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APPLICATION OF WIRELESS SENSOR NETWORK TO MONITOR FOREST FIRE

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Abstract

A forest fire is a disaster and threat not only to the forest but also to the wild animals, the entire ecology and to the environment. The early detection and monitoring of forest fire with accuracy leads to a boon to the wild life and the inhabitants because, as soon as the detection and monitoring is processed, the necessary and quick actions to that can be taken in time. In this paper we explore the use of wireless sensor network (WSN) for real-time monitoring of forest fire. The objective of this paper is to detect and forecast the information regarding forest fire efficiently and cost-effectively, so that the losses to forest wealth, its inhabitants and to the environment can be optimized.

Keywords

Forest fire, Wireless sensor network (WSN), Sensor node.

Introduction

Forest plays an important role in the balancing of environment, socio-ecological and recreational system. [1] In India the total forest and tree cover is 79.42 million hectare, which is 24.16 % of the total geographical area. Forests have high impact in balancing the equilibrium in atmospheric carbon absorption, regulation of temperature and rainfall, reduction of soil erosion etc. Forest fire also known as Wildfire is a severe disaster [2] which has negative effect on socio-ecological and economical balances. Every year thousands hectares of forest territory is ravaged due to this forest fire. In 2016 more than 4000 hectares of forest were destroyed in the hills of Uttarakhand due to various reasons of forest fire. In some cases forest fire leads to the death of the inhabitants at the affected zone. The main cause of forest fire may be natural like lightning, rolling of stones, and rubbing of dry bamboos due to strong winds or may be accidental fires created due to human carelessness. Forest fire is considered to be one of the causes of global warming. Forest fire detection methods mainly consist of patrolling, observation from watch towers, satellite monitoring or harbour watch system. The conventional methods like patrolling, watchtowers are easy but not effective. The problems with these methods are carelessness of guards, absence from the post, inability for real-time monitoring and the limited area coverage etc. The satellite based monitoring is a popular and most widely used method [2][8] but it requires a long scan cycle and till the completion, fire may have spread in an uncontrolled way. This method covers broad areas but resolution of images is low [3] and sometime clouds and fogs may mask the images which lead to distorted image broadcasting. Forest Watch [14] is another forest fire detection system. These systems are operational in different countries like South Africa (83 towers), USA (22 towers), Swaziland (5 towers), Canada (4 towers), Chile (20 towers), and Slovakia (4 towers). The Harbour Watch system has been deployed in South Africa and Namibia [15] as shown in figure 1. In this approach fire is reliably detected up to a range of 20 km but sometime it generates false alarms. So here we proposed the use of wireless sensor network as a real-time, energy efficient model in detecting forest fire.

Figure 1: Harbour watch system [15]

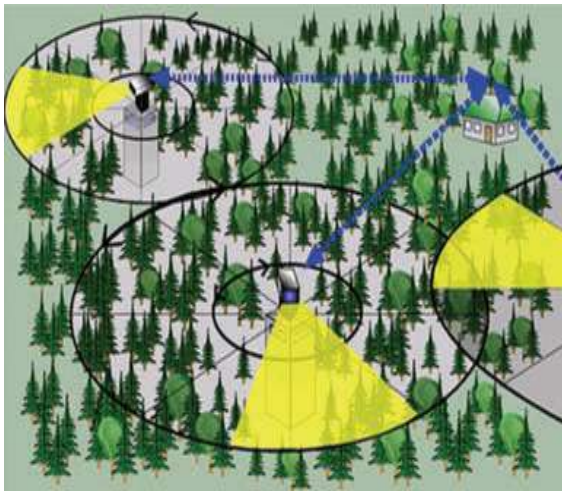

Figure 2: Fire watch system [16]

Related works

Wireless Sensor Network (WSN) is a most versatile research field by using that a lot of research and development work has been carried out in different aspects and areas, one of them is for monitoring and detection of forest fire. Zheping [17] proposed a wireless sensor network for forest fire detection. The design uses low-power IC which increases the stability and reduces the volume. Breejan [18] proposed an autonomous forest fire detection principle based on temporal contrast differences with the natural background and spatial characteristics of the smoke plume. These models were not emphasized on energy efficient sensor model as the sensors work in hazardous areas and works for a long time. Hartung, [20] in his paper presented FireWxNet, as a multi-tiered portable wireless system for monitoring weather conditions in rugged wild land fire environments. They used wireless sensor network for fire detection with web cameras. The issue with this is quality of images which requires processing of images using image processing techniques. Son [21] proposed a project for fire detection in South Korean Forest Fire Surveillance System (FFSS) using wireless sensor networks connected to the internet. They used a MCF (minimum cost path forwarding) as a routing protocol. But the issues are network coverage and localization.

WSN in Forest Fire Detection

A. Introduction to WSN

Wireless sensor network (WSN) refers to a group of spatially dispersed and multiple dedicated sensors for monitoring and measuring the physical conditions of the environment and forecast data in real-time. So for the past few years wireless sensor networks [7] attracts many researchers to implement a real-time, low energy consumption and cost effective network. Sensor networks include a large number of inexpensive, small sensor nodes with few sinks [4]. These sensors detect temperature, pressure, wind, flame and smoke levels of methane [5], carbon monoxide and carbon dioxide [6] and the acquired data can be transmitted through the radio frequency module to the nearest base station.

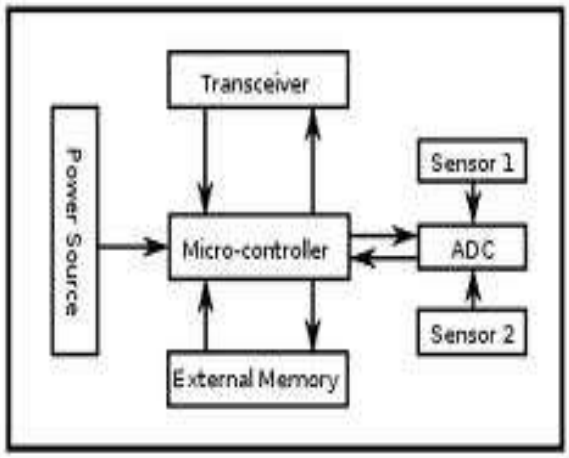

Figure 3: Block diagram of a Sensor node

Figure 4: Sensor node

A sensor node shown in the above figure 3 & 4 consists of sensor module, a processing module, a wireless communication module and a power module [9] [10]. The sensor module senses the different parameters of the environment. The processing module is responsible for controlling the operation of sensor, managing the data collected or transmitted by the sensor. The wireless communication module is responsible for communication or exchange of control information with other nodes. The power module supplies power to the other modules of a node.

The characteristics of a WSN includes

- Scalability to large scale of deployment
- Homogeneity and Heterogeneity of nodes
- Mobility of nodes
- Automatically replaces the failure nodes
- Cross-layer design[11][12][13]
- Power consumption constraints for nodes using batteries or energy harvesting
- Ability to withstand harsh environmental conditions

B. Applications of WSN

Sensor networks are used in many fields and have been deployed in a variety of applications ranging from monitoring a small room to the large area. Some of the application areas are:

- Environmental/Earth sensing
- Area monitoring
- Health care monitoring
- Forest fire detection
- Water quality monitoring
- Air pollution monitoring
- Landslide detection
- Natural disaster prevention
- Industrial monitoring
- Machine Health Monitoring and many more.

C. How it works

In wireless sensor network, a number of sensor nodes are deployed in the forest to monitor and measure the physical factors. The collected data is then sent to the main controller of the monitoring centre for analysis and the analysed results will later be sent to base station/sink as shown in figure.5 & 6 for further actions.

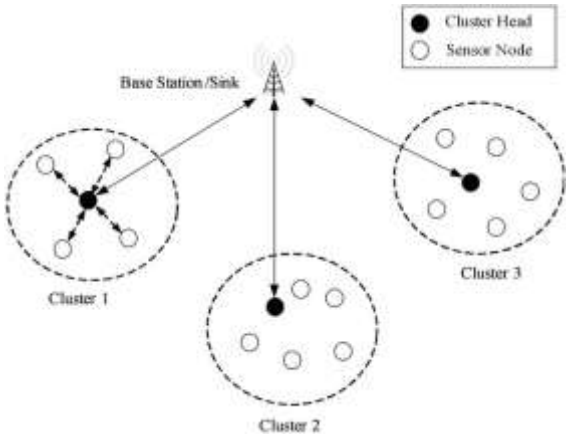

Figure 5: WSN with nodes linked to the base station [22]

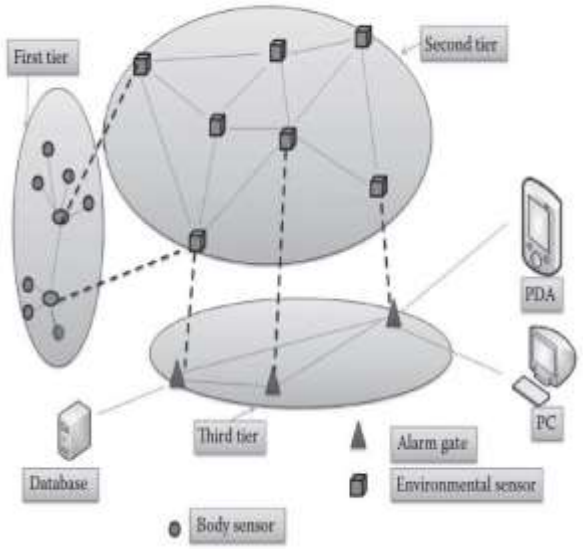

Figure 6: ALARM-NET architecture [19]

D. Architecture of Proposed Model

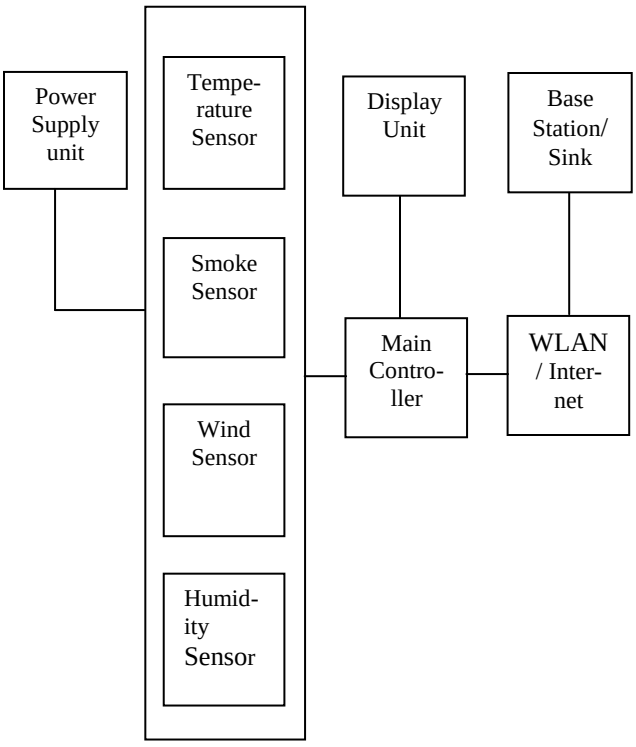

Figure 7: Block diagram of Proposed Model

The proposed architecture shown in figure 7 consists of different modules such as power supply unit, sensor unit, Main controller, display unit & communication unit. Here, the working principle is initiated by supplying power to the sensor module consisting of different sensors. These sensors then collect the required data and send them to the main controller. The controller unit route the detected information to the display unit or to the base station through WLAN/ Internet technology.

Conclusion and Future work

Forest fire is considered to be one of the serious issues for different countries. So they are interested in investing and promoting R & D activities in order to prevent this tragedy. In this paper we discuss various aspect of wireless sensor network in forest fire detection since WSN is considered to be real-time, cost effective and energy efficient model. The practical implementation of our above proposed model is in rigorous progress. We are also planning to use cameras along with the sensor nodes for more accurate results and for the improvement of the image quality we are planning to apply Image processing techniques such as Image classification, Image enhancement, Image restoration etc.

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