IoT based forest fire detection system

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PROBLEM STATEMENT UNDERSTANDING

What is a forest fire?

Forest fire, uncontrolled fire occurring in vegetation more than 6 feet (1.8 m) in height. These fires often reach the proportions of a major conflagration and are sometimes begun by combustion and heat from surface and ground fires. A big forest fire may crown—that is, spread rapidly through the topmost branches of the trees before involving undergrowth or the forest floor. As a result, violent blowups are common in forest fires, and they may assume the characteristics of a firestorm.[1]

Causes of forest fire?

Forest fires always start by one of two ways - naturally caused or human caused. Natural fires are generally started by lightning, with a very small percentage started by spontaneous combustion of dry fuel such as sawdust and leaves. On the other hand, human-caused fires can be due to any number of reasons. Some classifications include smoking, recreation, equipment, and miscellaneous. Human-caused fires constitute the greater percentage of forest fires in our forests, but natural fires constitute the great majority of the total area burned. This is because human-caused fires are usually detected early in their duration, and therefore they are usually contained easily. Natural fires, on the other hand, can burn for hours before being detected by firefighting authorities.[2]

How forest burns fire?

There are three elements that are required for a forest fire to burn: Heat, Oxygen, and Fuel. This is the so-called "fire triangle". Without all three of these elements, the fire will go out. Furthermore, the fire will spread in the direction of the most abundant supply of the three elements, while its rate of combustion is usually limited by one of the three elements. Once the fire enters the combustion stage, there are three main types of classifications for the fire. A smoldering fire is one that emits smoke but no flame and is rarely self-sustained. A fire is classified as flaming combustion when flames are present. Charcoal can be formed in the absence of oxygen with this type of fire. Glowing combustion is a later stage of the fire and is characterized by a slower rate of combustion and blue flame. Forest fires can also be classified by what part of the forest they burn in:

i. Ground fires occur on the ground, often below the leaves.
ii. Surface Fires occur on the surface of the forest up to 1.3 meters high.
iii. Crown fires are the most dangerous fires and can spread the fastest. They occur in the tops of the trees. They can be:

(a) dependent upon surface fires to burn the crowns.

(b) active in which they occur at the same rate as surface fires

(c) the most destructive, independent, where fire can "jump" from crown to crown.[2]

Effect of forest fires

Wildfires can have immediate and long-term effects on the quality of rivers, lakes, and streams. The most noticeable impact of wildfires is stormwater runoff. After the loss of vegetation, the ground's soil becomes

hydrophobic and prevents the absorption of water. This inability to absorb water promotes the transportation of debris and sediment into larger bodies of water, further polluting valuable and essential resources. Post-fire flash floods become a threat and allow the introduction of heavy metals from ash and soil to infiltrate waterways. Filtering these water sources can be costly as well as time consuming.
Depending on the temperature and time of year a wildfire occurs, vegetation can be significantly impacted. Plants on the forest floor or smaller trees are often destroyed by wildfires, while larger trees are able to survive as long as the fire does not spread into the tree canopy. The flames from these fires destroy the food source and homes of many animals, threatening their survival. For plants and trees that can survive the flames, they are susceptible to disease, fungus, and insects due to their decreased resistance following burn injuries.
Wildfires have both immediate and long-term impacts on air quality. As a forest burns, large amounts of smoke are released into the atmosphere. These smoke particles are typically small and made up of gases and water vapor. Air pollution from fires have the potential to travel great distances and oftentimes may pose a threat to human health. These small particles can become lodged deep within our lungs, making it difficult to breath as well as placing additional stress on our hearts. Additionally, wildfires produce an increased amount of carbon monoxide, which too can lead to a variety of health implications.[3]

Solutions

To overcome the natural and manmade forest fires there are 2 things that we can do. Firstly, prevent manmade fires by taking precautions on individual levels and secondly, of the fire caught is natural, we have to have proper devise, protocols and resources to terminate the disaster to turn into a large scale one.
To prevent these fires, it is advisable that we detect it when it is at a very small scale, so that large scale destructions can be prevented. To do so, an idea of IoT based forest fire monitoring system is discussed in this report using various sensors that can detect the fires and indicate us to take the necessary measures to prevent it.

HARDWARE AND SOFTWARE

Hardware

- IR Flame sensor: The IR flame sensor is used to detect the presence of fire or other infrared source.
    - Range: 760 nm to 1100nm (light wavelength) [5]
- DHT11 Sensor: The DHT11 is a basic, ultra-low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data. Temperature Range: 0°C to 50°C. Humidity Range: 20% to 90% Resolution: Temperature and Humidity both are 16-bit. Accuracy: ±1°C and ±1% [4]

- Ionization and photoelectric smoke detector:
    - **Ionization smoke alarms** are generally more responsive to flaming fires.
      How they work: Ionization-type smoke alarms have a small amount of radioactive material between two electrically charged plates, which ionizes the air and causes current to flow between the plates. When smoke enters the chamber, it disrupts the flow of ions, thus reducing the flow of current and activating the alarm.
    - **Photoelectric smoke alarms** are generally more responsive to fires that begin with a long period of smoldering (called "smoldering fires").
      How they work: Photoelectric-type alarms aim a light source into a sensing chamber at an angle away from the sensor. Smoke enters the chamber, reflecting light onto the light sensor; triggering the alarm.[6]
    - The characteristics of an ionization detector make it more suitable for detection of fast flaming fires that are characterized by combustion particles in the 0.01 to 0.4-micron size range. Photoelectric smoke detectors are better suited to detect slow smoldering fires that are characterized by particulates in the 0.4 to 10.0-micron range. Each type of detector can detect both types of fires, but their respective response times will vary, depending on the type of fire.[7]

- TEMP6000 sensor module: TEMT6000X01 ambient light sensor is a silicon NPN epitaxial planar phototransistor in a miniature transparent 1206 package for surface mounting. It is sensitive to visible light much like the human eye and has peak sensitivity at 570 nm.
    - Angle of half sensitivity: $\varphi = \pm 60°$ [8]
    - wavelengths in the range of 390–700 nm, which roughly covers the entire spectrum of visible light.
    - this won't pick up infrared, ultraviolet, or any other light we can't directly see.[9]

- RASPBERRY PI

- GSM modem

- GPS module

Software

- Arduino IDE
- Proteus Design Suite
- Python

ADDITIONS AND UPDATE

Nowadays, two different types of sensor networks are available for fire detection, camera surveillance and wireless sensor network. The development of sensors, digital camera, image processing, and industrial computers resulted in the development of a system for optical, automated early recognition and warning of forest fires.

Different types of detection sensors can be used in terrestrial systems:

(i) video-camera, sensitive to visible spectrum of smoke recognizable during the day and a fire recognizable at night,

(ii) infrared (IR), thermal imaging cameras based on the detection of heat flow of the fire,

(iii) IR spectrometers to identify the spectral characteristics of smoke,

(iv) light detection and ranging systems—LIDAR (detection of light and range) that measure laser rays reflected from the smoke particles.[10]

These devises can be used for better output of our project. Also, at the output end, a user-friendly interface is to be build so that the output can be observed as soon as possible and actions can be taken to prevent the fires.

APPLICATION

Millions of hectares of forests are destroyed by fire every year. Ares destroyed by these fires are large and produce more carbon monoxide than the overall automobile traffic. Monitoring of the potential risk areas and the early detection of fire can significantly shorten the reaction time and also reduce the potential damage as well as the cost of firefighting.[10]

ADVANTAGES

- Early Fire Detection**:** An audible or visual signal enables you to seek safety soon after the fire starts.
- Placement Flexibility**:** A fire alarm can be placed just about anywhere you want.

- 24/7 Monitoring**:** Fire alarms provide constant protection, weather you are present at that place or not.[11]
- Quick action can be taken: The quicker the message is received, the faster the firefighting staff can take action.
- It can help us save a huge portion of environment.
- It will be economically affordable and easy to install.

CONCLUSION

An efficient way of saving forests from unwanted fire will be created using various sensors and modules. In order to enhance safety, fire detection systems need to be provided a higher level of information and continue to operate throughout the emergency situation.

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