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Forest Fire Detection System (FFDS)

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ABSTRACT: As we all know, the forest is considered as one of the most important and indispensable resources and Forest fires represent a constant threat to ecological systems, infrastructure and environmental aspects of a community, forest fire detection is a very important issue in the pre-suppression process. This gives rise to the urgent need to detect forest fires as fast as possible. This paper highlights the powerful feature of wireless sensor networks as a potential solution to the challenge of early detection of forest fires. The device presented makes use of various sensors attached and wireless data transmission, to fulfill the task in question. These collected data are transmitted to the small satellite and the satellite transmits the data to the ground station where they are analyzed. The proposed scheme based on wireless sensor networks performs early detection of any fire threat.

KEYWORDS: TSS (Temperature Sensor setup), GPS Module, Small Satellite, Main and Secondary antenna, WSN (wireless sensor network).

I. INTRODUCTION

A Forest fire is an uncontrolled fire in an area of combustible vegetation that occurs in the countryside or in forest area. India witnessed the most severe forest fires in the recent time during the summer of 1995 in the hills of Uttar Pradesh and Himachal Pradesh. The Forest Survey of India's data on forest fire attributes around 50% of the forest areas as fire prone. They pose a threat not only to the forest wealth, but also to the entire regime of fauna and flora, seriously disturbing the bio-diversity, ecology and the environment of a region. During summer, when there is no rain for months, the forests become littered with dry senescent leaves and twinges, which could burst into flames ignited by the slightest spark. The Himalayan forests, particularly, Garhwal Himalayas have been burning regularly during the last few summers, with colossal loss of vegetation cover in that region.

Forest fires often start unnoticed and spread very quickly, causing millions of dollars in damage and claiming many human lives every year in the many countries. Early detection of hot spots and the initiation of appropriate measures can prevent, or, at least minimize damage and casualties. Common causes of forest fires are lightning, extreme hot and arid weather, severe drought, and human unawareness. Current satellite-imagery-based forest fire detection systems cannot detect forest fires with high precision and accuracy. A Wireless sensor network-based forest fire detection system has the potential to achieve the high detection resolution and accuracy that is required for early detection of forest fires.

II. LITERATURE SURVEY

Forest is considered as one of the most important and indispensable resource, furthermore, as the protector of the Earth's ecological balance. However, forest fire, affected by some human uncontrolled behaviour in social activities and abnormal natural factors, occurs occasionally. Forest fire was considered as one of the severest disasters [1].

In forest fire detection, it is essential to know how fire affects the soil mantle, stems and treetops, as well as how to detect underground fires. The sensor network must cover large areas, distributing high amount of sensing nodes,

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inexpensive sensors are needed to achieve cost reduction [2]. Video cameras sensitive in visible spectrum based on smoke recognition during the day and fire flame recognition during the night, Infrared thermal imaging cameras based on detection of heat flux from the fire, IR spectrometer which identifies the spectral characteristics of smoke gases, and “Light detection and ranging” system which measures laser light backscattered by smoke particles. Infrared and laser-based systems have higher accuracy than the other systems [3].

Generally if the infrared level exceeds a predetermined threshold, an alarm is sent; but this methodology has some drawbacks that affect detection capability and reliability. Detection capabilities are negatively influenced by the fact that often fires are not directly visible from the sensor because during the first phases they grow up in the underbrush and are occluded from the vegetation. On the other hand the smoke (water vapour plus carbon monoxide), copiously produced during the wood drying process, is perfectly transparent in the infrared region (3-7 μm) so it cannot be detected by means of IR sensors. To become directly IR-visible, generally a fire must be at the tree top, so that when it can be detected is already widely extended from the fire starting instant [4].

Handling uncertainty due to data aggregation and missing information requires space-time synthesis in rigorous formalism. Information granulation is at the heart of rough set theory. Rough set theory offers an attribute reduction algorithm and the dependency metric for feature selection [5]. Meteorological data and images are parameters that change over space and time with relatively high frequency. The change of meteorological data could be recognized in hour scale, and the change of image data, taking into account only information connected to forest fires, in minute scale. Also for the forest fire prediction system, meteorological data history (archive values) is quite important. In order to monitor meteorological parameters and collect images in real time, the sensory network has to be established [6]. The most critical issue in a forest fire detection system is immediate response in order to minimize the scale of the disaster. This requires constant surveillance of the forest area. Current medium and large-scale fire surveillance systems do not accomplish timely detection due to low resolution and long period of scan. Therefore, there is a need for a scalable solution that can provide real-time fire detection with high accuracy. We believe that wireless sensor networks can potentially provide such solution. Recent advances in sensor networks support our belief that they make a promising framework for building near real time forest fire detection systems. Currently, sensing modules can sense a variety of phenomena including temperature, relative humidity, and smoke which are all helpful for fire detection systems [7].

III. IMPACTS OF FOREST FIRES ON BIOLOGICAL ENVIRONMENT

Forest fires also pose serious health hazards by producing smoke and noxious gases, similar to the events in Indonesia after the forest fires on the islands of Sumatra and Borneo in 1977 have shown. The burning of vegetation gives off not only carbon dioxide but also a host of other noxious gases (Green house gases) such as carbon monoxide, methane, hydrocarbons, nitric oxide and nitrous oxide, that lead to global warming and ozone layer depletion. Burning forests and grasslands also add to already serious threat to the environment and also in global warming.

IV. FOREST FIRE DETECTION SYSTEM (FFDS)

It is well known, there will be large variations/increase in temperature from the normal temperature whenever forest fire occurs. This can be detected/ monitored continuously by using temperature sensors and in accordance with the simple arrangement of transmitters. This concept is quite reliable and cost-effective in detecting of forest fire's since simple equipment's are arranged in a simple configuration and also GPS is used in this project to get the location of the forest fire.

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V. SYSTEM DESIGN

Mainly this project contains 6 subsystems:

1) Main data collecting transmitters with antenna 2) Data receiver with secondary antennas 3) Temperature sensors 4) GPS module 5) Satellite 6) Ground station receivers.

VI. IMPLEMENTATION

Temperature Sensor Setup (TSS) and GPS Module are kept in a glass case/ box which are designed to withstand a high temperature and are located few feet above the ground. The TSS consists of Wired/Wireless temperature sensor and its associated circuitry, LNA (low noise amplifier) and power amplifier. Both the TSS and GPS Module are interfaced with the Microcontroller. This arrangement is connected to a Secondary transmitter. The function of the Secondary transmitter is to transmit the data/signals from Microcontroller to the Main transmitter cum antenna. The data from the main transmitter will be communicated to an orbiting small satellite. The main antenna's function is to transmit the signals to the satellite.

The satellite receives all the data from all such transmitters and transmits to the ground station where continuous monitoring of the data/signal takes place. At the ground station, the co-ordinates from the GPS and the TSS reading are decoded.

VII. WORKING

A) SITUATION 1 (CASE1): During Normal situation [No forest fire]

At the time interval 'X' and if the Temperature is 'T' which is the output of the TSS arrangement at the normal condition that is when there is no forest fire. This will be the initial readings from the setup and these readings will be the reference data/value for further observations. Since the setup is continuous monitoring process there will be some spikes/slight variation in the temperature sensed by the TSS arrangement because of physical reasons like temperature of the forest going high during summer, possibly lightning etc but such slight variations can be neglected.

B) SITUATION-2 (CASE2): During the forest fire:

The Basic observation during the forest fire is that the "Temperature of the environment goes very high and deviates more from the normal temperature readings". This criteria boost's up the probability of finding the forest fire using temperature sensors. Since during the forest fire, the surrounding temperature goes high the value/ output from TSS arrangement deviates more from the initial and basic reading. Then at the time interval 'X+nth', the temperature will be 'T+N' (N-increased value). Since this is a 'continuous monitoring system', the increased temperature is detected at monitoring systems of the ground station. The circuitry is developed in such a way that when the output of the TSS arrangement is increased/ deviated from fixed threshold value of temperature, the circuit triggers the GPS module to send the co-ordinates to the satellite and then satellite transmits these co-ordinates as a data to the ground station where it is decoded to know where exactly the forest fire has occurred.

VIII. BENEFITS

The arrangement is fire-proof and can withstand high temperatures, rugged, reliable, cost-effective, and easy to install. It is also easy to decode the data from satellite at the ground station and no experts are required to understand or

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decode the data from the satellite. All the components like temperature sensor and the GPS are easy to interface. The approximate value of temperature and the GPS co-ordinates are obtained. Since we are using wireless sensing networks, the attenuation during the transmission of the signal or the data is minimised.

IX. CONSTRAINTS

This project has some constraints, which can overcome easily with proper arrangement, alignment, and observations. The main constraints of this project are 1) Using/Installing of too many secondary antennas and directing them to the main antenna is critical. 2) Since it is quite difficult to keep a large number of sensors in the huge forest, only a few testing points (5-6 sensor's for demonstration) in the forest are decided and implemented 3) Continuous power supply to the TSS and Antennas. 4) Seasonal/ climatic changes.

X. CONCLUSION

This concept is just a basic one. The further development of the project can be done in a larger configuration by using the better and reliable sensor not only a temperature sensing kind of sensor and which has multifunctional features which are embedded in/on the same component or an IC. These may be implemented in an operational scenario, once the concept is demonstrated.

We can use Nano-satellite / Pico-satellite (small satellite) which is very small compared to normal satellite. A group/cluster of Pico satellites may be used to receive the data from the transmitter which is at the forest region and then transmitting to the ground station. When we are using cluster of small satellites, we may also consider using small satellites for different purposes like monitoring the forest fire, vegetation of the forest, for monitoring the climate changes of that particular area like this in low cost. Since the proposed project is easy for the installation due to the simple arrangements, the time frame for developing and integrating the sub-systems and installation process is less. Even for the demonstration purpose we can put up the fire manually in any plain land and we can test for the working of these components.

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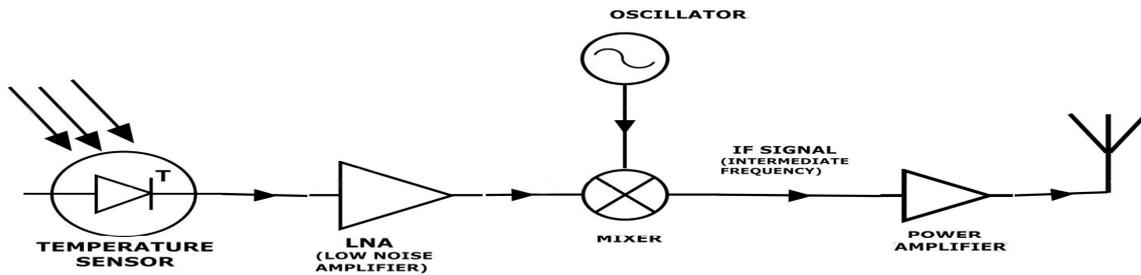
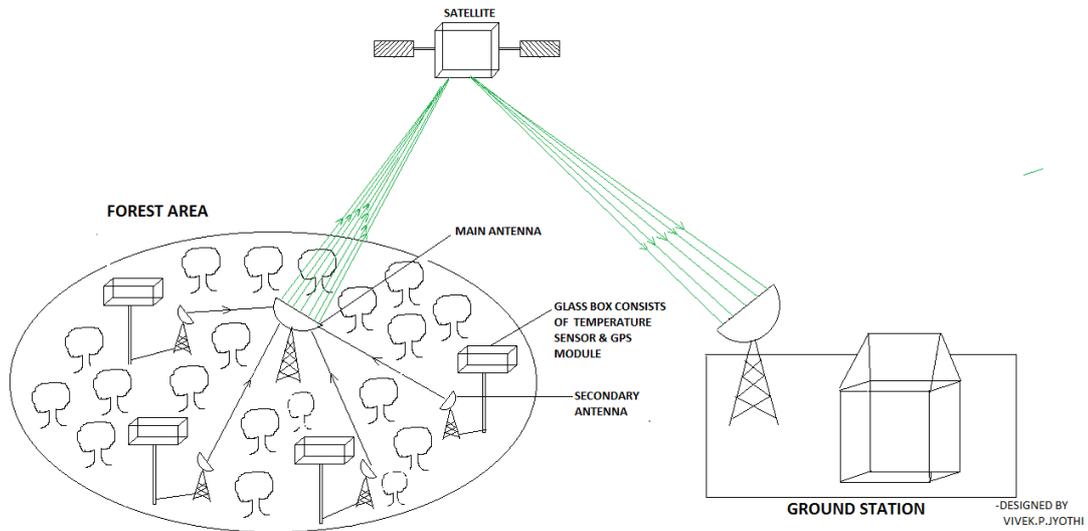
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XI. PROPOSED FFDS SYSTEM SETUP



SENSING THE TEMPERATURE & SENDING SIGNALS TO SATELLITE THROUGH T_x ANTENNA

XII. BLOCK DIAGRAM