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A Review of Fire Detection Techniques

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Abstract - *Apart from causing tragic loss to life and property, fire is a great menace to the environment. There are several methods available for fire detection. This includes monitoring through observation towers, satellite based monitoring, monitoring systems based on digital cameras and wireless sensor networks. Every method has its own points of interest and weaknesses. The paper sums up the pros and cons of the different techniques available for fire detection.*

Key Words: **Wireless sensor network, fire detection, multisensor, digital camera, satellite**

1. INTRODUCTION

Flames are typically seen when they have spread over a huge region, making its control and stoppage difficult. The result is loss of men and material resources and it causes harm to the earth and air as well [4]. The fire may start due to human activities like smoking or barbecue parties or due to normal reasons, like, very high temperature conditions during summer season or there may be a wrecked glass that acts as a focal point concentrating the daylight on a little spot for a time span, thus prompting fire-start. When fire begins, combustible materials available in the surrounding area act as a fuel leading to bigger and wider fires. Timely detection of occurrence of fire can significantly lessen the impending harm as well as the expense on fire fighting.

There are a number of fire detection techniques available. Some of them are listed below:

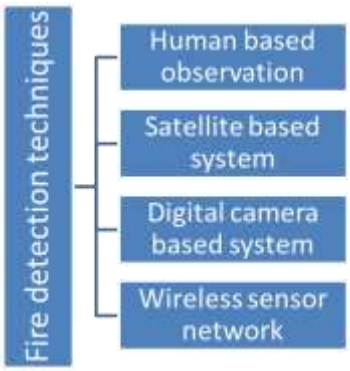

Fig.1. Fire detection techniques

2. FIRE DETECTION TECHNIQUES

In the section below, different fire detection techniques are discussed in detail.

2.1 Monitoring through observation towers

This technique is based on human observation [4]. For this fire towers are built. The fire lookout tower is a small house, generally situated on the top of a mountain to maximize the viewing distance and range. From this place, the fire lookout can observe smoke that might have developed due to fire. The location of fire is determined using a device known as an Osborne Fire Finder, and fire control personnel are then informed about it. Aerial patrolling can also be done to discover wildfires. In that, public reporting of fire is done through ground based field staff.

Drawbacks:

- This is not a reliable method since fire is not reported as long as it doesn't present peril to people or property.
- It does not consider seriously the environmental impact of fire.
- There are more chances of faulty alarms.

2.2 Satellite based fire detection systems [27]

Satellites have been used to detect fires for several years[4].Different satellites are launched for this purpose, namely, AVHRR (Advanced Very High Resolution Radiometer), MODIS (Moderate Resolution Imaging Spectroradiometer) and Visible Infrared Imaging Radiometer Suite (VIIRS).

AVHRR was initially proposed only as a meteorological satellite system that senses the presence of clouds and the temperature of sea surface by measuring electromagnetic radiations produced from Earth. Later it was discovered that it can also be used for fire detection. Its visible bands can spot smoke trails coming out of fires. Its thermal infrared bands can identify live fires. The capability of this satellite to detect fires is higher during night time, as during the day time, it can confuse live fires with heated ground surfaces, such as beach sand.

For around 15 years, MODIS satellite [15] has been checking the surface of Earth for flames. Since its launch in 2012, VIIRS satellite has been contributing in detection of fires by providing higher resolution pictures of the surface of Earth. Both MODIS and VIIRS satellites have similar orbits, however the spatial resolution of their thermal bands is divergent. The thermal band of MODIS has a resolution of 1,000 meters for each pixel whereas VIIRS has a resolution of 375 meters for each pixel. Higher resolution empowers VIIRS to recognize fires that MODIS overlooks. Thus, VIIRS is more appropriate for checking fire activity.

Drawbacks:

- The satellite coverage of the full region may be intermittent with substantial gaps in time.
- These satellites can provide images every two days which is quite a long time.
- The pictures received from satellites may be of poor quality due to bad weather conditions.
- The infrared radiations produced by fires in initial stages may be excessively weak in intensity to be identified by satellite.
- Satellites are launched to perform many diverse functions like media communications, remote detecting of earth's climate and so on, so it isn't practical to add to its capability to recognize fire.
- The activity of satellite framework is additionally bound by numerous national and universal guidelines and understandings so it isn't reasonable for the job of fire detection.

2.3 Fire detection using wireless sensor and digital camera

This fire detection system not only focuses on detection of fire, but also its verification to avoid false alarms. A wireless multisensor network which uses combination of sensors and digital cameras is developed to identify and confirm the occurrence of fires.

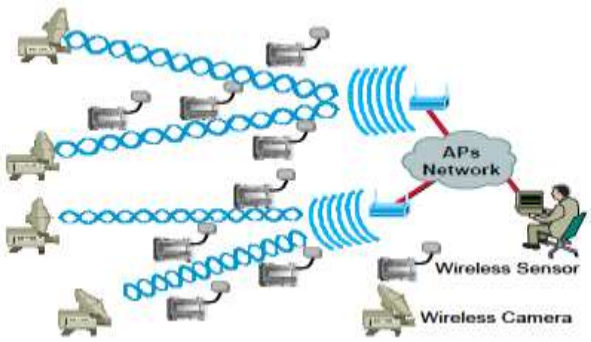

Fig.2. Fire detection using digital camera and wireless sensor [13]

The system works as follows: Wireless multisensors[9] are scattered deliberately over the area under observation. Digital cameras with high gain antennas are used. There are access points which connect these multisensors and digital cameras to a central server. The locations of multisensors are originally saved in the database of the central server. The database also contains information relating each multisensor with the nearby digital camera. When any multisensor detects fire, it transmits a fire alarm message to the central server through access points. Server then checks its database and decides which camera is closest to that multisensor. The closest camera to the multisensor is repositioned to capture pictures of the fire affected zone. These pictures are relayed to the people at emergence response center. This system provides complete information regarding the fire, thereby aiding the fire extinction tasks.

Drawbacks:

- It provides line of vision. In the event that high trees or slopes and mountains are present, it blocks the vision and pictures from the ignition point cannot be provided.
- Weather conditions and night also affects the quality of images.
- The system is very expensive because camera towers need to be built.

2.4 Wireless sensor networks

Deployment of a wireless sensor network [2,26] is considered as the best solution for fire detection. The sensor network consists of several sensor nodes which can communicate among themselves and have an in-built processor to analyze the parameters gathered from the atmosphere. These sensor nodes can gather various types of data like temperature, pressure, humidity, wind speed, presence of gases etc. in diverse environmental conditions. On the other hand, ZigBee [5] is a low-data rate, less-cost, low-power and short distance, wireless communication protocol. In contrast with different remote advancements [14], ZigBee has advantages of i) protected and dependable information correspondence, ii) a basic and versatile system arrangement, iii) involves less equipment cost, and iv) durable batteries that last long. By putting up a ZigBee based wireless sensor network [17], fire related parameters like temperature and humidity could be easily gathered and investigated any time, rather from any portion of the existing network arrangement.

A wireless sensor network system [6,17] based on ZigBee technology consist of i) sensor nodes, ii) routers or gateways, and iii) a monitoring host computer [3].

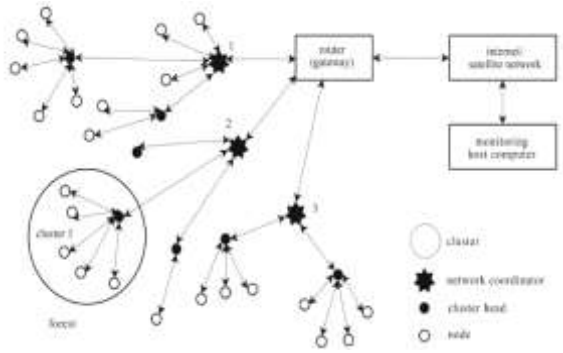

Fig.3. Fire detection using sensor network [17]

Sensor nodes [1] are strategically distributed in the area to be monitored for fire accident so as to collect fire related parameters, for example, relative humidity and environmental temperature. Contingent upon the job that these distinctive sensor nodes [20] play in the whole system, there are three classifications of sensor nodes:

- Usual end node
- Cluster head
- Network coordinator

End nodes gather data and transmit it to their cluster head. A *cluster head* chiefly handles data aggregation and data packet transmission. So, the data gathered by end nodes in the cluster is aggregated and transmitted to the adjacent network coordinator by the cluster head. A *network coordinator* primarily deals with basic network management functions like network formation, equipment record-keeping and access control. Network coordinator transmits data wirelessly to routers. Upon getting data, routers create a local database and then transfer the data to the monitoring host computer located at the remote end through internet.

Advantages of using WSN [19] for fire detection purpose:

- There is no need to build towers.
- It can be deployed even at inaccessible places.
- Different kinds of sensors can be added to sensor network to measure different parameters.

Table 1: Summary of different fire detection systems [4]

Human based observation	**Satellite based system**	**Digital camera based system**	**Wireless sensor network**
Fire observation done through lookout towers	Satellite coverage of full region may not be available	Focuses on detection of fire, as well as its verification to avoid false alarms	Best solution for fire detection
Not a reliable method	Existing satellites provide pictures every two days which is a long time	Offers line of sight vision. Nearness to tall trees and mountains hinders the vision, making it hard to catch pictures from point of fire start	No need to build towers
High probability of faulty alarms	Quality of pictures is affected by climate conditions	Climate conditions and night affects the quality of pictures	Deployed at inaccessible places
Do not think about the ecological effects of fire	Not cost-effective	Very expensive system	Network is scalable

3. CONCLUSION

Fire detection is a serious issue. In order to prevent fire disasters from happening, it is necessary to invest in different fire detection techniques that help predict fires in advance, thereby preventing its spread over a large area.

Existing techniques for fire detection are summarized in Table 1.

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