An enhanced system design of an IoT based Forest environment monitoring system

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Abstract: - The manual monitoring of the forest to prevent unauthorized activities is practically challenging job. Though sufficient manpower has been made available, it is inefficient because it might be life threatening. Various technologies have been developed and used effectively for achieving these objectives. These include the web of Things, Wireless Sensor Networks, Internet of Trees, Deep Learning, etc. In this work, exploring and assimilating the possibilities for technological improvements in forests to drastically develop their ecosystem is done. The main operations that are essential in monitoring the forest are developed, namely tree cutting detection, fire detection, temperature detection, humidity detection and water detection. IoT is widely used technology in forest monitoring application. Traditional approaches to the tracking of animals provide useful, but spatially constrained information. Sensing offers the prospect for area characterizations of biodiversity during a systematic, repeatable, and spatially exhaustive manner. Information and monitoring systems for the forest sector are beneficial for effective policies and planning, valuation of forest resources and investment. This project presents a system for monitoring forest and its vicinity supported by IoT based wireless sensor network technology. The need to be able to accurately monitor forest cover and quality is crucial to understanding the costs of deforestation. The monitoring of forest and the surrounding area can however still is taken into account as an open research problem to its substantial vast area. This project aims to stop forest mishaps, the intrusion of animals within the surrounding forest areas, illegal activities within the forest using wireless sensor technology and eliminating manual power to the highest possible extent.

Key-Words: - IoT (Internet of Things), GSM, Monitoring, Sensors, Deforestation, Forest operations

1 Introduction

The dense forest areas generate water supplies, biodiversity, pharmaceuticals, recycled nutrients for agriculture as well as flood prevention, and are central to the transition towards a Green Economy in the context of sustainable development and poverty eradication. Recent studies into the extent of illegal logging estimate accounts for certain percentage of the volume of all forestry in key producer tropical countries and around 20-30 percent globally. There are various fire preventive measures at home and other public areas such as artificial way of looking, forest aircraft, fire-watch forest fire automatic warning systems and satellite circuit monitoring system. The result of analysis and comparison with existing systems to monitor logging activities and forest fire explosion based on reconnaissance satellites and remote sensing we have determined several challenges of currently used systems. The over utilization of spring water has drastically reduced the bottom water level within the last 15 years. So it becomes utmost necessary to utilize each and every drop of water in an efficient manner so that it can also be used by upcoming generations. Also some new methods should be developed that use the renewable sources of energy. The development of these new techniques is going to reach the goal of sustainable development as well as to cut off the emission of greenhouse gases to a minimum level. Remote sensing has been used in a diverse range of forest ecology and management applications from mapping invasive species to monitoring land-cover changes, such as habitat fragmentation to estimating biophysical and biochemical properties of forests.

Forest is very important in life, that there is great dependency on the forest for survival. The forest trees help to breathe by pumping out the oxygen and absorb carbon dioxide. The significance of forest is often visible inside the newest exchange inside the climatic fluctuation thanks to deforestation. This paper goal is to watch forest by preventing tree cut, fire prevention, detecting contaminated water within the forest whether it's safe for the animals aren't and also detect presence of human in the forest. Set up the vibrator sensor within the area of forest during

which precious trees like sandalwood trees present. Suppose unknown people or thieves trying to chop the trees, vibrator sensor vibrate, immediately send tree cut message to microcontroller which will send this information to GSM module, and it sends an alerting message to the forest officer in order that they will take necessary actions and site tracking system facility also provided to android application. Similarly, if any fire happens by heat or by human, fire sensor will detect that fireplace happened and send signal to the microcontroller and microcontroller to GSM to send alerting message of fire detection to the forest officer. The PH sensor used to detect whether the water is contaminated or not and PIR sensor is used to detect movements of humans in the forest. In addition, using Wi-Fi router facility in proposed system during which suppose certain activities like fire detection, tree cutting detection operations happens, if the worker of forest officer is unable to send an alerting message to forest officer thanks to the network problem at that situation employee can use this idea of Wi-Fi module.

2 Problem Formulation

A number of monitoring, assessment, and experimental methods and procedures are developed, each aimed toward addressing informational needs for managing and conserving forest resources. Regional and national forest inventories provide estimates of standing volume by species groups and sizes classes. With repeated sampling, estimates of growth and alter also are possible. A standard fuzzy rule relates variables with different linguistic labels where each linguistic label is defined through a membership function having membership value during a range from 0-1[1]. The research presented during this paper extends this idea by associating each linguistic variable with intervals within the scope of its membership value to different classes. A study on the relationship between C-band SAR backscattering measurements over Amazonian tropical forests and hourly precipitation rates are done [2]. The study on the feasibility of a SAR-anomaly masking method based on orbital rain measurements and on conservation hotspot of the world biodiversity is conducted [3]. A key region for the agriculture production in Brazil, the Cerrado biome has only 7.5% of its native vegetation as fully protected areas. Given this, in 2016 the Brazilian government started a politician project to monitoring deforestation within the biome, through the so-called Prodes- Cerrado, liable for mapping deforested areas from 2000, and DETER-Cerrado, responsible to generate deforestation alerts. A study on deforestation is conducted, and it is a global concern due to its problematic consequences, which intensify natural phenomena such as floods [4]. In the past century, Brazil lost large areas of forests thanks to agricultural and livestock development, mining activities, the development of hydroelectric plants and therefore the expansion of the urban-industrial sector. Natural disasters are other crucial factors taken into consideration throughout this paper. In the summer of 2018, more than 100 people died, and 3 resorts were completely devastated in the Greek Attica peninsula by forest fires [5]. However, a faster detection of such events can be achieved by using the latest technology advancements. The purpose of the IoT concept is to transform the real world and every day electronic devices, appliances, etc., into intelligent interconnected virtual objects. By keeping the user informed on the state of things and giving the users control of things, a better global humans-devices-humans communication can be achieved [6]. A method to identify areas suspected of forest fires occurrence is also studied [7]. This kind of forest disaster may be a nonlinear problem that's difficult to assess and predict. The proposed method uses artificial intelligence, namely the neuro fuzzy interface, for classification in two classes, forest fire and non-fire. Furthermore, cloud computing can be used for processing time critical data [8]. A forest fire detection system is also described in [9]. The proposed system consists of a processing unit (Raspberry Pi) and three sensors: motion sensor, temperature sensor, and a gas sensor. The motion sensor is employed to stop the destruction of the system from wildlife. The two environmental sensors (temperature and gas sensors) are configured to detect temperature value and gas concentration. One of the critical issues within the current IoT world is that the security of devices either wired or wireless. Considering the wide range of protocols, high device count, and low number of universal, standard methods, attackers can easily easy steal users' information, disrupt the devices functionality or perform other user-threatening activities. The security risks in WSNs, develop an attacking scenario and also implement the attack a small WSN [10]. Their results include an analysis of parameters like packet loss and packet transmission delay. Previous work has presented about sound recognition, low-power IoT devices for measuring environmental values [11, 12]. The main driver of degradation in sub or tropical countries is unsustainable logging [13]. Rapid economic and population growth, expansion of commercial

agriculture and complacency in sustainable forestry practices are key contributing factors. The commercial demand for timber and unsustainable logging practices has introduced a cycle of degradation with persistent loss of biomass and canopy cover across insular South East Asia and Latin America [14, 15]. Shifting cultivation, over-grazing, fire, fuel wood collection and charcoal production have also resulted in degradation in large parts of Africa [13].

The Atlas of Forest Landscape Restoration Opportunities is a world-first attempt at characterising the spatial extent of degraded forests worldwide and areas of restoration potential [16]. Forest condition was mapped at 1 km resolution by comparison of current largely MODIS derived and potential modelled forest cover change estimates [17]. Forest condition and land use data were used to identify opportunities for restoration on degraded lands. The derived maps provide a global overview and may assist in identifying areas for more detailed analysis.

2.1 The Proposed System Design

The architectural configuration procedure cares with build up a fundamental basic system for a framework. It includes recognizing the important parts of the framework and interchanges between these segments. The beginning configuration procedure of recognizing these subsystems and build up a structure for subsystem control and correspondence is named construction modeling outline and therefore the yield of this outline procedure may be a portrayal of the merchandise structural planning. The proposed architecture for this technique is given below. It shows the way this technique is meant and brief working of the system.

System architecture as shown in Fig.1 is the conceptual model that defines the structure, behavior, and more views of a system. An architecture description may be a formal description and representation of a system, organized during a way that supports reasoning about the structures and behaviors of the system.
The major operations that are essential in monitoring the forest are developed during this work, namely tree cutting detection using vibration sensor, fire detection, temperature and humidity detection and water detection, fire sensor, water pump, humidity sensor, and soil sensor respectively. A microcontroller is used along with GSM to communicate to central server from remote place. The sensed data from sensors is collected and sent to the authorized person via GSM. IoT is widely used technology in forest monitoring application. GPS finds the longitude and latitude information of the tree using satellite signals. In addition, this paper uses Wi-Fi router module through which employee and forest officer can communicate with one another just in case if network is disabled. Traditional approaches to the tracking of untamed animals provide useful, yet spatially constrained information. Remote sensing offers the prospect for giant area characterizations of biodiversity during a systematic, repeatable, and spatially exhaustive manner. Information and monitoring systems for the forest sector are beneficial for effective policies and planning, valuation of forest resources and proficient investments. This project presents a system for monitoring forest and its vicinity supported IoT based wireless sensor network technology. The need to be ready to accurately monitor forest cover and quality is crucial to understanding the prices of deforestation. The monitoring of forest and therefore the surrounding area can, however, still is taken into account an open research problem thanks to its substantial vast area.
This system can monitor real-time related parameters, e.g., temperature, relative humidity, and send the data immediately to the computer of the monitoring. The collected data are going to be analyzed and managed by the computer. Compared with the traditional meteorological information and basic forest resource data, the system can make a fast assessment of a possible fire danger. With reference to the sensors, their output devices are activated through relay switch. For RF transmitter used in animal body to track and identify to communicate and interface in RF receiver in microcontroller and for temperature sensor a water pump is activated.

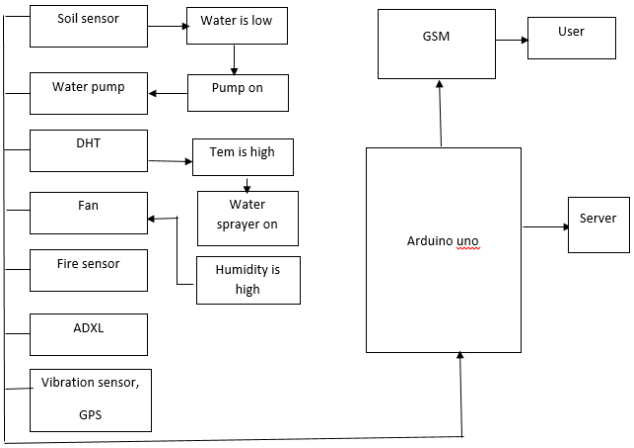

Fig.1 System architecture

2.2 Software Requirements

2.2.1 IOT module

The Internet of Things (IoT) is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and leading to improved efficiency, accuracy and economic benefit. Each thing is uniquely identifiable through its embedded computer system but is in a position to interoperate within the prevailing Internet infrastructure.

2.2.2 Arduino IDE Software

Arduino IDE software is employed for compiling the program into the microcontroller. In this software C programing language has been used for coding. For receiving data from the satellite and RFID reader and sending data into the server, program is written using Arduino IDE software.

2.3 Hardware Requirements

2.3.1 Arduino

Arduino IDE software is employed for compiling the program into the microcontroller. In this software C programing language has been used for coding. For receiving data from the satellite and RFID reader and sending data into the server, program is written using Arduino IDE software. An Arduino is an open-source microcontroller development board. In plain English, you can use the Arduino to read sensors and control things like motors and lights. This allows you to upload programs to the present board which may then interact with things within the world. With this, you'll make devices which respond and react to the planet at large. The pin configuration of the Arduino Uno board is shown within the above. It consists of 14-digital I/O pins, 6 pins are used as pulse width modulation o/ps and 6 analog i/ps, a USB connection, an influence jack, a 16MHz quartz oscillator, a push button, and an ICSP header. Arduino board are often powered either from the private computer through a USB or external source sort of a battery or an adaptor. This board can operate with an external supply of 7- 12V by giving voltage reference through the IORef pin or through the pin Vin.

2.3.2 NODEMCU

NodeMCU is an open source LUA based firmware developed for ESP8266 Wi-Fi chip. By exploring functionality with ESP8266 chip, NodeMCU firmware comes with ESP8266 Development board/kit i.e. NodeMCU Development board. Since NodeMCU is open source platform, their hardware design is open for edit/modify/build.

2.3.3 ADXL Sensor

The ADXL 335, 3-axis accelerometer, has an onboard 3.3V regulator making it an ideal sensor module for Arduino, Raspberry Pi, and similar Microcontrollers. This breakout comes with 3 analog outputs for X, Y and Z axis breakout board. The ADXL335 is the latest and greatest from Analog Devices, known for their exceptional quality MEMS devices and applications in Robotics is now available at thiruvalla, Kerala, India. The VCC takes up to 5V in and regulates it to three 3V with an output pin. The analog outputs are radiometric which means 0g measurement output is always at half of the 3.3V output (1.65V), -3g is at 0v and 3g is at 3.3V with full scaling in between, fully assembled and tested. The XYZ filter capacitors are 0.1uF for a 50 Hz bandwidth.

3 Problem Solution

This section presents and discusses the most results of the evolution of scientific production in a very global context on remote sensing applied within the forest management to optimize ecosystem services each year. Then, the distribution of articles by discipline is analyzed. Subsequently, the results obtained from the analysis of the most keywords related to this field of research are discussed, which allowed to spot the most current lines. The search in Scopus database generated 2066 scientific articles. An analysis is made and observed that, among 2066 articles within the 44 year period

studied, 1040 are published within the last 5 years (2015–2019), that is, 50.34% of all documents, while within the last decade (2010–2019) 1574 articles are published (76.19%). It is important to spotlight that within the last year (2019) 268 articles (12.97%) are published. These confirm the interest of the research topic in recent years by the scientific and academic community at the international level, with a growing publication. Sensor nodes are embedded within the different trees for sensing the environmental parameters within the forest within the real-time scenario. Generally, the sensor node is integrated with the environmental sensors and wireless communication module within the forest environment, wireless connectivity is that the main challenge and to beat it wireless personal network (WPAN) is embedded within the architecture. The fastest growing category of IoT connections, in industry deployments concerns wireless IoT connectivity. Zigbee may be a low-power communication protocol for transmitting sensory data to a short-range. Short-range transmission is another limitation because the sensory data must be communicated to long-range as an integration of multiple repeaters of Zigbee causes difficulty. The communication protocol LoRa and LoRaWAN, more specifically within the category of wireless wide area network technologies that require hiding an extended range but need little power and low bandwidth is employed during this work. LoRa communicates the info to the gateway node where the supply of internet connectivity enables the gateway node to log the info into the server over IP.

Advanced sensor and wireless communication protocol have provided a chance for innovating new devices for monitoring the wildlife and forest. However, the innovation in IoT devices is proscribed to the private entities that monitor the wildlife on their premises. Many private entities have developed different IoT based devices for real time monitoring of animal health conditions and track the real time location of the animal. Edge based IoT devices were also developed for detecting poachers. Hence there is a requirement for more innovation for developing an efficient and reliable device for forest and wildlife. The purpose of failure of connectivity is difficult to acknowledge. As large amount of forest data is logging in to the server, performing analytics on this huge information is to be done. Here the computing plays an important role to perform analytics during a short interval of your time in order that it provides fire alerts and other updates instantly. Figures 2 shows the analysis of soil sensor through which moisture could be analysed. Figure 3 and 4 shows analysis of fire sensor and vibration sensor respectively.

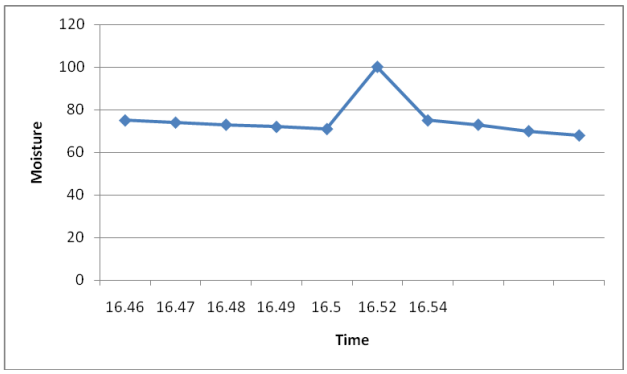

Fig.2 Analysis of soil Moisture

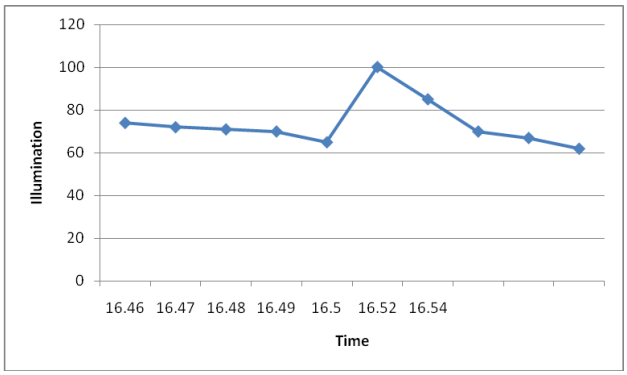

Fig.3 Analysis of Fire sensor

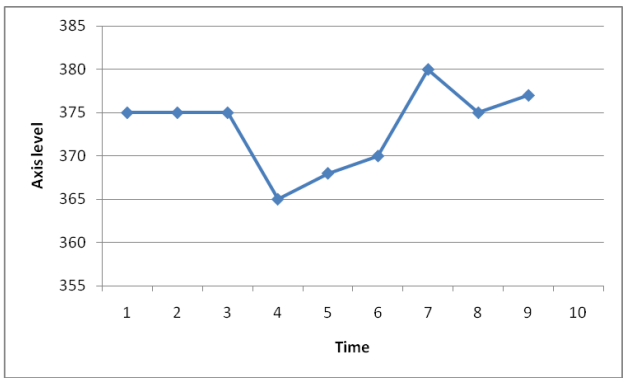

Fig.4 Analysis of Vibration sensor

3.1 Sensitivity Analysis

Sensitivity Analysis (SA) explores forms within which input variations is because of output variations within the performance of the numerical model [18]. SA is increasingly employed in environmental modeling for uncertainty evaluation, the dominant study of controls, and a robust decision-making model, calibration, and

diagnostic assessment for several purposes. SA is helpful because it increases or decreases model estimation by evaluating the model's response to changes in input variables qualitatively and/or quantitatively or by understanding the phenomena examined by observing the relationships between variables. During performing the SA, the subsequent settings like ranking, screening, and mapping are performed. The aim of the Ranking or Factor Prioritization is defined to order the input factors x1, x2,. . . xM supported their relative contribution to the variability of output. Screening tends to classify input factors, to test if there's any factor that's an insignificant influence on the output variability. The function of mapping is to define a part of the input variability that generates significance. A neighborhood sensitivity analysis (LSA) and global sensitivity analysis (GSA) is performed for evaluating the whole error range of the sensors for calculating the evapotranspiration (ET) within the agriculture regions [19]. In the LSA evaluation of the outputs of every sensor within the quoted precision range of every input. All regular values within the input parameter were modified and evaluated with the subsequent equation

$$ERR_i = |ETos\ (i_{max}) - ETos\ (i_{min})| \quad (1)$$

ERR_i means error range obtained by evaluating ETos at a minimum and maximum value of input parameter i, leaving all other inputs unchanged.

4 Conclusion

This paper presents design, development and prototype of wireless sensor network for forest monitoring. The deployment of multisensors needed to hide the forest area is finished. During fire accidents and animal monitoring, this technique immediately performs alerting of forest officials and will even be implemented in wildlife sanctuaries and zoos. It can even be implemented as pet tracking system. It mainly targets animal health monitoring, alerting the forest officials during fire hazards, smuggling of valuable trees and Poaching of species. This technique is additionally highly beneficial in preventing trespassing of untamed animals into the living areas within the forest's vicinity. It also aims on animal location and tracking applications. This paper presents an occasional power consuming, less complex and an economic solution to the present problem.

IoT may be a possible solution for implementing real-time monitoring by the mixing of IoT modules within the forest. In this, we've got addressed the prevailing IoT architecture for environmental and fire detection monitoring. An architecture is proposed for sensing, monitoring for applications like fire incidents, illegal logging of trees, poaching, etc. are discussed briefly. This study contributes to the educational, scientific, and institutional discussions in addition on improve the world of decision making, and are available up with new scenarios and uses of this technology to reinforce the administration and management of forest resources. Finally, various global research on remote sensing applied within the forest management to optimize ecosystem services shows an increasing trend, derived both from the amount of articles and from current and future lines of research.

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