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A Real Time Development Study for Automated Centralized Remote Monitoring System at Royal Belum Forest

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Abstract**—**Nowadays, illegal logging has been causing many effects including flash flood, avalanche, global warming, and etc. The purpose of this study was to maintain the earth ecosystem by keeping and regulate Malaysia's treasurable rainforest by utilizing a new technology that will assist in real-time alert and give faster response to the authority to act on these illegal activities. The methodology of this research consisted of design stages that have been conducted as well as the system model and system architecture of the prototype in addition to the proposed hardware and software that have been mainly used such as microcontroller, sensor with the implementation of GSM, and GPS integrated system. This prototype was deployed at Royal Belum forest in December 2014 for phase 1 and April 2015 for phase 2 at 21 pinpoint locations. The findings of this research were the capture of data in real-time such as temperature, humidity, gaseous, fire, and rain detection which indicate the current natural state and habitat in the forest. Besides, this device location can be detected via GPS of its current location and then transmitted by SMS via GSM system. All of its readings were sent in real-time for further analysis. The data that were compared to meteorological department showed that the precision of this device was about 95% and these findings proved that the system is acceptable and suitable to be used in the field.

Keywords**—**Remote monitoring system, forest data, GSM, GPS, wireless sensor.

I. Introduction

IN the previous few years, the intrusion and violation of preserved forest have caused many unhealthy phenomena such as hotter climate, serious landslides, and unpredicted flash flood [1]. If such phenomena are not being taken seriously, then the ecosystem will be damaged permanently and cannot be irreversible in many years ahead. Moreover, when this incident occurs, there is no device for signaling or to inform the authorities as soon as possible about the changes.

By the time action needs to be taken, often it is too late to prevent anymore. One of the preserved forests mentioned in this study is the Royal Belum forest [2]. Sometimes the temperature and the humidity change drastically from time to time. Likewise, some of the measurements for particles and gaseous have not been collected and measured in terms of quantifying the hazardous fine particles such as carbon monoxide, methane, propane, and butane [3]. Also, there are no specific devices that are currently located and implemented for actual real-time rainfall and fire detection that can easily occur at that location. This study presents a remote monitoring device that has been developed and installed in the forest areas to monitor various parameters such as temperature, humidity, gaseous, fire and rain detection, and capable of transmitting all the environmental data via GSM in real-time analysis[4]. Not only that, the location of the device will be monitored using the global positioning system (GPS) system for proof of larceny or intentionally removing this device from the designated area [5]. Furthermore, this study uses a wireless sensor system based on Arduino system, GSM/GPS/GPRS shield, and Adafruit Ultimate GPS shield that will be transformed into a fully single remote sensing and auto weather station network by intermittently sending the environmental data. This research focuses on developing a device that is capable of managing, displaying, and alerting weather warnings by using the GSM and GPS system [6]. In addition, this device is self and fully powered by solar energy and is in line with the recommendation of utilizing natural green technology and saving the resources.

II. Problem Statement

Recently, Malaysian government has put a momentous effort by inaugurating "Green the Earth: One Citizen, One tree" campaign in April 2010 which aims to plant 26 million trees by 2014 and also investing a huge sum of money (RM60 million) in central forest spine (CFS) project that will link four major forest complexes in Malaysia for preserving the forest, animal, and plant species in the country [7]. Of late, there are areas (Lojing and Royal Belum Forest) have been exposed to illegal logging activities, jungle clearing, and hill cutting made for farming activity and mixed development project [8]. Therefore, this study is vital in supporting the national plan. This research is to experiment and develop an automated multifunctional remote monitoring model for a sustainable forest management which can be used for protecting and monitoring purpose from afar and immediate response can be made if there is a disturbance in the rainforest. Also, this study aims to collect some crucial data that can be used by the scientist in making the rainforest healthy, strong, and free from growing sick and damages due to plants diseases.

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III. Methodology

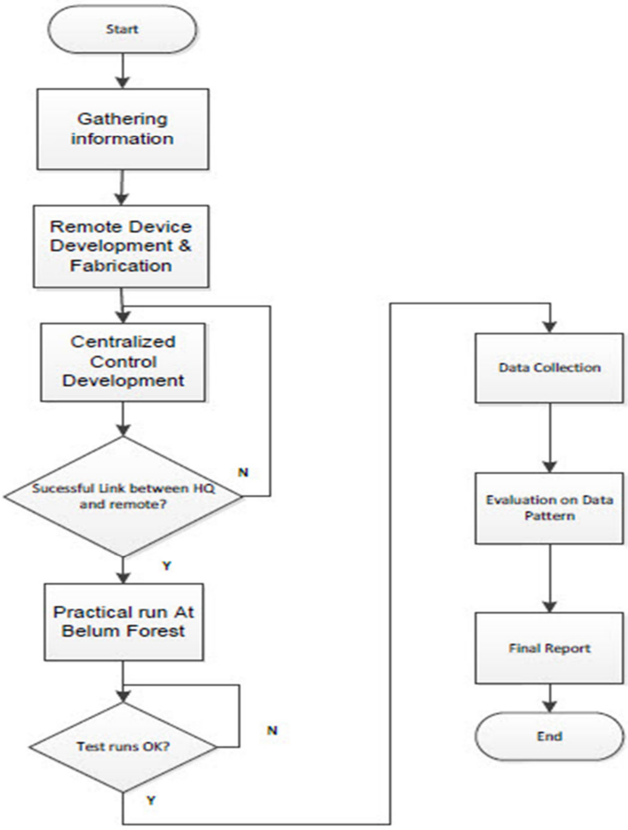

Fig. 1 Flow chart of research activity

This study aimed to experiment and develop an automated multifunctional remote monitoring model for a sustainable forest management [9]. A number of steps need to be examined and studied in order to achieve the above objectives [10]. Some of the identified methods undertook in this research were:

A. Stage 1

The purpose of this phase was to gather all information about the environmental pollution especially in Malaysia rainforest ecosystem. These data were obtained from Forest Research Institute Malaysia and Natural resources and Environmental Ministry.

B. Stage 2

This phase took the statement of the problem and generated broad solutions in the form of schemes. This was the phase where engineering science, practical knowledge, production methods, and commercial aspects need to be brought together and where the most important decisions were taken. A new model was developed for a multifunctional remote monitoring device that includes the standard features of data measuring along with new added features which can be assessable from the main control location. This study consisted of hardware and software development. All the components needed to complete this model are listed in next section. The current devices in the market are too bulky, very expensive, hard to operate, and need human power to take in the equipment needed into the forest in order to take the reading. This will not only capture all data on a single device but also able to instantaneously upload real and accurate data every minute of feeding into the control station. This will provide essential and crucial data that will give information on how to well manage the forests.

C. Stage 3

In this phase, the schemes worked up in greater detail; in which if there is more than one, a final choice is made between them. The end product is usually a set of drawing with general arrangements. There is (or should be) a great deal of feedback from this phase to conceptual design phase.

D. Stage 4

This is the last phase, in which a very large number of data were analyzed by the central monitoring system. This system was fully written in html5 in order to make it easier for the end users to view this data over a wide variety of different platforms. The overall system consisted of a central server that was a central hub for collecting the incoming environmental data from the remote sensing devices. The idea of centralized control location is to design a system that can automatically update a dedicated web page which does not only indicate the location of the remote monitoring device on the map but also displays a static line graph versus time (in days) for every incoming data such as all of the gaseous level, raining spells, humidity, and temperature readout. As a result, this information can be assessed on any computer and can be viewed on iPad or mobile phone.

IV. System Model

Fig. 2 shows the overview of the system model that was implemented in this research. It consisted of four tier models as in [5] which were data acquisition, data communication, data presentation, and alert notification. The hardware used in this research was based on Arduino Uno that acted as the development board for Programmable Embedded System. The communication system was handled by the GSM/GPS/GPRS shield V3 which was equipped with a SIM card to send the SMS alert to mobile phones. Also, the latitude and longitude of the device location were sent via SMS by synchronizing it with Adafruit Ultimate GPS shield. The data collected were temperature, humidity and hazardous gaseous, fire, and rain detection. As for the software programming, this system utilized Coolterm, Garmin BaseCamp, and Arduino Software Serial via UART which are able to change the input data to volts to appropriate temperature reading in Celsius, humidity reading in percentage, and gaseous reading in parts per million (PPM).

Fig. 3 illustrates the architecture features of the proposed system. The data for temperature, humidity, gaseous, fire, rain, and GPS are captured by the wireless sensor, which are then propagated to the access point at the mobile phone. This data is then relayed to the system's control panel. The data is extracted and keyed into the database and benchmarked by the threshold value set by the user. If the data exceeds the threshold value, an alert SMS will be triggered and sent via GSM modem through the cellular network to the user's mobile phone [11].

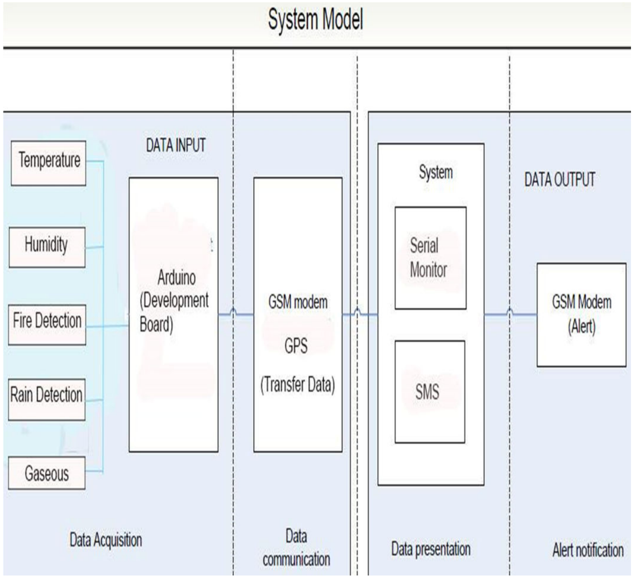

Fig. 2 System model

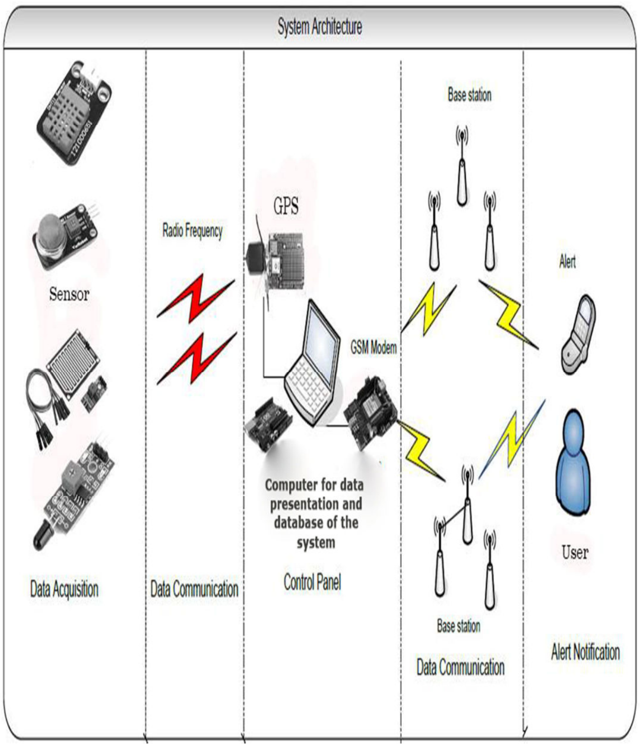

Fig. 3 System architecture

V. Proposed System Description

A. Hardware

The hardware used in this research consisted of microcontroller, sensor, shield, and other compatible devices with the controller.

1. Arduino Uno

This hardware comprises of a simple open hardware for the Arduino board with an Atmel processor and on-board I/O support. This development board is programmed with the help of a wiring-dependent language. The Uno is different from all previous boards in which it does not employ the FTDI USB-to-serial driver chip.

Fig. 4 Arduino Uno

2. DHT 11 Sensors

DHT11 temperature and humidity sensor features a calibrated digital signal output with a temperature and humidity sensor complex. By using the exclusive digital-signal-acquisition technique and temperature sensing technology, it ensures high reliability and excellent long-term stability. Its element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability, and cost-effectiveness.

Fig. 5 DHT11 sensor

3. Analog Gas Sensor

This sensor takes the reading of contaminant gaseous and combustible gas such as carbon monoxide, methane, propane, and hydrogen. Since it is very sensitive to air contaminant, this sensor can instantly detect any illegal clearing or burning in the adjacent area.

Fig. 6 Analog gas sensor

4. Adafruit Ultimate GPS Data Logger

This shield acted as a Global Positioning System (GPS). This can help in pinpointing exactly where the reading is and it can be used to easily and accurately point any relevant person to that location if there is a need to investigate. While it is handy for any new technician to easily locate the device for service maintenance or troubleshooting, this built-in-GPS also can be a tampered proof device in which no authorized person can disassemble or remove this device without being detected.

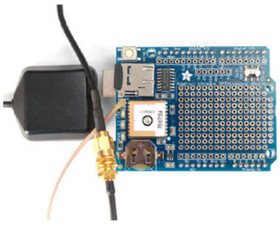

Fig. 7 Adafruit ultimate GPS data logger

5. GSM/GPS/GPRS Shield V3

The GSM/GPS/GPRS signals in 900/1800/1900 MHz tri-band. All the data will be instantaneously transmitted from the remote location to the control location. For instance, if the main control location is in Kuala Lumpur, Malaysia, the data can be pooled from the device located remotely or at any time intervention. Another study is needed to find out if any changes or any updates on the main software can be uploaded easily.

Fig. 8 GSM/GPS/GPRS shield V3

6. Rain Detection Sensor

This sensor collects the data that will give the real-time of raining spell time in a day whenever there is rain in the area. This allows us to do the calculation if cloud seeding is needed in order to preserve the forest or to maintain the new samplings.

Fig. 9 Rain detection sensor

7. Flame Sensor

This sensor is sensitive to flame and any radiation. It also detects an ordinary light source in the range of wavelength 760 nm – 1100 nm. The detection distance is up to 100 cm. The flame sensor has two types of output which are digital and analog signal. The analog output (A0) is a real-time output voltage signal on the thermal resistance while the digital output (D0) is when the temperature reaches a certain threshold; the high output and low signal threshold are adjustable via potentiometer.

Fig. 10 Flame sensor

8. Energy Shield and 7v Lipo Battery

These combined devices act as the battery backup. This device will be powered by a long live battery and this study needs to investigate how to design a device that only consume low power so this battery could last longer (perhaps in months) without needing any replacement.

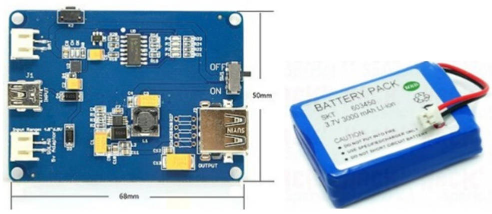

Fig. 11 Energy shield and 7v Lipo battery

B. Software

1. Arduino Software Serial

The Arduino development contains a text editor for writing code, a text console, a toolbar with buttons for common functions, and a series of menus [12]. It connects to the Arduino hardware to upload programs and communicate with them. Software that is written using Arduino is called sketches. These sketches are written in the text editor. Sketches are saved with the file extension *.ino*. It has the features for cutting/pasting and searching/replacing text. The message area gives feedback while saving and exporting, and also displays errors. The console displays text output by the Arduino environment including complete error messages and other information. The bottom right-hand corner of the window displays the current board and serial port. The toolbar buttons allow users to verify and upload programs, create, open, save sketches, and open serial monitor.

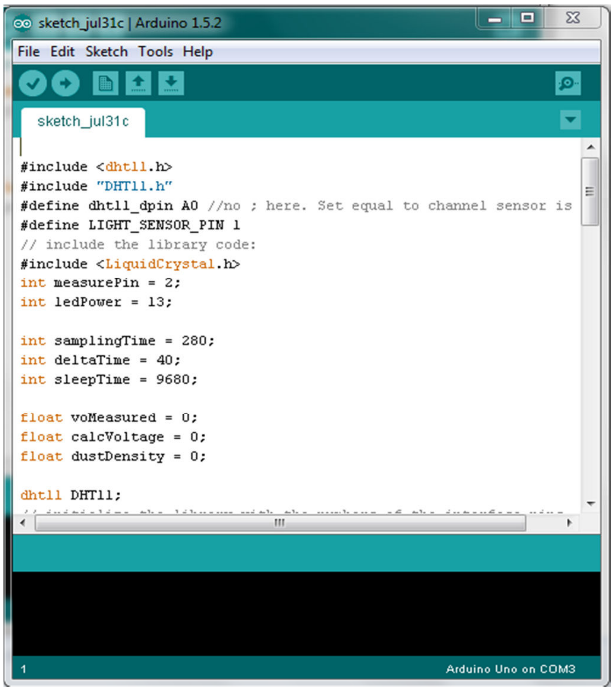

Fig. 12 Arduino Software Serial interface

2. Garmin BaseCamp

BaseCamp is a 3D mapping application that allows users to transfer Garmin Custom Maps, Birds-Eye Imagery, waypoints, tracks, and routes between the operating system in Window and Garmin device. It allows users to manage data practically on all Garmin map products, but topographic maps are required for 3-D rendering.

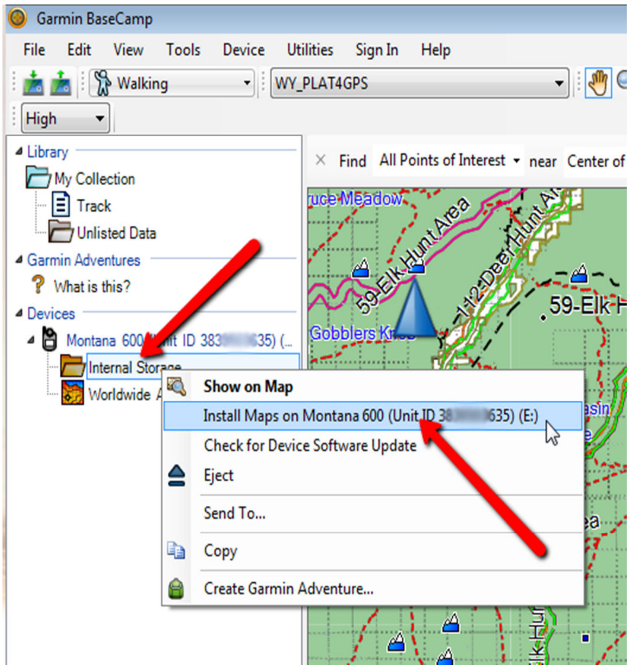

Fig. 13 Garmin Base Camp interface

VI. Field Experiments and Results

The research was conducted in Royal Belum forest, Malaysia. The first thing that we want to see was the location of the device after it was implemented in the forest. The GPS systems played its role in this part. 21 locations were set up to see whether the devices will show us its location via latitude and longitude. Hence, Fig. 13 shows the results of the functionality of the GPS system.

Fig. 14 GPS location of the device within Royal Belum forest

The automated centralized remote monitoring system (ACRMS) in Fig. 15 was tested in the forest for almost 4 days from 6 December 2014 until 9 December 2015. The implementation of the system operated successfully and the data gathered were sent based on real-time for further analysis and process. Based on Fig. 14, we can see that the system was successfully implemented in the forest and the locations of each region of the forest can be seen within it. In this case, each of the components in the Global Positioning System (GPS) and Global System for Mobile Communication (GSM) in the prototype are capable of sending and displaying data and location through Short Messaging System (SMS) and at the same time, user will also be notified through their mobile phone. Each colored flag in Fig. 14 is the collected node of the environmental data during the four days of experimenting in Royal Belum Forest as shown in Fig. 16. One of the limitations of this experimental study is that sometimes it is difficult to locate the satellite in the field. If that happens, the value is fixed at 0 for GPS, meaning that the signal strength is weak, but if the value of the GPS is 1, then the value of the latitude and longitude will be valid to be transmitted over SMS.

Fig. 15 The proposed system of the ACRMS

Fig. 16 The implementation of the 1st prototype at Royal Belum Forest

VII. Conclusion

The automated system for detecting environment (ACRMS) system is ready to be employed in the real environment using all the hardware components and software discussed. It had the combination of all system plus an improvement in data collection technique, portable and scaled to smaller size, self-powered by solar, and can be a direct substitution to the current equipment used in meteorological department. The actual experiment showed that ACRMS can detect temperature, humidity, and hazardous gaseous as well as rain and fire detection with 90-95% accuracy in addition to the implementation of GPS and GSM system. Researchers that are currently involved in researching deforestation and the increase of forest ecosystem temperature, humidity, and phase particle may find that the data taken will be useful for real-time analysis in the investigation of what factors contribute to global warming due to deforestation and open burning in the suspected hot spot areas.

Acknowledgment

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References

[1] K. E. Percy and M. Ferretti, “Air pollution and forest health: Toward new monitoring concepts,” in Environmental Pollution, 2004, vol. 130, pp. 113–126.
[2] Malaysia Natural Heritage. (2013). Belum-Temengor Rainforest Complex. Retrieved 29 January, 2013,
[3] Daily, G. (Ed.). (2007). Nature's Services, Societal Dependence on Natural Ecosystem. Washington DC: Island Press.
[4] C. L. Brack, “Pollution mitigation and carbon sequestration by an urban forest,” Environ. Pollut, vol. 116, 2002.
[5] I. D. A. Aziz, M. H. Hasan, M. J. Ismail, and N. S. Haron, “Remote Monitoring in Agricultural Greenhouse Using Wireless Sensor and Short Message Service (SMS),” Int. J. Eng. Technol. IJET, pp. 1–12, 2009.
[6] R. Kuśmierek-Tomaszewska, J. Żarski, and S. Dudek, “Meteorological automated weather station data application for plant water requirements estimation,” Computers and Electronics in Agriculture, vol. 88. pp. 44–51, 2012.
[7] A. D. Siuli Roy and S. Bandyopadhyay, “Agro-sense: Precision agriculture using sensor-based wireless mesh networks,” in International Telecommunication Union - Proceedings of the 1st ITU-T Kaleidoscope Academic Conference, Innovations in NGN, K-INGN, 2008.
[8] B. Brunekreef, “Air pollution and human health: From local to global issues,” in Procedia - Social and Behavioral Sciences, 2010, vol. 2, pp. 6661–6669.
[9] Yusoff, Amri, Richard Crowder, and Lester Gilbert. "Validation of serious games attributes using the technology acceptance model." Games and Virtual Worlds for Serious Applications (VS-GAMES), 2010 Second International Conference on. IEEE, 2010.
[10] K. T. Ulrich and S. D. Eppinger, “Development Processes and Organizations,” in Product Design and Development, 2011.
[11] G. Irwin, J. Colandairaj, and W. Scanlon, “Understanding wireless networked control systems through simulation,” Comput. Control Eng., vol. 16, pp. 26–31, 2005.
[12] Yusoff, Amri, et al. "A conceptual framework for serious games." Advanced Learning Technologies, 2009. ICALT 2009. Ninth IEEE International Conference on. IEEE, 2009.