Forest Fire Prediction Modelling Using Fuzzy Logic

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ABSTRACT

Forest fire is an essential part of the livelihood of mankind. It provides us flora and fauna as well as produces oxygen and absorbs Carbon di oxide which is very essential for the life. A large part of these precious forests get destroyed due to fire which occurs due to various reasons like human negligence, natural disaster, lightening, accident etc. The forest fire not only engulf the tree but produces toxic gases which is very harmful for the environment. The proposed model trying to develop a WSN (wireless sensor network) based model which will detect the fire and also can predict the occurrence of fire in forest by analyzing parameter such as temperature, humidity and time using fuzzy logic.

Keywords: forest fire; fuzzy logic; WSN; forest

I.INTRODUCTION

India is blessed with large part of natural dense covered forest. Indian forest plays an important role in providing home to animal and birds. In India approx 90000 species are found in which around 1300 species of birds are lives in these forest. Forest fire is at risk of biodiversity in forest. It is basically caused by man-made factors such as shifting cultivation, clearing path through the forest, tribal tradition and environmental factor such as lightening, friction due to rolling stones. Management and monitoring of forest fire is big challenges as it destroys loads of life and property. The carbon di oxide which emits from fire can effects overall global warming and also causes respiratory and cardiovascular problems. The annual forest fire is approx 7 % of total fire cover in India which cause different adverse impact such as ecological, social and economical.

1.1 Wireless sensor network

Wireless sensor network is a distributed network that has a

collectionf sensor node. Every sensor node in WSN has a tiny powered sensor node. These sensor nodes are deployed to collect various physical and environmental sensory data such as temperature, humidity, wind speed, pressure, light intensity and so on. WSN used in different application such as forest fire detection, traffic monitoring, battle field surveillance, medical. It provides connectivity between the real and virtual world. WSN are mainly developed to control and monitor high risk region such as cross-border, forest and ocean etc.

Fire

There are various natural disasters which causes loss of human life, animal life and property. Fire is one of them which encountered in the workplace, forest, buildings and many place. Fire is one of them which encountered in the workplace, forest, buildings and many place. Wild fire occurs in rural area and country side. Wild fire

mainly classified into hill fire, forest fire, deserts fire, vegetation fire and so on. It causes many issues such as due to emission of carbon it effects the atmospheric pollution and also causes respiratory and cardiovascular problems. During periods of increased drought and temperature wild fire mainly occurs.

1.3 Forest Fire

Forest fire is basically caused into two types. One is the naturally cause and other is artificially caused by human for their benefits. Natural fire start by the ignition with a very minute percentage with the conclusion of dry type of fuels which are leaves and saw dust. On the other hand, human fire can be caused due to various reasons such as recreation, smoking and so on. The fire caused by human caused greater percentage but natural fires cover the large area of the total burned area. The human caused fire can be detected but the natural fire can burn slowly covering the major area without being detected. Mainly there are three parameters that cause fire such as oxygen, fuel, and heat which is also known as triangle of fire. The fire will ignite at its peak where there is abundant supply of these three major parameters [2].

Forest fire is classified on the part which is burning.

1. Ground fire (below the leaves).

2. Surface fire (upto 1.3 m in height on the forest surface).

3. Crown forest (one of the most dangerous fire which is held on the peak of tree). Thus it is the most overlooked disaster as there is not a proper communication , so that the control system can be reported on the initial stage so that it can be extinguished other than the fire which is igniting for some hours. Therefore, the detection of forest fire is essential so that the destruction caused by the forest fire on land vegetation and environment can be prevented.

According to FSI (forest survey of India) annually fire affects 1.45 million hectares of forest land, where forest with 6.17% has chances of severe damage of fire [1].

During 2014 in India under vegetation include scrub, grassland and forest around 57127.75 square km has burnt area i.e. approx 7% of forest cover in India.

Western ghat and north east is the region where maximum amount of burnt area has recorded.
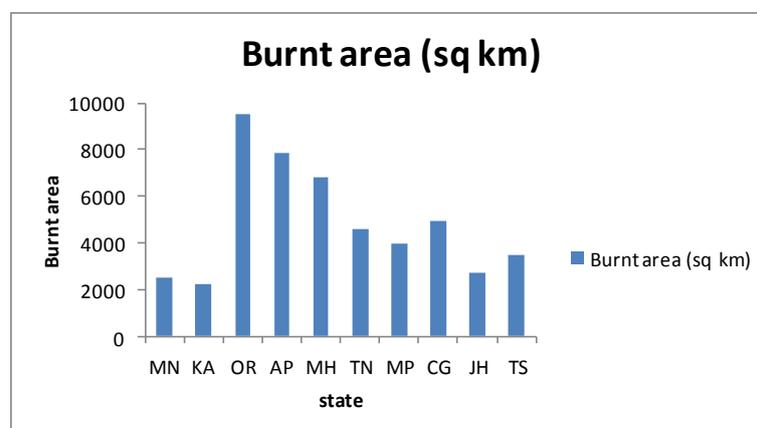

Figure 1. State Wise Maximum Burnt Area In India

Taking the concern of environment detection of forest fire is mandatory because the carbon emit from forest fire which effects global warming. It was estimated 90% from forest releasing carbon di oxide of 13 million metric tones which include 4.2% by grassland and 5.3% by scrubs.

Among the different disaster the forest fire also effects in ecological , social and economic matter .major chances of forest fire is due to the climatic change and activities of human.

1.4 Role of WSN in Detection of Forest Fire

Sensors are randomly predeployed in forest for detection of forest fire and calculate the various sensory data such as temperature, pressure, humidity, soil content, light intensity, which causes the fire in forest. After deployment all the sensory data are sent to its base station and through the GPS, satellites and other transmission medium data is sent to the control system. The proposed model used   the fuzzy logic concept for detection of fire occurs in forest so that we can prevent the many losses and effects which occurs due to the fire. Due to the detection spread of fire can be controlled as after getting the fire it is very difficult to put out.

1.5 Fuzzy Logic:

Fuzzy logic was introduced by Dr. Lotfi Zadeh at Berkeley in 1960. Rather than true of false. The fuzzy logic approach is based on degree of truthfulness or falsehood .Iit have a continuous value between 0 and 1 which have approximate value rather then having extreme cases of truth as 0 and 1.The concept of fuzzy logic system is used in various application such as washing washine, rainfall prediction,vaccum cleaner,microwave . the FLS is basically built upon IF-THEN proposition. IF part is antecedent whereas THEN part is consequent. The structure of fuzzy logic system is consists of fuzzification, fuzzy rule, inference engine and deffuzification. Fuzzification is the process that converts crisp value into fuzzy input. Deffuzification is the process that convert fuzzy output to the crisp output. Over the interval of crisp value Membership function has a value between 0 and 1.trapezoid, triangular and bell curves shapes are used for MF [7].

II. RELATED WORK

Arnoldo et al. [3] has proposed two algorithm based on technique of information fusion for detection of forest fire. Threshold method is used in first algorithm whereas dumpster Shafer theory is used in second algorithm. With the different sensor such as light, temperature, humidity nodes are equipped in first algorithm and with the help of humidity and temperature sensors nodes are equipped in second algorithm.

Murat et al. [4] has proposed detection of fire system which help to track the fire with the help of wireless sensor network in certain area. author also concluded that proposed system can be performed in mobile platform and as well as on web based.

Kechar et al. [5] has proposed the comparative study of different forest fire detection method (Korean and Canadian) and concluded that in terms of execution speed and consumption of energy has more effectiveness.

Pooja chaturvedi et al. [6] has proposed detail analysis of WSN (wireless sensor network) and explained issue related in WSN such as architecture, application, sensor technology advancement. Author also given overview of work done and issue related to security, coverage and routing.

Pourya Bolourchi et al. [7] has proposed detection of forest fire in wireless sensor network using fuzzy logic. To predict the probability of fire five membership function has used in algorithm such as temperature, humidity, smoke, distance and light. simulated results show the probability of fire using fuzzy rules.

III. PROPOSED WORK

The proposed model considers various parameter for detection of forest fire such as relative humidity, season, temperature, precipitation, wind. Fuzzy logic has range varies according to its reference and can be extended into further level and the level can be 5 level, 6level, 7level as these level increases combination of parameter increases.

In our simulation we have considered the three input parameter such as temperature, humidity, time for forest fire detection MF for temperature and humidity has three variable as low(L), medium (M), high(H). MF for time has three variables as morning, noon, night. Output parameter is chances of fire.

IV. ROLE OF DIFFERENT PARAMETER

Temperature: This parameter plays the most crucial role in detecting the fire. The value of temperature is directly proportional to the occurrence of fire.

Relative humidity: Lower the humidity more the chances of ignition in fire because the moisture absorbs the heat which discourages the spread of fire. So, the humidity is inversely proportional to occurrence of fire.

Time: The chances of fire are high at the time of noon. since the role of time is depending on temperature. The time in which temperature is higher the chances of fire is high and the time in which temperature is low the chances of fire is low.

The dataset for temperature, relative humidity, time was recorded by P. Cortez and A. Morais, 2007[8]. In the proposed model dataset is supported for prediction of forest fire and rule set is designed using Fuzzy Logic.

Range of Input Parameter as Follow

Parameter	Range	Level
Temperature	(0 to 130 degree Celsius)	(L , M, H)
Humidity	(0 to 100 %)	(L, M, H)
Time	(5 am to 11.59 am)	Morning
	(12 pm to 4 pm)	Noon
	(4.01 to 4.59)	Night

The maximum number of possibilities by considering all rules according to input parameters is 27 since all the 3 inputs has 3 degree of membership.

The first 15 rules out of 27 rules are as follow:

If (temperature is High) and (relative humidity is High) and (time is morning) then (chances of fire is medium)

If (temperature is High) and (relative humidity is High) and (time is noon) then (chances of fire is medium)

If (temperature is High) and (relative humidity is High) and (time is night) then (chances of fire is low)

If (temperature is High) and (relative humidity is medium) and (time is morning) then (chances of fire is medium)

If (temperature is High) and (relative humidity is medium) and (time is noon) then (chances of fire is high)

If (temperature is High) and (relative humidity is medium) and (time is night) then (chances of fire is low)

If (temperature is High) and (relative humidity is low) and (time is morning) then (chances of fire is high)

If (temperature is High) and (relative humidity is low) and (time is noon) then (chances of fire is very high)

If (temperature is High) and (relative humidity is low) and (time is night) then (chances of fire is medium)

If (temperature is medium) and (relative humidity is high) and (time is morning) then (chances of fire is low)

If (temperature is medium) and (relative humidity is high) and (time is noon) then (chances of fire is medium)

If (temperature is medium) and (relative humidity is high) and (time is night) then (chances of fire is very low)

If (temperature is medium) and (relative humidity is medium) and (time is morning) then (chances of fire is medium)

If (temperature is medium) and (relative humidity is medium) and (time is noon) then (chances of fire is high)

If (temperature is medium) and (relative humidity is medium) and (time is night) then (chances of fire is low)

Suppressing If- Then sentence below table gives the alternative way to signify fuzzy rules.

Table 1: For Detection of Fire the First Fifteen Fuzzy Rules

Temperature	Humidity	Time	Fire(%)
High	High	Morning	Medium
High	High	Noon	Medium

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High	High	Night	Low
High	Medium	Morning	Medium
High	Medium	Noon	High
High	Medium	Night	Low
High	Low	Morning	High
High	Low	Noon	Very High
High	Low	Night	Medium
Medium	High	Morning	Low
Medium	High	Noon	Medium
Medium	High	Night	Very Low
Medium	Medium	Morning	Medium
Medium	Medium	Noon	High
Medium	Medium	Night	Low

For each sensor the level of sensitivity is pre defined. Chances of fire can be easily calculated using fuzzy logic toolbox. The last column in the table is output and the first three column represents input parameter such as temperature, relative humidity, time.
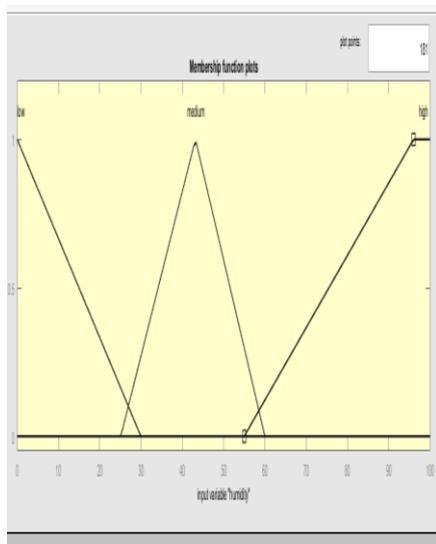
Figure 2: MF For Temperature
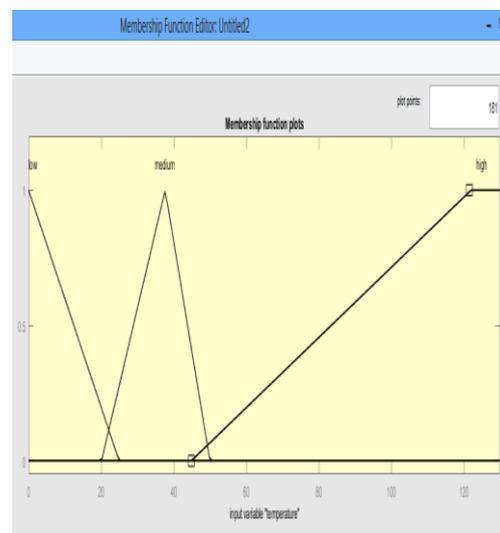

Figure 3 : MF For Humidity
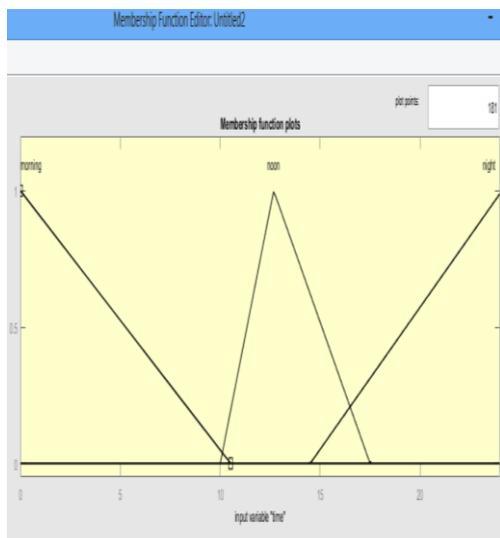
**Figure 4:** MF For Time
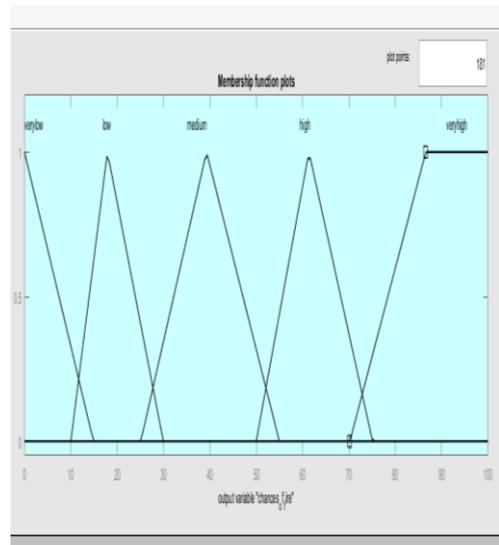
**Figure 5:** MF For Output
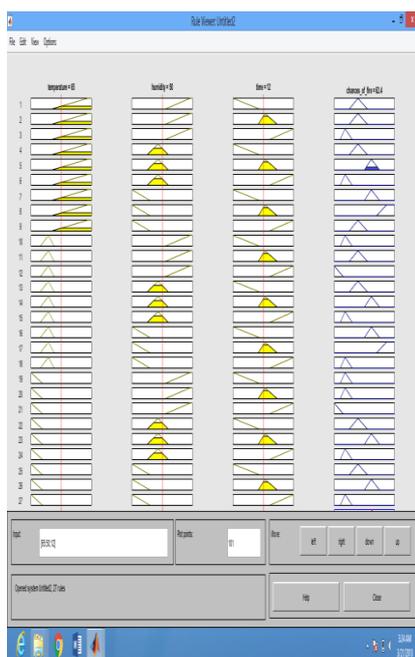
Figure 6: Ouput 1 of Corresponding Input input
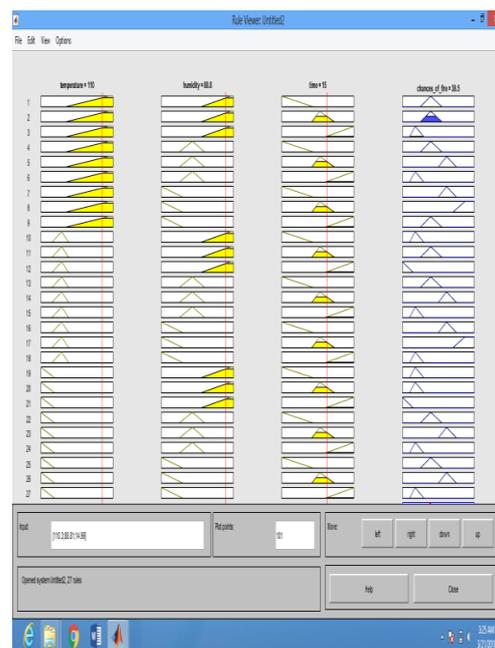
Figure 7: Output 2 of Corresponding

Different result can come from these experiment when the input is varied the desired output will also varied. as temperature is high and humidity is low and the time is noon then the chances of fire in forest is very high , similarly as temperature is high humidity is high and time is night the chances of fire in forest is low. In table 2

we can see our simulated results that when the temperature is 65 degree Celsius and humidity is 50% and the time is noon then the chances of fire is 62.4%

Table 2: For Different Input Evaluated Results

S.no.	Temperature (^{o} C)	RH (%)	Time (hour)	Results (%)
1	24.9	8.21	1.85	62.3
2	109	8.21	11.3	87.2
3	109	8.21	22.3	39.8
4	99.9	24.1	13.8	86.1
5	13.3	87.3	14.7	19
6	13.3	17.7	14.7	60

In the below figure we examine surface view on the basis of input and output
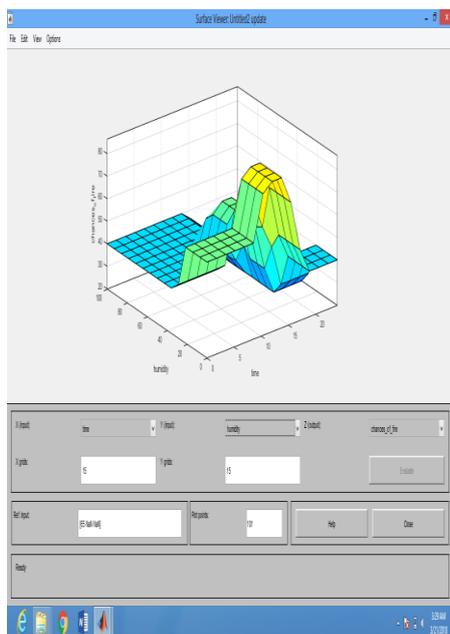
**Fig.8**.Surface View of Chances of Fire (Time Vs Humidity)   **Fig.9**.Surface View of Chances of Fire (Time Vs temperature)
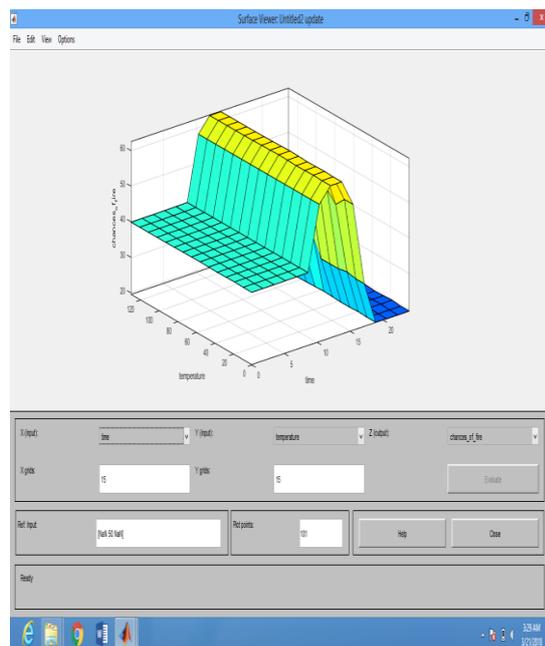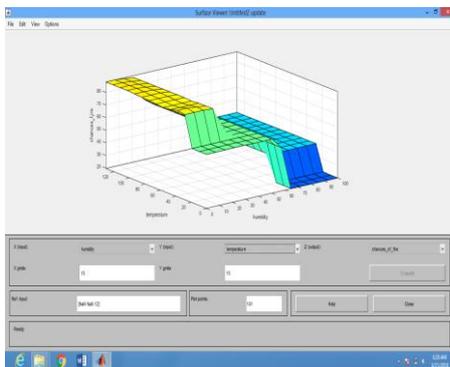
**Fig.10.**Surface View of Chances of fire (Humidity Vs Temp)   **Fig.11**.Surface View of Chances of Fire (Temp Vs Time)
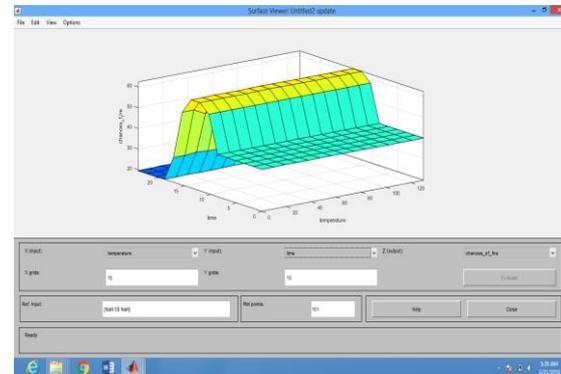
V. CONCLUSION

Forest fire not only affects the life of living organism but has drastic impact on environment. when the forest burn it not only emit carbon di oxide but also release many other toxic gases such as methane, nitric oxide, carbon mono oxide, hydrocarbon that causes depletion of ozone layer and global warming and also effects thousands of people who suffer from respiratory and cardiovascular problem. The detection of forest fire helps us to overcome with these problems. With the fuzzy logic toolbox in MATLAB we can detect the chances of fire by taking the input parameters temperature, humidity and time. With the help of our model we don't claim to stop the forest fire but surely can help in reducing it. Due to complexity other parameters such as wind speed, pressure , light intensity are not taken which analyzed for future work.

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