Forest Fire Detection using Wireless Sensor

Harjinder Singh

Department of Instrumentation and Control Engineering,
Graphic Era University, Dehradun

ABSTRACT: With the advancement in human technology the risk of natural and man induced catastrophes increased exponentially. One of most dangerous disaster is forest fire. The forest fire represents continuous threat to species of flora as well as fauna. This paper highlights the powerful feature of wireless sensors for forest fire detection. The sensor data is collected using Arduino development board and transmitted to base station wirelessly. Also an alert is send using GSM module.

KEYWORDS: GSM (Global System for Mobile Communication), DHT-11(Digital Temperature Humidity Sensor) , Smoke Sensor, WSN(Wireless Sensor Network)

◆

I. INTRODUCTION

Forest fire also known as bush fire or hill fire is an uncontrolled fire occurring wild or forest areas. It is very important to detect these kinds of fires as early as possible so as to prevent the damage from it to ecological system. Every year millions of acres of forest are burnt down .The land were forest is burnt it becomes impossible to grow vegetation over there. This is because soil becomes water repellent and accepts no more water, leading to reduction in ground water level. The Global Warming Report 2008 mentions forest fire as one of the major cause behind increase in global warming. In recent year 2016 more than 4000 hectares of forest were burnt in the hills of Uttarakhand. Common causes of forest fire are lightning, extreme hot and arid weather and human carelessness. The use of wireless sensor in this paper presents one of the techniques for early forest fire detection.

II. LITERATURE SURVEY

Many solutions for detection of forest fire are presented and implemented in past few years. Video Surveillance System is most widely used for detection of forest fire[1]. It is divided into four categories : Video Cameras sensitive in visible spectrum based on recognition of smoke during day light and fire flames at night, Infrared(IR) Thermal Imaging cameras based on detection of heat flux from the fire, IR Spectrometer which identify spectral characteristics of smoke gases and Light Detection and Ranging (LIDAR) system which measures the laser light backscattered by smoke particles. The limitation of these systems was high false alarm rate due to atmospheric conditions such as presence of fog, shadows, dust particles etc.

Another method is the use of Visual Cameras that take snapshots of the forest to detect the fire. These cameras were mounted on the top of communication towers[2,3]. A rotating motor is installed to provide a full round view of the forest. The images obtained from the camera are processed using program or MATLAB code and are compared with the reference images taken at initial stage. This system also had limitation of high false alarm rate. Also the cost of installation of visual cameras on communication towers was very high.

Another method is the use of satellite system to detect the forest fire. The main components of the system are satellite(s) and the base station that collects the data send by the satellite(s) and runs the analyzing algorithm. The raw data from the satellite(s) is processed and then Advanced Very High Resolution Radiometer (AVHRR) instrument is used to detect presence of Hot Spots. However the clouds greatly affect the system [4,5].

Forest Fire Surveillance System which consists of WSN was also proposed for detection of forest fires in South Korea. The WSN determines the temperature and humidity after which middleware program and web application analyzes the collected data .However in this approach of detection of forest fire there was some loss of data during communication [6].

WSN consisting three different kinds of sensors which can detect temperature, flame and smoke levels of methane, carbon monoxide and carbon dioxide was also proposed for forest fire detection .The data acquired by sensors is transmitted using radio frequency module. The radio frequency module used has limited bandwidth and also picks up noise easily [7].

WSN consisting of temperature sensor setup and GPS module was also proposed for detection of forest fire .In this temperature data was transmitted to base station via primary and main antenna using satellite. Some of the limitation of system was installation of too many antennas; continuous power was required to both temperature sensor setup and antennas. In addition to this climatic/seasonal changes can affect the system [8].

III. Proposed Solution

The proposed solution presents the prototype for early forest fire detection in which an alert is send to base station via SMS(Short Message Service) and call using GSM module when the temperature exceeds the threshold value. Also data is send continuously to base station using Bluetooth module. The components used for forest fire detection are as follows:

A. Temperature Sensor

One of the important phenomenons that usually accompany forest fire is the increase in the temperature. The increase in the temperature may be because of fire in the forest. DHT-11 (Digital Humidity Temperature Sensor) is used to detect the temperature. An increase in the temperature than normal temperature can give us indication of forest fire. DHT-11 can be used to detect temperature in the range of 0- 50°C with the accuracy of ±2°C. Figure 1 shows DHT-11 sensor.

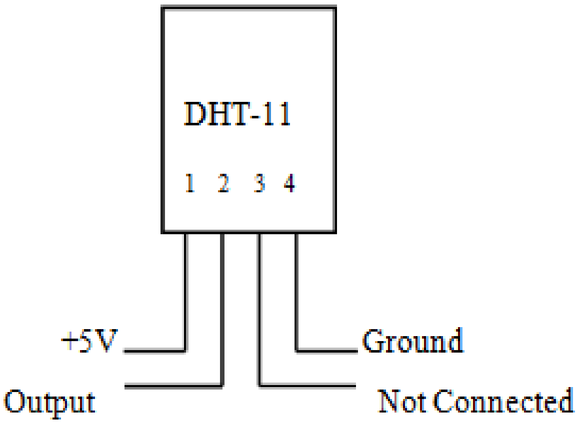


Figure 1: DHT-11 Sensor

Now the temperature alone cannot give us clear indication of forest fire and hence we also need to detect humidity and smoke level.

B. Humidity Sensor

Humidity is a very important feature in detecting a fire. In case fire the air will be dry thus decreasing the humidity. This decrease in humidity can give us indication of forest fire. The DHT-11 sensor can be used to detect humidity in the range of 20-90% RH with the accuracy of ±5% RH. DHT-11 uses resistive type humidity measurement component.

C. Gas and Smoke Sensor

One of the main characteristics of fire is the smoke. Thus smoke sensors can play a vital role in detecting fire in the forest. Various types of smoke sensors are available in the market. Depending upon the availability and cost factor of sensors the smoke sensor used in this project is MQ-2 sensor which is sensitive for methane, butane and LPG. The sensor is also sensitive for flammable and combustible gases. The principle of MQ-2 sensor is that when gas interacts with the sensor it is first ionized into its constituents and is then absorbed by sensing element. This absorption creates potential difference on the element which is conveyed to the processor unit through output pin in the form of current. Figure 2 represents MQ-2 sensor.

Figure 2: MQ-2 Sensor

D. Bluetooth Module

Bluetooth is a technology used for wireless communication. It is used for point to point communication. Bluetooth module used in this prototype design is HC-05 which can transmit data continuously at the asynchronous speed of 2.1 Mbps and has a frequency band of 2.45 GHz. It operates a voltage of 3.3 to 5 V and has a default baud rate of 38400 .

E. GSM Module

GSM (Global System for Mobile Communication) is a digital mobile telephony that is widely used across the world. GSM uses a variation in time division multiple access (TDMA) which allows different users to share same frequency channel by dividing signal into different time slots.

The GSM used in this project is SIM-300 GSM module. It is a tri band based engine that works on frequencies 900 MHz, 1800 MHz and 1900 MHz. In India at a frequency of 900 MHz. SIM-300 is used to make a call and send SMS to base station when temperature exceeds threshold value. The SMS obtained will contain real time values of temperature, humidity and smoke.

Now in order to acquire the sensor data Arduino Development Board is used. The data acquired by Arduino Development Board is then transmitted wirelessly to base station using Bluetooth and GSM module.

Arduino is a tool for the design and development of embedded computer system, consisting of a simple open hardware design for single board microcontroller, with embedded input/output (I/O) support and standard programming language. An Arduino is tool for making that can sense and control more of the physical world. Arduino can sense the environment by receiving input from variety of sensors and affect its surroundings by controlling lights, motors and other actuators. The microcontroller on the board is programmed using Arduino programming language.

IV. Working

CASE 1: During Normal Conditions

At a particular time interval if the temperature 'T' which is output of temperature sensor is below the threshold value will indicate that there is no forest fire. These temperature values along with the value of humidity and smoke will be transmitted in real time to base station so as monitor the forest environment condition continuously. Any increase in the temperature than normal threshold value will give us indication of chances of fire.

CASE 2: During Forest Fire

Now if the temperature becomes greater than the normal or threshold temperature at the particular time an alert is send to base station through call and SMS. Also the sensor values are send continuously to the base station. The SMS will indicate the real time values of sensor data. Figure 3 represents block diagram of proposed prototype model.

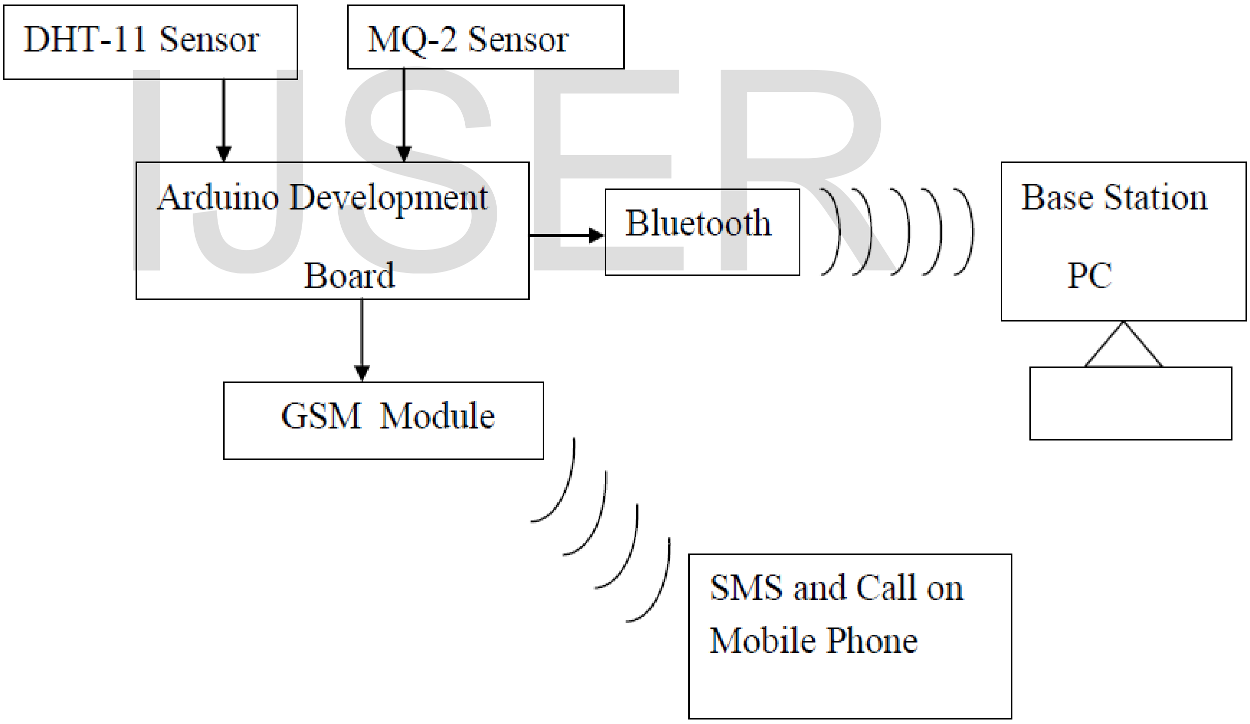
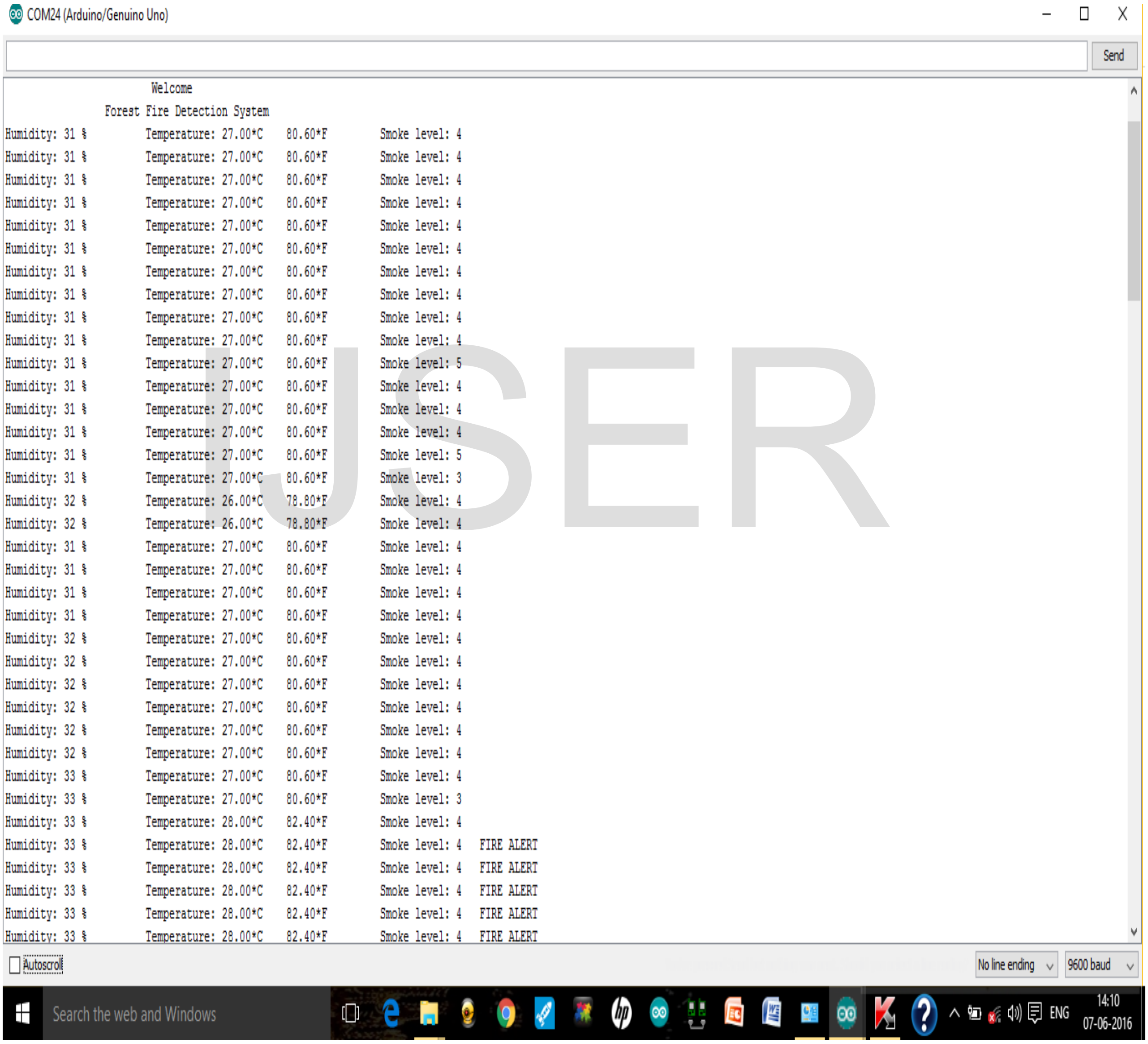


Figure 3: Proposed Model Block Diagram

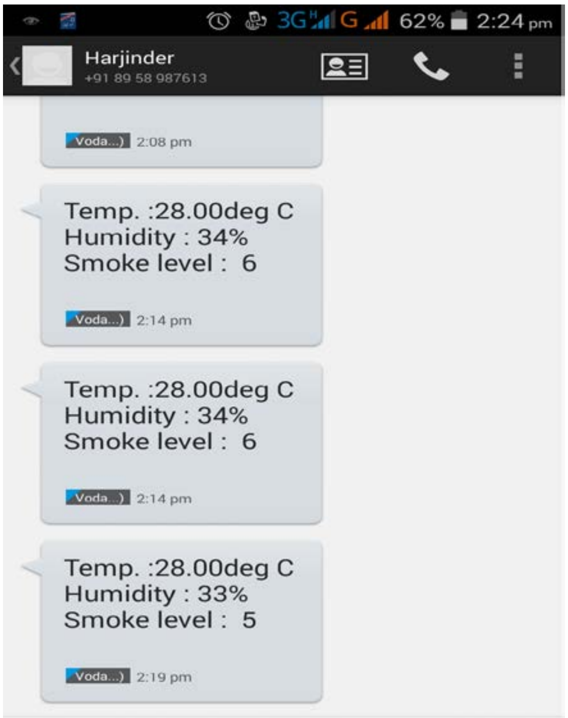
V. Result and Discussion

After designing the prototype for forest fire detection the data acquired from the sensors are transmitted wirelessly to base station where we can monitor it continuously. To detect the fire in the forest fire threshold value of temperature is taken as 27°C. When temperature exceeds this threshold value in addition to transmitting sensor values continuously to base station PC it will send an SMS and makes a call as an alert for forest fire. Figure 4 shows the snapshot of data values obtained whereas Figure 5 and Figure 6 shows the SMS and call obtained when temperature exceeds threshold value.



```
                    Welcome
              Forest Fire Detection System
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 5
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 5
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 3
Humidity: 32 %        Temperature: 26.00*C    78.80*F        Smoke level: 4
Humidity: 32 %        Temperature: 26.00*C    78.80*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 31 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 32 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 32 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 32 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 32 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 32 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 32 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 33 %        Temperature: 27.00*C    80.60*F        Smoke level: 4
Humidity: 33 %        Temperature: 27.00*C    80.60*F        Smoke level: 3
Humidity: 33 %        Temperature: 28.00*C    82.40*F        Smoke level: 4
Humidity: 33 %        Temperature: 28.00*C    82.40*F        Smoke level: 4   FIRE ALERT
Humidity: 33 %        Temperature: 28.00*C    82.40*F        Smoke level: 4   FIRE ALERT
Humidity: 33 %        Temperature: 28.00*C    82.40*F        Smoke level: 4   FIRE ALERT
Humidity: 33 %        Temperature: 28.00*C    82.40*F        Smoke level: 4   FIRE ALERT
Humidity: 33 %        Temperature: 28.00*C    82.40*F        Smoke level: 4   FIRE ALERT
```

Figure 4: Screenshot of Sensor Values



Voda...) 2:08 pm

Temp. :28.00deg C
Humidity : 34%
Smoke level : 6

Voda...) 2:14 pm

Temp. :28.00deg C
Humidity : 34%
Smoke level : 6

Voda...) 2:14 pm

Temp. :28.00deg C
Humidity : 33%
Smoke level : 5

Voda...) 2:19 pm

Figure 5: Screenshot of Message

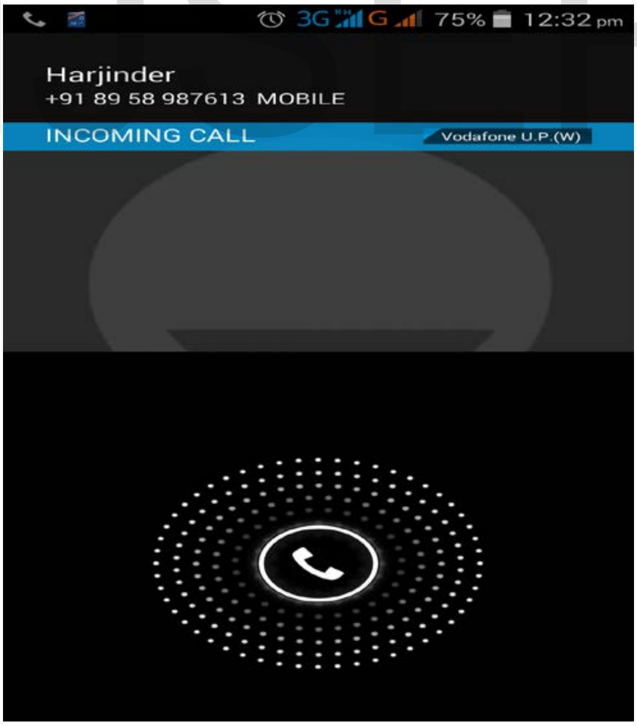


Figure 6: Screenshot of Call

VI. Conclusion and Future Work

As this prototype presented makes use single sensor node. In future we can use multiple sensor nodes which can be used to transmit data. In addition to this wind sensor and Global Positioning System (GPS) can be used. The wind sensor will give us indication of speed of spread of fire whereas GPS system can be used to obtain location where forest fire occurred. It will indicate the longitude and latitude values where forest fire takes place. Also we can replace the BT-Bee module by Zig-Bee module in order to increase the transmission range. There are three WSNs topological structures supported by Zig-Bee : star shaped, cluster type and mesh type[9]. There can be a number of links for network structure from the source node to the destination node, and the establishment of these links is dynamic and dynamic maintenance. When there are problems in links, ZigBee can find another link to maintain communications and improve reliability. In the mesh structure with multi-hop, the communications power consumption of each node can be greatly reduced, which no doubt has great appeal for wireless sensor networks with the special requirements of power saving. In addition, the mesh structure of the network can also make up more complex network, with greater routing depth and network node size. The distance between each network node can be extended to several hundred meters, even a few kilometres from the standard 75 meters. Thus, the wireless sensor networks with mesh structure are appropriate in a wide range of environmental monitoring.

REFERENCES

[1] Stipanicev D., Vuko T., Krstinic D., Stula M., Bodrozic L., “ Forest Fire Protection by Advanced Video Detection System- Croatian Experiences”, Split, Croatia, 2006

[2] Losso A., Corgnati L., Perona G., “ Early Forest Fire Detection: Smoke Identification through innovative Image Processing using Commercial Sensors”, Environment Including Global Change, Palermo, Italy, 2009

[3] Kovacs R., Kiss B., Nagy A., Vamos R., “Early Forest Fire Detection System For Vegetable Fire in the Aggtelek National Park”, Budpest, Hungary,2004

[4] Kelha V., Rauste Y., Buongiorno A., “Forest Fire Detection by Satellites for Fire Control”, European Space Agency, Finland, 2000

[5] Manyangadze T., “Forest Fire Detection for Near Real Time Monitoring using Geostationary Satellite”, International Institute for Geo-information Science and Earth Observation, Enschede, Netherland, 2009

[6] Son B., Her Y., Kim J., "A Design and Implementation of Forest Fire Surveillance System based on Wireless Sensor Network for South Korea", International Journal of Computer Science and Network Security, Vol 6 No. 9B, September 2006

[7] Hariyawan M.Y., Gunawan A., Putra E.H., "Wireless Sensor Network for Forest Fire Detection", ISSN:1693-6930,Vol. 11, No. 3, pp. 563~574, September 2013

[8] P.J Vivek , G. Raju , S. Akarsh, "Forest Fire Detection System", International Journal of Innovative Research in Science, Engineering and Technology, ISSN: 2319-8753, Vol 3, Issue 6, June 2014

[9] Tao H., Zhang H., "Forest Monitoring Application Systems Based on Wireless Sensor Networks", Third International Symposium on Intelligent Information Technology Application Workshops, IEEE, 2009