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Road flood warning system with information dissemination via social media

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ABSTRACT

Flooding is one of the most devastating natural disasters in the world. It occurs when water from heavy rains exceeds the capacity of the river banks into which it runs. Some roads are also being affected when this natural phenomenon happens which lead to closure of roads. This closure, however, are often dissiminated late to the people that are passing through the closed roads. For this purpose, a Road Flood Warning System with Information Dissemination via Social Media has been developed to provide timely flood alert information to the public. The system determines the depth of the water through an ultrasonic sensor and disseminates the data gathered to the Internet through the use of social media sites specifically Twitter and Facebook. Moreover, the system has a LED matrix and light emitting diode to display whether the roads are passable during the occurrence of floods. The test results on the performance of ultrasonic sensor showed an accuracy of 98.69% while dissemination of information was 90% successful.

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1. INTRODUCTION

Tuguegarao City is the capital of the province of Cagayan in the Philippines. It is where higher education institutions, business establishments and regional government offices are located. However, when the rainy season comes, it becomes a catch basin causing floods in the city. During floods, some of the roads and bridges which serve as major routes to Tuguegarao are impassable [1] but the public who needs to travel to the City are often late to be informed about this. Majority of the public are students and employees who need to go to Tuguegarao for their classes and works, respectively. They would travel to their usual routes since they are unaware that the road was blocked due to flooding and would always result to traffic jams [2]. They may later resort to taking alternative but longer routes, but time and fuel was already consumed and wasted. But there are also drivers who forced their way through the flooded road which sometimes causes accidents.

The continuing efforts of the Cagayan Provincial Climate Change and Disaster Risk Reduction Management Office (PCCDRRMO) on informing the people about impassable roads during flooding are still not enough because they need to be on the area and look on the severity of the situation. They measure it by how they see it and not by using a device to get the actual depth of the flood on the road. Most of the flood hazards monitoring systems that are currently used by concerned agencies in the government concentrate on river systems [2, 3]. Other system focuses on communities [4] that are vulnerable to flooding so that they can pre-emptively evacuate when flood reaches critical levels.

Spreading information has a deep impact to people preparedness during flooding. Flood warning systems use different medium in distributing information about flood. The simplest yet effective in distributing information is text messaging [5] that can directly alert the respective victim's through their mobile phone however, network traffic occur in certain times [6]. Another medium in communicating information about flood is through graphical presentation on websites. This is considered by public as the easiest way to know the status of the current level of water [7] however, information on websites may not load sometimes because of high latency.

One communication medium that can be utilized in flood warning systems is social media. Social media has emerged as a critical factor in dissemination of information [8]. It does not just inform people but it also communicates, interact, connect people with the government and other people who are within and outside a place.

Keeping in mind the problems that arises when information about flood levels on important roads are delayed to be broadcast in televisions, radios and websites, a Road Flood Warning System (RFWS) that immediately reports the status of the flooded road as it happens in social media was developed. This constructed system measures the depth of the flood in the road and interpret the accessibility of the flooded road before disseminating information in social media. The warning system has timely updates about the exact depth of the flood and condition of the road if it is impassable or passable by specific kind of vehicles. The benefits from this system includes avoidance of traffic in the area, elimination of delayed time going to alternative routes, reduction of fuel cost, prevention of accidents, better information on which to base decisions, providing information that was not previously available and preparing a base for future projects.

2. RESEARCH METHOD

This study presents a road flood warning system with information transmission via social media updates that will constantly post the current situation of the road in a social networking site particularly Facebook and Twitter. The system was constructed to post the information in social media to spread it to a wide audience instead of using previous methods like text messaging, television and radio broadcasting and website updates.

Figure 1 shows the interconnection of the different components of the RFWS. It consists of several electronic modules that include microcontroller, ultrasonic sensor, Wi-Fi shield, LED and LED matrix. The microcontroller uses Wi-Fi shield as a medium to connect to the internet and an ultrasonic sensor to detect the water level. The data gathered by the ultrasonic sensor interprets necessary information and sends it to social media sites with the use of the Blynk app. The LED and LED matrix serves as a guide for those who are on the road during the occurrence of flood.

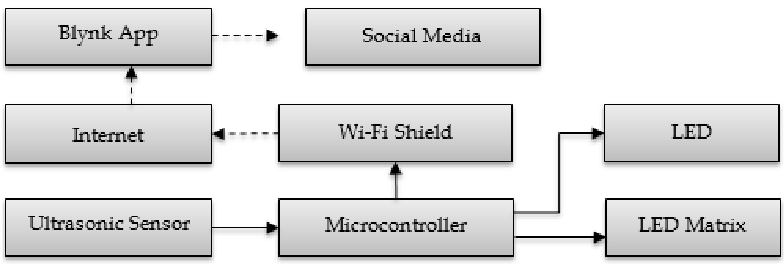

Figure 1. The blockd iagram of RFWS

2.1. General description

The RFWS is composed of different parts namely: Arduino Mega, ultrasonic sensor, ESP Wi-Fi Shield, LED matrix, light emitting diode and the solar power source as shown in Figure 2. A rectifier circuit was added to control and provide the direct current supply for the system. The ESP shield was mounted on top of the Arduino board. The ultrasonic sensor's trigger pin and echo pin were connected to the Arduino board's pin 16 and 17, respectively. The four channels of the relay module were connected to pins 10,11,12,13 of the microcontroller. The LCD display which uses the Tx pin and Rx pin were connected to pins 23 and 25 of the microcontroller, respectively. The relay where the LED indicator was connected was set to normally open state which will be supplied upon initialization of the system.

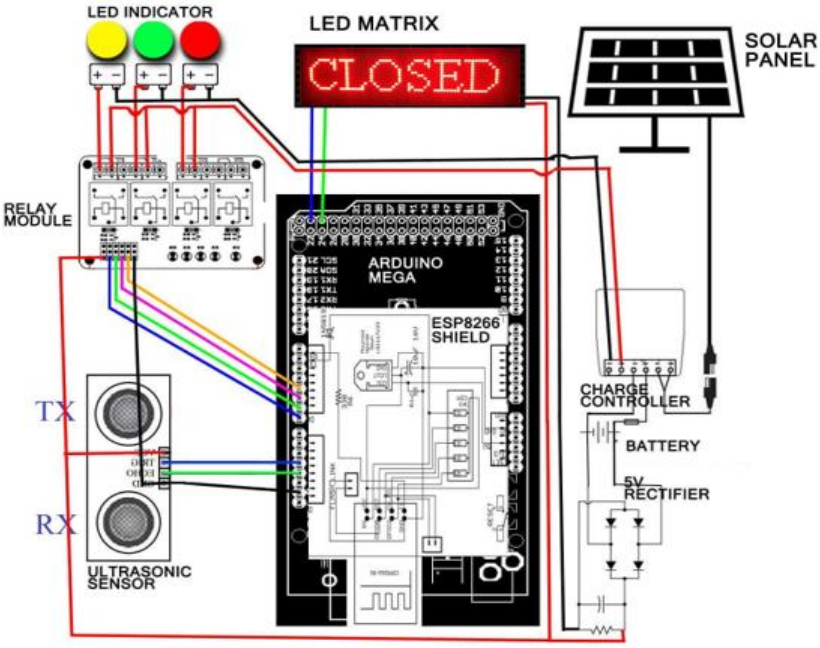

Figure 2. The schematic diagram of the system

2.2. Arduino mega microcontroller

Arduino microcontrollers are among the long-established [9] general purpose microcontroller [10-12] used by developers and researchers for electronic projects [13-16] and other embedded systems. Arduino microcontrollers are programmable circuit boards that are programmed using a C-based programming language called Arduino Integrated Development Environment (IDE) [17]. The Arduino boards as well as the programming tool are both open-source [18].

The RFWS used an Arduino Mega 2560 Microcontroller that has a 54-digital input/output pins, 16 analog inputs, 4 UARTs, 16MHz crystal oscillator, a USB connection, power jack, ICSP header, reset button and a larger sketch memory. It contains everything that is needed to develop the warning system. This is an important component which makes the whole functionality of the system works. The microcontroller holds the code for the sensors.

2.3. Ultrasonic sensor

An ultrasonic sensor is a device which measures physical quantity then converts it into a signal that can be read by an instrument. It operates from a wide voltage range and provides both digital and serial output modes. The system used an ultrasonic sensor to detect and measure the water level on the road. The ultrasonic sensor performs water level detection between the sensor and water surface without physical contact [19].

2.4. WIFI shield

ESP8266 is an inexpensive Wi-Fi/microcontroller System-on-Chip (SoC) which can be re-programmed to act as a standalone Wi-Fi connection device and interacts to the internet world over Transmission Control Protocol (TCP) or User Datagram Protocol (UDP). It has many I/O that can be utilized as either digital inputs or outputs. The ESP8266 Wi-Fi shield is easy to use because it only needs to be attached with an Arduino and no extra wires are needed. The ESP8266 was used as a medium to connect the RFWS to the Internet.

2.5. Blynk app

The RFWS used Blynk Application as a server. Blynk App is a platform to control Arduino, Raspberry Pi and other microcontrollers over the Internet. It is downloadable in the App store and Play store. The Blynk App user interface is a digital dashboard where widgets can be drag and drop according to needs of the users. A Twitter widget from the Blynk app was utilized in this study to serve as a bridge that connects the RFWS to social media websites. The Twitter widget uses a unique identifier called Auth Token that needs to be configured so that sending of information will be possible.

2.6. Water level color coding

The flood level classification of the RFWS was based on the Metro Manila Development Authority (MMDA) Flood Gauge shown in Figure 3. This is a standard flood measurement for the public in the Philippines during the rising of water in roads. People could assess the road accessibility through this flood gauge. The depth measurement was based on the standard human height. All types of vehicles can still pass by the flooded road if the level is half knee and below. When the depth of the road flood is 13 to 19 inches it is not passable anymore to light vehicles. The road will not be passable anymore for all type of vehicles when the depth of the flood is more than 19 inches.

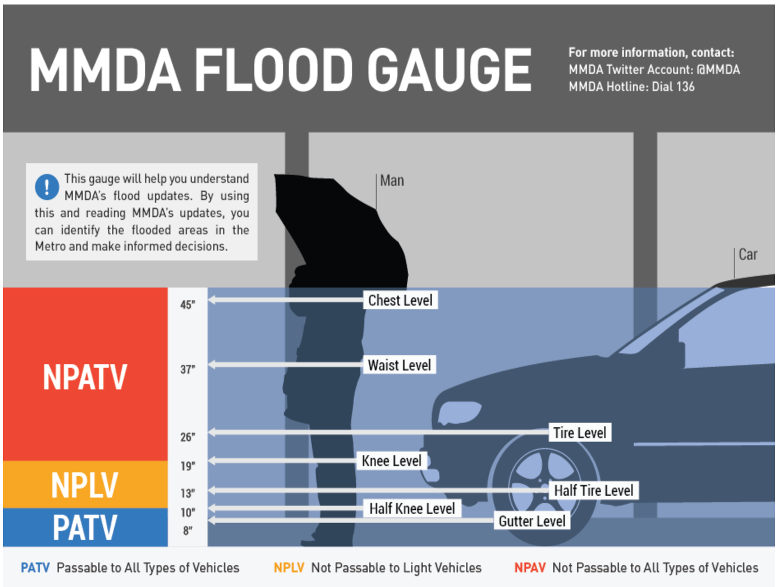

Figure 3. The Metro Manila Development Authority flood gauge

3. RESULTS AND ANALYSIS

3.1. The Road Flood Warning System

A ready for deployment RFWS is shown in Figure 4. It was supported by two posts. Attached to the post was a level indicator to show the depth level of the flood which consists of three levels: red LED for NPATV flood level, green LED for NPLV flood level and yellow LED for PATV flood level. This on-site feature is not exhibited on most floods warning systems [4-7] that only sends the information in websites or through text message.

The microcontroller and other electronic components were placed inside the casing of the LED matrix. With the help of the information board attached to the system, people will become familiar with the color codings. The three color codes as to the level of the flood are not yet implemented in previous systems [4-7] as this system only shows whether the road is passable or impassable. A screen was placed below the ultrasonic sensor to avoid other things to flow from it that may cause incorrect readings. The LED matrix was visible enough to give the warning to the commuters and motorists. The solar panel was placed at the top for better power generation. The case of the LED and LED matrix was painted blue so that it can be seen from afar.

3.2. Social media post

The RFWS posts the flood depth every 15 minutes on Twitter. A sample of this post is shown in Figure 5. The posting of flood depth in the Facebook page shown in Figure 6 follows immediately because the accounts on the two sites are linked together. The tweet Id is included to identify repeated post. The message to be posted for the different level is shown in the Table 1.

Figure 4. The road flood warning system

Table 1. The social media post for each flood level

Level	Message
PATV	Road is passable to passerby and to all types of vehicles.
NPLV	Heavy vehicles can only pass the road.
NPATV	Road is impassable.

Figure 4. Road flood information in Twitter

Figure 5. Road flood information in Facebook

3.3. Testing the RFWS

Multiple laboratory trials were conducted to check the accuracy of the system in measuring the depth of the flood. Based on the data gathered shown in Table 2, the expected flood depth was approximately the same with the actual flood depth. Expected flood depth was measured using a tape measure while actual flood depth is the measurement of the system. The accuracy of the system in measuring the flood depth was computed in every trial using the percent accuracy (1).

$$\textbf{Percent Accuracy} = 100 - \left(\left| \frac{expected\ flood\ depth - actual\ flood\ depth}{expected\ flood\ depth} \right| x\ 100 \right) \quad (1)$$

Table 2. The accuracy of the system in measuring flood depth

Trial	Expected Flood Depth (in)	Actual Flood Depth (in)	Accuracy (%)
1	4	3.87	96.75
2	6	5.96	99.33
3	7	6.78	96.86
4	8	8.01	99.88
5	9	9.11	98.78
6	10	9.82	98.20
7	12	11.85	98.75
8	16	15.89	99.31
9	20	20.11	99.45
10	25	24.89	99.56

The average accuracy of the road flood monitoring system in measuring the depth of the flood using the ultrasonic sensor was 98.69% which is almost the same with the 98.88% average accuracy of a river water level monitoring system [3] that also uses an ultrasonic sensor in detecting the depth of the water. The ultrasonic sensor is an ideal sensor for flood depth measurement since it can detect the actual depth of the flood anytime unlike a water level sensor [2] that waits for the water to reach a certain level before the actual depth is detected. Compared with water level sensor [2] and barometric pressure sensor [5], the ultrasonic sensor does not need physical contact with the water to detect the depth of the flood which prevents it from being taken away during severe flooding.

In the laboratory trials conducted, the reliability of the system in determining the accessibility of the road was also verified. Using the MMDA flood gauge, the measured depth of the flood using the tape measure was checked wether it falls on PATV, NPLV, or NPATV. This was then compared to the output of the system wherein a 100% success rate was recorded as shown in Table 3. The success rate of the system in interpreting the road accessibility proved that the algorithm utilized in the development of the system works.

Table 3. The accuracy of the system in interpreting road accessibility

Trial	Flood Depth using Measuring Tool (in)	Expected Road Accessibility	Actual Road Accessibility
1	4	PATV	PATV
2	6	PATV	PATV
3	7	PATV	PATV
4	8	PATV	PATV
5	10	PATV	PATV
6	12	NPLV	NPLV
7	16	NPLV	NPLV
8	20	NPATV	NPATV
9	25	NPATV	NPATV
10	26	NPATV	NPATV

Knowing the road accessibility is better than just knowing the flood depth [20] since motorist and passerby can easily decide to cross the flooded road or choose an alternative route. The road accessibility of the RFWS is shown online through social media and on-site through LED indicators which makes it unique to existing flood monitoring systems [2-4, 19, 20] that only utilized broadcasting of information through text messages or websites but not on-site.

The messages were all posted in Twitter and Facebook except for the third trial as shown in Table 4. This could have been due to the slow Internet [21-24] connectivy that is one of the major problems in the Philippines. However, it was still able to post majority of the message with a success rate of 90%.

Dissemination of information through sosial media sites like Twitter and Facebook is widely used today because of the wide audience on these social media sites. In fact, the number of Facebook active users monthly in the third quarter of 2018 according to statista.com is 2 billion while Twitter had 326 million monthly active users. This only shows that when the information about the flooded road is being posted in social media the likelihood that it will reached the right audiences is very high. More importantly this message can be shared by anyone and because of the interconnections between people [25] on this social media sites the dissemination of information will be enhanced.

Table 4. The posting of the information in social media

Trial	Message	Status
1	Road is passable to passerby and to all types of vehicles.	Posted
2	Road is passable to passerby and to all types of vehicles.	Posted
3	Road is passable to passerby and to all types of vehicles.	Not Posted
4	Road is passable to passerby and to all types of vehicles.	Posted
5	Road is passable to passerby and to all types of vehicles.	Posted
6	Heavy vehicles can only pass the road.	Posted
7	Heavy vehicles can only pass the road.	Posted
8	Road is impassable.	Posted
9	Road is impassable.	Posted
10	Road is impassable.	Posted

4. CONCLUSION

In this study, a system construct named Road Fload Warning System was developed to disseminate information about the accessibility of flooded roads through social media. Moreover, the system has on-site road accessibility information that utilizes LED indicators for drivers who are already on the road. The system should be properly situated in the road in such a way that the LED indicators will be visible to the drivers. The results revealed that the ultrasonic sensor was highly accurate in detecting depth of the flood. This flood depth was successfully classified by the system based on the MMDA flood gauge. Posting of information in social media was successful most of the time as long as the Internet is stable. The social media posts as the flood happens is very valuable information especially for commuters because they will not anymore wait for the information to be broadcasted in televisions, radios and website which will only cost further delays. The system can still be improved by incorporating other flood monitoring devices like rain gauges so that it can forecast the possible depth of the flood in the next hours. Also, the posting of road accessibility information in social media should be done through the social media accounts of concerned government agencies to ensure the reliability of the information.

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REFERENCES

[1] M. V. Cagayan, "Isabela remain flooded; classes suspended," The Philippine Star [newspaper online], 2017.
[2] Dange K., *et al*., "Advanced river bridge monitoring system and alert using GSM," *International Journal of Scientific Development and Research*, vol. 2, pp. 42-47, 2017.
[3] Sulistyowati R., *et al*., "A river water level monitoring system using android-based wireless sensor networks for a flood early warning system," *Second International Conference on Electrical Systems, Technology and Information 2015 (ICESTI 2015). Springer, Singapore*, pp. 401-408, 2016.
[4] Abon C. C., *et al*., "Community-based monitoring for flood early warning system: An example in central Bicol River basin, Philippines," *Disaster Prevention and Management: An International Journal,* vol. 21, pp. 85-96, 2012.
[5] Azid S., *et al*., "SMS based flood monitoring and early warning system," *ARPN Journal of Engineering and Applied Sciences,* vol. 10, pp. 6387-91, 2015.
[6] Panganiban E. B. and Cruz J. C., "Rain water level information with flood warning system using flat clustering predictive technique," *IEEE Region Ten Conference. Penang, Malaysia*, pp. 727-732, 2017.
[7] Islam M. A., *et al*., "Implementation of flash flood monitoring system based on wireless sensor network in Bangladesh," *IEEE International Conference on Informatics, Electronics & Vision (ICIEV)*, pp. 1-6, 2014.
[8] Lerman K. and Ghosh R., "Information contagion: An empirical study of the spread of news on Digg and Twitter social networks," *Fourth International AAAI Conference on Weblogs and Social Media*, vol. 10, pp. 90-7, 2010.
[9] Abana E., *et al*., "Electronic Glove: a Teaching Aid for the Hearing Impaired," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 8, pp 2290-2298, 2018.
[10] Gunawan T. S., *et al*., "Performance Evaluation of Smart Home System using Internet of Things," *International Journal of Electrical and Computer Engineering (IJECE*), vol. 8, pp. 400-11, 2018.
[11] Abana E., *et al*., "Rakebot: a robotic rake for mixing paddy in sun drying," *Indonesian Journal of Electrical Engineering and Computer Science (IJEECS)*, vol. 14, pp. 1165-1170, 2019.
[12] de Oliveira E. M., *et al*., "Instantaneous Frequency Measurement Subsystem implementation using low-cost microcontroller," *2015 SBMO/IEEE MTT-S International Microwave and Optoelectronics Conference (IMOC),* pp. 1-4, 2015.

[13] Mishra Y., *et al*., "Arduino Based Smart RFID Security and Attendance System with Audio Acknowledgement," *International Journal of Engineering Research and Technology*, vol. 4, pp. 363-7, 2015.
[14] Juang H. S. and Lurrr K. Y., "Design and control of a two-wheel self-balancing robot using the arduino microcontroller board," *2013 10th IEEE International Conference on Control and Automation (ICCA)*, pp. 634-639, 2013.
[15] Baraka K., *et al*., "Low cost arduino/android-based energy-efficient home automation system with smart task scheduling," *2013 Fifth international conference on computational intelligence, communication systems and networks*, vol. 201, pp. 296-301, 2013.
[16] Gupta S., *et al*., "Arduino based smart cart," *International Journal of Advanced Research in Computer Engineering & Technology*, vol. 2, 2013.
[17] Dessai S., *et al*., "Design and Development of Low Cost Navigation and Security System for Indian Fisherman Using Adrino Nano Platform," *International Journal of Reconfigurable and Embedded Systems*, vol. 4, 2015.
[18] Gogineni V. R. and Matcha K., "Real Time domestic power consumption monitoring using wireless sensor networks," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 5, pp. 685-94, 2015.
[19] Jatmiko S., *et al*., "Prototype of water level detection system with wireless," *Journal of Theoretical and Applied Information Technology*, vol. 37, 2012.
[20] Hashim N. M., *et al*., "Flood Detector Emergency Warning System," *International Journal of Engineering and Computer Science (IJECS)*, vol. 2, pp. 2332-6, 2013.
[21] Lardizabal C. and Bonalos P., "Slow PH Internet hurts businesses," CNN Philippines, 2015.
[22] Lorenzo A. R., "Effectiveness of the Computer and Internet Literacy Project in Public High Schools of Tarlac Province, Philippines," *Turkish Online Journal of Educational Technology-TOJET*, vol. 15, pp. 38-46, 2016.
[23] Cruz F. and Jamias S. B., "Scientists' use of social media: The case of researchers at the University of the Philippines Los Baños," *First Monday*, vol. 18, 2013.
[24] Xiaoming H. and Kay C., "Factors affecting internet development: an Asian survey," *First Monday*, vol. 9, 2004.
[25] Luarn P., *et al*., "The network effect on information dissemination on social network sites," *Computers in Human Behavior*, vol. 37, pp. 1-8, 2014.

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