International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 07 | July 2020 www.irjet.net p-ISSN: 2395-0072

Early Forest Fire Detection with the Internet of Things

Mourya Mahidhar Mindi, Mandavilli Premchand

[1]*B. Tech student, Mechanical, MVGR College of Engineering, Vizianagaram, India*
[2]*B. Tech student, Mechanical, MVGR College of Engineering, Vizianagaram, India*

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Abstract – *A drastic increase in natural calamities was seen by the earth in the past decade. Many of these were due to pollution, technical error negligence, and sometimes geological faults. Whatever the catastrophe maybe there will be loss of lives, assets, forced migrations, and many other worse effects. Out of all, the worst calamity the earth is facing is the forest fires. These wash away countless flora and fauna every year. Stats say that if the fires were discovered in the very first moments, and immediate actions were taken to control them, the matter wouldn't have turned into an issue. That's the reason why researches started taking place across the globe trying to figure out a solution for early detection of these fires. These counts started from conventional observation towers. The idea of using sensors and microcontrollers here made the work easier. The most used forest fire detection system until the concept proposed here is a wired system with sensors, microcontrollers, and processors. But considering an important disadvantage of the wired system that wires get damaged during the fires and data transfer becomes non-reliable, a wireless system using the Internet of things is developed. It is the best way to serve the purpose with no risk to mankind. This makes the system work efficiently delivering reliable information to the monitoring office.*

***Key Words*: Calamities, Flora and Fauna, sensors, microcontrollers, reliability, Internet of things, monitoring office.**

1. INTRODUCTION

In this day and age, natural calamities come on the spur of the moment and leave a tremendous loss on mankind, property, flora, and fauna. The catastrophe may be an avalanche, tsunami, cyclone, or drought. One such devastation is forest fires, also called wildfires, wildland fires, rural fires, or bush fires. They are responsible for 32% of global CO, 10% of methane emissions, and over 86% of soot emissions every year. It's due to the release of immense quantities of carbon stored in tree populations and soils by the fires. But they play a vital role in maintaining the plant and life as sunshine and rain for over 46% of ecoregions on earth [1]. They may not be a matter of consideration until the forest fires become more minacious and eat up the forests and species. Forest fires, if not identified and controlled initially, would leave a remarkable scar. An area of 700,000 to 1 million hectors in the Mediterranean region gets slain by these fires every year. Reports say that nearly 906 thousand hectors, 2.3 million animals of Amazon habitat were burned down during Amazon wildfires in 2019. Australian government declared a state of emergency in November 2019 due to the record-breaking bushfires that did away with nearly 1.25 billion animals.

Stats say forest fires occur mainly due to human negligence or arson. Lightning is responsible only for 7% of the fires. Henceforth, whatever the cause may be, the late detection of catastrophe threatens our very own existence. Thanks to modern solutions, science served us with the Internet of things. In a sentence, the internet of things is the concept of connecting any device to the internet and other connected devices [2]. In this situation, describing "The rule of 30" really makes a lot of sense [3]. It says the 3 important factors that conduct forest fires: temperatures below 30°C, humidity mark below 30%, and wind speed value above 30kmph in the same area. Proper usage of the data can assist in the identification of areas which has a high probability to catch fires and in sequence to utilize the setup to detect the fires and prevent loss.

In this experimentation, we have tried to make use of atmospheric pressure, humidity, and physical parameters: fire and smoke to detect the calamity. The measure of hazardous CO gases that are usually omitted during wood burn is really important in air quality management. The setup consisted of sensors and actuators assisted by IoT is developed to detect the fire, alert the forest agencies as well as to indicate the location and intensity to them.

2. PROPOSED SYSTEM:

A wireless system employed with sensors and transmitters that works for collecting information, transmitting it to the ad-hoc style offices and indicate the intensity of forest fires to the forest safety management is developed(fig – 1) Geographical and climatic conditions of that area taken from records help us predict the forest fire situation in the very first line. But that prediction serves as a blind reference. However, the sensors employed would detect even normal weather conditions. So, based on the record data, critical points can be fed to the microcontroller so that they indicate an emergency only if the parameters cross safety values. The proposed system based on IoT consists of mainly the following components: Sensors, microcontroller, 4G module, transmitters. Sensors and microcontroller than can be best employed in this system are proposed below. These are so far the best that can be used from that of available from the market.

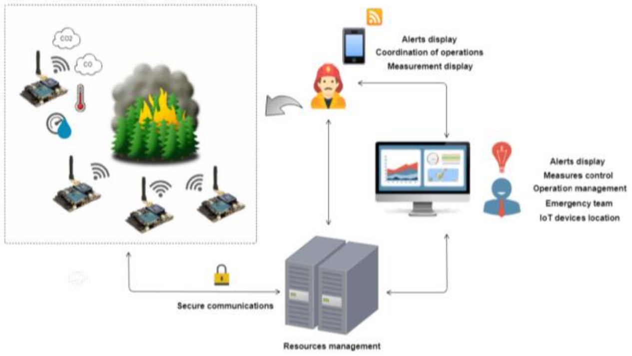

Fig – 1: Operation of the system [4]

2.1 Fire Detection Sensor:

Fire causes the rise in temperature which can be sensed using a temperature sensor. The best sensor that can be used for temperature rise in forest fire detection is AD595AQ (fig-2). These are manufactured by 'Analog devices.' It is a complete instrumentation amplifier with thermocouple cold junction compensator on a monolithic chip [5]. This sensor runs from 5V to 15V with a sensing range accuracy of ±3°. Its temperature measuring capacity is from -55°C to +125°C. The sensor is to be programmed so that it indicates the temperature if it exceeds 30°C more than the weather conditions.

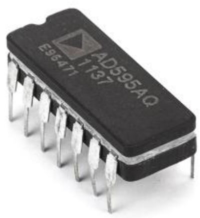

Fig – 2: AD595AQ Temperature Sensor

2.2 Humidity Detection Sensor:

Humidity is the amount of vapor present in the atmosphere. DHT 11(fig – 3) is the most suitable humidity sensor of all. It provides information about atmospheric humidity from 20% to 80% with 5% accuracy. Apart from its principal function of measuring humidity level in the atmosphere, DHT 11 also measures temperature of range 0-50°C with 2-degree accuracy. This temperature measuring ability can be used as a front-line indication to check whether the temperature in this sensor's proximity is at safe levels. Also, the sample reading 1Hz makes it very precise. It needs a very low operating voltage from 3V to 5V with a maximum current that draws being 2.5mA.

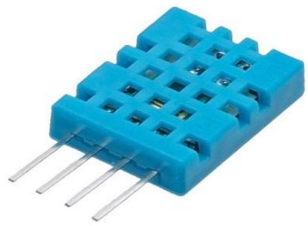

Fig – 3: DHT11 Humidity Sensor

2.3 Relative Atmospheric Pressure sensor:

To measure the relative atmospheric pressure, a barometric pressure sensor should be used. For this purpose, OMC 509 pressure port (fig -4) is the best-suited component. It inputs effective static pressure to the barometric pressure sensor. Generally, wind speed above 20m/s makes it difficult for barometer inlet tube which in turn makes errors up to 4 millibars. To avoid these errors a unique parallel plate design is employed in this pressure port. It reduces the dynamic pressure errors by slowing the wind speed at the inlet. There is extremely light in weight and has 0.5mb maximum dynamic pressure error at 20m/s. [6]

Fig – 4: OMC 509 pressure port

2.4 CO emission sensor:

To detect the CO and other flammable gases in the forest, the MQ9 smoke detection sensor (fig – 5) can be installed. The method of sensing CO of this sensor is cycle high and low temperature and detects the CO when the temperature is low (it gets heated up to 1.5V) and its conductivity rises as the temperature rises (up to 5V). It can detect CO from 200-2000 ppm. Alongside CO, it can also sense the levels of methane (500 -10000ppm) and LPG (500-10000ppm).[7]

Fig – 5: MQ9 smoke sensor

2.5 Microcontroller:

Arduino Uno (fig -6) can be used as it is cheap, very much available, and best at functioning. It is based on the ATMEGA 328P microcontroller. It is easy to connect to any computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. It can operate with very little voltage of 5V. It also has a flash memory of 32kb which is very high enough for this project.

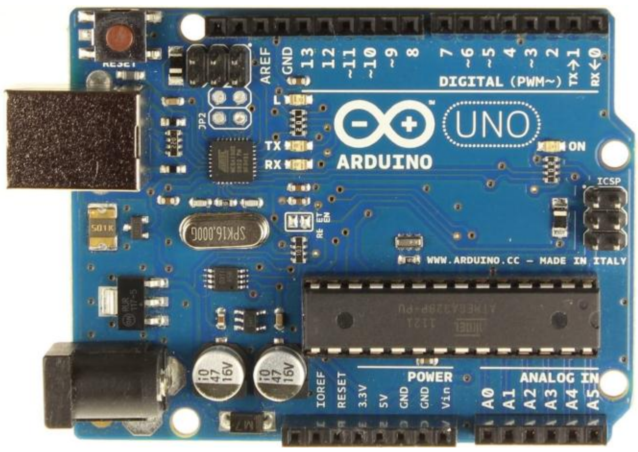

Fig – 6: Arduino Uno

3. WORKING OF THE SYSTEM:

The sensors should be pre-arranged with individual power supplies and their battery status should be indicated through a mobile application to assess it in real-time. Sensor assisted systems should be set out at distant locations in the forest where the inspection can be done covering the whole arena. The whole architecture of the IoT enabled system is presented as a block diagram (fig – 7). Here the rule of 30, as mentioned earlier plays a significant role. The sensors will be fed with the instruction to notify only if the parameters there cross the preset values.

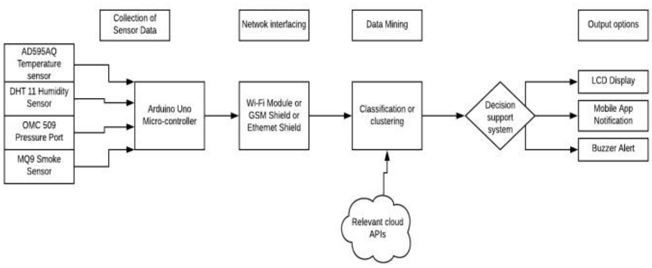

Fig – 7: Architecture of the proposed IoT system

Arduino which contains ATMEGA 328P microcontroller collects the data, processes it, and transmits it through the transmitter. There are a lot of transmitters available in the market which are compatible with Arduino Uno and can transmit the signals for long ranges. Once all the required data is collected, it is sent to the transmitter that transmits data to a certain range to reach the forest safety monitoring station. The receiver collects the data from the transmitter. Then the receiver sends the data to the controller IC of the attached Arduino Uno embedded in the receiver circuit in digital form making the controller possible to do the programmed actions for monitoring the parameters. The receiver circuit's Arduino is programmed with a lot of library functions for the ethernet shield interfacing. This allows us to create a webpage in a locally created network. It can be named as a Fire detection system using a router. Arduino Uno is connected to the internet with the help of the ethernet that is already connected to the microcontroller. Ethernet shield R3 can be used. It is based on the Wiznet W5100 ethernet chip. It provides a network (IP) slack capable of both TCP and UDP [8]. It supports up to four simultaneous socket connections. The ethernet controller used is W5100 with an internal 32K buffer with connection speed 10/100Mb.

The data now can be either displayed using an LCD connecting to Arduino Uno. Another option that can be employed for digital display is through a mobile application. A mobile application can be developed so that it receives data from the cloud data. Since the microcontroller and ethernet module is present there itself in the monitoring office, ethernet can be used. Wi-fi can also be installed instead of the ethernet module if the requirement is fully wireless.

4. CONCLUSION:

The impact and aftermath of the wildfires are discussed at the beginning of the writing which drew the attention towards the importance of early detection of the forest fires. A wireless system assisted by different types of modules and microcontrollers is proposed. The best type of components was discussed along with their specifications so that when a new version of sensors comes into the market, these would serve as a reference to help which specifications should be considered while replacing the old ones. The working procedure of the whole system was explained starting from the sensor functioning to indication to authorities. The system proposed was a continuous real-time system. So, the indications can be observed only if the parameters of the situation crosses preset values. A lot of research scope is also mentioned below to amend this idea.

5. RESEARCH SCOPE:

A rapid increase in updating technology creates new versions of components every day. So, the nominated system can be modified. A wireless system with even more accuracy is one of the fields of research that can be done. Also, a backup for the sensors, if they get burned down can be improved.

Another different approach that can be worked on is to use drone technology for intensity inspection. As mentioned earlier, forest fires are useful to maintain plant and life as rain and sunshine [1], every single time this proposed system warns the firefighting agents don't need to reach the place to check the intensity. If the display output of this system indicates an increasing level of threat, alongside sensors drones can be sent for checking the intensity. It can be automated too.

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