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Review Article

Forest Fires: Challenges and Impacts

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Abstract

As we all know; the forest is considered one of the most important and indispensable resources. 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. Among the great disasters on this earth are forest fires. Many attempts to detect disaster events have been made with the aid of monitoring technology. Nevertheless, the problem is that the sensor is less responsive in detecting the presence of the fire. Moreover, sending data about fire incidents throughout the forest cannot use the existing communication podium. Thus, the design of a forest fire monitoring system is required. This technology is based on wireless, which can transmit information across the forest. To detect the presence of fire, an Arduino microcontroller is used as the brain of the research to regulate input from the AMG8833 sensor and GPS Ubox 6M. In the research, it is seen that the AMG8833 sensor is more sensitive in detecting the presence of fire as the catch range changes between 2.5 to 10 meters. In that distance range, hotspots were detected from 19.25 °C to 122.5 °C when testing of the sensor node was done.

Keywords: Fire Detection; AMG8833; LoRa; Arduino.

INTRODUCTION

Fire is a catastrophe that always causes many undesirable things and can result in many losses: material losses and threats to human life safety. One of the major disasters is forest fires. The forests have many functions for human life. This includes forests as a source of oxygen and medicine. The forests prevent wind and flooding. They also provide jobs and many other forest functions [1], [2]. These functions the forest provides will be lost when this forest burns. Many efforts to minimize the occurrence of fire disasters in forests have been carried out both technologically through environmental monitoring systems [3], [4]. In this research, monitoring is carried out by observing the variables of changes in the environmental temperature [5-7]. If climate change rises harshly, the potential for forest fires is quite high. The use of several tools, such as a temperature sensor, gas sensor, and fire sensor as a fire detector, indicates the use of existing environmental monitoring system technology. Nevertheless, this effort is still not the best in terms of the detection sensitivity of the sensor [8-10]. Another issue is the information transmission from sensor readings to monitoring systems that still rely on the internet network. In general, connecting to the internet network in forest zones is enormously problematic [11–13]. Consequently, it is essential to create or install a monitoring system that is more ideal in terms of long-range and sensor sensitivity data transmission without relying on the internet network connectivity in the forest areas. The potential problem-solving in this research is through a forest digitization method. The term forest digitization applies to the latest technology for monitoring, information procurement, and information transmission [14].

Information procurement is obtained from the sensors that have virtuous exactness in detecting the presence of fire and a large monitoring area, namely AMG8833 [15]. This fire detection sensor is based on a thermal camera to recognize even small fire points. Long-distance wireless communication-based tools, such as LoRa [17]-[21], can be used to inform data communication networks about forest fires in real time. There have been several earlier studies regarding thermal camera sensors and LoRa. Thermal camera sensors are used for tracking and facial recognition because there is abuse in facial manipulation by using excessive makeup and using masks that do not follow the rules [22], [23]. In addition, a thermal camera sensor is used to find out the whereabouts of a person somewhere [24]. This sensor is even capable of measuring a person's body temperature [33]. During the COVID-19 pandemic, tracking human activity is very important to know the scope of the distribution area marked by an increase in body temperature, especially in a closed room [25]. This thermal camera sensor can be used because there is a connection between the increased body temperature and identifying someone positive for COVID-19 [26]. In education, thermal camera sensors monitor a teacher to prevent learning focus from dropping in engaging learning activities [27]. In terms of information transmission, the use of LoRa as an early warning system for forest fires in Riau Province can send information from sensors to a gateway as far as 30 miles [28]. Thus, this research focuses on developing a monitoring system that can detect the presence of fires and monitor forest fires in real time. This study proposes using AMG8833 to improve the detection technology over the existing sensors [29], [30]. This thermal camera sensor has never been used in a fire monitoring system, so this research is unique in the field of forest digitization. In addition, the use of information communication technology for forest fire monitoring systems is likewise installed with low-power wireless devices in the form of LoRa-IoT. It is hoped that this work can contribute to efforts to anticipate forest and land fires, especially in South Sumatra. In this study, we used the Arduino microcontroller for sensor nodes. This microcontroller is attached to the AMG8833 sensor and the Ublox 6M GPS module on the input pin. On the output pin, there is LoRa-Tx (module RA-01), which is called the transmitter. The AMG8833 sensor is a thermal camera type sensor with a reading capability of 0 °C to 80 °C [31]. This thermal camera sensor will detect the presence of hotspots. The AMG8833 reading results will be transformed into an image with a resolution of 8x8 (array) through I2C communication. The GPS module will then initiate the coordinates of the fire. At the same time, the Lora-Tx will publish information obtained from the thermal camera sensors and GPS module. This section used the Arduino microcontroller and installed LoRa-Rx (RA-01), which is called a receiver, and ESP8266. This microcontroller will process information from LoRa-Rx through the LoRa-Tx pin as an information traffic controller. The collected information is then continued to the ESP8266 on the Wi-Fi pin. Users can access it after the ESP8266 publishes information to the Blynk App (cloud). The design of a forest fire monitoring system consists of two main sections. In the first part, there are sensor nodes placed in the forest. The forest areas usually do not have internet access services, so LoRa-Tx must send information to the gateway. In the second part, there is a gateway (LoRa-Rx) that receives information from LoRa-Tx. Then the gateway will send the sensor data to the cloud service, which can then be processed and monitored by the user. For the experimental scenario in this research, two stages were carried out, namely the stage of testing the responsiveness of the sensor node and the gateway connectivity when receiving information from the sensor node. The second stage of this experiment is to measure the information transmission signal strength (RSSI) between the sensor node and the gateway. This was especially true for the second stage of the experiment, which was carried out by placing sensor nodes at five different points (locations), where each point was 100 meters away. The software design transmits data from the AMG8833 sensor readings and GPS (sensor node). The software design is made to trace information from the gateway (base station) to the cloud. The AMG8833 sensor carries out fire detection in the sensor node. The Arduino's temperature information acquisition comes from digital and analog input/output pins. This sensor node sends data over a LoRa-Tx connection. The information sent by the Lora-Tx will reach the cloud through a LoRa-Rx link (gateway). The user can monitor the processed information to ensure that a forest fire is detected at a certain point. The AMG8833 sensor is set up on the microcontroller to respond to a temperature of 60 °C. The threshold value is set as the basis for detecting forest fires. The detected temperature value will be recorded and represented in an image in 64 pixels (array) of AMG8833. Of the 64 pixels, only one value with the highest temperature will be taken. The GPS on the sensor nodes is used to determine the location of forest fires [32].

The components used in the implementation of the forest fire detection system

1. Arduino microcontroller

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. This board is equipped with sets of digital and analog input and output pins that may be interfaced to various expansion boards and other circuits.

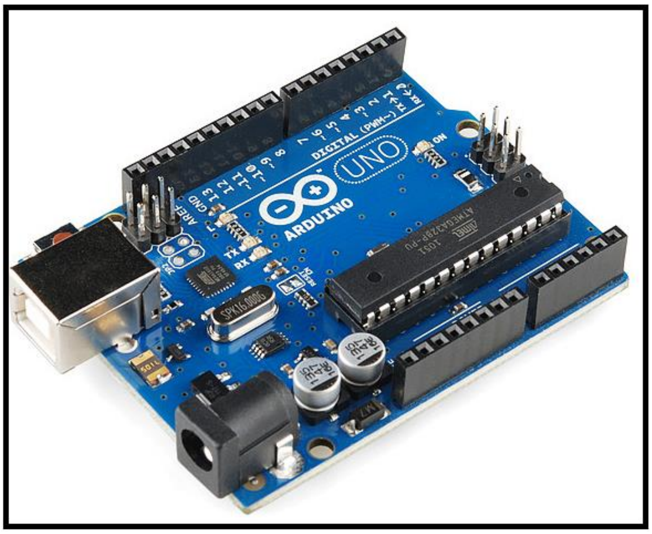

Fig. 1: Arduino

2. AMG8833 Sensor:

The AMG8833 sensor from Panasonic is an 8x8 array of infrared (IR) thermal sensors. When this sensor is connected to a microcontroller or raspberry pi, it will return an array of 64 individual infrared temperature readings over I2C. It's like those fancy thermal cameras, but compact and simple enough for easy integration. This part can measure temperatures ranging from 0°C to 80°C (32°F to 176°F) with an accuracy of +-2.5°C (4.5°F). It can detect a human from a distance of up to 7 meters (23.3 feet).

Fig. 2: AMG8833 Sensor

3. Lora Module:

The LoRa module is a device that provides wireless connectivity over the Lora WAN protocol. LoRa is wireless technologies that offers long range, low power, and secure information transmission for M2M and IoT applications.

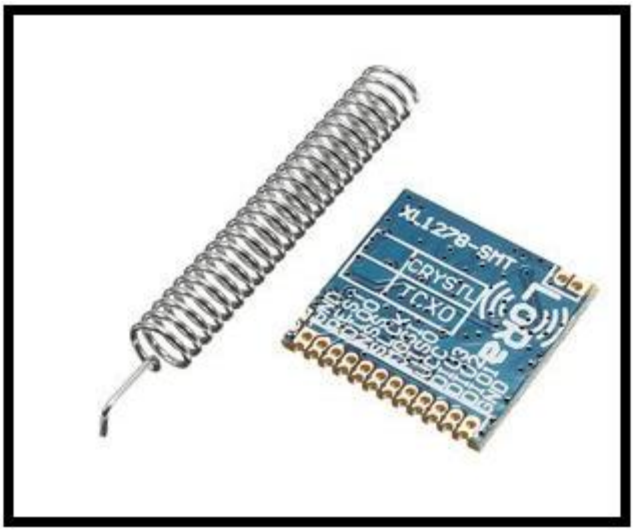

Fig. 3: Lora Module

The impact of the forest fire

1. **Forest fires aid in killing disease.**
There are several insects and diseases that will prey on the growth of the forest. Though we fight fires to save trees, the fact is that more insects kill trees every year than forest fires do. Without fire, a forest struggles to adapt to infestations and sets the stage to have a more serious fire later on than if a controlled burn took place right now.
2. **It provides nutrients for new generations of growth.**
The forests need to experience change in order to survive. Fire aids in encouraging the decomposition process of vegetative matter so that nutrients return to the soil. Some plants even need the intense heat from fire to be able to begin the germination process. If fires were prohibited constantly in a forest, eventually it would just grow old and die because there wouldn't be another generation to take its place.
3. **It refreshes the habitat zones.**
Fire clears out plants and trees to make more natural resources available to the habitat. Fewer trees means more water becomes available for the remaining plants and animals that call the area their home. New grass and shrubs are food sources for a number of animals as well. Ground cover that comes back after a fire becomes a new micro-habitat. Everything is refreshed with a fire.
4. **Low-intensity fires don't usually harm trees.**
The bark of a tree is like an armored shell against fire, pests, and other things that could damage them. Most forest fires burn at low temperature levels when conditions are optimal and this causes minimal damage to the trees of the forest when it occurs. The end result is a clearing of the ground floor of the forest while the trees are able to continue standing majestically.

The disadvantages of forest fire

1. **A forest fire sets up the potential for soil erosion to occur.**
The forest fires clear the underbrush away and encourage new growth, but there is a period of time between the fire and the new growth where the forest is exposed. A heavy rain can create a tremendous amount of soil erosion which can lead to landslides, river contamination, and danger to people and wildlife in the area.
2. **Forest fires always bring death in some form.**
Maybe it's just the weak plants of the forest that are killed during a fire, but there is always some sort of death that occurs when a fire occurs. Sometimes it is the firefighters who are tasked with stopping the fire. It could be animals or pets. Homeowners who went back to save their homes have been trapped in the fire as well. This is why it is so important to recognize the dangers of a forest fire so it becomes possible to reach safety.
3. **Uncontrolled fires can cause localized air pollution.**
Despite the amount of global development that has occurred, there are many forests that are difficult or nearly impossible to reach. Fires in these areas are left to burn in an uncontrolled fashion, and this creates air pollution that can affect the local environment and make it difficult to breathe.
4. **Homes can be destroyed without compensation.**
Did you know that many homeowners' insurance policies don't cover damage that would be caused by a forest fire? It may be required as a rider to a policy instead of being included in the general policy. This may leave property owners with nothing after a forest fire goes through because they didn't double-check their insurance coverage on a regular basis [34].

CONCLUSION

The AMG8833 sensor is very responsive in detecting the presence of fire. Changes in the detection distance to the gradation of color changes in the sensor array provide a significant value. Second, the test results of the sensor and gateway nodes show the success of the two tools in sending and receiving information with a size of about 30 bytes for one send. Third, the implementation of LoRa in the forest provides performance in the form of communication capabilities as far as 500 m. The advantages and disadvantages of forest fires are discussed also.

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