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DEVELOPMENT OF PORTABLE WATER LEVEL SENSOR FOR FLOOD MANAGEMENT SYSTEM

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ABSTRACT

The early warning systems for flood management have been developed rapidly with growth of technologies. These warning systems help to alert the people earlier. Many proposed system used sophisticated techniques to alert flood such as Short Message Service (SMS) via Global System for Mobile communications (GSM), however, they are still complex to program and interface, in addition to their high cost. This paper proposed a simple, portable and low cost of early warning system using Arduino board, which is used to control the whole system and GSM shields to send and receive data. This work applies on study area in Taman Ira and Kampung Bakau, Kangar. The proposed model determines the water levels using ranging sensors. Then it analyses the collected data and determine the type of danger present. The GSM network is used to connect the overall system units via SMS. The system has been designed and implemented based on two components, hardware and software. The system units are powered from the rechargeable batteries. Two additional temperature sensor and humidity sensor also embedded as to relating the water level with the current temperature and humidity. The early data obtained by the SMS is used in determining the of flood impact toward the population by using the assessment table.

Keywords: arduino, early warning system, portable water levels, ranging sensor, flood.

INTRODUCTION

Flood is a regular natural disaster around the world. It is happening every year during the rainy season. The study location, Kampong Bakau is one of the low areas in Perlis. During normal days, the river water level is low and may not present at all. However in heavy rain, this area may flood fast as the river level increase rapidly. The current flood warning system implemented in Perlis is not widely use. The point of monitoring is focused on one location per river. Because of few number of monitoring, several area that flooded during rainy season happen to received late aid. The developed of this model is to assist in early warning of flood thru water level detection. By using the Arduino microcontroller, the model embedded with ultrasonic ranging sensor that acts to determine the distances of water level. It is also equipped with temperature and humidity sensor, this model able to measure these two parameters on the real time. This data is processed and transferred to user or specifically the authorities for next steps. The data received in form of Short Message Services (SMS). The model is built in small size as it able to operate on various sites according the need. This disaster cannot be eliminated, but warning people earlier can avoid its effects. This can help people to escape and avoid any expected harms. Therefore, the goal of early warning is to give people the chance to save their life and their properties.

Current Jabatan Pengairan dan Saliran (JPS) system use telemetry that utilize online database for data access. For gaining an access to water level data, ones must have an internet connection. This online and real time data is an advantage but the flood occurrence usually happen in rural area and not all the locals are educated or having technologies to use the online system to monitor the river. Some of other product also utilize flood sensor using short circuit theory that implies the height scale. This method is not practicable in monitoring on several river because of each river has different depth. A SMS also being used in flood warning, but instead of warning local and authorities, it is apply in controlling mechanical operation such as pump and gate level.

New technologies produce simple and low cost tools that can be used to solve such problems. In this work, some of these tools are used such as Arduino UNO board that works as a controlling device. This board has low cost, simplicity in programming and the ability to interface with other devices. Another tool is the GSM shield, which is a ready board deals with GSM networks without additional interfacing circuits. By all the data received, the local authorities could predict the level of flood impact toward the area of this model covered. The flood impact is calculated using the risk assessment table that modified from the flood assessment relation with population in African. Therefore, the model will be tested on study area and the data obtained is recorded for analysis.

MATERIALS AND METHODS

Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328 It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter. Revision 2 of the Uno board

has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode. Figure-1 shows Arduino Uno pin structure.

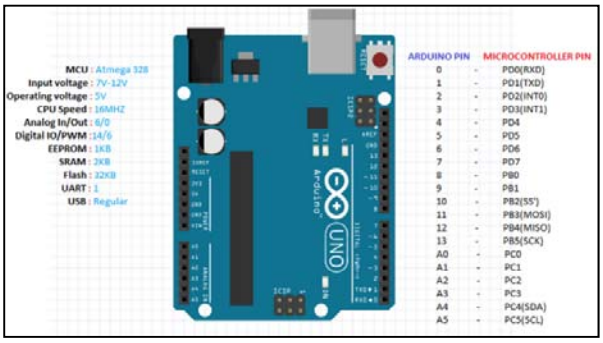

Figure-1. Arduino Uno pin structure.

Ultrasonic sensor

An ultrasonic transducer is a device that converts energy into ultrasound, or sound waves above the normal range of human hearing. Ultrasonic sensor generates high frequency sound waves and evaluates the echo which is received back by the sensor. The physical shape of ultrasonic sensor is shown in Figure-2. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. Sometime ultrasonic detector (transceiver) use separate transmitter and receiver components while others combine both in a single piezoelectric transceiver. This detector, usually, is used in submarine for detecting surrounding objects.

Figure-2. Physical shape of ultrasonic module.

Liquid crystal display (Lcd)

LCD (Liquid Crystal Display) is a viewer module which is widely used because it simple looks. The most widely LCD module used today is M1632 LCD because the price is quite cheap. M1632 LCD display is an LCD module with 2x16 (2 rows x 16 columns) with low power consumption. The module is equipped with a microcontroller specifically designed to control the LCD. The LCD module used is shown in Figure-3.

Figure-3. LCD with example display of data.

Wireless

Wireless telecommunications is the transfer of information between two or more points that are not physically connected. Distances can be short, such as a few meters, or as far as thousands or even millions of kilometres for deep-space radio communications. Wireless communication can be via, radio frequency, microwave communication, and infra-red. SIM900 GSM/GPRS Shield IComsat PreviewIComsat is a GSM/GPRS shield for Arduino and based on the SIM900 Quad-band GSM/GPRS module. It is controlled via AT commands (GSM 07.07, 07.05 and SIMCOM enhanced AT Commands), and fully compatible with Arduino.

Programming

Normally programming for a micro-controller is a time consuming task, but with the Arduino platform, an entire suite of pre-built functions already exists. Most importantly, an integrated development environment (IDE) built especially for the Arduino is available. This cross platform IDE, written in Java, is based on the wiring project, an open source programming environment. It is used to write the actual code for the Arduino. The coding editor has many features of other mainstream IDE's such as syntax highlighting, automatic indentation of code and bracket matching. This is especially helpful for programming novices who wish to get right into coding and may be unfamiliar with many of the finer details of coding syntax. The programming language itself is C based. Since C is the most widely known high level programming language, this will make programming for the Arduino relatively simple. An included C library called "wiring" has many of the basic input and output functions built in that will be necessary for all the sensors and motor control.

River water data

For obtaining better data collection, data from JPS Malaysia, is used as references in monitoring on study area. By using the data, sensor is programmed as to give warning base on each river attribute. Table-1 shows Perlis river level data.

Table-1. Perlis river level data (JPS Perlis).

Station Name	Sungai	(m) above Mean Sea Level (MSL)			
		Normal	Alert	Warning	Danger
Sg Jarum	Jarum	30	33.3	33.39	33.6
Sg Pelarit	Pelarit	35.6	38.6	38.72	39
Kg Kuala Tunggang	Arau	12.45	12.85	13	13.25
Batu Bertangkup	Perlis	24.48	25	25.3	26
Kpg Sg. Bakau	Perlis	1.5	3	3.3	3.5
Sg Chuchoh	Sg Chuchoh	35.5	37.5	37.8	38.5
Sungai Repoh	Sg Repoh	2.3	4.3	4.39	4.6
Balik Guar	Perlis	13	13.5	14	15
Tok Bidok	Perlis	21.5	23.5	24	25
Genting Kabu	Perlis	38	39.5	40	40.5
Kuala Perlis	Perlis	3	4	4.5	5
Bukit Tok Poh	Perlis	3.8	5	6	7

Matrix analysis for flood impact toward population

Using the flood hazard and risk assessment factor (Gashaw, 2011), the simplify analysis conducted based on the data obtained by the sensor is shown in Table-2. From the Table-2, the analysis conducted is based from population. The population indicates the magnitude of the impact while the trigger for the magnitude is the type of warning.

Table-2. Matrix for flood impact analysis.

Condition	Score	Multiplier	Population (Monitored Area Population / states, district population)	Score	Final Score
Normal	1	No	Very High 100%	5	15
Alert	2		High 80 %	4	12
Flood	3	Yes	Medium 60 %	3	9
			Low 40%	2	6
			Very Low 20% and below	1	3

Final Score	Comments
3 and 6	Loss of Property less, injury may present, few setup of flood relief centre
9	Loss of property is medium, Injury and death casualties may present, proper flood relief centre may required
12 and 15	Loss of property is high, injury and death casualties present, huge and big facility for flood relief centre

RESULTS AND DISCUSSIONS

Hardware design

Basically, the prototype of Water Level Detection System consists of two segment, receiver and transmitter. Transmitter module responsible to transmit and display data received from the ping sensor. Receiver segments accept the data transmitted from transmitter module and transfer it to the any type of device that supports the local Telco SIM. The operation starts from the data collection from the ultrasonic sensor, temperature sensor and humidity sensor. This three data is passed to Arduino UNO microcontroller. The microcontroller will analyse the real time data and compared to the pre-programmed value. All of data are transmitted to designated phone number. Instead of output is presented in SMS form, the data collected also is displayed on the front panel of sensor as easier to conduct error checking or calibration. Figure-4 shows Prototype Block Diagram.

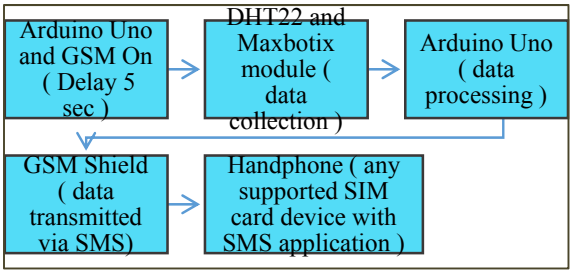

Figure-4. Prototype block diagram.

The use of ultrasonic instead of probe is driven by the efficiency in gaining the water height at every area. Using probe as water level indicator has limitation on the determining smaller unit of height such millimetre. Most common use of probe in water level detection is applied on fix tank such aquarium and raw water supply tank.

Prototype monitoring test

The study is conducted on the Kampung Bakau Kangar. All the monitoring data is collected and used for afterward analysis. The height of water with the sensor must be calibrated as to obtain accurate result. Monitoring is conducted on different time and weather as to test the prototype efficiency in all condition. By using dry cell batteries, the prototype is able to operate more than 28 hours non-stop operation. Figure-5 shows Prototype Tested on Site.

Figure-5. Prototype tested on site.

All the monitoring is conducted by placing the prototype with tripod. The used of tripod help to increase the accuracy of height detection because of the ultrasonic sensor is located at the bottom of model case.

Data collection

Data collection is collected via SMS input. The data is manually interpreted by the user or local authority as to declare the situation according with sensor output. Figure-6 is example of data obtained thru SMS.

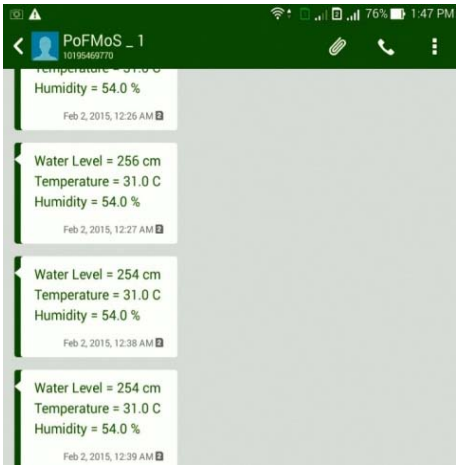

Figure-6. Data collection via SMS.

By using programming, all the data can be interpreted directly if the sensor detecting the water level is in warning level. Figure-7 is one of the SMS input that give the water level warning with 40 cm water height from sensor.

Figure-7. Warning alert in SMS format.

In the development of water level sensor, the data collected giving warning when the distance between sensor and water level become smaller. The concept of using ultrasonic is the reading is obtained thru the reflected pulse. Compared to current system, alert in water height is issued when the increase of water height and is able to set up the increment of water level proportional to the warning level because of the fixed point of monitoring. However, before installation of this system, the river is measured it depth, afterward the sensor is programmed with the measured water level. Comparing to one point sensor, this model show lower height is more significant to warning alert because portability concept makes it more convenient for monitoring on different site.

Flood impact assessment

For early warning flood or water level alert, this prototype already achieves the target. Instead of having early warning thru SMS, the flood assessment is conducted as to give better understanding in flood impact itself (Shook, 1997). Figure-8 shows the Flood Impact Assessment.

Flood Risk Assessment						
Location : Kampung Tepi Sungai / Taman Merpati nearby Jalan Padang Behor						
Date and Time : 29 Jan 2015 / 1400 hours						
Remarks : Data Referred From 29 Jan 2015 with 300 minute monitoring						
Water Level Status	water level (metre)	Increment water level per time	Estimated Time For Flood Warning Issues	Estimated Flood Time		
Normal	1.00	0.78 mm / min	9.50 PM	10.09 PM		
Warning	0.55					
Flood	0.51					
Flood Level Impact Analysis						
Key Item	Population	Estimated : 300	Water Level	Normal	Total	Status
Scale	1		1		1	
Result : No action should be taken as the water level is safe						
Legend	If water level is " 1 " , No action should be taken			Start Impact Analysis when Water level Category is "3"		
	If water level is " 2 " , Precaution and warning for evacuation for lower area					
	If water level is " 3 ", Issue an evacuation for all affected area					
Flood Level Impact Analysis Matrix Score References						
	Population	Comments				
	3 and 6	Loss of Property less, injury may present, few setup of flood relief centre				
	9	Loss of property is medium, Injury and death casualties may present, proper flood relief centre may required				
	12 and 15	Loss of property is high, injury and death casualties present, huge and big facility for flood relief centre				

Figure-8. Flood impact assessment.

The assessment is conducted based on the population of the flooded area. According to article on Population Trends, not Climate, Causing the increased Fatalities in Africa (Jefferson, 2010), the associate professor shows a study in Africa that the population itself is the factor in flood impact. By using the Table-2 matrix, Figure-8 shows the assessment conducted on study area.

The assessment started when the sensor is giving alert level. Alert level referred to flood status. By using matrix in Table-2, Local Authorities able to conduct early preparation for evacuating people with sufficient manpower and equipment such life jacket or boats (Azreen, 2012).

CONCLUSIONS

Based on the result and analyses done, the usage of this sensor is better compared to current flood monitoring in Malaysia. The current system utilizes the fixed point of river monitoring instead of focusing on flood hotspot area. The concept of portable sensor for this project enables the sensor to be deployed only during in needed period. In term of flexibility, this project model can be deploying anywhere compared to fixed monitoring spot. In terms of annually maintenance cost, this project only consumes fewer budgets in battery consumption and telecommunication services. This eventually became advantages because of flood occasion only happen during monsoon changes. This also helps reducing the foot print of operator for onsite monitoring. From the data recorded by sensor, the trend of water level whether the rises of water level that leads to flood or not can be predicted. Because of using microcontroller, the frequency of data taken also can easily be monitored and even adjusted the delay of data taken. Instead of this, there are several programing can implemented such automatic flood prediction via using pre calculation from the microcontroller itself.

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