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Conjunction Weighted Average Method with Fuzzy Expert System for Weather Event Forecasting – A Monthly Outlook

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Abstract

Fuzzy logic as a limiting case of approximate reasoning is viewed in exact reasoning, consider everything in a matter of degree. A collection of elastic or equivalently interpreted to knowledge, a collection of variables in fuzzy constraint. Inference is process as a propagation of elastic constraints. Every logical system is fuzzified in fuzzy logic. Fuzzy logic is fascinating area of research, it trading off between significance and precision. It is convenient way to map space of input to a space of output. Fuzzy logic as so far as the laws of Mathematics refers to reality, they are not certain and so far, as they are certain as complexity rises, precise statements lose meaning and meaningful statements lose precision. Most meteorological infrastructure is surprisingly versatile. For example, the same radar system that can detect oncoming storms will also be useful for gathering general rainfall data for the farming sector. Being able to predict and forecast the weather also allows for data to be gathered to build up a more detailed picture of a nation's climate, and trends within it.

Keywords: Fuzzy logic, rainfall and weather forecasting

Mathematical classification: 94D05[3]

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1. Introduction

Fuzzy logic models have been developed as a solution forecasting method, because the weather parameters can be easily classified unlike the other techniques mentioned above [4, 6]. Also, it does not require a computational mapping of inputs to outputs or no need for precise inputs. Fuzzy logic is simply a means of representing human reasoning. The main components of fuzzy logic are fuzzy set, membership function and fuzzy IF-THEN rule base. IF – THEN rule base is used to convert the fuzzy input into the fuzzy output [8]. In this research, the temperature, pressure, wind speed, humidity and the precipitation will serve as the input parameters for the Month forecasting. The aim of this work is to develop fuzzy logic methodology for weather forecasting with the following objectives: to formulate fuzzy logic membership function that will facilitate the monthly weather forecasting. Also, proposed monthly weather forecasting using fuzzy logic based on weather historical data (temperature, humidity, wind speed, pressure and precipitation) for the year 2021. Weather data used is from State Tamil Nadu, India. The work focused on month wise for the year 2021. Rainfall forecasts have significant value for resources planning and management e.g., reservoir operations, agricultural practices and flood emergency responses. To mitigate this, effective planning and management of water resources is necessary. In the short term, this requires a good idea of the upcoming season. In the long term, it needs realistic projections of scenarios of future variability and change [3].

2. Monthly Weather Forecasting

Monthly forecasting has the potential to play a significant role in enhancing end users' resilience to the impacts of climate change and variability. Smallholder farmers, for example, are vital to the economies and food security within the majority of the developing world, yet they are confronted with increasingly scarce resources, changing weather patterns, and extreme events that pose significant threats to the stability of both production and income. Monthly forecasts can provide this key stakeholder group with information to support their decision making regarding which crops they should plant, when to plant and harvest, and when to apply fertilizer and other inputs to maximize their yields and mitigate their losses.

2.1 Data and Area of Study

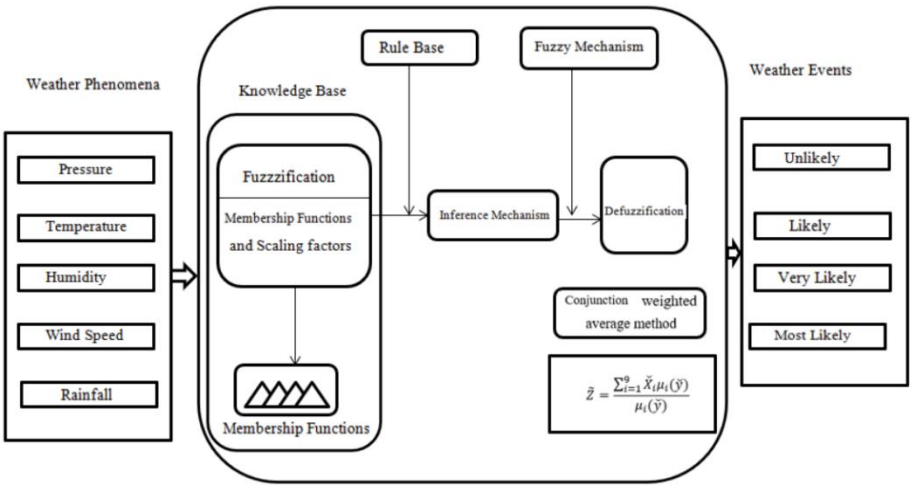
The study area is Tamil Nadu, which is one of the states in India where the climate is influenced mainly by the rain-bearing southwest monsoon winds from the ocean and the dry northwest winds from the Sahara Desert. When using Monthly forecasting as part of a Forecast-based Action system, it is important to comprehend how the prediction relates to the harm you are trying to mitigate. For instance, even a "above normal" rainfall season may have less flooding than a "normal" rainfall season depending on the type of rainfall (i.e., whether it falls gradually over several days or weeks versus all at once during a period of several hours). However, if there is a

forecast for below-average rainfall and a humanitarian organization wants to take proactive measures to address a drought, they may do so by using the monthly outlook.

Seasons of Tamil Nadu	
Season	**Period**
Winter Season	January-February
Summer Season	March- May
Southwest Monsoon	June-September
Northeast Monsoon	October –December

Table 1: Seasons of Tamil Nadu

3. Architecture of Proposed Model



4. Methodology

A fuzzy set is a function that transfers the universe object y on to the interval [0, 1]. a set b's fuzzy membership function represented mathematically, where the functional mapping is provided.

$\mu_{\widetilde{M}}$ (y)ϵ [0, 1]

similarly, the symbol $\mu_{\widetilde{M}}$ (y) in the degree of membership element y in the fuzzy set $\widetilde{M}$. A membership function that maps a component of a domain, space, or universe of discourse to the unit interval [0, 1] defines a fuzzy set. A fuzzy set $\widetilde{w}$ in a universe of discourse y is defined as following set of pairs

$\widetilde{w} = \{ y, \mu_{\widetilde{w}}$ (y); y $\in Y$ }

Here, $\mu_{\widetilde{w}}$: y→ [0,1] is a mapping called degree of membership function of fuzzy set $\widetilde{w}$ and $\mu_{\widetilde{w}}$ (y) is called the membership value of y ∈ Y in the fuzzy set $\widetilde{w}$. These membership levels are frequently expressed as real numbers between [0, 1].

4.1 Algorithm

Step 1:

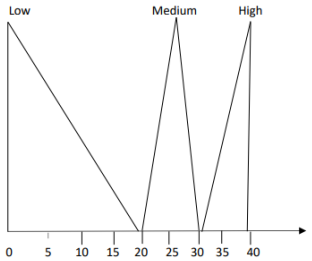
Construct a set$\sum_{i=1}^{12} \widetilde{W_i} = \sum_{i=1}^{12} \sum_{j=1}^{5} \widetilde{M}_i \, \tilde{O}_j$

Step 2:

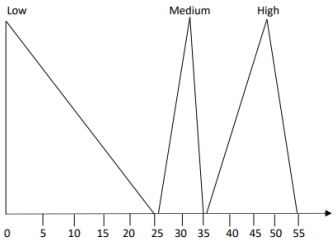
Create a triangular fuzzy membership function with respect to the decision makers parameters of their own choice.

Step 3:

Construct the Membership function for Pressure, Temperature, Humidity, Wind Speed, Rainfall.



Membership function of Wind Speed



Membership function of Temperature

Step 4:

Determine the product fuzzy conjunction

$\mu(\widetilde{W}) = \mu(\widetilde{M}_1\tilde{O}_1) \wedge \mu(\widetilde{M}_1\tilde{O}_2) \wedge \mu(\widetilde{M}_1\tilde{O}_3) \wedge \mu(\widetilde{M}_1\tilde{O}_4) \wedge \mu(\widetilde{M}_1\tilde{O}_5)$

Step 5:

Calculate the product fuzzy weighted average defuzzification method $\tilde{X} = \sum_{i=1}^{12}\sum_{j=1}^{5}\frac{\widetilde{W}_i \cdot \mu(\widetilde{W}_J)}{\mu(\widetilde{W}_J)}$

5. Case study

Consider the set $\widetilde{M} = \{\widetilde{M}_1, \widetilde{M}_2, \widetilde{M}_3 \ldots\ldots\ldots\ldots \widetilde{M}_{12}\}$ as a universal sets where $\widetilde{M}_1, \widetilde{M}_2, \widetilde{M}_3 \ldots\ldots\ldots\ldots \widetilde{M}_{12}$ represent the month from January to December for the Year 2021 and let the set $\tilde{O} = \{\tilde{O}_1, \tilde{O}_2, \tilde{O}_3, \tilde{O}_4, \tilde{O}_5\}$ where

$\tilde{O}_1 -$ Pressure
$\tilde{O}_2 -$ Temperature
$\tilde{O}_3 -$ Humidity
$\tilde{O}_4 -$ Wind Speed
$\tilde{O}_5 -$ Rainfall

The set $\tilde{O}$represent the parameter Environmental factors exposure to Monthly Weather forecasting outlook. It gives the relationship $\widetilde{W}$ called the set month and parameter data. Here, following steps made for weather forecasting in January 2021 in Tamil nadu.

Step 1& 2:

$\widetilde{W_1} = \{(\widetilde{M}_1\tilde{O}_1), (\widetilde{M}_1\tilde{O}_2), (\widetilde{M}_1\tilde{O}_3), (\widetilde{M}_1\tilde{O}_4), (\widetilde{M}_1\tilde{O}_5)\}$
= {(97.86), (22.85), (86.88), (2.27), (100.2)}

Step 3:

When $\widetilde{M}_1\tilde{O}_1 = 97.86$

$$\mu_{Low}(\widetilde{M}_1\tilde{O}_1) = \begin{cases} 0 & \widetilde{M}_1\tilde{O}_1 \geq 98.10 \\ 1 & \widetilde{M}_1\tilde{O}_1 = 96.01 \\ \dfrac{(98.10 - \widetilde{M}_1\tilde{O}_1)}{(98.10 - 96.01)} & 96.01 < \widetilde{M}_1\tilde{O}_1 < 98.10 \end{cases}$$

= 0.11

$$\mu_{Moderate}(\widetilde{M}_1\tilde{O}_1) = \begin{cases} 0 & \widetilde{M}_1\tilde{O}_1 \leq 98.11 \; or \widetilde{M}_1\tilde{O}_1 \geq 101.5 \\ \dfrac{(\widetilde{M}_1\tilde{O}_1 - 98.11)}{(99.13 - 101.5)} & 98.11 < \widetilde{M}_1\tilde{O}_1 < 99.13 \\ 1 & \widetilde{M}_1\tilde{O}_1 = 101.5 \\ \dfrac{(101.5 - \widetilde{M}_1\tilde{O}_1)}{(101.5 - 99..13)} & 101.5 < \widetilde{M}_1\tilde{O}_1 < 120.0 \end{cases}$$

$$\mu_{High}(\widetilde{M}_1\tilde{O}_1) = \begin{cases} 0 & \widetilde{M}_1\tilde{O}_1 \leq 101.6 \\ 1 & \widetilde{M}_1\tilde{O}_1 = 120.0 \\ \dfrac{(\widetilde{M}_1\tilde{O}_1 - 101.6)}{(120.0 - 101.6)} & 101.6 < \widetilde{M}_1\tilde{O}_1 < 120.0 \end{cases}$$

Step 4:

$= \mu_{Low}(\tilde{M}_1\tilde{O}_1) \wedge \mu_{Low}(\tilde{M}_1\tilde{O}_2) \wedge \mu_{High}(\tilde{M}_1\tilde{O}_3) \wedge \mu_{Low}(\tilde{M}_1\tilde{O}_4) \wedge \mu_{Low}(\tilde{M}_1\tilde{O}_5)$

$= 0.11 \wedge 0.086 \wedge 0.43 \wedge 0.9294 \wedge 0.0457$

Step 5:

$$= \frac{0.11\ X\ 97.86+0.086\ X\ 22.85+0.43\ X\ 86.88+0.9294\ X\ 2.27+0.0457\ X\ 100.2}{0.11+0.086+0.43+0.9294+0.0451}$$

$$= \frac{56.7769}{1.6011}$$

= 35.46 %

(i.e) January Month got 35.46 % that it is to be chance of possibility of to get Likely weather event.

6. Result and Justification

In this effort, Pressure, Temperature, Humidity, Wind Speed and Rainfall are taken as a important parameter of weather forecasting for monthly outlook based on Fuzzy Expert System with Product conjunction. The result appear for the month of February is 15.09% (i.e.,) Very less Rainfall and high temperature so it is considered to be unlikely weather event, meanwhile July 92.24% and November 97.67% (i.e.) more rainfall and less temperature so it is considered to be a most likely weather event month. For, remaining month weather event are given in table 2. This method is used to determination of monthly outlook weather forecasting with high accuracy.

Table 2: Weather Event prediction – A Monthly outlook.

Terminologies of Likely(L), Unlikely (UL), Most Likely (ML) are justified with standard operation procedure – weather forecasting and warning services given by Indian metrological department also discussed with expert metrologiest.

7.Conclusion

The effect of the shape of membership functions upon the solution is very important. Broader input membership functions, those with an extended domain with membership of 100%, have a larger weighting during the rule evaluation. This will be reflected in the final solution. In this work, fuzzy methodology for one-year 2021of Tamil Nadu weather event forecasting is discussed.

In this model, that is month wise weather Event prediction model, we applied the notion of Fuzzy Triangular membership function in Fuzzy Expert system. The benefit of this

model is that if the weather parameter and Triangular Fuzzy number are known, it is possible to find out monthly outlook of weather event as forecasting.

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