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Comparison of Forest Fire Detection Techniques Using WSNs

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Abstract:Forest fire is defined as a disaster caused by nature that destroy forest areas by means of fire. Reasons behind fire includes the following factors - Human carelessness, Extreme dryness, (Discloseness to) Extreme heat, Lightening Temperature, Smoke, Light, Humidity, Distance etc. Various fire detecting techniques can be used to detect the fires. But the techniques should be sufficient enough to detect the fires as early as possible. It decreases the risk of destruction. The tool for detecting fires include-Human observation, CCD Cameras, IR, Satellite systems, WSN(s). Dempster-Shafer Method, Fuzzy Logic , Threshold method are few algorithms that are used for evaluation of sensed data. The aim of this paper is to survey the false and positive aspects of each method. Future plansis to implement a better algorithm which overcome the shortcomings like accuracy, energy consumption, etc.

Keywords: **Wireless sensor networks, forest fire detection, fuzzy logicI, simulation, Energy conservation..**

I. INTRODUCTION

The occurrence of forest fire leads to natural as well as human resource destruction. Elimination of forests ,high human death rate are the damages caused by forest fire.Best alternate to minimize such damages is to detect the fire as early as possible rather than controlling it. The following detecting technologies can be used to minimize the damage of fire that are based on advance detection & termination of fires ,the technologies are :-

1) Satellite Systems: - Perhaps these systems provides a complete image of the earth but after a long scan period . This is not much accurate method because it prevents fire detection just at a time, the fire starts.

2) CCD CAMERAS: - This technology includes spatial temporal visual features extracted from Camera image & a pattern classification technique. Comparison can be made between two consecutive key frames to detect the moving regions visual features that are extracted includes:-Motion Orientation, Wavelet coefficients, Intensity,Upward Motion, Texture, Color of smoke.

1) Human Observation :- In this method, to monitor forest fire, personnel are appointed to look out fires through high areas present in forest areas.It is one of the traditional method of fire detection.
2) WSN :- WSN help in detecting various factors which lead to forest fire like relative fog, temperature ,etc. To implement this technology, a network of Sensor Nodes can be installed in the forest to sense the fire.It is one of the efficient method.
5). IR- In IR, an optical fire detection instrument works in the various regions of forest. Several detection modules are used at the same time, each having beam splitter, camera lens, spectral filters and silicon linear array.Infrared detectors are very sensitive to various atmospheric effects and may cause scatter of the transmitted beam.

II. ALGORITHMS FOR FOREST FIRE DETECTION:

The algorithm based on Dempster Shefer ,Threshold method use the state machine shown in fig1

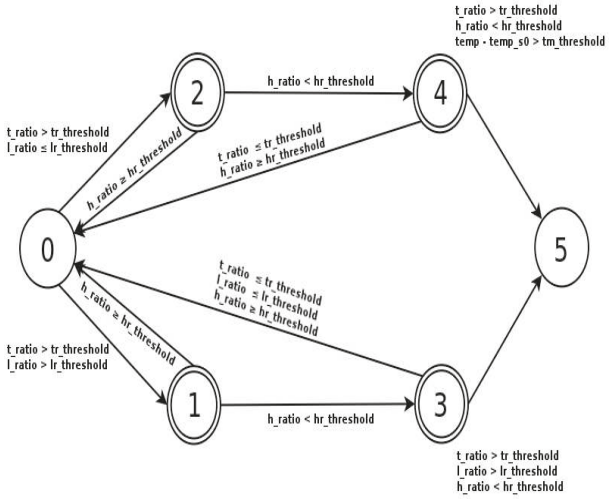

Fig1..State machine diagram[10]

Where, State 0 Initial State
1 Occurance of night fire
2 Occurance of day fire
3 Sunshine
4 presence of fire

To evaluate the performance of the algorithm following metrices are used -

a) False positives- indicates fire has occurred.
B) False negatives- indicates that it fails in identifying when a fire is really occurring.

Algorithm is based on the concept that when a fire occurred as the temperature increased and the relative humidity decreased. Operations- To assign mass values to the information collected from sensors, spline interpolation is used, and ,For evaluation, the Lagrange interpolation methods are opted.

The nodes are periodically sensing the temperature and relative humidity condition of the environment. Every time a new temperature value is registered, the algorithm calculates the ratio between the average of the values of a sliding window of size WT and the new temperature value. The value of the size of the sliding window WT varied from 5 to 35, with increments of 5.Thee values for tr-threshold=1.01 and m-threshold = 0.6. In order to use the Dempster's rule two independent sources of evidence are defined.

1. The first one (m1) uses the measured values of temperature and humidity, and the Lagrange interpolation method to assign mass values.

II. The second one (m2) uses the measured values of temperature and humidity, and the Newton polynomial interpolation method to assign mass values. To assign the mass values, the most recent temperature values are employed to calculate the expected humidity value using the interpolation method. Then, it is compared with the sensed humidity value. If the sensed value is less than or equal to the calculated values, the algorithm assigns to the {fire} hypotheses a mass value greater than or equal to 0.6. Otherwise, it assigns a mass value from 0.59 to 0. The {no-fire} hypothesis is assigned a mass equal to 1-m ({no-fire}). If both methods assign to the {fire} hypothesis a mass value >=m-threshold, then the algorithm indicates that a possible fire is occurring. On the other hand, if both methods assigns to the {fire} hypothesis a mass value<m-threshold, the algorithm continues collecting data. However, if one of the methods assigns a mass value>=m-threshold and the other one assigns a mass value<m-threshold, then following equation is used to calculate the combined mass (m12).m1,2(f)=m1({f})m2({f})+m1({f})m2({u})+m1({u}) m2({f})/1-m1({f})m2({n})-m1({n})m2({f})

Table1: Evaluation results of the Threshold Method[10]

Window Size	Number of Experiments	Fires Detected	False Positives	False Negatives
5	6	4	1	2
10	6	4	2	2
15	6	6	3	0
20	6	6	3	0
25	6	6	3	0
30	6	6	2	0
35	6	6	2	0

Table 2. Evaluation result of the Dempster's-Shafer method[10]

Window Size	Number of Experiments	Fires Detected	False Positives	False Negatives
5	6	5	4	1
10	6	5	5	1
15	6	5	5	1
20	6	5	6	1
25	6	5	6	1
30	6	5	6	1
35	6	6	6	0

The algorithm was able to detect all the existing fires using a sliding window value of WT=35. For smaller WT values, the algorithm failed in detecting a night fire. However, the number of false positives can be reduced if the motes are protected from direct sunlight.

Evaluation results showed that both methods are able to detect fires in their initial stages. Both algorithms reported false positives when the motes were exposed to direct sunlight.

Another algorithm based on Fuzzy logic system can have a continuous value between 0 and 1 which are approximate values. The first Fuzzy logic system was reported by Lotfi Zadeh in 1965.The basic structure of fuzzy logic system consists of: Fuzzification,Inference, Defuzzification.

Fuzzification is a process in which crisp inputs are converted to fuzzy inputs. A MF (membership function) defines the degree of truth of input and output. MF has a value between 0 and 1.This function has different variables according to number of variables which are predefined for each individual I/O.Example: In this fire detecting system five inputs that can be taken are_Temperature,Smoke,Light,Humidity,Distance.MF for output is the probability of fire, having five variables: Very Low (VL), Very High (VH), Medium (M), High (H), Low (L).For distance, we have three variables:Close,Average,Far.The other inputs include the variables: Low(L),Medium(M),High()H.These fuzzy inputs are then fed into the inference in which the fuzzy rule base manages the inference for yielding a fuzzy output. We can define the fuzzy rule as:-

If x1 is F1 and x2 is F2.....& Xn is Fn,then y is yk

In the final step, the fuzzy outputs are converted into crisp outputs & which is known as defuzzifications.

The AND fuzzy operation can be used for all the rules.The minimum and the intersection between two sets are given as:-

$$ABCDE(x)=\min[\mu_A(x),\mu_B(x),\mu_C(x),\mu_D(x),\mu_E(x)]$$

Where, A,B,C,D,E are temperature, smoke, height, humidity and distance respectively.

The evaluation results for this algorithm are shown in table3.

Table3.Evaluation results of Fuzzy Logic System[11]

	Temp (C)	Smoke (ppm)	Light (lux)	Humidity (ppm)	Distance (m)	Threat of Fire (percentage)
1	20	30	300	80	70	27.8
2	80	30	300	80	70	41
3	20	80	300	80	70	33.8
4	20	30	900	80	70	39.7
5	20	30	300	100	70	19.3
6	20	30	300	80	50	30.3
7	80	80	300	80	70	50
8	80	80	800	80	70	53.6
9	80	80	800	40	70	63.1
10	100	80	800	40	20	70.1

III. CONCLUSION AND FUTURE WORK:-

The previously discussed algorithms are not hundred percent accurate. There may be chances of occurrence of error in data compilation in such algorithms. In these also include energy conservation problems.In future, we plan to

implement algorithm that attain maximum accuracy in WSNs by dynamically allocating cell locations and with variable radius cells,high monitoring rates at more prone/sensitive areas.Use of fuzzy logic for data compilation techniques to make the data organization more efficient.Use of switching technique to turn nodes ON or OFF to conserve energy using fuzzy logic (more power at less prone areas and more duty cycles at more sensitive areas).

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