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IoT and Image Processing based Forest Monitoring and Counteracting System

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***Abstract*-Forests are the indispensable resource of our life as they cover one third of the land on earth. They provide us with plenty of amenities required to sustain our life. However, for the past few decades, the forest area has been degrading immensely. Recently forest fire has become the greatest menace to our planet. In 2019 Amazon rainforest wildfire destroyed thousands hectors of forest. To get a control over it, a well-organized forest monitoring system is created. This system is based on the emerging technology of IoT and image processing. In our system, these technologies are utilized with the Wireless Sensor Network (WSN). This system provides a continuous live data of the forest environmental conditions. Utilizing this in our work helps us to detect fire intensity which enables water discharge for extinguishing fire when the conditions become unfavourable. This process will be helpful for controlling the wildfire.**

Keywords: Wildfire, Internet of Things (IOT), Image Processing, Wireless Sensor Network (WSN).

I. INTRODUCTION

In recent years researchers has been attracted towards the detection of forest fire due to its effects on eco-system. Forest fire damages about 5 billon hectors every year in addition to it there have been thousands of reregistered forest fire every year. And the number is increasing every passing year [1]. Hence there are various forest fire detection techniques. However, four major detection systems which are immensely used in past years named Human based observation system, Satellite System, Optical cameras and wireless Sensor Network (WSN) [2]. Among them it is found that WSN is so far the best system available for forest fire detection and monitoring. WSN is consists of a strong base station with several sensor nodes [3]. However, the lacking in response time due to the huge distances in forest can be a big issue. In order to overcome the drawback of transmission delay one can use IoT [4]. It is the advance technology used in many applications and is best suited for transmission of data in forest. In this work, different sensors are connected together for the complete surveillance of the forest. The data is continuously transmitted to the base station. Another challenge in the forest fire detection is power supply, as this system requires a continuous power supply. The best suited solution is Solar power system due to its distinct advantages and availability over other power supply system [5]. Hence, solar power system is used in our work. In order to have a continuous monitor and relative response for fire detection, utilised image processing technique, which enables us to detect and control fire from remote distances. The detailed methodology and system are explained in the following sections.

II. METHODOLOGY

Forest fire monitoring system is divided in two parts. One is the transmitting part which consists of microprocessor, camera and different types of sensors, and another is the receiving part which consists of computers and act as our base station. For sensing the fire, different sensors are used namely temperature sensor, fire sensor, smoke sensor and a Wi-Fi camera which will capture an image and send it to the base station using the Wi-Fi module.

At the base station, this data will be processed by MATLAB software. On receiving, image that contains fire and data of high temperature, fire and smoke, an alert message will be generated. This enables the response and sends it back to the submersible pump. On receiving the response, the submersible pump will spread out water from the Water tanks situated near every sensor node for a particular duration according to the situation.

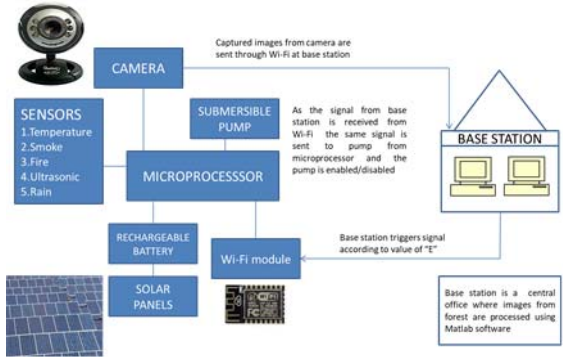


FIG 1-BLOCK DIAGRAM

In order to understand a situation and response accordingly the image processing technique is utilized which is explained in a separate section II.I

This method enables three things, firstly that can control the fire without going to the forest area. Secondly by using the image processing, The timing of opening and closing of the

pump can be controlled. Lastly, can easily manipulate it, by changing the time of capturing the images. Currently it takes an image in every 5 to 10 seconds, furthermore can continuously do the monitoring, if the larger storage space is available. In this way the IOT and image processing-based forest fire monitoring system is utilized.

II.I The Image Processing Technique at Base Station –

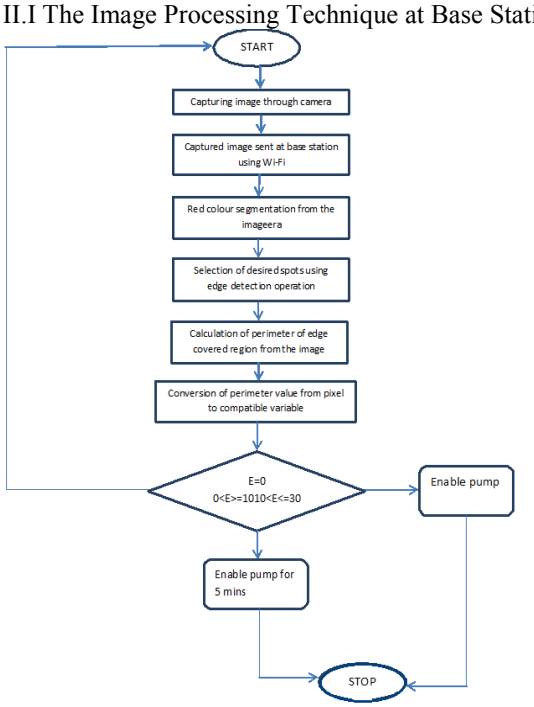


FIG 2-FLOW CHART

According to the above flow chart, initially an image is captured by the camera and is sent at base station using the Wi-Fi module. At base station, processing of image is done with the help of MATLAB tool. The images in forest are captured by the camera, which is connected to the sensor node. These images are sent at base station using Wi-Fi module. Firstly, the image is converted from RGB to grey format. As red colour is dominating in fire, so segmented the red colour from the image. After this, the image is converted into binary images and morphological operation is applied on it. Then the image is passed through the Sobel filter for the edge detection.

In terms of computation SOBEL edge detection is the fastest, simple and time efficient. The SOBEL operator measures a 2-Dimensional spatial gradient of image and focus more on high spatial gradient then edges. Hence is more efficient for processing the images which received from forest.

Later on, the perimeter of these edge covered figure is calculated to measure at what scale the forest fire is occurring. The perimeter value is converted in pixels to mm and later stored in the variable "E" with the help of variable "E" the pump is turned ON/OFF. The following table shows the different values of E with its appropriate actions.

TABLE 1

Value of "E"	Fire status	Pump status and timing
E=0	No fire detected	OFF
0<E>=10	Fire at initial level	ON for 5 minutes
10<E<=30	Fire in controllable state	ON

In Order to understand its working, a small model of this system is stimulated. This is explained in section III.

III. EXPERIMENTAL SET-UP

In our model, it consists of a main processor that is the ATMEGA328. It is powered by a rechargeable battery which is charged by solar cells. In the circuit, there is a rectifier which converts the AC into DC power supply. After rectifier, there is a voltage regulator which converts the 6-volt power supply via battery into 5 volts for devices in the circuit. There are two conductors for noise cancellation. These all devices together make the main power supply for the circuit.

Furthermore, following sensors are connected through the ATMEGA328 microcontroller.

- Temperature Sensor (LM35)- It is used for prior detection of any hike in temperature. It has long term stability and doesn't require any extension wire. Its drawback is its self-heating error.
- Fire Sensor - It is used for instant alert of fire and is easy to install and modify. Its drawback is that it has range restrictions and may have an issue with transmitting information to the base station.
- Smoke Sensor (MQ3) - It will report the presence of carbon monoxide in the air. It detects low energy fire and is faster than heat detectors for most fires. The disadvantage it has is that it is more expensive and has higher life cycle cost.
- Rain Sensor – It is used as a monitoring sensor to know the climatic change and occurrence of rain in the area. It will help in saving water. The rain sensor cons are that it occasionally need to be serviced and batteries should be changed once per year.
- Ultrasonic Sensor (HC-SR04) - It is used for the device security as well as for keeping an eye on the trespassers in that area. It can also be used in the dark environment, which will help in detection at night time as well. Its limitation is that it has a limited detection range.

The above-mentioned sensors collect all the data and send it to the microcontroller. After that, ATMEGA328 transmits all this data to the centrally placed base station using the Wi-Fi module.

For real time image processing, a Wi-Fi camera is mounted on our device, which will capture real time images of the forest, after every 4-5 seconds and send it to the base station for further processing.

A submersible pump is also attached with the device, which will fetch water from the nearest water tank and helps in extinguishing the fire. This makes the counteracting system of our system. It consists of three main components-

1. Water tank- Water tanks of capacity up to 500 litres will be present with every sensor node.
2. Submersible pump- A submersible pump will be present with every water tank to pump the water to the sprinklers.
3. Sprinklers- They will be turn on when there is a alert for fire. They will help in extinguishing the fir.

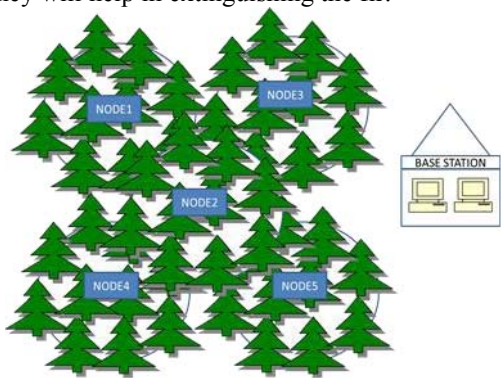


FIG 3- WIRELESS SENSOR NETWORK (WSN)

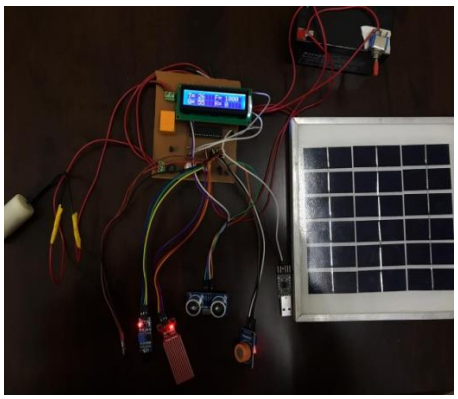


FIG 4- SENSOR NODE

IV. RESULTS

The table 2 given below shows that how the captured image from forest is processed at base station. Column 1 of the table 2 shows the real image of forest, column 2 shows how after the colour segmentation the image is viewed and the column 3 shows the edge bordered image of colour segmented image. By the help of column 3 images, the perimeter is calculated and try to find out the range of fire and according to this enable our pump at sensor node to counter act the fire. By this counteracting stopped the fire at a very basic level, by which can save our ecosystem from the disastrous effect of wildfire. The calculated perimeter of the fire from the images is shown in Table 3 with the status of pump.

TABLE 2

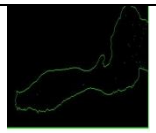
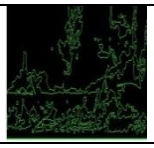
Fig. No.	Original Image from Camera	Color Segmented Image	Edge detected Image
Fig 1			
Fig 2			
Fig 3			
Fig 4			
Fig 5			
Fig 6			

TABLE 3

Figure number	Perimeter value in mm	Pump status
1	37.84	ON
2	22.36	ON
3	0	OFF
4	24.51	ON
5	43.98	ON
6	7.42	ON for 5 minutes

The system is highly efficient and with the help of IOT and image processing detects prior indication of fire in forest. It is 24*7 monitoring system for climate change, but it does have a few limitations which can be improved in the future:

1.The ultrasonic sensor can only detect the trespassing around device but can't give the precise knowledge about the trespasser.

2. Line of sight can falsify the fire detection.

V. CONCLUSION

On the basis of this experiment, the proposed setup can be implemented in the real scenario and also it can be utilized for forest fires. Different types of fire are captured and our system is capable enough to response back and acts accordingly.

In future, by using image processing, animals and human beings can also be distinguished and can monitor and protect the endangered species and can keep a count of forest animals. So, it can be utilized for the future.

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