Advisory and Real Time Monitoring System for Water Level of River Using Raspberry PI

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ABSTRACT

A water level advisory and real-time monitoring system was developed and tested to major rivers in Oriental Mindoro to measure and monitor actual river stage and generate early warnings via short message services (SMS) to stakeholders for potential risks of flooding. The Input-Process-Output (IPO) model served as system guide and sensor, raspberry Pi, web and computer file full of information server and user-friendly mobile for system development and use. The development and descriptive methods of research were used to develop the system and hardware to interpret the study results and findings. Data were obtained through onsite demonstration, interviews, research, internet and questionnaire. The developed system using Raspberry pi combined with ultrasonic sensor can measure the water level of rivers and using GSM technology its measured data can be transmitted to the web and mobile service. Database of river water level with illustrated line graph can be programmed using the transmitted data reading from the Raspberry pi with an ultrasonic sensor. Furthermore, the data generated from the developed system device can successfully generate line graph with numerical values. Based on the tests results of ISO 9126 software product quality standard, the system was considering acceptable. The system was recommended to be established and used by locals, Provincial Disaster Risk and Reduction Management Office and Municipal Disaster Risk and Reduction Management. For isolated areas, a solar panel can be used as power source for the device to make it portable and for data transmission speed, the device can also be tested in areas with low connectivity.

Keywords: *sensor, raspberry Pi , real time monitoring, water level, SMS*

1. INTRODUCTION

One of the major problems of lowland areas and communities nearby rivers is overflowing of rivers to heavy rainfall or typhoon. Relatively, there is direct relationship between water levels and rainfalls in measuring stations of waterways therefore, if rainfall intensity increases water level and volume of discharge increases too and thus, rainfall is a major factor that causes flooding resulting to immediate impacts of flooding such as loss of human life and damage to property [1]**.** Flooding also causes destruction of crops, and loss of livestock and deterioration of health conditions owing to waterborne diseases. In the Philippines, flash flooding is frequently experienced by Filipinos leading to panic and fears and despite of the numerous efforts and projects of the government and non-government organizations and sectors in improving mechanisms to warn alarming situations, flash floods are considered to be nature's worst killers [2]**.** Communities within lowland areas and along rivers are most vulnerable thus, there is really a need to mitigate its impacts.

Real time monitoring of water levels in river's stage and prompt and direct advisory to communities will aid in reducing flood risks. Current technologies make use of sensing device, flood modeling using software and internet, automated rain gauge and water level monitoring station and lidar technology. The Department of Science and Technology Water Level Monitoring System (WLMS) makes use of an ultrasonic sensor to accurately measure and determine the river stage equipped with solar panel[3]**.** The ultrasonic sensors calculate time interval between sending the signal and receiving the echo to determine water level. Collected data are sent wirelessly, via cellular network, as a text message. Every WLMS has an ASTI-developed arQ, which serves as the mini-computer that intelligently controls all functions and data communications of the station. However, the DOST Project NOAH website under sensors stream gauge does not provide numerical representation of data on a per minute interval and does not deliver mobile text alert directly to the community.

Objectives of the Study

In general, the study aimed to design and develop an advisory and real time monitoring system for water level of rivers using raspberry Pi. Specifically, it aimed to: (1) design and write the program in the raspberry pi to detect and measure the level of river water, (2) create a database cloud of the water level measurements taken from the raspberry pi, (3) compare the results of water level measurements taken from raspberry pi against the existing device used by DOST and (4) test and evaluate the functionality, reliability, efficiency and usability of the system

2. MATERIALS AND METHODS

System development involved use of hardware and software tools. Hardware part includes prototyping accessories which come with breadboard, assortment of resistors, LEDs used for an rPi and ultrasonic sensor. Shown in Figure 1 are ultrasonic sensor and the rapsberry Pi used in the development of the project.

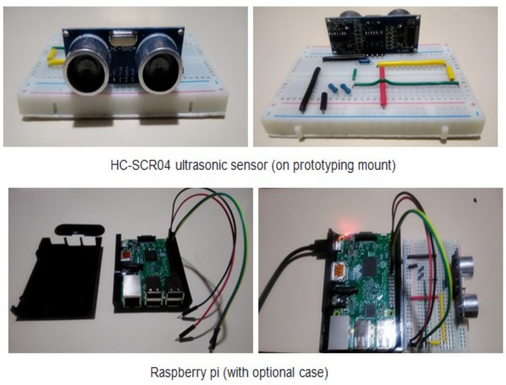

Figure 1. Ultrasonic Sensor and the Raspberry Pi

Software Development Tools

The development of the project was done by using API provided by Globe Telecom Incorporated and the Raspbian Operating System.

Globe Labs API. This is an application created by Globe Labs under Globe Telecom Inc. It is a tool to help developers integrate their software applications with Globe platform for calls, short messaging service (SMS), open authentication, charging, and location detection. With the SMS API, Globe Labs API becomes the intermediary software application that can send and receive information through text. As of now, the Globe Labs is available for Globe and Smart sims.

Globe Labs API provides an access tokens to the SMS subscriber upon registration. This access token is the securing protocol to access both the Globe Labs API and the application which in this case is the BahaAlert data. Without the token, both the BahaAlert server and the subscribers will never have access to the Globe Labs API.

By default, Globe Labs API runs in Node.js server and Phyton scripts. Globe Labs provides the proponent free credits (worth 1000 credits, or 2000 points for outgoing SMS and 13,000 points for incoming SMS) to accomplish the API testing together with the BahaAlert application. A total of 13,000 incoming SMS messages are allowed during the creation of an account. Every outgoing message costs 50 centavos. One thousand pesos credit expires in a month just like a regular load[4].

Raspbian Operating System. Raspbian is a free operating system based on Debian optimized for the raspberry pi hardware. An operating system is the set of basic programs and utilities that makes raspberry pi run. However, Raspbian provides more than a pure OS: it comes with over 35,000 packages, pre-compiled software bundled in an orderly format for easy installation on raspberry pi.

Python Programming Language

Phython syntax is very clean, with an emphasis on readability and use of standard English keywords. It is a widely used high-level, general purpose, interpreted, dynamic programming language. Its design philosophy emphasizes code readability, while its syntax allows programmers to express concepts in fewer lines of code than possible in languages such as C++ of Java. The language provides constructs intended to enable writing clear programs on the both a small and large scale. Python supports multiple programming paradigms, including object oriented, imperative and functional programming or procedural styles. It features a dynamic type system and automatic memory management and has a large and comprehensive standard library.

Process Flow Chart

The process flow chart of the system, development is shown in Figure 2. The ultrasonic sensor senses the water level of the river and raspberry pi device serves as a means of communication protocol between the device and web server. The distance between the ultrasonic sensor and water is measured and the height level of the water is calculated. The calculated height value is updated in the web page. Every minute reading of water height level detection through the analysis of raspberry pi is automatically sent to the server to have initial data saved on the server.

The server then requests the information be resent to verify the validity of data. When similar information is taken, data are recorded in the database and ready for dissemination on web. The water level calculated will then be compared with the set threshold is the current level is more than the set threshold value, the microcontroller will sending SMS to local authorities via the GSM module.

The system will send request SMS to Globe API once the water level reaches the threshold limits.

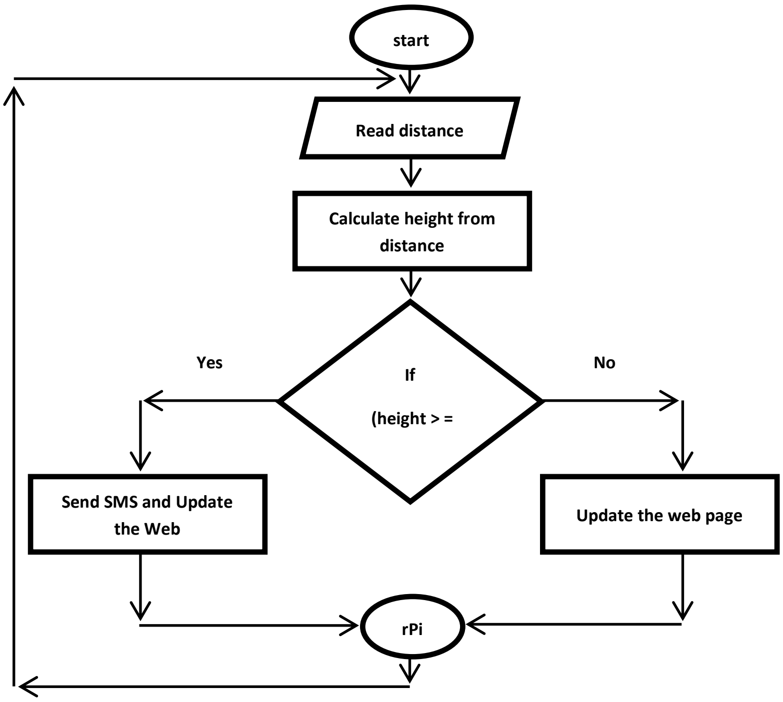

Figure 2. Process flow chart of the system developed

System Testing and Implementation

The system was tested as to its conducted against the system/data and technical requirements to ensure the system was built to specification. System testing was conducted against the user requirements to ensure the system was operationally satisfactory. The prototype or pilot concept also allowed for refinements or adjustments based on user feedback prior to larger scale implementation. The key output of this phase was validation of the design prior to full commitment.

Respondents of the System Evaluation

The evaluator—respondents of the developed system were local authorities of the municipalities, DOST and Provincial coming from the there flood municipal in Oriental Mindoro the Municipal Disaster Risk and Reduction Office (MDRRMO).

Scaling and Quantification of Data

Weighted mean was used to quantify the respondents' evaluation of the system.

A rating scale with 1 to 4 with 4 as highest to 1 as lowest was used to evaluate the system. Corresponding verbal descriptions were used for the numerical assessment. The scale was use to interpret and analyse the results:

Numerical Value	Scale	Description
3.50 – 4.00	4	Strongly Agree
2.50 – 3.49	3	Agree
1.50 – 2.49	2	Disagree
1.00 – 1.49	1	Strongly Disagree

3. RESULTS AND DISCUSSION

Design of the Raspberry Pi

The researcher used the Raspi-Sump model in the development of the project. It is well-fitted to the project as it is a sump pit water level monitoring system using a raspberry Pi, an HC-SR04 ultrasonic sensor and written in Python. It monitors the water level in sump pit and alerts if the water level is getting too high, possibly indicating a sump pump problem. Figure 3 shows the circuit diagram of the raspi-sump.

Raspberry pi is used to read sensors (inputs), store their values in a database for historical trending and turn relays (outputs) on and off when a sensor value goes outside of a certain range. Raspberry Pi 3 Model B is connected to an external power supply rated at 5V dc, and a minimum current of 2Amp[5][6][7].

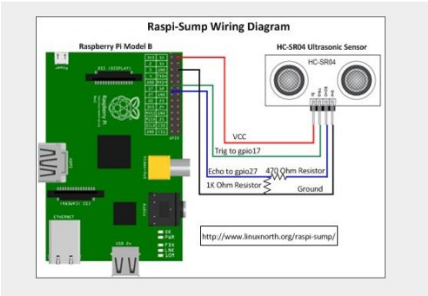

Figure 3. Circuit diagram of the raspi-sump.

The ultrasonic sonar module requires a power input of 3 volts or within the range of 3 to 5 volts and an ampere rating of 3.5 milli- Amperes. The sound produced by the sensor is in frequency of 40 kilohertz. The sensor's range of detection is from 2 cm to 400 centimeters (4.0 meters).

In order to disseminate information detected by the prototype, the researcher developed a web and mobile application. The application was developed using Hypertext Mark Up Language 5 (HTML 5), Cascading Style Sheet 3(CSS 3) and JavaScript for the client -side programming and Node.js + express framework for the backend.

Web and database server stored information received from the sensors. This served as the resource needed to view the information via web browsers or mobile application.

Database Generated

Figure 4 shows the screen shot of output of real time water level readings: (1) is the IP address assigned to access the website; (2) is the per minute interval monitoring to show the abrupt changes of water level which is very important and helpful to the authorities; (3) is the water level readings in meters that indicate signal warning when it reaches the threshold limit of water level alert; and (4) is the date relevant in terms of recording of data as reference.

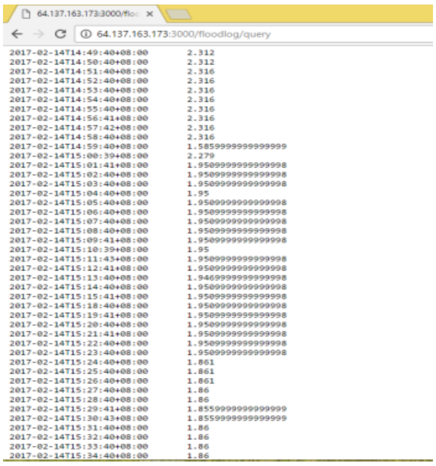

Figure 4. Screenshot of flood log query

Figure 4 shows the screen shot of the water level chart for easy understanding and analysis; (1) is the IP address to gain access to the website; (2) is the water level in meters that indicates signal warning when it reaches the threshold limit of water level alert; and (3) is the time monitoring to show the abrupt changes of water level.

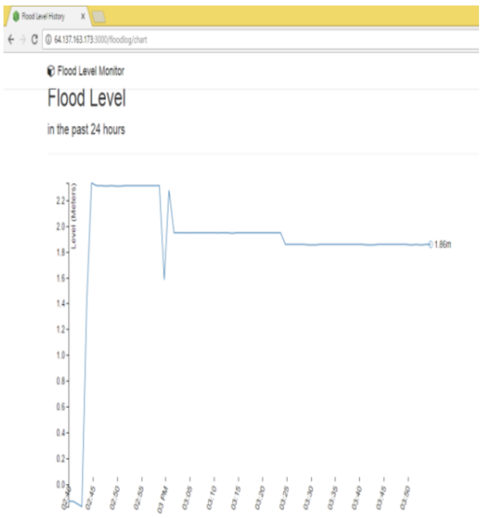

Figure 5. Screen shot of water level chart

Shown in Figure 6 is the SMS sent once the sensor and raspberry pi detect that the water level reaches the threshold limits of the river water level. SMS will be sent concerned authorities for safety precautions. The SMS shows the river which may cause flooding in the vicinity and the contact number of the PDRRM.

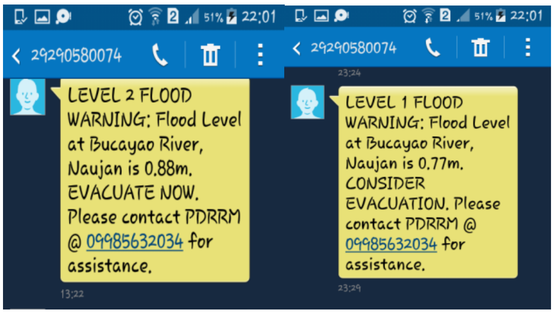

Figure 6. Screen shot of Flood Warning Notification

Comparison of Results between the Existing DOST Project NOAH from the Developed System

Shown in Figure 7 is the screen shot of Project NOAH web site of the Department of Science and Technology Water Level Monitoring System (WLMS). Project NOAH likewise uses an ultrasonic sensor to accurately measure and determine the river stage uses[8].

The ultrasonic sensors calculate time interval between sending the signal and receiving cellular network, as a text message. Every WLMS has an ASTI—developed arQ, which serves as the mini—computer that intelligently controls all functions and data communications of the station, the echo to determine water level. Collected data are sent wirelessly, via cellular network, as text message. Unlike the developed system, the DOST Project NOAH website sensors stream gauge does not provide numerical representation of data on a per minute interval. It also has no feature that will send mobile text alert to local authorities.

The developed system on the other hand transmit data, the data that was transmitted online every minute via network IP address. Data were presented in numerical values and in form of a line graph as well. The SMS warning feature of the developed system when tested, successfully sent SMS message to the selected mobile device.

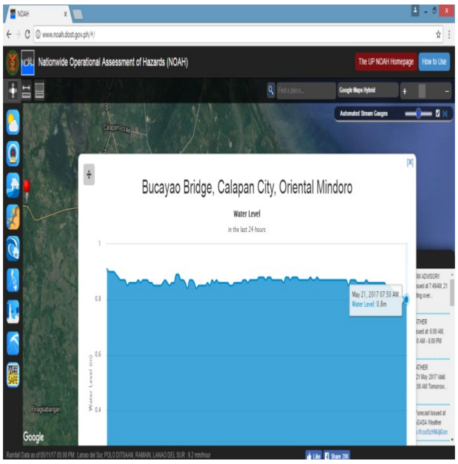

Figure 7. DOST's Project NOAH Water Level Monitoring

Results of the System Evaluation

On Functionality

The results of the evaluation of the system in terms of functionality are presented in Table 1. As can be gleaned from the table, the respondents' highest evaluation was on the ability of the system to operate according to its purpose, which obtained a numerical rating of 3.93 indicating strong agreement of respondents, strongly agree. Corollary to this, the respondents likewise gave a high rating on the easy in using the system and its capability to send the data to the web server with same rating of 3.86. The respondents likewise strongly agreed that the system was well structured and could securely transmit data to the server. The composite mean of 3.77 indicates that the respondents strongly agreed that the system worked properly as to its functionality.

Table 1
Evaluation of the Functionality of the System

FUNCTIONALITY	Mean	Description
1. Is well-structured according to the needs of the users	3.57	Strongly Agree
2. Runs according to its uses and functions. (per minute reading/ monitoring of data)	3.93	Strongly Agree
3. Can easily be operated by a given user in a given environment	3.86	Strongly Agree
4. Is secured and protected in terms of data transmission	3.64	Strongly Agree
5. Is capable of generating data Web based	3.86	Strongly Agree
Composite Mean	3.77	Strongly Agree

On Reliability

As presented in Table 2, results show that in terms of notifying the community of status of water level and nearby areas, respondents rated the highest described as "Strongly Agree" with mean score of 3.79. Respondents strongly agreed the system achieved expected output needed of the community gave relevant & reliable information and followed standard measurement of mean scores of 3.50—3.64. Rated the lowest was (facilitating recovery procedures in the event of system failure) with mean score of 3.29. System's reliability had overall mean score of 3.56 indicating strong agreement on reliability of the system.

Table 2
Evaluation of the Reliability of the System

RELIABILITY	Mean	Description
1. Achieves its expected output based the needs of the community	3.64	Strongly Agree
2. Sends / gives relevant and reliable output / information to the users	3.50	Strongly Agree
3. Facilitates recovery procedures in the event of system failure	3.29	Agree
4. This community on water level and near-by areas	3.79	Strongly Agree
5. Follows the standard measurement / alert level of floods	3.57	Strongly Agree
Composite Mean	3.56	Strongly Agree

On Efficiency

Table 3 presents the results of evaluation in terms of efficiency of the system. The resources were available and efficiently used was rated the highest with mean score of 3.86 strongly agreed as the description. All items were all strongly agreed on by the respondents as reflected in weighted means ranging from 3.64—3.71. Respondents strongly agreed and gave highest assessment on the system's capability to notify the community on weighted mean of 3.79. Results revealed that though having the lowest mean score, item 4 which states that the system generates more effective results of data from the prototype was also strongly agreed. Overall, efficiency of the system was strongly agreed with mean score of 3.73.

Table 3
Evaluation of the Efficiency of the System

EFFICIENCY	Mean	Description
1. The data was transmitted online every minute via local network using IP address	3.71	Strongly Agree
2. The resources (sensors, circuits, etc.) are available and efficiently used	3.86	Strongly Agree
3. The messages are clear and respond to user properly (text level alert information)	3.71	Strongly Agree
4. More effective results of data are generated from the prototype.	3.64	Strongly Agree
5. The system only notifies the end users based from the default value of the standard measurement of water	3.71	Strongly Agree
Composite Mean	3.73	Strongly Agree

Table 4
Evaluation of the Usability of the System

USABILITY	Mean	Description
1. Meets the needs of the target – users. (water level monitoring information and text alert)	3.79	Strongly Agree
2. Uses appropriate hardware components for water / flood level monitoring	3.57	Strongly Agree
3. Helps the authorities in monitoring the water level.	3.86	Strongly Agree
4. Easy to install and maintain.	3.57	Strongly Agree
5. User friendly and easy to understand by the end users	3.79	Strongly Agree
Composite Mean	3.71	Strongly Agree

On Usability

Table 4 shows the evaluation of the useability of the system. Respondents strongly agreed on the usability of the system specifically monitoring water level and text alert along with its being user—friendly as reflected in composite mean of 3.71.

4. CONCLUSIONS

The developed advisory and real-time monitoring system using raspberry pi combined with ultrasonic sensor can measure the water level of rivers and using GSM technology its measured data can be transmitted to the web and mobile service. Database of river water level with illustrated line graph can be programmed using the transmitted data reading from the raspberry pi with an ultrasonic sensor. Furthermore, the data generated from the developed system device can successfully generate line graph with numerical values as compared to DOST Project Noah which generates line graph only. Further, as per ISO 9126 software product quality standard, the developed system is acceptable as to functionality, reliability, efficiency and usability.

5. RECOMMENDATION

Generally, the output of this study is recommended to be established and used by locals near rivers, Provincial Disasters Risk and Reduction Management Office and Municipal Disaster Risk and Reduction Management personnel. For isolated areas, solar panel can be used as power source for the device to make it portable and for data transmission speed the device could also be tested in areas with low connectivity.

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