Innovations, Technology: Forest Fire Detection

Monica Rathee

NIT Hamirpur

Abstract - Forest fires are considered as a significant environmental issue because they cause prominent economical and ecological damage despite endangering the human lives. Every year, forest fires cause enormous and irreparable damage to forest ecosystems and cost much to be handled efficiently. Forest fire is a big threat to forests these days. Many methods have been adopted for forest fire detection like charge-coupled device (CCD) cameras and Infrared (IR) detectors, satellite systems and images, and Wireless sensor networks, Video surveillance. Therefore, this paper reviews different traditional methods with new innovation in this field.

Keywords: WSN, SNs.

I. INTRODUCTION

Forests play a crucial role in preservance of natural human resources and the environment, which in return play a major role in maintaining ecological balance. Forest fires are unpredictable in nature. There are three types of forest fire i.e. Surface Fire, Crown Fire and Ground Fire. A forest fire may burn primarily as a surface fire, spreading along the ground as the surface litter (senescent leaves and twigs and dry grasses etc) on the forest floor and is engulfed by the spreading flames. The other type of forest fire is a crown fire in which the crown of trees and shrubs burn, often sustained by a surface fire. Whereas, A crown fire is particularly very dangerous in a coniferous forest because resinous material given off burning logs burn furiously. On hill slopes, if the fire starts downhill, it spreads up fast as heated air adjacent to a slope tends to flow up the slope spreading flames along with it. If the fire starts uphill, there is less likelihood of it spreading downwards. Ground fires are the most infrequent type of fire but make for very intense blazes that can potentially destroy all vegetation and organic manner, leaving only bare earth. These Forest fires are caused by Natural causes as well as Man made causes. Many forest fires start from natural causes such as lightning which set trees on fire. However, rain extinguishes such fires without causing much damage. High atmospheric temperatures and dryness (low humidity) offer favorable circumstance for a fire to start. According to statistical data, 80-99% forest fires are caused by humans. Hence, relative humidity and air temperature are regarded as the two major factors which affect the moisture content of the fuel. Wireless Sensor Networks (WSNs) comprise of numerous tiny sensor nodes that are deployed in an application area to measure the given physical phenomenon. Sensor nodes communicate wirelessly and often self organize after being deployed in an ad-hoc fashion. Sensor nodes (SNs) have limited processing capabilities. SNs cooperatively transmit their data through the network to a central gateway also called as base station. This data is collected at base station, get analyzed and processed according to needs. Therefore, wireless sensor network is an area of interest for researchers to develop new techniques for forest fire detection.

II. MOTIVATION

Forests are indispensable rich resources and also crucial for well being of our earth's ecosystem. It is reported that for the last decade, more than wild fires happened 100,000 in all countries. There have been various traditional methods for forest fire detection and monitoring. The early methods were based on manned observation towers but this technique was inefficient and ineffective. Subsequently, camera surveillance systems and satellite imaging technologies were tried but this also proved ineffective at being able to efficiently monitor the initial start of the fire. WSNs bring a new revolution for applications like forest fire detection, but there is lack of standardized protocols in this application field.

III. TRADITIONAL METHODS OF FOREST FIRE DETECTION

Forest fire is not a new problem that the world is facing, but it is as old as life on this earth. There have been various methods from the manned lookouts, to remote sensing detection systems like satellites, cameras, aircraft and wireless systems and aim of all methods is to establish a better cost effective and efficient forest fire detection system. Therefore, this section discusses various traditional and latest approaches with their advantages and disadvantages.

The fire detection systems can be divided in three major groups:

- Terrestrial detection systems – It includes fixed ground surveillance (lookout towers) and mobile ground surveillance (mobile brigades);
- Aerial detection – helicopters, airplanes;
- New technologies for fire detection – Infrared and video cameras, satellites with remote sensing, laser detection and unmanned aerial vehicles (UAV's), Wireless sensor Network.

Terrestrial detection systems

Lookout towers- They are fixed ground surveillance structured with brick, wood or steel and are positioned on high points of the plantation to minimize blind spots. The observer has to keep an eye on forests to detect smoke and must climb high towers and spend long hours in full exposure to sun and storm .

Advantage

1. Cheaper approach.
2. Height of the tower favours visibility.

Disadvantages

1. Requires well trained staff.
2. Some areas may not be visible.
3. Unfavourable to harsh environmental conditions, like visibility difficulties with dust clouds.

Mobile Grounds Surveillance (mobile brigades)-

It is complimentary to fixed ground surveillance and they could be 4x4 vehicles, motorcycles, bicycles, i.e. mobile in nature. Generally, they have a radio to communicate with the detection coordination centre, a map of the area and binoculars, fire first attack kit in the vehicle (water container, motor pump, etc) [6].

Advantages

1. Complimentary to lookout towers.
2. Accuracy is improved.
3. Better coverage of forested areas.

Disadvantages

1. Continuous surveillance is not provided.

Aerial detection-Aerial detection includes from detection from helicopter, airplanes or light weight aircraft with goal to provide early detection. The reserve to perform first attack in case of fire. The aircraft is controlled by an operator on the ground with a radio transmitting devise [6].

Advantages

1. More flexibility is supported.
2. Effective in discriminating false alarms.
3. Accurate information is supported.

Disadvantages

1. Not convenient to use at nights and in poor weather conditions.
2. More cost is associated with this kind of aerial detection.

New technologies for fire detection

Remote Sensing Using Satellites- In this system, many sensors are deployed on low-altitude satellite, which perform monitoring, through land surface scanning while completing its orbital trajectory. It allows the capture of infrared images and videos from fires which is very useful in determining the position and extent of the fires. [6].

Advantages

1. Information can be broadcasted.
2. Low operational cost compared to aerial systems.
3. Operational capacity is more and effective.

Disadvantages

1. Prompt response is not supported.

Usually, satellites provide a complete image of the earth every 1–2 days. This long scan period, however, is not acceptable for detecting forest fires quickly.

Surveillance Cameras- These cameras can be used by both terrestrial means as well as aerial. These images through these camera and data of fire are reported to the operators in coordination centres that are communicated through radio links, GPRS, or other communication lines. The operator performs the fire confirmation and verification after getting useful data [6]

Advantages

1. Night detection is enabled.
2. Precision of location as information captured is associated to a GIS;
3. Fine to work with adverse conditions of weather.

Disadvantages

1. Smoke detection is not possible.
2. Installation and maintenance costs are high and
3. They are also vulnerable to theft.

IV. DESIGN ISSUES AND CHALLENGES

Wireless sensor networks have advantages in their application to forest fire detection and monitoring due to its

unique features. But, design issues like limited power resources, vulnerable node structures and harsh environmental conditions should be taken into account for forest fire detection via use of wireless sensor networks. Considering the various challenging conditions which complicate the installation of the network, the following are some of the design goals that are to be satisfied while designing a successful network.

Energy Efficiency

In short, the energy consumption should be as low as possible, since sensor nodes in WSNs are powered with batteries and the energy consumed by different sensor nodes should as balanced as possible for the efficient working, in a wireless sensor network designed forest fire monitoring model. The possibility of dying of a sensor because of energy consumption should be minimized, in order not to cause false-alarm situations regarding the death of sensor nodes. As a result, fair energy consumption should be obtained throughout the network. Energy consumption is also affected by the deployment pattern of sensor nodes.

Early Detection

It is important to detect a forest fire as early as possible and to estimate the fire location with high accuracy. A forest fire usually grows exponentially and it is crucial that the fire should be detected and interfered in about six minutes to prevent the fire from spreading to a large area (National Fire Danger Rating System (NFDRS), 2011). Accurately estimating the fire position is important to send the fire fighting personnel to the correct spot in the shortest possible amount of time.

Forecast Capability

Forecasting the progress of forest fire is another important issue. Forest fires spread very quickly and the fight against forest fires requires accurate and fresh data. Temperature and humidity values, especially from the critical region where the fire has occurred should be propagated to the sink node as soon as possible. Then the sink node at the centre can perform the necessary calculations for forecasting the spread direction of the forest fire rapidly. After making the forecast, the sink node should be able to order the cluster-heads in the critical areas to be more active (send data more frequently to the centre) and less in non-critical.

V. CONCLUSION

The main advantage of using WSNs for environmental monitoring is the increased spatial resolution in comparison to classical monitoring approaches that rely on significantly fewer but more complex and more costly sensors, which usually demand additional infrastructure for power supply and communication. Particular challenges of this application area arise from the relatively large area to be monitored, the usually large number of sensor nodes needed due to their limited sensing range, the nodes' environmental compatibility, and the relatively long operation time aspire.

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