A CUMULATIVE USE OF SENSING NODES TO PROTECT FOREST AGAINST POACHING

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Abstract : Protection of forest trees against poaching has been a continuous problem for the Forest department as a result of which more valuable trees are sold on the black markets leading to country's economic downgrade. Soil erosion causes landslides in hilly regions putting lives at stake. Our main objective is to develop a WSN module that gathers vibration and sound parameters to detect slaying of trees and also use GPS sensors to track down smuggling. Consequently, the forest ecosystem would be protected and balanced. The existing system used by the Forest department is to put a steel armor around the tree which prevented axing only to certain extent. Also satellite imagery of forests are used but they cannot guarantee protection for scarce canopy. Cloud covers poses a problem for satellite imaging. Some poachers managed to cut down trees in spite of increasing forest official's efforts. The proposed system overcomes the need for an automated system by using vibration, sound, fire, smoke, MEM and GPS sensors to detect and track a live poaching scenario. The whole unit including the microprocessor has been fit to the stem of the tree. The initial processing is done using a microcontroller that processes the input from the sensors and sends an alert to the server when the threshold is violated. GPS sensors track the live location of the trees providing an easy way to arrest the criminals. The communication between the tree unit and server is achieved using the Zig-Bee module. The server end comprises of a PC where alerts and live location are displayed to the administrator. Since this is fully automated, protection of trees could be guaranteed till a distant future.

IndexTerms - **Forest, Poaching, Sensors, MEMS, WSN.**

I. INTRODUCTION

Forests in India are one of the most significant environmental resource. India is one of the top-ten countries with a vast forest cover including other countries like China, Russia. The geometrical land mass of India is roughly about 3.28 million sq. kilometers. Estimates show that about 22% of this land mass is covered with forests. Forests are home to hundreds of thousands of species. A decline in forest cover would force the species to trespass human boundaries. Global warming is another threat that arises due to decreasing number of tress. While most parts of India have been seeing growth in forest cover, Northeastern states saw a decline in the forest cover. It is predicted that other states might also see a decline in the forest cover mainly due to increasing population and governmental laws. India's paper industry alone produces a whopping 3000 million cubic meters of paper every year. Other sectors that use forest products have a value of 30,000 crore Indian rupees. Recent ban on plastics increased the demand for paper in almost every segment of marketing. This is led to increased focus on the paper producing mills forcing them to cut down more trees than they plant a year. Unfortunately, Forest departments in India have failed to guarantee the protection of trees. Poaching is an unlawful practice that has been popular all around India. India loses more number of trees to smugglers than it had lost in natural disasters. This is due to the high economic value of the trees like Rosewood, Sandalwood and many other trees with excellent durability. Forest department had been installing steel armor around the trees but the need for an automated system is imminent. Areas where automated systems were used showed a decline in deforestation. They proposed a system which uses data like forest height and vegetation scattering fraction to determine forest scattering. It was able to locate 15 out of 19 arears where canopy loss was over 50%. The paper aims to protect the trees using a set of sensing nodes and wireless technology and also providing the location of poaching.

II. LITERATURE SURVEY

Maciej J.Soja et al.(2018)[10], proposes three approaches and compares them. It identifies the changes in forest by modeling in the multitemporal InSAR data which is gathered with the help of X-band system TanDEM-X on forest whose topography is known. Using the two-level model, volume decorrelation's amount is modeled, where two parameters are used to determine the forest scattering. Both h and ζ are allowed to change between acquisitions by the single temporal approach. h is kept constant and ζ is varied constantly to model all changes in the multitemporal approach. The three inversion approaches are applied to 12 VV-polarized TanDEM-X data that was made in 2011–2014 over Remningstorp, which is located in Sweden. This approach was able to detect deforestation in 15/19 areas where the canopy loss was over 50%. A loss of 50% means that half of that area had been axed down but protection to all the trees is essential to guarantee the ecological balance.

Maciej Pawel Trawka et al.(2016)[11], proposes a system to work as a gas sensor using UV-light induced fluctuations. It is based on the fact that UV light affects the gas sensors changing the dissociation rate of the absorbed gases and generating charge carriers by increasing the number of electron-hole pairs. The sensing layer in this methodology is comprised of Tungsten oxide (WO_3). It

was found that WO_3-NW gas sensors response was directly proportional to an estimated photochemical reaction rate on the surface. It was tested on gases like ethanol and nitrogen dioxide. The sensor was sensitive to both the gases and the sensitivity changed based on the concentration of the gases. In their experiments, changing the operating temperature required an additional power of 1.4 Watts.

Yael Nemirovsky et al(2018)[22], proposed the idea of new generation gas sensors termed as GMOS which is similar to the thermal sensors termed as TMOS. MOS is the suspended thermal transistor on which this thermal sensor is based upon which is fabricated using the usual CMOS-SOI process. The main objective is to develop a gas sensor that works in high temperature conditions and possess mobility in application. The principle behind its operation is that a resistor heats up a catalytic reaction plate that activates the oxidation reaction of organic volatile components and gases such as ethanol. TMOS is flamed by the heat absorbed during the reaction and causes a potential difference proportional to the composition of the gases. The results showed that use of tungsten in the sensor made it operational even at temperature as high as 450 °C. This gas sensor may be used in our methodology to sense the presence of any combustible gases which is operational at high temperature also.

Michael Schultz et al.(2019)[13], the paper aims at monitoring deforestation using time series algorithms that capture gradual to abrupt changes. In Brazil, Ethiopia and Vietnam, Landsat time series was used to test the generic time series algorithm BFAST Monitor. This method used satellite imaging to identify the vegetation changes to calculate the amount of deforestation. Using standard f-mask parameters, 96% of the cloud cover was eliminated for clear viewing. The changes caused in the vegetation signal due to deforestation is identified based on the current and previous readings. LEDAPS, ATCOR 1, ATCOR 2 and DOS were the radiometric correction methods used in this methodology. It is to be noted that different areas of forests yielded different results leading to varying accuracies. Out of the 4 methods, only the first 3 methods were tested. Results showed that the accuracies of deforestation detection was only upto 80% in Brazil and Vietnam. In some cases where the vegetation was much more scattered, the results were not promising.

Xiaofang Pan et al.(2016)[19], proposed the use of gas sensors based on semi-conductor metal oxide nanomaterial due to its offering of large surface to volume ratio. Zinc Oxide nanomaterial is proposed for fabricaiong NO_2 gas sensor through a customized vapor trapping chemical deposition process. Tests were carried out at the room temperature for NO_2 concentration ranging from 1 to 20 ppm. The results showed that the response time significantly improved as the number of particles per million in the air increased. The peak responses of 0.9 and 11.06 were measured for 1 ppm and 20 ppm respectively. It also features humidity-insensitive property and exhibits good selectivities to several of the common interfering gases that widely existed in the environment. This methodology is only limited to NO_2 gas and not applicable to other gases released when burning a tree and hence it is assumed to be infeasible.

E. Roitberg et al.(2018)[5], used the MODIS Enhanced Vegetation Index and the Land Surface Temperature datasets to evaluate the performance of a change detection algorithm for deforestation. Each pixel's EVI and LST historical values were important because the algorithm was based on it. The main objective of this model is to continuously monitor the sudden decreases in those variable dynamics. During the 2004-2016 period when deforestation over Dry Chaco Forest in Argentina was very common, this model was tested using actual satellite time series on that pilot area. As validation, 51.6% accuracy was shown in a comparison with a benchmark product based on Landsat images is also presented. This also showed F-score of 0.60 and 74.4% recall for deforestation in 2013.

Manabu Watanbe et al.(2018)[12], proposed a JJ-FAST system for which a prelim version of semi-auto deforestation detection algorithm was developed, which can be used to monitor deforestation and changes in forest in tropical areas that covers over 77 countries and approximately for every 1.5 months. The principle behind this approach was to use PALSAR-2/ScanSAR HH, HV, HH and HV ratio to detect series of deforestation stages. Multitemporal data were used to suppress the effect of seasonality and rainfall. Moreover, the deforestation accuracies for the active deforestation spots in Brazil and Peru were estimated. The maximum of accuracies achieved was as high as 80.5% in the dry season, but during rainy season, it fell to a low of 11%. Another disadvantage is that this method does not offer real time protection.

Pratishka Bhuta et al.(2017), who proposed that monitoring poaching of trees can be achieved using a wireless sensor network (WSN) tech by developing an energy efficient model. To ensure a reliable communication, there are several routing protocols that are available to forward the information within a network. The main objective of this paper was to propose an effective method to signal a nearby forest ranger about the ongoing poaching activity using a vibration sensor to measure vibrations . Keeping in mind the requirement of low power consumption, the protocol was designed based upon the layout of the field, design of the system and application. Since this approach uses only the vibration sensor, it cannot distinguish between vibrations caused by strong winds and vibrations caused by a chain saw. Although some level of accuracy is achieved, we cannot say that this method is reliable.

III. PROPOSED SYSTEM

The sensor module consists of collection of various sensors that are connected to a single Arduino microcontroller. The sensors used in this methodology are gas, thermal, sound, vibration, MEM and GPS sensors. All the sensors are interfaced with the

microcontroller and is coded using embedded C. The digital gas sensor senses the carbon monoxide released when burning tress and creates a potential difference across its electrodes. The output is 1 when the gas is detected and 0 if not. The microphone fitted digital sound sensor creates a potential difference upon vibration of diaphragm works more like the digital sound sensor. The thermal sensor used is analog and hence it can produce dynamic outputs of live temperature. The thermometer reads the temperature of the environment and reports the system every 10 seconds. The threshold of the temperature is set at 60 ºC considering the test conditions. To avoid false alert messages during storm climate, the MEMS sensor is threshold at 90 º angle. The vibration sensor produces a piezo electric charge upon any vibrations. The sensor is also of digital type which can produce an output of either 0 or 1. The GPS sensor fitted with this module refreshes every 10 mins of its live location and sends the coordinates along with the alert message. The microcontroller is given with the input of threshold values which when violated triggers an alert message that is transferred to the administrator through the Zigbee module. The alert is generated based on multiple sensors output. Zigbee is similar to a Wi-Fi module only that it can cover large areas. Threshold values are set for each and every sensor so that even if one sensor shows abnormal values due to malfunction, other sensor values are also taken into consideration to determine live deforestation activity. The GPS sensor embedded within the whole module enables us to know the exact location of the sensors and help the forest ranger to take immediate action when poaching is happening. When threshold is violated, then an alert message containing the coordinates of the module is sent to the administrator via Zigbee module.
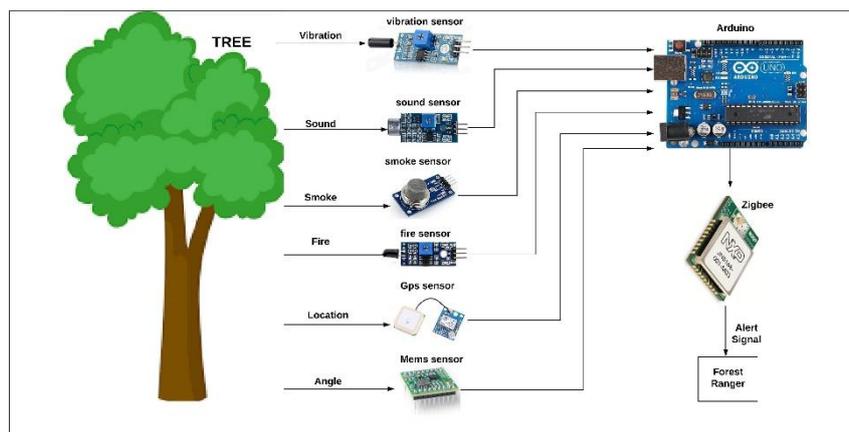

Figure 3.1. SYSTEM ARCHITECTURE

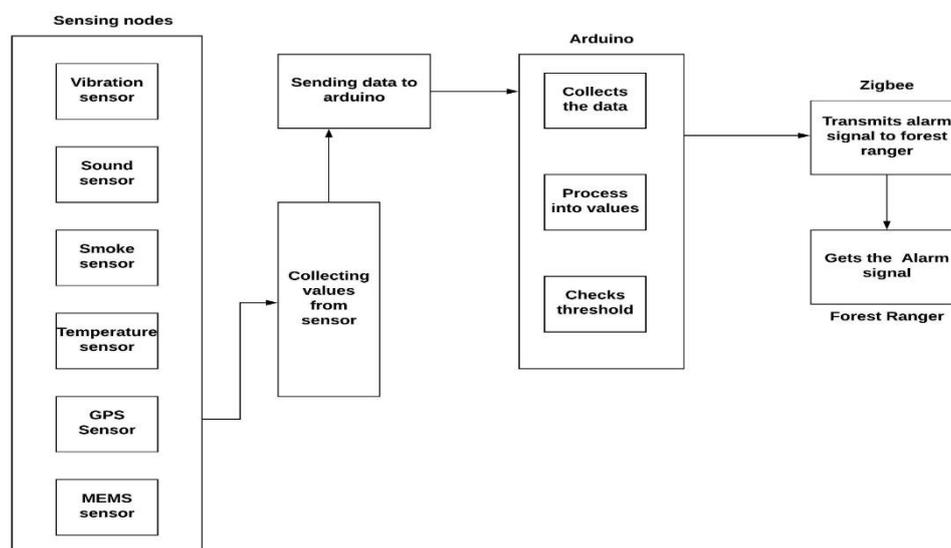## IV. SYSTEM IMPLEMENTATION AND PERFORMANCE ANALYSIS

Figure 4.1. FUNCTIONAL ARCHITECTURE

4.1 Sensing Environmental Factors

This module consists of five sensors namely gas, thermal, sound, vibrations and MEM which detects ongoing deforestation. The gas sensor is responsible for detecting gases like Carbon monoxide, Carbon dioxide that are released when wood is burnt. The thermal sensor senses for any changes in heat upto a certain extent. The sound sensor collects the surrounding sounds and checks if the sound levels are permissible in a forest. Vibration sensor detects any vibrations caused during deforestation. The MEM sensor checks the angle of the tree and sends an alert if the tree falls. Each of these sensors is interfaced to a single Arduino microcontroller using embedded C.
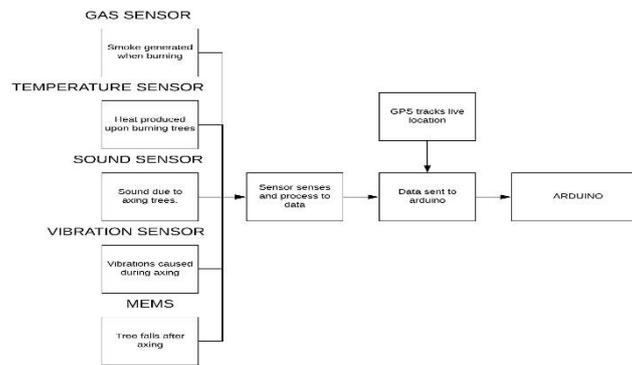
Figure 4.1.1. SENSING ENVIRONMENT FACTORS

4.2 Analysis Module

The microcontroller is programmed using the embedded C software. Once all the sensors are interfaced with the Arduino microcontroller, threshold values for each and every one of the sensor is set. The threshold values are set based on tests carried out studying a forest environment. Alerts are not generated based on a single sensor but multiple sensor values are checked to generate the alert to prevent any false threat notifications. The GPS module is then interfaced with the microcontroller that checks the location only when an alert message is generated.
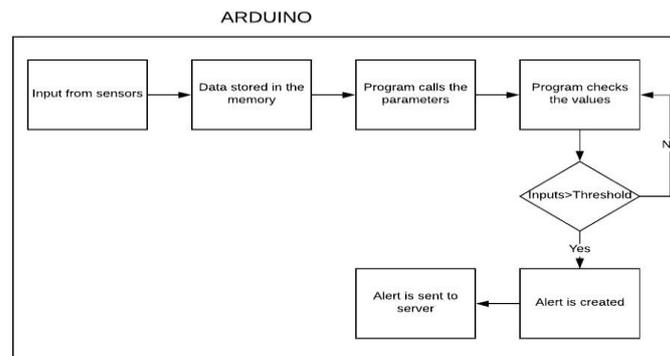

Figure 4.2.1. ANALYSIS MODULE

4.3 Alert Module

The transfer of alert messages along with the location coordinates takes place in the third module. Once the alert message is created, Arduino microcontroller transfers the data to the Zigbee coordinator. It handles and stores the data in memory. The message is then transferred to the router the transmits the message to the end device. The alert message is viewed by the forest ranger and enables him to take immediate actions.
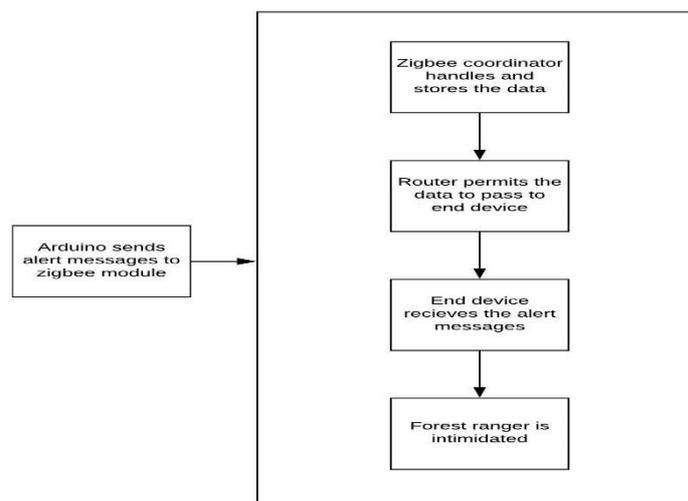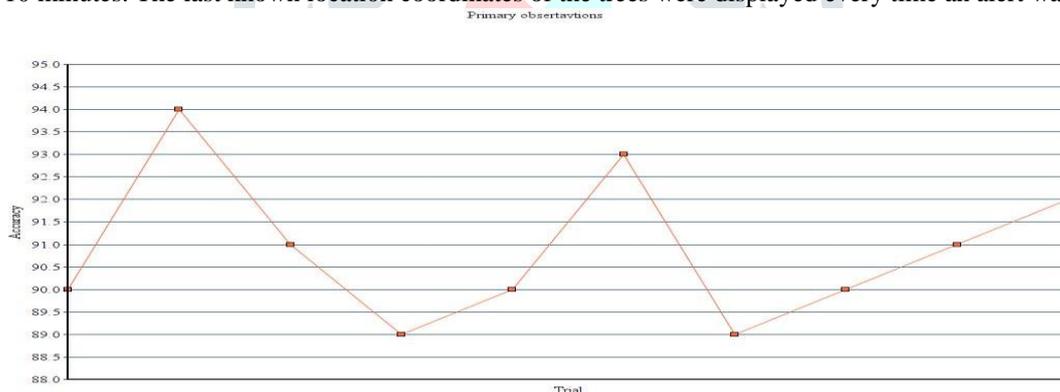

Figure 4.3.1. ALERT MODULE

V. RESULTS AND DISCUSSION

5.1 Primary readings:

The module is tested by attaching it to the top of the tree and the results are noted. A small tree is used for testing since it is not possible to measure vibrations and MEMS readings on a big tree without actually axing it. Primary observations of the environment are noted such as temperature and humidity. There was no loud sounds in that environment. The temperature was noted at 31 degree celcius The module is powered using a battery and the readings are noted. For the effect of increased temperature, wood is burnt using petrol as fuel. It was made sure that the test site was free from carbon monoxide. A total of 10 readings were noted to approximate the accuracy of the module. The initial observation included the working of sensory module. The temperature sensor was threshold at 60 degree celcius. A wireless speaker was used to produce sounds imitating the machinery. It was noted that the sensory module was able to detect the temperature change all the time proving that the module can be used in a group of 5 trees. Low volumes of sound went undetected by the module which is necessary in a forest ecosystem since animals or birds can trigger false alarms. As volume was increased, the module was able to detect the sounds and it sent a message saying that a sound was detected. The tree was gently shaken using bare hands to test the vibration sensor and the sensor was able to detect the movements. The gas released by the burning wood was also detected by the module. The tree was gently removed without damaging the root to test the MEMS sensor. When the angle was measured at 90°, the reading was shown in the display. On the average of the 10 readings, the accuracy of the sensors was 93%. The below graph shows the accuracy readings for the sensors.

5.2 Deforestation detection:

Instead of individually testing the sensors, all the activities were carried out at the same time to test whether the module is able to detect poaching. As the above mentioned activities were carried out, the module was able to generate the alert message for 10 out of 10 readings for the tree on which the module is placed. Same activities were carried out on the nearby tree to check whether the sensors were able to detect the changes. The temperature and sound sensor was able to detect the changes 9 out of 10 readings. It is to be noted that the maximum distance between the trees should not exceed 2 meters. The ability of the sensors to detect deforestation activity was measured as 90% accurate. The alert message is generated based on the data sent by the sensors to the Arduino. Multiple sensor values are used to determine whether the trees are subjected to deforestation. Once an alert is generated, the ZigBee module transmits the data from the Arduino to the laptop. The GPS module detects the location of the module and refreshes every 10 minutes. The last known location coordinates of the trees were displayed every time an alert was sent.
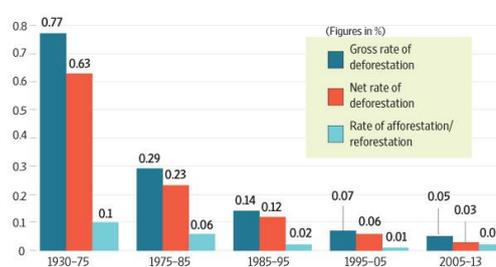

Figure 5.4.1 PRIMARY ANALYSIS AND DEFORESTATION STATISTICS

VI. CONCLUSION AND FUTURE WORK

The primary goal of this approach is to detect any poaching activities carried out in a protected forest containing valuable trees. The approach used here is to make use of sound, temperature, smoke, MEMS, vibration and GPS sensors and detect the changes in the forest environment. Although this approach is more realistic considering a group of trees that are closely spaced, it lacks the hardware to detect changes in the trees that are far away from each other.

This study shows us that it is possible to discover the location of the poaching activity and alert the forest ranger about it. Using the sensors for a prolonged time can deteriorate the accuracy of the readings, future work is needed before the changes can be accurately measured. The main advantage of this approach is that being cheap and power effective, it is able to detect poaching activity to a accuracy of 91.5 %. It is safe to say that this approach can protect 90% of a forest from any poaching activity. Any changes to improve the efficiency of the module should be focused on the placement of the module on the tree and using the right sensors to extend the application to 1 in 10 trees.

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