Forest Fire Detection: Various Approaches

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Abstract— Forest fire has been a severe risk to the forest capital and individual life from a long time. The threat could effectively be mitigated by timely and precise detection. In past there were many methods used for detection of fires among them were cameras, satellite images method, human observation. Wireless sensor network was introduced to remove the drawbacks of existing techniques. In this paper we will review different papers and will try to find out the advantages and disadvantages of existing techniques.

Index Terms—Artificial neural network, Fuzzy logic, Image processing, Intelligent system, Satellite, Wireless sensor networks

I. INTRODUCTION

Forest fire is a fatal threat throughout the world. It is reported that for the last decade, each year, a total of 2000 wild fires happened in Turkey and more than 100,000 in all countries. Early detection of forest fires is very important in fighting against fires. Spread features of forest fires show that, in order to put out a fire without making any permanent damage in the forest, the fire fighter center should be aware of the threat in at most 6 min after the start of the fire. Besides early detection capability, estimating the spread direction and speed of fire is also important in extinguishing fires. Unreliability of human observation towers, in addition to the difficult life conditions of fire lookout personnel, has led the development and use of various technologies aiming to make the fire fighters aware of the forest fires as early as possible. Some important technologies and systems that are currently used towards this goal are: systems employing charge-coupled device (CCD) cameras, infrared (IR) detectors, satellite systems and images, and wireless sensor networks [2]. In a camera based system, CCD cameras and IR detectors are installed on top of towers. In case of fire or smoke activity, the cameras and detectors sense this abnormal event and report it to a control center. Another alternative technology for detecting forest fires is the use of satellites and satellite images. As a promising alternative, wireless sensor networks (WSNs) are an emerging technology that can be used for forest fire detection and related activities. A WSN is comprised of one or more powerful base stations and hundreds of sensor nodes Base stations serve as gateways between the Internet users and sensor nodes. Sensor nodes are integrated with the microcontroller, the Radio Frequency (RF) transceiver and sensing units, and are spatially scattered into a specified area to monitor physical and environmental conditions.

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II. LITERATURE SURVEY

Different researchers have worked upon different techniques for early detection of fire which cause a great threat to both humans and wildlife. Among the techniques some of these to be discussed are:

A. Artificial Neural Network

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements working in order to solve specific problems. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons.

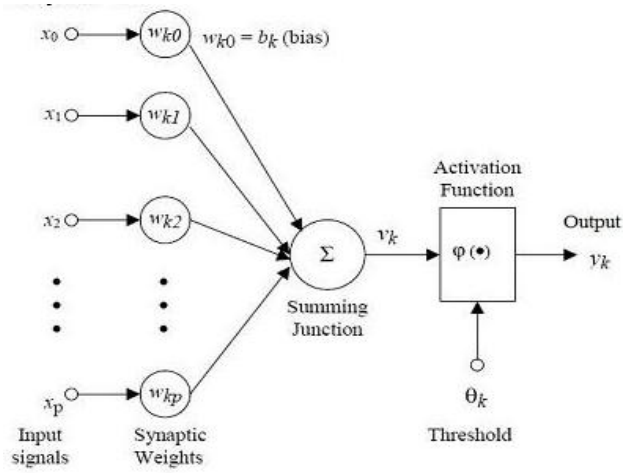

Figure 1: Model of Artificial Neural Network

Figure 1 represents the model of neural network. A set of synapses or connecting links is characterized by a weight or strength of its own. A signal x_p at the input of synapse p connected to neuron k is multiplied by the synaptic weight w_{kp}. An adder is used for summing the input signals and activation function for limiting the amplitude of output of a neuron. In 2010, Hamdy Soliman analyzed the potential of combining wireless sensor networks with artificial neural networks (ANNs) to build a "smart forest-fire early detection sensory system" (SFFEDSS). In this system, Temperature, light and smoke data from low-cost sensor nodes spread out on the forest bed is aggregated into information. The information is spatially and temporally labeled into knowledge which will be encoded as input to ANN models that convert it into intelligence. The automated SFFEDSS system can be used to monitor the forests without constant human supervision [3].

B. Fuzzy Logic

The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s. Dr. Zadeh was working on the problem of computer understanding of natural language. Natural language is not easily translated into the absolute terms of 0 and 1. Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. Fuzzy logic consists of fuzzification, inference rules and defuzzification as shown in Figure 2.

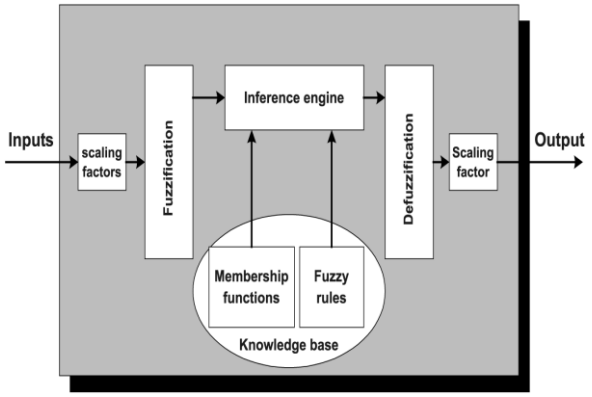

Figure 2: Block Diagram of Fuzzy Logic

In 2013, Vikshant Khanna proposed an approach of implementing Fuzzy Logic on the information collected by sensors. This collected information will be passed to the cluster head using Event Detection mechanism by finding shortest path. Thus information collected from multiple sensors is used for detecting probability of fire as well as direction of fire. Each sensor node consists of multiple sensors that will sense temperature, humidity, light and CO density for calculating probability of fire and azimuth angle for calculating the direction of fire. It will improve accuracy of the detection system, as well as reduce the false alarm rate[4].

In 2013, Parul Mohindru and Rajdeep Singh proposed an approach of using multi-sensors for detection of fire and fuzzy approach for fire calculating probability of fire with varying time. Thus, the proposed forest fire detection handles the vagueness present in the statistics successfully and gives the finest results with very low false alarm rate. The decision based on this approach is more precise as it gives accurate results with variation of time and other physical parameters [5].

C. Image Processing

Image Processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. In 2012, Stuart Matthews presents the results of a field trial of two image- based systems in south-eastern Australia during March–May 2010. The aim of the trial was to measure the performance of the systems in an operational context. The detection systems were assessed on their ability to detect and report fires to fire managers, and on the speed and accuracy of the reports. For a subset of fires the performance of image-based detection was benchmarked against a trained and experienced tower observer. Both image-based systems could adequately locate fires once they were identified, with a similar level of error to the human observer.

D. Satellite Constellation

A group of artificial satellites working in concert is known as a satellite constellation. Such a constellation can be considered to be a number of satellites with coordinated ground coverage, operating together under shared control, synchronized so that they overlap well in coverage and complement rather than interfere with other satellite important coverage as shown in Figure 3.

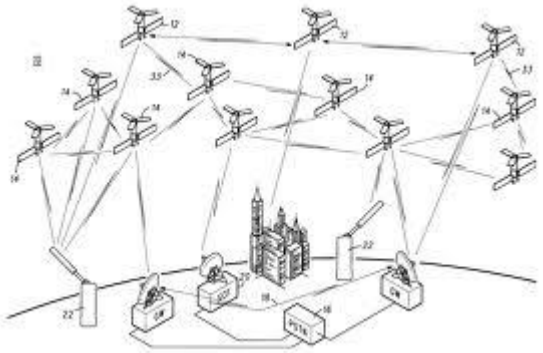

Figure 3: Satellite Constellation

S.D. Wang proposed technique using the characteristics of the environment and disaster monitoring and forecasting small satellite constellation (HJ). The moderate resolution imaging spectroradiometer (MODIS) forest fire detection contextual algorithm was improved to adapt the HJ-infrared sensor (HJ-IRS). The enhanced method consisted of potential fire pixel identification, absolute and relative fire pixel judgment, background characteristics analysis, and fire pixel confidence. The improved algorithm was programmed in IDL7.1 and tested using HJ forest fire data from Heilongjiang Province in 2009. Results show that improving the forest fire detection contextual algorithm to adapt HJ-IRS is feasible and highly accurate. HJ data are much more sensitive to smaller and cooler fires than MODIS or the advanced very high resolution radiometer (AVHRR) data, and the improved capabilities offers a good potential for application in forest fire detection.

E. Multisensor Data Fusion:

Multisensor data fusion is the combining of sensory data from disparate sources such that the resulting information is in some sense better than would be possible when these sources were used individually. The term better in this case can mean more accurate, more complete, or more dependable. The data sources for a fusion process are not specified to originate from identical sensors.E. Zervas presented an approach in which deployment of Wireless Sensor Networks at the ‘‘Urban–Rural-Interface” (URI) aiming to the detection, monitoring and crisis management of natural hazards such as forest fire. One of its primary objectives is the development of an advanced multisensor data fusion scheme which feeds a CUSUM sequential test used in the early detection of fires. Reasoning about the probability of fire in a geographical area covered by temperature, humidity and vision sensors is achieved through Evidential Reasoning.

F. Intelligent system:

An intelligent system is a computer system that emulates the decision-making ability of a human expert. The first intelligent system was created in the 1970s and then reproduceed in the 1980s. These systems are designed to solve complex problems by reasoning about knowledge, like

an expert, and not by following the procedure of a developer as is the case in conventional programming. So these systems were among the first truly successful forms of AI software.

This system used new infrared-image processing techniques and Artificial Neural Networks (ANNs), using additional information from meteorological sensors and from a environmental information database, taking information database, taking advantage of the information redundancy from visual and infrared cameras through a matching process, and designing a fuzzy expert rule base to develop a decision function. This system provides the human operator with new software tools to verify alarms. This system helped in minimizing the false alarm rate which was found as a major problem in many existing techniques.

III. CONCLUSION

Table 1: Summary of Forest Fire Detection Techniques with Their Pros and Cons

S. No.	Techniques	Key idea	Pros	Cons
A	**Artificial Neural Network**	Inspired by biological nervous system in which large number of highly interconnected processing elements working in order to solve specific problems.	Does not use preprogrammed knowledge base. Suited to analyze complex patterns. Clear output. Robust and Flexible.	Large training sample required. Risk of over fitting. Requires high quality data.
B	**Fuzzy Logic**	Form of probabilistic logic which deals with reasoning that is appropriate rather than fixed.	Uses linguistic variables. Allows imprecise and contradictory inputs. Rule base or fuzzy sets easily modified. Easier to design.	Hard to develop a model from a fuzzy system. Requires more fine tuning and simulation before operational.
C	**Image Processing**	Method to convert an image into digital form and perform some operations on it, in order to extract some useful information from it.	Faster. Effectively stored and efficiently transmitted.	Very costly depending on the system used. Time consuming. Lack of qualified professional.
D	**Satellite Constellation**	Number of satellites with coordinated ground coverage, operating together under shared control	Broadcast possibilities. Provision of service to remote or underdeveloped areas.	Large up front capital costs. Interference and propagation.
E	**Multisensor data Fusion**	Combining of sensory data from disparate sources such that the resulting information is in some sense better than would be possible when these sources were used individually.	Redundancy Complementarity Accuracy	Complexity
F	**Intelligent System**	Computer system that emulates the decision-making ability of a human expert.	Quick availability. Scalability. Preservation and improvement of knowledge.	Rules may not exist or contradictory.

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