzy metric space and its application
- To study the application of fuzzy in weather forecasting.
- To apply fuzzy logic in making relation between humidity, temperature and precipitation or rainfall with the help of fuzzy inference.

Preliminaries and Definitions

Fuzzy Set and Membership Function

Let X be the universe of discourse and $A \subseteq X$. A fuzzy Set $\boldsymbol{A}$ in X is defined as the collection of ordered pair $(x, \mu_A(x))$ where $\mu_A : X \to [0,1]$ and $x \in X$. Here $\mu_A(x)$ is called the degree of membership of x. If $\mu_A(x) = 1$, we say x is fully include in A, and if $\mu_A(x) = 0$, we say that x is not include in **A**.
The membership function of **A** on X is defined as $\mu_A : X \to [0,1]$, where each element of X is mapped to a value between 0 and 1. This value is called a degree of membership of the element in X to fuzzy set.

Support of a Fuzzy Set

The support of fuzzy set A is defined as the set of all points in X having a membership value greater than 0. It is denoted by $S(A)$.

Symbolically,

$$S(A) = \{ x \in X : \mu_{\boldsymbol{A}}(x) > 0\}.$$

Convex Set

A fuzzy set A on X is **convex** if $\forall x_1, x_2 \in A$ and $\lambda \in [0,1]$

$$\mu_A(\lambda x_1 + (1 - \lambda)x_2) \geq minimum\,[\mu_A(x_1), \mu_A(x_2)]$$

Definition (Linguistic Variable)

Linguistic variables are variables that are qualitatively and quantitatively described by a fuzzy set. The input or output variables of the system whose values are in words instead of numerical values. A linguistic variable is generally decomposed into a set of linguistic terms.

Definition (Fuzzy Logic)

Fuzzy logic is defined as many valued logics from which may have a truth values variable in any real number between 0 and 1. Fuzzy logic provide a methodology for dealing with linguistic variable and describing modifiers like vary, fair, not etc. It facilitates common sense reasoning with imprecise and vague proposition dealing with natural language and serve as a basis for decision analysis and control action. Fuzzy Logic is an approach of computing based on degree of truth rather than the usual 'True or False (1 or 0).

Definition (Fuzzy Number)
A fuzzy set A is fuzzy number if the following conditions are satisfied

- A is a convex set.
  i.e. for all $x_1, x_2 \in A, \mu_A(\lambda x_1 + (1-\lambda)x_2) \geq \text{minimum}[\mu_A(x_1), \mu_A(x_2)]$
- A is a normalized set
  i.e. $\exists x \in A: \mu A(x) = 1$ or the height of the fuzzy set is 1.
- Its membership function is piece-wise continuous.

Definition (Triangular Fuzzy Number)
Let a, b, c be three real numbers with $a < b < c$. Then the triangular fuzzy number $A = (a, b, c)$ is a fuzzy number with the membership function $\mu_A(x)$ defined by

$$\mu_A(x) = \begin{cases} \dfrac{x-a}{b-a} & if\ x \in [a,b] \\ \dfrac{c-x}{c-b} & if\ x \in [\,b,c] \\ 0 & if\ \ a > x, \quad or\ x > c \end{cases}$$

We note that, in the above definition, we have $\mu_A(x) = 1$, while b need not to be mid-point of a and c.

Definition (Trapezoidal Fuzzy Number)
Let a, b, c and d be real numbers with $a < b < c < d$. Then a fuzzy number of the form $A = (a, b, c, d\,)$ is a trapezoidal fuzzy number with the membership function defined by,

$$\mu_A(x) = \begin{cases} 0 & if\ \ x \leq a \\ \dfrac{x-a}{b-a} & if\ a \leq x \leq b \\ 1 & if\ b \leq x \leq c \\ \dfrac{d-x}{d-c} & if\ c \leq x \leq d \\ 0 & if\ \ x > d \end{cases}$$

Definition (Fuzzification)
Fuzzification is the process of assigning numerical in- put to fuzzy sets with varying degrees of membership, ranging from 0 to 1. This concept is fundamental in fuzzy logic, as it allows for the representation of ambiguity and uncertainty in real-world scenarios. Fuzzy logic provides a flexible and expressive framework for decision-making, allowing for more flexible thinking when precise limits are not relevant or difficult to establish.

Definition (Defuzzification)
Defuzzification is a process using crisp logic to obtain quantitative answers for fuzzy sets and matching membership degrees. Fuzzy logic systems use fuzzy sets and linguistic variables to

handle imprecise or uncertain data. Defuzzification applies fuzzy logic rules to fuzzy input values, producing fuzzy output values. The best approach depends on the application and desired behavior of the fuzzy logic system.

Definition (Fuzzy Inference)

Fuzzy inference mechanism is the main module of a fuzzy logic system that performs decision-making. It utilizes the ”If...Then” rule together with the connector ”AND” or ”OR” for forming necessary decision rules. The output of this module is always a fuzzy set while the input may be a fuzzy or crisp set.

In this work we studied the relationship between temperature, humidity and precipitation with the help of Mamdani fuzzy model was shown.

Mamdani Fuzzy Inference System

Mamdani Fuzzy Inference System (FIS) is one of the most widely used fuzzy logic systems for implementing fuzzy rules. It was introduced by Ibrahim Mamdani in 1975 and is known for its simplicity and definition. Here is an overview of the Mamdani FIS. At that time, this model was used to control steam engines and assembly boilers using language codes derived from the professional community.

The procedure of Mamdani Fuzzy Inference System

Fuzzification: This stage transforms crisp inputs into fuzzy sets using membership functions. The membership function defines how each point in the input space maps from 0 to 1 to a membership value.

Rule Base: The system contains a set of fuzzy rules. Each rule is of the form: IF X is A AND Y is B THEN Z is C.

Here A, B, C are linguistic variables, and X, Y, Z are linguistic values represented by fuzzy sets.

Inference: This step combines the fuzzy rules to produce a fuzzy output. The most common inference method used in Mamdani systems is the min-max method:

Min Operation (AND): The true number of a complex is the minimum true number for its parts.

Maximum operation (OR): The true number of a complex is the maximum true number for its parts.

The fuzzy output of each rule is then aggregated (typically using the max operation) to form a single fuzzy set.

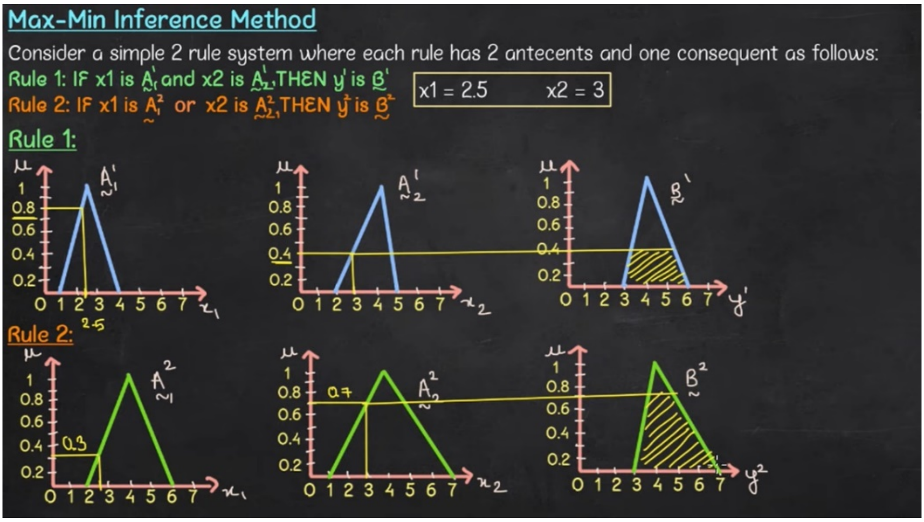

Fig. 1. Max-Min Inference Method [4]

Defuzzification

This step converts the aggregated fuzzy output back into a crisp value. Common defuzzification methods include:

Centroid Method (Center of Gravity): The crisp output is the center of gravity of the fuzzy set

Max Criterion: The crisp output is the point at which the membership function reaches its maximum value.

Example

Consider a simple example with two inputs: temperature and humidity, and one output: fan speed.

Inputs and Membership Functions

Temperature (low, medium, high)

Humidity (low, medium, high)

Fan Speed (slow, moderate, fast)

Fuzzy Rules

The higher the temperature AND the higher the humidity, the faster the fan speed.

If the temperature is moderate AND the humidity is moderate, the fan speed is moderate. When the temperature is low AND the humidity is low, the fan slows down.

Application of Fuzzy Set in Rainfall Prediction

The temperature, humidity, and rainfall primary data used in this thesis were sourced from the Surkhet district's hydrology and meteorology department, situated within the Birendranagar Municipality. The goal of this thesis is to forecast the pattern of rainfall, which is affected by variations in temperature and humidity. The relationship between temperature, humidity, and rainfall is discussed in the study by Prateek Pandey, Ratnesh Litoriya and Akhilesh Tiwari, (2018) and I have used this paper as a reference to conclude my dissertation. In this dissertation we use Mamdani Fuzzy Inference System to find the relation of temperature, humidity and rainfall.

Mamdani fuzzy inference system is performed in four steps which are as follows,

- fuzzification
- application of fuzzy rule base to fuzzy set
- inference of fuzzy result
- de-fuzzification

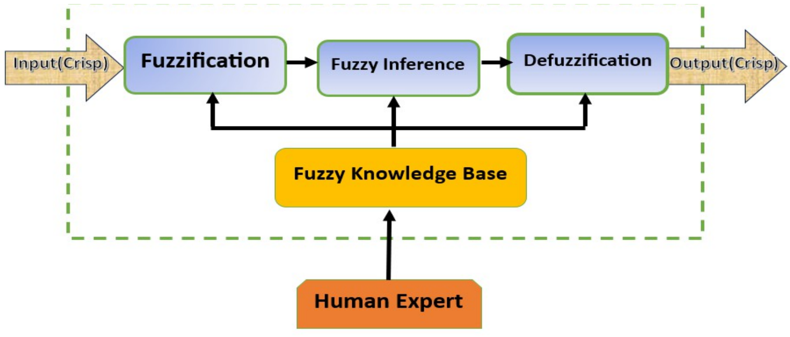

Fig. 2. Mamdani Fuzzy Inference System

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Ave. Max TEMPERATURE In ^{O}C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2000	20.1	20.6	27.2	34.0	33.6	31.0	30.9	30.5	29.5	29.5	25.6	22.0	27.9
2001	20.5	25.0	28.5	33.8	32.2	30.6	30.8	31.3	31.3	29.5	26.0	22.5	28.5
2002	20.3	23.3	28.5	32.6	32.5	33.0	32.1	30.6	29.5	29.0	25.8	22.4	28.3
2003	20.0	22.3	26.9	33.9	35.2	32.6	30.8	31.4	29.7	29.6	25.7	21.7	28.3
2004	20.3	23.9	31.5	33.7	34.5	32.6	30.7	31.5	30.6	27.8	24.3	21.1	28.5
2005	19.4	22.6	28.1	33.7	35.6	37.3	30.6	30.5	30.5	28.5	24.8	20.9	28.5
2006	22.7	27.2	28.0	32.8	32.8	33.0	31.1	31.5	31.0	29.3	25.0	21.8	28.9
2007	20.4	21.9	26.2	32.7	33.1	32.9	29.5	30.3	29.8	29.0	25.0	20.7	27.6
2008	19.9	12.0	29.4	33.3	33.9	30.6	30.2	30.6	30.4	29.1	26.1	22.7	27.4
2009	23.2	25.5	29.4	34.8	33.5	35.0	32.0	30.9	30.4	28.5	24.2	20.7	29.0
2010	20.5	23.3	30.8	36.8	35.5	37.0	32.1	31.9	30.4	30.0	26.5	23.0	29.8
2011	21.0	24.7	30.1	34.4	34.8	33.0	31.9	32.3	32.4	30.9	26.7	23.6	29.7
2012	21.0	24.9	29.9	34.4	38.1	38.0	32.0	33.0	32.6	30.6	27.0	23.9	30.5
2013	22.8	23.9	30.9	35.1	37.0	31.7	32.2	32.6	33.1	29.5	25.7	22.4	29.7
2014	21.4	23.2	28.1	33.8	36.2	36.3	31.4	31.9	31.9	29.2	26.5	22.3	29.4
2015	21.5	24.7	26.8	30.0	36.0	35.2	32.0	31.2	33.0	30.6	26.9	22.4	29.2
2016	21.8	25.9	31.2	36.2	34.6	32.8	30.7	32.7	31.7	30.5	26.5	23.6	29.9
2017	22.2	25.8	28.1	34.6	34.9	33.5	31.1	30.9	32.1	30.7	26.7	23.1	29.5
2018	21.7	24.6	30.8	32.5	33.3	33.9	31.2	30.8	31.6	29.8	25.9	21.5	29.0
2019	20.9	22.6	27.9	32.9	36.8	35.3	31.2	32.6	31.3	29.2	26.6	20.3	29.0
2020	21.7	23.7	29.3	33.7	37.8	36.7	33.2	34.7	32.9	30.5	21.9	20.3	29.7

Average maximum temperature of 2019 ranges from 20.3 to 36.8 so the domain for average temperature is [20.3, 36.8] and average maximum temperature of 2020 ranges from 21.7 to 37.8 so the domain for average temperature is [21.7, 37.8]

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Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2000	12.65	13.5	18.7	25.3	27.8	26.95	27.25	26.8	25.55	22.5	18.5	13.85	21.6
2001	12.4	16	19.9	25.35	26.5	26.55	27.25	27.2	26.2	22.8	18.15	14.15	21.87
2002	12.95	15.85	20.25	24.65	26.5	27.75	27.95	26.7	25	22.2	17.9	14.45	21.85
2003	12.2	14.95	19.05	24.95	27.25	27.55	27	27.35	25.8	22.55	17.9	13.85	21.7
2004	12.5	16.05	22.2	25.7	27.5	27.35	26.8	27.2	26.2	21.35	16.8	13.75	21.95
2005	12.6	15.75	20.2	24.75	27.45	30.5	27.1	26.8	26.35	22.6	17.05	12.85	22
2006	13.65	18.95	19.95	24.75	27	27.6	27.45	27.45	26.55	23.1	18.15	14.2	22.4
2007	12.05	15.45	19.2	25.35	26.85	28.25	26.6	27	25.85	23.05	18	13.4	21.75
2008	12.8	9.5	21.2	25	27.1	26.85	26.9	27	25.75	22.55	18.55	15.3	21.54
2009	14.65	16.85	20.55	26	27.05	28.9	28	27.4	26.15	21.8	17.4	13.65	22.37
2010	12.9	15.6	22.25	27.5	27.65	29.95	27.65	27.75	26.15	23.35	19.25	14.15	22.85
2011	12.75	16.3	20.95	25.15	27.6	27.6	27.55	27.75	27.4	23.8	19	14.65	22.54
2012	12.9	16.1	20.45	25.5	29.35	31.4	27.9	28	25.35	21	16.2	14.55	22.39
2013	13.35	16.35	21.9	25.85	29.05	27.25	28	27.85	27.5	23.7	17.65	14	22.70
2014	13.5	15.5	19.75	24.5	28.1	30.1	27.6	27.7	26.8	22.65	18.55	14	22.39
2015	13.9	16.6	19.6	22.75	28	28.95	27.85	27.15	27.25	23.2	18.75	14	22.33
2016	13.1	16.95	22	26.35	27.45	27.9	26.95	27.95	26.7	23.45	18	14.95	22.65
2017	13.55	17	19.75	26.2	27.45	28	27.1	27	27	23.45	18.35	15	22.49
2018	12.5	16.5	21.9	24.65	26.5	28.65	27.6	27.25	26.8	21.8	17.8	13.2	22.1
2019	13.15	15.8	19.7	25.1	28.6	29.2	27.45	28.3	26.95	23.15	19.8	13.1	22.53
2020	6.8.	9.9	11.2	16.3	19	22.9	23.9	23.8	22.9	18.4	8.2	8.9	16

Average temperature ranges from 13.1 to 28.3 so the domain for average temperature is [13.1, 28.3].

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Ave. Min TEMPERATURE In ^{O}C

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2000	5.2	6.4	10.2	16.6	22.0	22.9	23.6	23.1	21.6	15.5	11.4	5.7	15.4
2001	4.3	7.0	11.3	16.9	20.8	22.5	23.7	23.1	21.1	16.1	10.3	5.8	15.2
2002	5.6	8.4	12.0	16.7	20.5	22.5	23.8	22.8	20.5	15.4	10.0	6.5	15.4
2003	4.4	7.6	11.2	16.0	19.3	22.5	23.2	23.3	21.9	15.5	10.1	6.0	15.1
2004	4.7	8.2	12.9	17.7	20.5	22.1	22.9	22.9	21.8	14.9	9.3	6.4	15.4
2005	5.8	8.9	12.3	15.8	19.3	23.7	23.6	23.1	22.2	16.7	9.3	4.8	15.5
2006	4.6	10.7	11.9	16.7	21.2	22.2	23.8	23.4	22.1	16.9	11.3	6.6	16.0
2007	3.7	9.0	12.2	18.0	20.6	23.6	23.7	23.7	21.9	17.1	11.0	6.1	15.9
2008	5.7	7.0	13.0	16.7	20.3	23.1	23.6	23.4	21.1	16.0	11.0	7.9	15.7
2009	6.1	8.2	11.7	17.2	20.6	22.8	24.0	23.9	21.9	15.1	10.6	6.6	15.7
2010	5.3	7.9	13.7	18.2	19.8	22.9	23.2	23.6	21.9	16.7	12.0	5.3	15.9

2011	4.5	7.9	11.8	15.9	20.4	22.2	23.2	23.2	22.4	16.7	11.3	5.7	15.4
2012	4.8	7.3	11.0	16.6	20.6	24.8	23.8	23.0	18.1	11.4	5.4	5.2	14.3
2013	3.9	8.8	12.9	16.6	21.1	22.8	23.8	23.1	21.9	17.9	9.6	5.6	15.7
2014	5.6	7.8	11.4	15.2	20.0	23.9	23.8	23.5	21.7	16.1	10.6	5.7	15.4
2015	6.3	8.5	12.4	15.5	20.0	22.7	23.7	23.1	21.5	15.8	10.6	5.6	15.5
2016	4.4	8.0	12.8	16.5	20.3	23.0	23.2	23.2	21.7	16.4	9.5	6.3	15.4
2017	4.9	8.2	11.4	17.8	20.0	22.5	23.1	23.1	21.9	16.2	10.0	6.9	15.5
2018	3.3	8.4	13.0	16.8	19.7	23.4	24.0	23.7	22.0	13.8	9.7	4.9	15.2
2019	5.4	9.0	11.5	17.3	20.4	23.1	23.7	24.0	22.6	17.1	13.0	5.9	16.1
2020	6.8	9.9	11.2	16.3	19.0	22.9	23.8	22.8	18.4	8.2	13.0	8.9	16

Minimum temperature

Average minimum temperature of 2019 ranges 5.4 to 24 so the domain for minimum average temperature is [5.4, 24] and average minimum temperature of 2020 ranges 5.4 to 24 so the domain for minimum average temperature is [6.8, 22.8]

Membership Function of Temperature [2019]

Min = 16.1 Average = 22.53 Max = 29

$$\mu_{2019}(x) = \begin{cases} 0 & for\ x < 16.1 \\ \dfrac{x-16.1}{6.43} & for\ 16.1 \le x < 22.53 \\ \dfrac{29-x}{6.47} & for\ 22.53 \le x < 29 \\ 0 & for\ x \ge 29 \end{cases}$$

Then,

$$\mu_{min}(x) = \begin{cases} 0 & \text{for } x < 5.4 \\ \dfrac{x-4}{11.5-5.4} & for\ 5.4 \le x < 11.5 \\ \dfrac{16.1-x}{16.1-11.5} & for\ 11.5 \le x < 16.1 \\ 0 & for\ x \ge 16.1 \end{cases}$$

$$\mu_{avg}(x) = \begin{cases} 0 & \text{for } x < 16.1 \\ \dfrac{x-16.1}{8} & for\ 16.1 \le x < 18 \\ \dfrac{22.53-x}{22.53-18} & for\ 18 \le x < 22.53 \\ 0 & for\ x \ge 22.53 \end{cases}$$

$$\mu_{max}(x) = \begin{cases} 0 & \text{for } x < 22.53 \\ \dfrac{x-22.53}{25-22.53} & for\ 22.53 \le x < 25 \\ \dfrac{29-x}{29-25} & for\ 25 \le x < 29 \\ 0 & for\ x \ge 29 \end{cases}$$

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2019	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Average	76.45	74.52	61.55	57.55	41.58	62.88	82.86	82.04	84.14	78.32	78.97	78.69	71.63
Max.	98.76	98.79	98.83	97.12	88.04	100	98.41	98.37	100	99.02	98.9	98.76	97.92
Mini	41.6	37.68	25	25.5	15.6	23.1	56.9	63.93	62.59	52.77	47.09	46.13	41.5

Ave. Humidity in Percentage

2020	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
Ave	84.7	77.98	69.26	59.61	65.64	79.79	82.75	83.84	81.99	71.33	72.01	74.38	74.42
Max.	98.89	98.89	98.88	97.97	98.16	99.17	98.38	98.38	98.35	100	98.53	98.86	98.71
Mini	56	40.44	38.35	30.91	32.18	35.07	-0.23	65.2	57.57	37.56	41.53	38.93	39.46

Membership Function of Humidity [2019]

Min=41.5 Average=71.79 Max=97.92

$$\mu_{2019}(y) = \begin{cases} 0 & \text{for } y < 41.5 \\ \dfrac{y-41.5}{71.79-41.5} & for\ 41.5 \le x < 71.79 \\ \dfrac{97.92-y}{97.92-71.79} & for\ 71.79 \le x < 97.92 \\ 0 & for\ x \ge 97.92 \end{cases}$$

Then,

$$\mu_{min}(y) = \begin{cases} 0 & \text{for } y < 15.6 \\ \dfrac{y-15.6}{25-15.6} & for\ 15.6 \le x < 25 \\ \dfrac{41.5-y}{41.5-25} & for\ 25 \le x < 41.5 \\ 0 & for\ x \ge 41.5 \end{cases}$$

$$\mu_{avg}(y) = \begin{cases} 0 & \text{for } y < 41.5 \\ \dfrac{y-41.5}{61.55-41.5} & for\ 41.5 \le x < 61.55 \\ \dfrac{71.79-y}{71.79-61.55} & for\ 61.55 \le x < 71.79 \\ 0 & for\ x \ge 71.79 \end{cases}$$

$$\mu_{max}(y) = \begin{cases} 0 & \text{for } y < 71.79 \\ \dfrac{y-71.79}{88.04-71.79} & for\ 71.79 \le x < 88.04 \\ \dfrac{97.92-y}{97.92-88.04} & for\ 88.04 \le x < 97.92 \\ 0 & for\ x \ge 97.92 \end{cases}$$

GOVERNMENT OF NEPAL
DEPARTMENT OF HYDROLOGY & METEOROLOGY
Office of Hydrology & Meteorology (OHM), Kohalpur (Current Surkhet)
Station: Surkhet
Ave. Rainfall In mm

year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
2019	61.8	126.8	18.6	35.6	7.0	192.0	462.7	185.6	316.4	6.1	0.0	73.5	123.8
2020	179.0	63.8	71.2	60.3	116.5	306.7	348.4	458.0	199.6	0.0	4.2	0.0	150.6

Membership Function of Rainfall (2019)

Min=6.1 Average=123.8 Max=462.7

$$\mu_{2019}(z) = \begin{cases} 0 & \text{for } z < 6.1 \\ \dfrac{z-6.1}{123.8-6.1} & for\ 6.1 \le x < 123.8 \\ \dfrac{462.7-z}{462.7-123.8} & for\ 123.8 \le x < 462.7 \\ 0 & for\ x \ge 462.7 \end{cases}$$

Rule Base

S.N.	Rule
1	If temperature is LT and humidity is LH, then rainfall is LR
2	If temperature is AT and humidity is LH, then rainfall is LR
3	If temperature is HT and humidity is LH, then rainfall is AR
4	If temperature is LT and humidity is AH, then rainfall is AR
5	If temperature is AT and humidity is AH, then rainfall is AR
6	If temperature is HT and humidity is AH, then rainfall is AR
7	If temperature is LT and humidity is AH, then rainfall is LR
8	If temperature is AT and humidity is HH, then rainfall is HR
9	If temperature is HT and humidity is HH, then rainfall is HR

Rule evaluation

For this paper direct observation is not done so we assume that the value of input parameter as humidity is 70 percentage and temperature is 20-degree celcius for 2019.

For the temperature i.e x = 20, by the triangular membership function of temperature, it lies between 18 ≤ x < 22.53. The membership function is given by

$$\mu_{avg}(x) = \frac{22.53 - x}{4.53}\ for\ 18 \le x < 22.53$$

Then,

$$\mu_{avg}(x = 20) = \frac{22.53-20}{4.53} = 0.56.$$

For the humidity 70 percentage i.e $y = 70$. By the triangular membership function of humidity, it lies between $61.55 \le y < 71.79$.

The membership function is given by

$$\mu_{avg}(y) = \frac{71.79 - y}{71.79 - 61.55} \qquad for\ 61.55 \le x < 71.79$$

Then

$$\mu_{avg}(y = 70) = \frac{71.79-70}{71.79-61.55} = 0.17.$$

Then, the strength rule is evaluated by 'Max' operator.
The strength rule,

$$\begin{aligned} s_1 &= max\{\mu_{avg}(x = 20),\ \mu_{ave}(y = 70),\} \\ &= max\{0.56,0.17\} \\ &= 0.56. \end{aligned}$$

Then

$$\mu_{avg}(z) = \frac{462.7 - z}{462.7 - 123.8}$$

$$or,\quad 0.56 = \frac{462.7 - z}{338.9}$$

$$or,\quad 0.56 \times 338.9 = 462.7 - z$$

$$or,\quad 189.784 = 462.7 - z$$

$$or,\quad z = 462.7 - 189.784$$

$$or,\quad z = 272.916\, mm$$

Conclusion

The paper underscores the significance of fuzzy logic as a valuable tool for improving decision-making processes in complex and uncertain environments, leading to better outcomes and resource allocation in various application domains. The work highlights the application of fuzzy logic in establishing relations between humidity, temperature, and precipitation or rainfall through fuzzy inference. Here, we have used primary data from Surkhet's hydrology and meteorology station to show the application of fuzzy set theory with specific rules based on data, and the utilization of average humidity and temperature data from 2019.

Here we use the primary data of temperature humidity and rainfall of Surkhet district of 2019. we take average temperature x=20 and average humidity y=70 and which result is average rainfall.

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