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A New Design and Implementation of Wireless Flood Monitoring System

Abdul Hafiz Bin Mohd Idzhan and Yasir Hashim
Faculty of Engineering Technology, University Malaysia Pahang (UMP), Malaysia

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Corresponding Author:
Yasir Hashim
Faculty of Engineering Technology, University Malaysia Pahang (UMP), Malaysia

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Abstract: This research paper is for designing and implementation of a flood monitoring system that could be used individually or as a sensor unit in the flood monitoring network. In recent years, natural disaster, specifically flash flood frequently affects major property damage and taken many lives, due to the inattentiveness of flood level as it rise rapidly in the flood prone area. A real-time alert flood monitoring system equipped with wide communication range and warns locals to be the solution for this problem will act as a crucial component that can prevent the inattentiveness during heavy rainstorm season.

INTRODUCTION

Electronics devices plays an important role in our modern lives, especially the automated based electronics devices (Hashim, 2015). Advances in electronics devices towards nano-dimensions leads to improve microcontrollers architecture and its ability in processing data (Hashim, 2016). Recently, climate changes is one of the major issues that has mind boggled the world leaders, its effects of thinning of the ozone layer caused the melting of polar ice cap has raised the sea level that leads to weather abnormality (Ali *et al*., 2009; Bayindir, 2011). Abnormality such as mega hurricane that caused billions of dollars of property damage and thousands of life casualties has struck few nations of the world. Flash floods are one of the minor abnormality that also cause damage, but the impact on human lives is rather preventable. As the name given flash flood rises rapidly without any signs, if the flood struck at time humans are in their vulnerable state the probability of casualty is considered highly plausible. In Malaysia, commonly flood gates in water canals are traditionally operated manually, which in need of operator to constantly supervise the water level, if in any circumstances that the operator isn't available or unaware of the level, leads to halt of river flow that would cause overflow in the canal. This scenario is rather preventable by the presence of a monitoring system.

In some developed countries, a similar system is applied, but the range of the information that can be received by the public is limited, it is usually relayed through meteorology agencies or department then passed through to response team that involve in rescuing civilians. This paper demonstrates the complete system that aims to provide an alert for the locals living in the flood prone area for them to react first while waiting for the response team to arrive.

The system alert consists of three aspects alerting through visual alerts, audible alerts, close proximity alert (i.e., via. Bluetooth interface through smartphone) and long distance alert (i.e., via. short message system (SMS)). These alerts would be helpful to the residence whether they are indoor or outdoor.

MATERIALS AND METHODS

Figure 1 and 2 shows the system block diagram and flow chart of flood monotering system and explain the working principle of the system by transmitting and

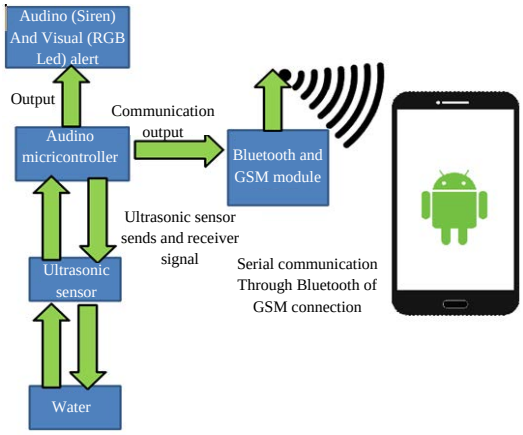

Fig. 1: Flood monitoring system block diagram

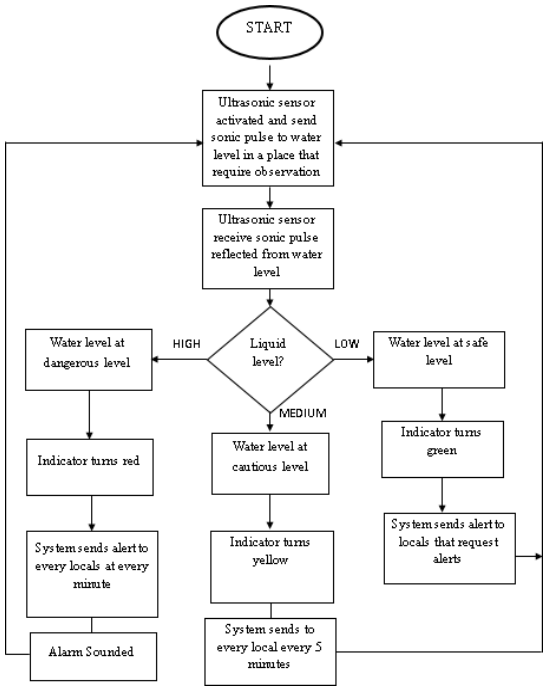

Fig. 2: Flow chart of flood monitoring system

receiving the ultrasonic pulses to enable the system identifying the water level. The ultrasonic sensor will emit the ultrasonic signal from (Trigger) pin and receive the pulse to (Echo) pin. (Echo) pin and (Trigger) pin sends a digital reading to Arduino microcontroller module to be computed.

The versatility of ultrasonic sensor that enable to detect any solid material is an advantage of this application. Digital reading that received from (Trigger) pin and (Echo) pin will convert to time duration after the pulse is transmitted using formula:

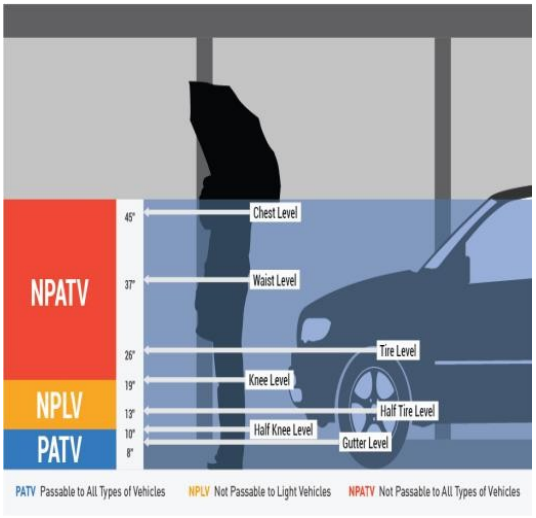

Fig. 3: Water level height based on the passing ability of the vehicle

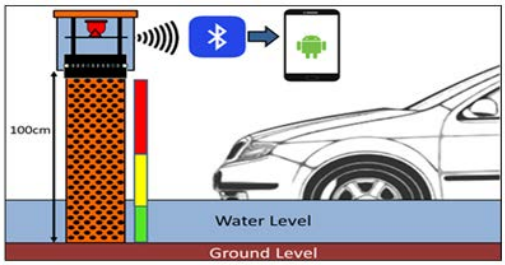

Fig. 4: FMS beacon on field

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}} \quad \text{where speed of sound 340 m sec}$$

Normally, the levels of the waters could be classified based on the passing ability of the vehicle as shown in Fig. 3. The three ranges of levels of water that will be the parameters which manipulate the system are represented the height of water, the first range of water, which is the default for the system is the safe level ranging from 0-30 cm height. The cautious level range between 31-49 cm and the crucial condition which is the danger level above 50 cm about the height of an average adult knee. Each of the conditions has its reaction upon the system which are based on Table 1.

From Fig.4, the flood monitoring system is fitted to the beacon for the deployment of field. The beacon's design is fulfilled by using a UPVC pipe with a diameter of 8inch as the properties of the material is suitable for the application as it able to withstand the harsh weather conditions throughout time. From Fig. 5, the beacon is designed to a perforated cylinder shaped, the perforated

Table 1: Conditions and response for the FMS

		Response		
Conditions	Flood level	System	GSM module	Bluetooth module and Android app
Secure	<30 cm	LED green	Idle	Sends reading
Cautious	<50 cm, >30 cm	LED yellow	Send alert to civilians	Sends reading
Dangerous	>50 cm	LED red, siren sound	Send alert to civilians	Sends reading and sounds an alarm

Table 2: Pin configuration of Arduino nano microcontroller unit

Arduino pin	Connected pin	Description	Component
A0 (Analogue In)	RS	Register Select	
A1 (Analogue In)	E	Enable	LCD Display
A2 (Analogue In)	D4		
A3 (Analogue In)	D5	Data pin	
A4 (Analogue In)	D6		
A5 (Analogue In)	D7		
0 (RX)	TX	Transmitter pin	Bluetooth
1 (TX)	RX	Receiver pin	
2	TRIG	Send ultrasonic pulse	Ultrasonic
3	ECHO	Receive Ultrasonic pulse	Relay
7	RELAY	Connect to the normally open of the relay	
9 (PWM)	BLUE	PWM controls the blue cathode pin of the LED	
10 (PWM)	RED	PWM controls the red cathode pin of the LED	RGB LED
11 (PWM)	GREEN	PWM controls the green cathode pin of the LED	

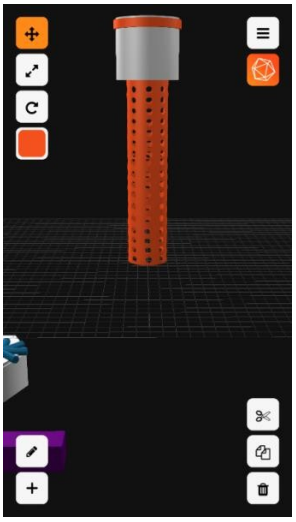

Fig. 5: 3D drawing of the main frames

Fig. 6: Android application interface

made to enable the water to fill the cavity of the cylinder and also to eliminate any disturbance for the reading to be accurate.

Figure 6 shows the Android application that was built to read out the readings from the FMS remotely from Android phone at a close proximity range. Since the FMS comprises of Bluetooth module the range is limited to about 10 m in radius to the beacon. The addition of GSM module to the system will increase the range to be unlimited as long as there is mobile network signal in the area of the receiver (Table 2).

Microcontroller is the heart of the system, as all the control signals pass through and are processed by the microcontroller. The Arduino nano microcontroller unit is a computer on a chip that is programmed to perform

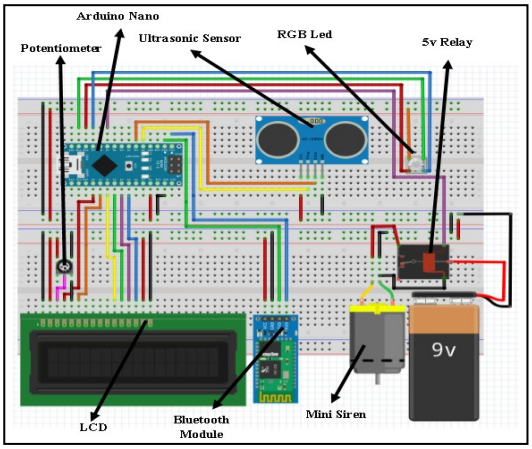

Fig. 7: Flood monitoring electrical circuit diagram

almost any control, sequencing, monitoring and display the function. Because of its relatively low cost, it becomes the natural choice to the designer. Its great advantage is no other external components are needed for its application because all necessary peripherals are already built into it. Thus, save the time, space and cost which are needed to construct low cost devices. Table 2 shows the pin configuration of Arduino nano microcontroller unit and Fig. 7 illustrate the connection of circuit diagram.

Sensor selection is a significant action to be considered in any system design (Benet *et al*., 2002; Hashim and Sidek, 2012) as it will have an incredible effect on the process of the system performance during its whole lifetime and could even have outcomes related to the quality of the product. To design the flood monitoring system that is different than other systems. Application of ultrasonic sensor applied to monitor levels of the flood water. Ultrasonic sensor (Flynn, 1988; Mustapha *et al*., 2012) able to detect any types of obstacles it has the angle of detection of 15° and the ranging module HC-SR04 provides 2 cm until 400 cm non-contact measurement function yet the ranging accuracy can reach to 0.3 cm. The modules include receivers, ultrasonic transmitters, and a control circuit. The ultrasonic sensor has four pins which are Vcc pin, Trigger pin, Echo pin and Ground pin. Liquid crystal display is used as an interface for the user to read out the height of flood level, the LCD can be used to calibrate the accuracy of the water level while on the field.

The Bluetooth module HC-06 Bluetooth Module is used to send signals from the microcontroller to the Android devices, by sending signals. The module has a built-in transceiver to transmit and receive signals to the Android device, working at 9600 baud rate and ability to be accessible at a distance remotely about 10 m.

The mini siren (MS-190 Mini Motor Siren) functions as the audio output to alerting the locals if the monitoring reached the dangerous state, other than the visual alert or by the Android application. The mini siren theoretically is operated by forcing the air from an array of fan blade through opening design to create a high sound pressure that could reach about 120 dB of sound pressure it is equivalent to the thunder clap at a close distance. The low voltage consumption of the mini siren should be enough for this application as the audible output, working voltage as minimum as 5 V to the maximum of 12 V it is a relevant choice component of the system (Ali *et al*., 2011). RGB Led is required as a visual alert for the nearby locals to notice whether the flood conditions. The RGB Led is controlled by using the Pulse Width Modulation (PWM) of the Arduino Nano board which could control the brightness and the color of the Led by mixing the three radiance of the diode (Red, Green and Blue). The voltage rating of the Led strip is about 12V and recommended input current is 2A, which can be provided by using the rechargeable battery which will provide 2200 mAh (milliampere per hour) and the voltage can be boost using a DC booster to step the voltage from 9-12 V. The system can be powered with 9V rechargeable battery and be increase or decrease by using DC buck-boost converter to be regulated suitable power rating of each component. The use of solar panels will provide the system with renewable energy continuously for few months until the rechargeable battery needed to be changed.

The design of the system needs to comply with a few properties for the system to operate properly. As the system need to be put in the water environment areas and able to withstand harsh weather, waterproofing the beacon is a priority. Water could easily fill any cavity of the circuit compartment that would lead to short circuits. Using custom HDPE container as the circuit compartment eliminate the problem of humidity and water reaching into the circuit compartment as it tightly sealed enabling it to be water-proof. Threaded rod and aluminum sheet is used to withhold the circuit in place of the compartment which make the built sturdier than other material.

RESULTS AND DISCUSSION

The flood monitoring system achieves its aims to act as an early warning or a real-time alerting system as its properties can assist the civilians to be alerted by the flood level that endanger them. But in some circumstances the system has its pros and cons that needed to be taken into consideration, that can be improved in the next version of the system. The advantage of this system that it uses a modular circuit enables the user to modify without changing the whole system. The

electronic component is interchangeable with better quality component if it is necessary. The system could be integrated into a vast network of FMS beacon placed in strategic places, flood prone places, or industrial area that need to be alerted when flood rises. The use of radio frequency to transmit the signal between beacons and the main hub can be utilized as it is covered is vaster than the mobile network. Data logging of water level in the river could be used for flood forecasting which will be more useful as civilians can prepare for flood earlier rather than unexpectedly confronting the flood. The beacons can improve by having an energy saving plan that would minimize unnecessary power output, for instances the system turns on only when the temperature drops down or barometric pressure changes and humidity increases. These are all the conditions that could verify the weather when it is starting to rain, so that, the system would be on alert when necessary rather than turned on all the time.

CONCLUSION

This research paper is aimed to minimize or further extinguish the possibility of human casualties during flood seasons. The system is easy to use, to install and can be used by anyone, civilians or government agencies. This system would be an improvement to the previous system that limited the information to the civilians by having it on demand and in any conditions they are in. The aspects of the system mainly have been designed to enable the civilians to be alert in any way possible to them, the audio visual, the close proximity, and the long range alert.

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