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Design and Implementation of Wildfire Monitoring System

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ABSTRACT

In today's era, wildlife and forest departments are facing the problem of movement of animals from forests to residential area. The number of trees has reduced drastically which creates an unhealthy environment for animals and for humans. Findings of a survey suggest that 80% losses are caused due to wildfire. This could have been avoided if the fire was detected in the early stages. This paper suggests a system for alarming the authorities in case of a bushfire. Nowadays, IoT (Internet of Things) devices and sensors allow the monitoring of the forest ecosystem, such as temperature and smoke. Arduino platform based IoT enabled fire detector and monitoring system is the solution to this problem. In this paper, fire detector using Arduino NANO is built which is interfaced with a fire sensor and smoke sensor. Whenever fire occurs, the system automatically senses and alerts the administrator by sending the message on the user's mobile device.

KEYWORDS: *Wildfire, Smoke sensor, Fire sensor, Arduino NANO, GPS, GSM*

I. INTRODUCTION

The frequency of large-scale forest fires continues to increase aided several factors such as climate change, urbanization and arson. These resulting fires have devastating effects on lives, property and the environment. To provide some perspective, between January – February 2019, there have been 558 forest fires in India. In February 2019, massive forest fires broke out in numerous places across the Bandipur National Park of the Karnataka. ISRO estimated the extent of burnt area to be about 10,920 acres in the last five days since 21 February 2019. To this effect, over the ages, various technologies have been deployed for the monitoring of regions susceptible to such fires [1]-[2]. These have ranged from manned watch towers, to advanced cameras as well as satellite imaging.

However, these methods are limited by various factors such as the need to build expensive, dedicated infrastructure on what is often challenging terrain or being reliant on visual cues which may not always be easily detected on time. In addressing these challenges, and certainly in keeping up with technology and the advent of the Internet of Things (IoT) [3], there has been a shift towards the use of Wireless Sensor Networks (WSN) in this area [4]-[5].

WSNs afford numerous advantages when it comes to monitoring and detection of wildfires. They can be highly scalable in covering large areas allowing control over node density to align with cost/performance requirements as well as providing better position accuracy in locating potential incidents. In addition, the use of a range of sensors can potentially enable earlier detection of fires before any visual cues manifest.

Evolving technology makes possible ever tighter integration of sensors and electronics into a smaller

footprint as well as delivering power and cost benefits [6]. These advantages have led to notable developments in the use of WSNs for forest fire detection/monitoring with active deployments in various countries as well as an increasing number of publications in the field.

Therefore, to reduce the damages in the forest due to wildfires, this device can be used which is built by using wireless sensor network. It helps immensely by sharing the event immediately without much delay. It is extremely important that such information is sent without hindrance. This data further helps the authorities to act quickly which eventually assists them to get control of wildfire.

II. System Configuration

A. Block Diagram

In the system depicted in the Figure 1, the main component is Arduino Nano which acts as a microcontroller. It is interconnected with some sensors like fire sensor and smoke sensor. Fire sensor helps in detecting fire and smoke sensor detects in wildfire.

Few more components are connected to Arduino Nano like Buzzer, LED panel to indicate the occurrence of fire and smoke. GPS takes the location co-ordinates and transfers it to GSM to send the location of fire and smoke to the administrator. Arduino receives input from fire & smoke sensor. Further, it forwards instructions to GPS & GSM. Simultaneously buzzer and LCD get activated.

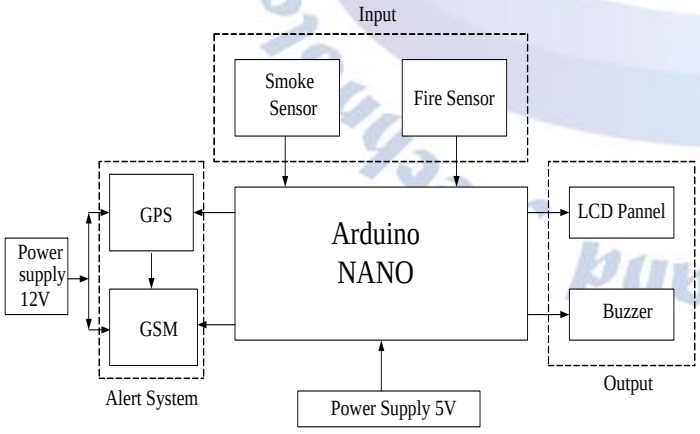

Figure 1. Block Diagram of the suggested system

B. Hardware Components

Arduino Nano

Arduino Nano is a small, compatible, flexible and breadboard friendly Microcontroller board, developed by Arduino.cc in Italy, based on ATmega328p (Arduino Nano V3.x) / Atmega168 (Arduino Nano V3.x).It comes with exactly the same functionality as in Arduino UNO but quite in small size.

It comes with an operating voltage of 5V; however, the input voltage can vary from 7 to 12V. Arduino Nano Pin out contains 14 digital pins, 8 analog Pins, 2 Reset Pins & 6 Power Pins. It works as a CPU of our equipment.

Global System for Mobile communication (GSM)

A customized Global System for Mobile communication (GSM) module is designed for wireless radiation monitoring through Short Messaging Service (SMS). This module is able to receive serial data from radiation monitoring devices such as survey meter or area monitor and transmit the data as text SMS to a host server.

Global Positioning System (GPS)

The use of GPS with equipment on wildfires offers many valuable opportunities: tracking the location of these resources is often a difficult task on large wildfires, especially when non- local units are assigned to an unfamiliar area. For the solution of this burning issue the suggested system is designed based on GSM (Global System for Mobile Communication) & GPS (Global Positioning System) technology. This system has interesting properties that make it useful for detection and prevention of forest fire. The intuitive description of this system is quite simple, can be implemented practically at a reasonable cost. The GPS (Global Positioning System) is a "constellation" of approximately 30 well-spaced satellites that orbit the Earth and make it possible for people with ground receivers to pinpoint their geographic location. The location accuracy is anywhere from 100 to 10 meters for most equipment.

Smoke Sensor

A smoke sensor is a device that senses smoke, typically as an indicator of fire. Commercial and residential security devices issue a signal to a fire alarm control panel as part of a fire alarm system, while household detectors, known as smoke alarms, generally issue a local audible or visual alarm from the detector itself. Smoke can be detected either optically (photoelectric) or by physical process (ionization); detectors may use either, or both, methods. Sensitive alarms can be used to detect, and thus deter, smoking in areas where it is banned.

Fire Sensor

A flame detector is a sensor designed to detect and respond to the presence of a flame or fire, allowing flame detection. Sensor is the most sensitive to ordinary light that is why its reaction is generally used as flame alarm purposes. This module can detect flame or wavelength in 760 nm to 1100 nm range of light source. The sensor and flame should keep a certain distance to avoid high temperature damage to the sensor. The shortest test distance is 80 cm, if the flame is bigger, test it with farther distance.

The detection angle is 60 degrees so the flame spectrum is especially sensitive. The detection angle is 60 degrees so the flame spectrum is especially sensitive.

LCD Panel

LCD draws its definition from its name itself. It is combination of two states of matter, the solid and the liquid. It is used to display the current situation of our monitoring system like the exact coordinates of our location.

Buzzer

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical or piezoelectric. It is used to signal when fire or smoke sensors get triggered.

III. Pin Diagram

Figure 2 shows the pin diagram of an Arduino Nano. Pin D2 is connected to data pin of fire sensor (input device). D3 is connected to data pin of buzzer (output). D4 is connected to data pin of smoke sensor. D8 & D9 are connected to RX & TX of GPS. D11 & D12 are connected to Data pin of GSM. Fire sensor, Smoke sensor and Buzzer get 3.3V from Arduino Nano and common ground. GPS & GSM use 12V supply. Arduino uses 5V supply. LCD gets 5V from Arduino Nano, SCL is connected to A5, and SDA is connected to A4.

IV. Result and Discussion

For hardware implementation, smoke sensor and fire sensor are connected to Arduino NANO which consists of a program for smoke sensor and fire sensor.

The hardware prototype is presented in Figure 3.

After successful implementation of fire and smoke sensor, LCD panel and buzzer are connected to show result of smoke and fire sensor. Then GPS and GSM are connected to Arduino NANO and a program for smoke sensor, Fire sensor, and LCD panel, Buzzer, GPS and GSM is installed on Arduino.

When the power supply is turned ON, a message is sent to administrator i.e. “GSM is OK” then fire and smoke is detected by fire sensor and smoke sensor. Then administrator receives a message “Alert! Alert! Alert! Fire is detected inside forest on this location” and location is also embedded in the text as depicted in Figure 4.should *not* be selected.

Table1. Arduino Nano Pin Configuration

Pin no.	Name	Type	Description
1-2, 5-16	D0-D13	I/O	Digital input/output port 0 to 13
3,28	RESET	Input	Reset (Active low)
4,29	GND	PWR	Supply ground
17	3.3V	Output	+3.3 output (from FTDI)
18	AREF	Input	ADC reference
19-26	A7-A0	Input	Analog input channel 0 to 7
27	+5V	Output or input	+5V (input from external power supply)
30	VIN	PWR	Supply voltage

Several tests were performed to analyze the system's performance. The trials were done by lightning up a matchstick and holding it in the vicinity of the fire sensor. As expected, it tripped the sensor and activated the buzzer, followed by a text to registered mobile numbers which accommodates SOS message and the precise location coordinates as shown in the Fig.4. Simultaneously, it also displays the information on the LCD panel. Same procedure was followed for checking the smoke sensor which yielded similar results. The link to the location can be opened on Google Maps as shown in the Figure 5.

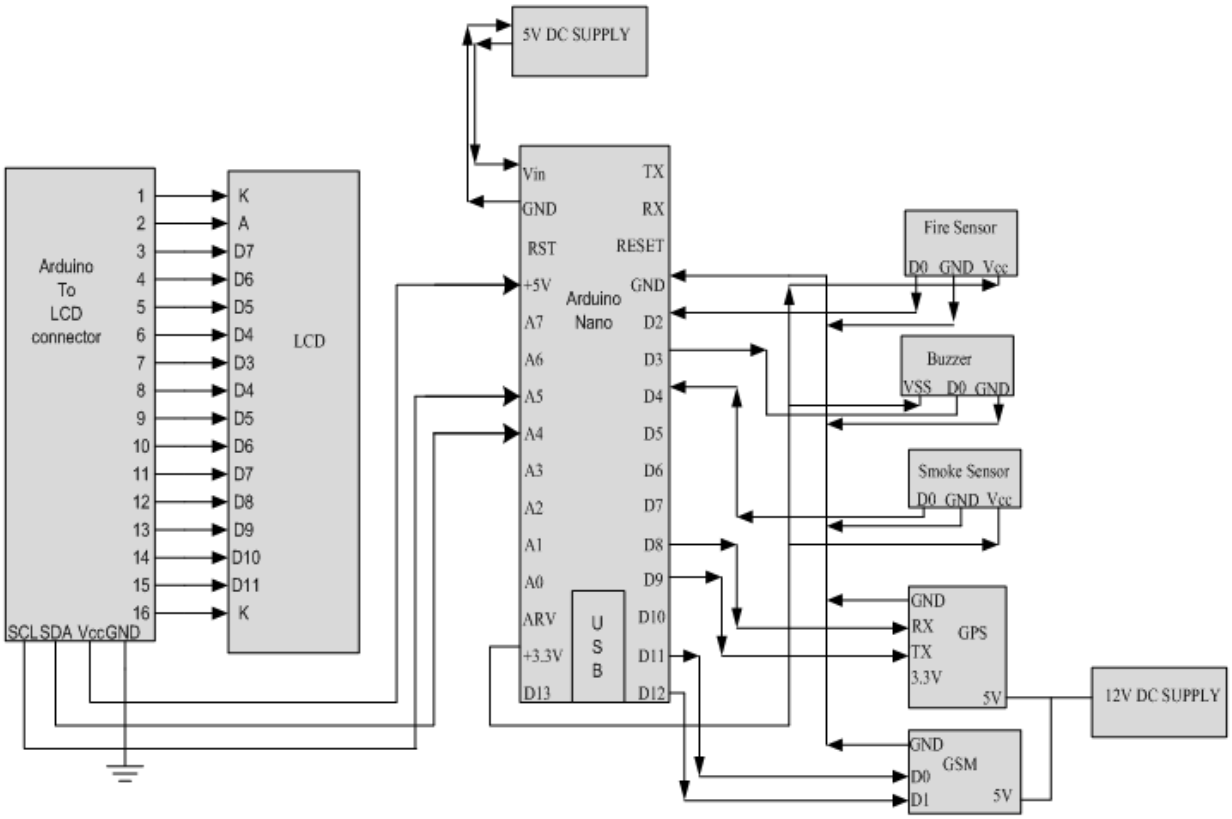

Figure 2. Pin Diagram of Fire Monitoring System

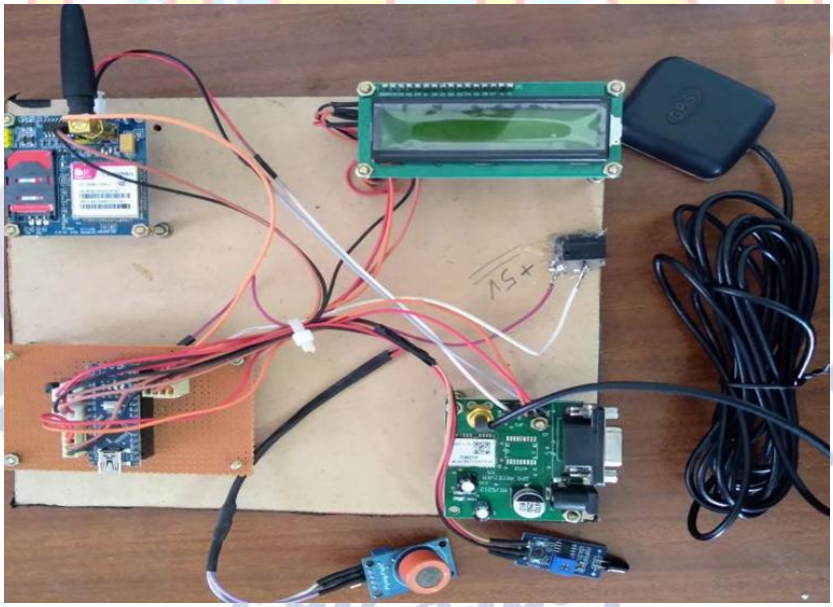

Figure 3. Hardware Implementation of Fire Monitoring System

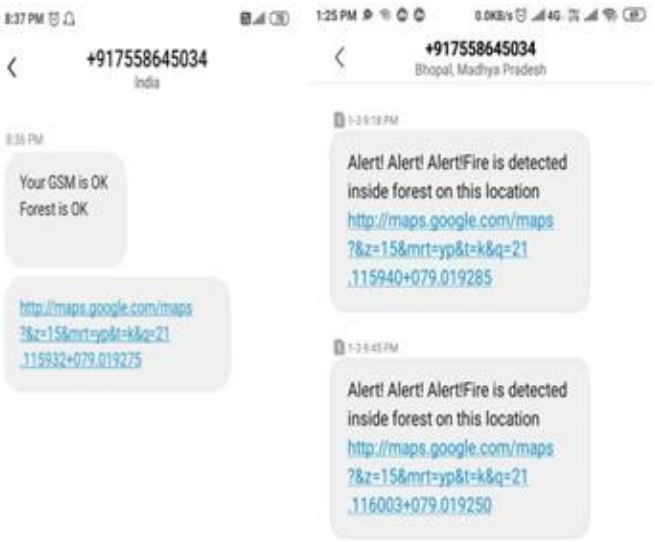

Figure 4. Message received by the administrator

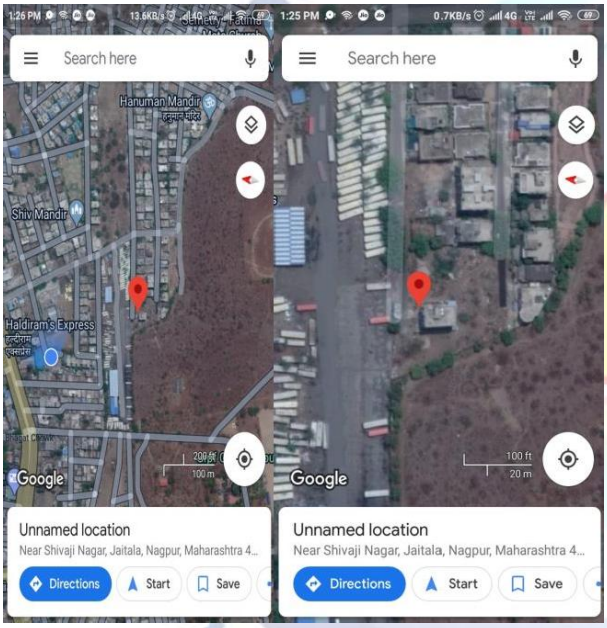

Figure 5. Location of the event on Google Map

V. CONCLUSION

Science & technology is boon for all upcoming challenges. Predicting the natural processes is highly complex and such systems needs to be tested against real time conditions. Though this system is self- sustaining and standalone, other factors which would affect the hardware were tested against time.

It shall be implemented in small forest areas where chances of occurrence of forest fires are high. The system needs to be robust to withstand all the weather changes which may affect its functioning. However, our system will play a crucial role in curbing the forest fires which would prevent loss of huge resources and financial losses.

This device can be applied in varied areas due to its flexibility and simplicity in handling while also being cost efficient at the same time. Whenever there's a fire the device will alert the authorities by sending a text via GSM.

This will make the authorities become aware of the dangerous situation and can easily prevent it from happening by quick prevention.

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