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DEVELOPMENT AND VALIDATION OF AN AUTOMATED CENTRALIZED REMOTE SENSING SYSTEM FOR FOREST ENVIRONMENTAL ACTIVITY

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ABSTRACT

The aim of this research is to develop a remote monitoring device that could capture critical real-time data such as temperature, humidity, gaseous, fire, and rain detection that shows the current preserved natural state and habitat in the forest. The forest ecosystem is essential in supplying high natural resources for flora and fauna. This unprotected resources are exposed and susceptible to the threat of illegal logging which can lead to unhealthy phenomenon and irreplaceable assets. The methodology is to employ the rapid prototyping modeling in developing this prototype and also to include a system model that explains the implementation of the temperature, humidity, and hydrogen gaseous variables. All the readings were recorded in real-time for data management and statistical analysis by using SPSS, as well as to analyze the model based on Technology Acceptance Model (TAM) by AMOS. The paired sample T-Test and two-group MANOVA analysis showed that there are significant between mean temperature and humidity. The prototype was implemented at selected locations in the Royal Belum forest to monitor and gather data at two phases. The field experiment was conducted in April 2015. The data consisted of 60 samples for temperature, humidity and hydrogen gaseous from both the upper and the lower parts of the forest. The findings also proved by regression and covariance analysis that the lower part of the forest was more significant than the upper part of the forest area. The results obtained from this research would definitely benefit the monitoring bodies or relevant authorities in applying the system that capable to protect and preserve the forest in its natural



environment.



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PEMBANGUNAN DAN PENGESAHAN SISTEM PENGESAN AUTOMATIK BERPUSAT BAGI AKTIVITI PERSEKITARAN HUTAN

ABSTRAK

Tujuan penyelidikan ini adalah bagi membangunkan peranti kawalan pemantauan bagi mengumpulkan data kritikal secara langsung seperti suhu, kelembapan, gas, dan pengesanan api dan hujan yang menunjukkan keadaan semasa alam semula jadi yang dilindungi dan habitat di dalam hutan. Ekosistem hutan adalah penting bagi membekalkan sumber semula jadi kepada flora dan fauna. Sumber yang tidak dilindungi ini terdedah kepada risiko pembalakan haram yang secara tidak langsung mengundang kepada fenomena yang tidak sihat dan khazanah yang tidak dapat dipulihkan. Metodologi kajian ini terdiri daripada model prototaip berterusan yang digunakan untuk membangunkan prototaip dan juga termasuk sistem model bagi memberi penerangan mengenai pelaksanaan terhadap pembolehubah suhu, kelembapan, dan gas hidrogen. Kesemua bacaan dihantar secara langsung untuk pengurusan data dan analisis secara statistik dengan menggunakan perisian SPSS dan menguji model yang dibangunkan berdasarkan Technology Acceptance Model (TAM) oleh AMOS. Dapatan kajian berdasarkan analisis persampelan berpasangan ujian T dan MANOVA dua kumpulan menunjukkan bahawa terdapat perbezaan signifikan diantara mean suhu dan kelembapan. Prototaip ini dilaksanakan di lokasi-lokasi yang terpilih di dalam hutan Royal Belum untuk pemantauan dan kutipan data melalui dua fasa. Eksperimen kajian telah dijalankan pada April 2015. Sampel data terdiri daripada 60 pensampelan bagi suhu, kelembapan dan gas hidrogen daripada bahagian atas dan bahagian bawah hutan. Dapatan kajian dibuktikan melalui analisis regresi dan kovarian mendapati bahagian bawah hutan adalah lebih signifikan berbanding bahagian atas hutan. Dapatan kajian daripada kajian ini diharapkan mampu memberikan manfaat kepada badan-badan pemantauan atau pihak berkuasa yang berkenaan dalam menjaga hutan di dalam habitat semula jadi.



TABLE OF CONTENTS

	Pages
DECLARATION	ii
ACKNOWLEDGMENTS	iii
ABSTRACT	iv
ABSTRAK	v
TABLE OF CONTENTS	vi
LIST OF TABLES	xii
LIST OF FIGURES	xiv
LIST OF ABBREVIATIONS	xvii
LIST OF APPENDIXES	xix
CHAPTER 1 INTRODUCTION	20
1.1 Introduction	20
1.2 Problem Statement	24
1.2.1 Direct Cause	27
1.2.1.1 Expansion of farming land	27
1.2.1.2 Forest and other plantations	28
1.2.1.3 Logging	28
1.2.1.4 Overgrazing	29
1.2.1.5 Fires	29
1.2.1.6 Quarrying	30

1.2.1.7 Urbanization/industrialization and infra-structure	30
1.2.1.8 Air contamination	31
1.2.1.9 Warfare and Military's role	31
1.2.1.10 Tourism	31
1.2.2 Effects of Deforestation	32
1.2.2.1 Climate change	32
1.2.2.2 Flooding, Loss of Water and Soil Resources	32
1.2.2.3 Decreased biodiversity and habitat losses	33
1.2.2.4 Economic losses	33
1.2.2.5 Social consequences	33
1.3 Purpose of the study	34
1.4 Research Objectives	35
1.5 Research Questions	36
1.6 Hypotheses	37
1.6.1 Research Hypotheses	37
1.6.2 Null Hypotheses	38
1.6.3 Alternative Hypotheses	39
1.7 Conceptual Framework	41
1.8 Significance of the study	42
1.9 Limitation of the study	43
1.10 Research Design	44
1.11 Operational Definition	45

1.12 Conclusion	48
-----------------	----

CHAPTER 2 LITERATURE REVIEW 50

2.1 Introduction	50
------------------	----

2.2 Previous Literature Topics	50
--------------------------------	----

2.3 Literature on Global Positioning System	56
---	----

2.4 Literature on GSM	58
-----------------------	----

2.5 Literature Concept	58
------------------------	----

2.6 Summarization from previous research	67
--	----

2.7 Conclusion	72
----------------	----

CHAPTER 3 METHODOLOGY 73

3.1 Introduction	73
------------------	----

3.2 Flow Chart of Research Activity	74
-------------------------------------	----

3.2.1 Gathering Information	75
-----------------------------	----

3.2.2 Remote Device Development and Fabrication	75
---	----

3.2.3 Centralized Control Development	75
---------------------------------------	----

3.2.4 Successful Link between HQ and Remote	76
---	----

3.2.5 Practical Run at Royal Belum forest	76
---	----

3.2.6 Test Run	76
----------------	----

3.2.7 Data Collection	76
-----------------------	----

3.2.8 Evaluation on Data Pattern	77
----------------------------------	----

3.2.9 Final Report	77
--------------------	----

3.3 Gantt chart of Research Activity	78
--------------------------------------	----

3.4 Milestone and Date	78
------------------------	----

3.5 Procedure of Data Analysis	79
--------------------------------	----

3.6 Validation of Standard	79
----------------------------	----

3.7 Technology Acceptance Model	80
---------------------------------	----

3.8 Conclusion	84
----------------	----

CHAPTER 4 DEVELOPMENT	86
------------------------------	-----------

4.1 Introduction	86
------------------	----

4.2 Rapid Prototyping Modeling	87
--------------------------------	----

4.3 ACRSS Development Modeling	90
--------------------------------	----

4.4 Requirement Analysis and Definition	90
---	----

4.5 System Design	90
-------------------	----

4.5.1 System Model	91
--------------------	----

4.5.2 System Architecture	92
---------------------------	----

4.5.3 Hardware	93
----------------	----

4.6 Software Design	114
---------------------	-----

4.6.1 Arduino SoftwareSerial	114
------------------------------	-----

4.6.2 Garmin Base-Camp	116
------------------------	-----

4.7 Implementation/Coding	116
---------------------------	-----

4.8 Software Integration and Verification	119
---	-----

4.8.1 Unit Test	119
-----------------	-----

4.8.2 Unit Integration	122
4.9 System Verification	123
4.10 Operation and Maintenance	129
4.11 Conclusion	130
CHAPTER 5 DATA ANALYSIS	132
5.1 Introduction	132
5.2 Sampling Result	133
5.3 Paired Sample T-Test Analysis	133
5.4 Two-Group MANOVA Analysis	137
5.4.1 Correlation	137
5.4.2 P-Plot Normality Test	138
5.4.3 Descriptive Statistic	140
5.4.4 Box's Test of Equality of Covariance	142
5.4.5 Multivariate Tests	142
5.4.6 Levene's Test of Equality	143
5.4.7 Test of Between-Subject Effect	144
5.5 Amos Statistic Analysis	144
5.6 Conclusion	147
CHAPTER 6 RESULT AND CONCLUSION	149
6.1 Introduction	149
6.2 Hypotheses Testing	150



6.3 Revisiting the Original Research Proposal 152

6.3.1 Research Questions 152

6.3.2 Aims 153

6.3.3 Research Objective 154

6.3.4 Validation of Standard 156

6.4 Limitations 157

6.5 Further Research 159

6.6 Conclusion 160

REFERENCES 162

APPENDIX 171



LIST OF TABLES

No. of Table		Pages
1.1	Conversion in forest from 1990-2010 (Source: Anon., 2010)	26
2.1	ACRSS Research Gap	70
2.2	ACRSS Research Gap (Continued from Table 2.1)	71
4.1	Arduino Technical Comparison	95
4.2	Arduino Technical Comparison (Continued from Table 4.1)	96
4.3	Temperature and Humidity Technical Comparison	98
4.4	Gas Sensor Technical Comparison	100
4.5	Rain Detection Technical Comparison	103
4.6	Fire Detection Sensor Technical Comparison	105
4.7	GSM module Technical Comparison	108
4.8	GSM module Technical Comparison (Continued from Table 4.7)	109
4.9	GPS Modul Technical Comparison	112
5.1	Paired Sample T-Test	133
5.5	Correlations	137
5.6	Between-Subjects Factors	141



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Kampus Sultan Abdul Jalil Shah

PustakaTBainun



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5.7	Descriptive Statistic	141
5.8	Box's Test Equality of Covariance	142
5.9	Multivariate Tests	143
5.10	Levene's Test of Equality	143
5.11	Test of Between-Subject Effect	144
5.12	The significant paths for the regression data (identified by $\checkmark$)	146



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LIST OF FIGURES

No. of Figure		Pages
1.1	ACRSS Conceptual Framework	41
2.1	VRS Technology. (Source: Kamburov, 2010)	57
2.2	WSN detecting trunk. (Source: Wang, Wang, Wang, & Liu, 2012)	59
2.3	Demonstration Scenario using WSN. (Source: Mittal et al., 2012)	60
2.4	Simplified WSN hierarchical network structure. (Source: Sidén, 2007)	61
2.5	Wireless Node Structure. (Source: Yatskiv & Sachenko, 2014)	62
2.6	Wireless sensor with structure. (Source: Babiš et al., 2011)	63
2.7	Deployment of sensor in the forest. (Source: Kirubaharan et al., 2014)	65
2.8	PCB Board of the System Hardware. (Source: Sidek et al., 2014)	66
2.9	The System GUI. (Source: Sidek et al., 2014)	66
2.10	System Architecture (Source: Yusoff, Shafiril, Abas, & Yusoff, 2015)	67
3.1	Research Flow Chart	74
3.2	Research Gantt Chart	78
3.3	Model Developed	82
3.4	Upper Part Location of Royal Belum Forest	83

 05-4506832  pustaka.upsi.edu.my  Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah  PustakaTBainun  ptbupsi				
3.5	Lower Part Location of Royal Belum Forest	84		
4.1	Rapid Prototyping Modeling	89		
4.2	System Model	92		
4.3	System Architecture	93		
4.4	Arduino Uno	94		
4.6	DHT 11 Temperature and Humidity Sensor	98		
4.7	Analog Gas Sensor	99		
4.8	Rain Sensor Module	102		
4.9	Future electronic flame sensor	104		
 05-4506832  pustaka.upsi.edu.my  Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah  PustakaTBainun  ptbupsi				
4.10	GSM Module	107		
4.11	GPS Module	111		
4.12	Solar Panel with JST pin	113		
4.13	Lithium Polymer Battery	114		
4.14	Arduino Software-Serial	115		
4.15	Garmin Base-Camp	116		
4.16	Flow Chart of the Coding	118		
4.17	Temperature and Humidity code testing	120		
4.18	Schematic for DHT11 sensor and LCD	121		

 05-4506832  pustaka.upsi.edu.my  Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah  PustakaTBainun  ptbupsi			
4.19	Unit Test for DHT11 sensor readings	122	
4.20	Main Page of ACRSS	123	
4.21	Side View of ACRSS	124	
4.22	Front View of ACRSS	124	
4.23	Top View of ACRSS	125	
4.24	Temperature Data Interface	125	
4.25	Humidity Data Interface	126	
4.26	Gaseous Data Interface	127	
4.27	GPS Coordination Data	128	
 05-4506832  pustaka.upsi.edu.my  Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah  PustakaTBainun  ptbupsi			
4.28	Real Time Data Capture Interface	129	
4.29	The implementation of the prototype at Royal Belum	130	
5.1	Graph of Temperature Statistic	134	
5.2	Graph of Humidity Statistic	135	
5.3	Graph of Hydrogen Statistic	136	
5.4	Temperature Normal P-P Plot	139	
5.5	Humidity Normal P-P Plot	139	
5.6	Hydrogen Normal P-P Plot	140	
5.7	The standard output estimates	145	

LIST OF ABBREVIATIONS

A/D	Analog to Digital
AC	Alternate Current
CFS	Central Forest Spine
CLASlite	Carnegie Landsat Analysis System
DC	Direct Current
GFCD	Global Forest Change dataset
GIS	Geographic Information System
GPS	Global Positioning System
GSM	Global System for Mobile Communication
I/O	Input/Output
ID	Instructional Design
IHR	Indian Himalayan Region
LCD	Liquid Crystal Display
MANOVA	Multivariate of Covariance Analysis
MODIS	Moderate Resolution Imaging Spectroradiometer
PLC	Programmable Logic Circuit
PPM	Part Per Million
RP	Rapid Prototyping
RS	Remote Sensing
RX	Receive
SMS	short message service
SPSS	Statistical Package for Science Sosial



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TX

Transmit

USB

Universal Serial Bus

VCF

Vegetation Continuous Fields



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LIST OF APPENDIXES

Appendix	Pages
A Permission Letter to Conduct Research	171
B Royal Belum Map	172
C EduInERI participant certificate	173
D EduInERI Bronze Medal Certificate	174
E ICESR Letter of Acceptance	175
F List of Publications, Exhibition, Conferences	176
G SPSS Paired Sample T-Test Analysis	177
H Two Group Manova Analysis	179
I First Order Structure Analysis using AMOS	183
J Turnitin Digital Receipt	184
K Proofread Receipt	185



CHAPTER 1

INTRODUCTION



1.1 Introduction

The ecosystem and the natural environment of the Earth have gradually becoming eradicate due to negligence and total lack of control by human population, thus affecting our rainforest ecosystem that is not just for shelter to the biodiversity of flora and fauna, but on the contrary and more crucially, to establish an equilibrium ecosystem to us human too. Moreover, it would be incapable for rainwater to be stowed, filtered down to the ground, and flowed to the dam without the rainforest. In fact, the Royal Belum Forest is the oldest rainforest in the world and it has been thriving for more than 100 million years. The rainforest covers about 117, 500ha of land in Perak and it is the biggest in Malaysia (Malaysia Natural Heritage, 2013). It contributes rainwater to water catchment areas at Ahning, Pedu, and Muda dams. Unfortunately, the present forest ecological system has been heavily damaged since human has begun exploiting forests



disorderly, especially through illegal logging, which has become a primary factor of deforestation.

As a result, it has created widespread environmental damage, irreversible climate change, contamination of air and surrounding rivers, recurrent avalanches, as well as deterioration of the colony regions and the living conditions among Aborigines (Singh & Abdullah, 2013). Furthermore, an interesting study by Daily (2007) revealed that half of the land on the Earth has been used up by human. Besides, nearly 30% of carbon dioxide occasioned from human acts has filled up the earth. Thus, crucial inquiry has to be carried out urgently in order to conserve the ecosystem of our Earth. In fact, two methods are available to prevent illegal logging activity. The first method is enforcing stricter forest preservation regulation to punish those who commit it, while the second method is tightening the observation of illegitimate forest harvest.

Nonetheless, conventional method for monitoring large-scale forests, which saves time and labor resources is by keeping the ranger manually patrolling the area. Moreover, the desolate state of the forest ecosystem is also making it too harsh to constant patrol. Therefore, the purposes of this study had been to maintain the ecosystem of the Earth by preserving and regulating our treasured forest, especially the Malaysian rainforest at Royal Belum Forest, through a new technology that could assist in alerting real-time, as well as to provide faster response to the authority to act on these illegal activities.

Furthermore, the concept of ecosystem complexity, consisting of mapping and modelling including their overtime rate of changes is the main issue in biogeography and spatial ecology. Besides, remote monitoring has been recognized as one of the most dominant methods to map abiotic and biotic ecosystems' components for example, land

use, soils, land cover and vegetation as well as estimating their changes over time (Rocchini et al., 2013). In addition, remote sensing and alerting have existed since a long time and they have been used to enhance the quality of monitoring and alerting. Moreover, because of the advancement of wireless sensor technology and innovation in communication, it is now likely for business users to implement this technology for their productions (Hema, Murugan, & Priya, 2014). In addition, providing cellular network saturation into rural areas has made remote sensing a better option. Therefore, applying remote sensing to forestry and agricultural sectors is recommended as it is feasible.

The research depicts the development of an automated centralized remote monitoring system for detecting rainforest activities. The main focus for developing this device was to measure current temperature, humidity, and hazardous gas, such as carbon monoxide, butane, propane, methane, and smoke. In addition, the device could detect fire and rain, where all the data gathered from the device were transmitted to GSM by sending messages in near real-time and then, the data were sent to database, which after that, displayed all the data captured on the website that had been developed. The device was also equipped with GPS functionality to track the location of the device by its latitude and longitude. The implementation of the device was done within the Royal Belum preserved forest. In fact, the sensor had the main role in this research as the data gathered had to be accurate and validated by calibrating the sensor. After obtaining the real calibration of the sensor, the device was compared with a multifunctional environment meter and a handheld gas monitor to ascertain the validation of the data values.

Moreover, the microcontroller and the shield used in the development of this system have often been used by engineers to design and develop a technology that is based on the field of robotic technology. Not only that, the microcontroller that was used to develop the system displayed numerous potential for innovation of various kinds of beneficial products that can be implemented to the society. Furthermore, in this research, green energy was employed to replace electric energy. In this case, this device used the solar energy gained from the sun, which was absorbed by the solar panel, and then, the energy flowed through another shield that converted the solar energy to current before being supplied to the microcontroller used in this device. Through the use of this green energy, the rate of using electrical energy had been reduced and thus, can help save the Earth, besides offering healthy environmental conditions (Hammer et al., 2003).

This prototype highlights the initiative to prevent illegal logging. Even though the developed device cannot be compared to remote sensing with high resolution, such as satellite imagery, it is more affordable and easy to use. Besides, the combination of all of the features within the hardware and the software, such as Arduino as the main component, generated the new device. Other components, such as sensor, GPS, and GSM, played their own role towards the development of this prototype. Furthermore, if this prototype could be developed and function as specified; then the combination of separate devices, such as those at the Meteorological department, could be transformed into one single handy device that should be able to capture and measure the collected data, thus generating a new technology that is affordable as well as easy to be use compare high resolution remote sensing components, such as satellite image and radar

which is need an understanding in order to be use or if researcher is someone who is an expert a field regarding to Geographical Information System (GIS).

1.2 Problem Statement

Deforestation can be simplify as a transformation of forest into alternate non-forested permanent land that been used as development of an urban area, grazing or for agriculture purpose (van Kooten & Bulte, 2000). The main concern about deforestation is involving emerging tropics countries (Myers, 1994) as the areas of the tropical forest has been lessening (Barraclough & Ghimire, 2000) initiating damage within biodiversity and increasing the effect of greenhouse (Angelsen et al., 1999). Food and Agricultural Organization (FAO) has suggested to establish a tree plantation in order to be forest for timber production and consequently it does not categorize as a forest alteration to estate by way of deforestation (however it is still consider to damage the natural forests). However, tree plantation cannot be cogitate for supplying non-timber produces to be forest though rubber plantations been classify as a forest as stated by FAO. Forest dilapidation happens when the functionality of ecosystem are ruined however where the remnants of forested area rather cleared (Anon., 2010).

Deforestation happened with a frequency of 9.2 million hectares for each year since 1980 until 1990 while from 1990 until 2000, the rate increased about 6.8 million to be 16 million hectares for each year and in 2000 until 2010, the rate decreasing toward 13 million hectares for each year. The net conversion for the area of the forest throughout the last period was probably around -5.2 million hectares per annum which

the area of the loss are equal around 140km² of forest each a day or approximately about the size of Costa Rica, though reduced than that stated in 1990-2000 which was 8.3 million hectares per annum equal to 0.20 per cent loss for the remaining of forest area each year. The recent annual net loss is 37 per cent slighter than that in the 1990s and equivalents a loss of 0.13 per cent for the remaining of forest area a day respectively during this period. By dissimilarity some smaller countries have great losses per annum plus they are in jeopardy of practically losing their entire forests in the following decade doubly if existing proportions of deforestation are continued. Undeniably, an approximate of 31 countries do not even reach to the list since they have now removed most of their forest and even the remain are completely degraded and fragmented. The changes in area of forest by region and sub-region are shown in **Table 1.1** below.

Table 1.1

Conversion in forest area from 1990-2010 (Source: Anon., 2010)

Region/sub-region	1990-2000		2000-2010	
	1 000 ha/year	%	1 000 ha/year	%
Eastern and Southern Africa	-1841	-0.62	-1839	-0.66
Northern Africa	-590	-0.72	-41	-0.05
Western and Central Africa	-1637	-0.46	1535	-0.46
Total Africa	-4067	-0.56	-3414	-0.49
East Asia	1762	0.81	2781	1.16
South and Southeast Asia	-2428	-0.77	-677	-0.23
Western and Central Asia	72	0.17	131	0.31
Total Asia	-595	-0.10	2235	0.39
Russian Federation (RF)	32 n.s.	n.s.	-18	n.s.
Europe excluding RF	845	0.46	694	0.36
Total Europe	877	0.09	676	0.07
Caribbean	53	0.87	50	0.75
Central America	-374	-1.56	-248	-1.19
North America	32	n.s.	188	0.03
Total North and Central America	-289	-0.04	-10	-0.00
Total Oceania	-41	-0.02	-700	-0.36
Total South America	-4213	-0.45	-3997	-0.45
World	-8327	-0.20	-5211	-5211