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SMS-Based Water Level Monitoring System using GIZDUINO

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Abstract

This study presented the design and development of an SMS-Based Water Level Monitoring System using Gizduino. Gizduino is an Arduino compatible microcontroller kit. It's a single board Alf and Vegard's RISC processor (AVR) microcontroller platform based on highly popular open source Arduino design. It can be used as well with AVR's traditional programming tool which is written in C language. The researchers used developmental research following the Software Development Life Cycle (SDLC) process using the Rapid Application Development (RAD) Model. The phases of a RAD model are: Requirements Planning, User design, rapid Construction and Transition and Testing and Turn Over. The device is a sensor integrated dynamic system for mobile water level monitoring that uses Gizduino as its microcontroller. The sensor tested different water levels to obtain the real-time water level information and will send status obtained to the mobile number registered in the SIM card installed on the Gizduino device. The Global System for Mobile Communications (GSM) module is used for sending the mobile text messages while the Gizduino microcontroller is used to read in the input from the sensor and then calculate the height of water. The information texted to the registered mobile numbers will serve as an early warning to the people in the community to prepare for possible evacuation in case the water level reaches the critical level. When the water level reaches the critical level, the device has also the capability of generating warning sounds. This simple yet effective warning system is deemed to be one of the fastest and cost-effective methods of alerting the authorities and the vulnerable residents.

Keywords: Water level sensor, water level board, speaker amplifier, Gizduino

Introduction

Climate change is the greatest threat the world faces. It is already killing hundreds of thousands of people a year and, if left unchecked, will put hundreds of millions of others at risk. *(Addressing The Impacts of Climate Change in the Philippine Agriculture Sector, retrieved from http://www.neda.gov.ph)*

It is already wreaking havoc across the world with increased intensity and frequency of extreme weather events such as floods, droughts and storms, sea level rise, water scarcity, the decline in agricultural output, the proliferation of pests and diseases, and the extinction of species. The Philippines is already reeling under the impacts of climate change, and the effects of this catastrophe such as stronger typhoons, rising sea levels, and corresponding effects on Filipinos, the national economy and the environment are not inescapable. They are projected to continue and worsen unless effective steps for mitigation and adaptation are implemented immediately. Green Peace Philippines, Retrieved from *http://www.greenpeace.org/seasia/ph/What-we-do/Climate-and-Energy/*

This study aims to analyze the concept of mobile computing, design and develop a SMS-Based Water Level Monitoring System using Gizduino. Water level sensor is used and configured to measure the water level from Low, Medium and High. A warning via SMS will be sent depending on the said level to warn the people surrounding the area to prepare or evacuate in case the critical level is reached by the sensor.

The following studies were conducted for the same purpose of sending early warning to the nearby areas to be affected by floods and other disaster caused by the rising of the water level.

A flood risk assessment study for the entire Metro Manila and surrounding basin area was undertaken from February 2011 to February 2012 by the Department of Public Works and Highways with the objective of preparing a comprehensive flood risk management plan and to determine a set of priority structural measures (DPWH Official Gazette, 2015). The proposed measures would have to undergo individual feasibility studies and detailed design prior to implementation, including non-structural measures that will provide sustainable flood management up to a designated safety level and serve as the roadmap/vision of the government until 2035 (23 years from now).

As part of the implementation of the above-mentioned plan, local government units find ways to adhere to this endeavor. By the year 2008, GIZ and local government partnered in setting up Local Flood Early Warning System in different watershed and river basin to monitor and predict floods. LFEWS means a watershed-based system managed by government units and affected communities. It has an integrated system of communication that works for 24/7 to monitor river water level and issues the official appropriate alert signals to communities It also integrates indigenous knowledge systems and practices traditional local coping mechanisms such as home-made bating-ting (bell) and modern technology in monitoring and forewarning.

Monitoring and warning lie at the core of LFEWS. The best data for predicting a flood is measuring the water level of the river. The second best way is predicting a flood from rainfall data. LFEWS uses both and the system operates 24 hours a day. The variability of rainfall and river water levels are processed and converted into warning signals to inform courses of action in the form of warning signals.

Detection of a flood condition upstream and the arrival of the warning at the inhabitants of the flood-prone area take time. This time depends on how frequent data are gathered, the communication of the data to an operation center, the decision to issue a warning and the communication of the warning to the households (possibly via a chain). A very fast system may need only 10 minutes for this, but under normal circumstances many households may be informed only after 30 to 60 minutes, some even later.

This mainly consists of an effective communication network that serves as platform for risk monitoring data and alert signals using radio, mobile telephony and indigenous and traditional communication media such as bells (bamboo and iron), megaphones and human communicators (neighborhood "rondas") on foot, on horseback or motorbike who and which can communicate warning levels to the communities.

The Binahaan Watershed LFEWS uses three colors to communicate warning and alert levels. Yellow for Flood Level 1 and Standby, Orange for Flood Level 2 and Preparation and Red for Flood Level 3 and Evacuation. The LFEWS flood and alert signals and symbols are already adopted in Leyte Island. It may need to be harmonized to emerging national and international standards and procedures.

The Operation Center (OPCEN) is the communication hub – for receiving data on water level and rainfall and for sending alert signals. In the Binahaan LFEWS, the OPCEN communications network flows along three vertical layers – province, municipality and barangay – through the respective Disaster Risk Reduction Management Offices (DRRMO) and Barangay Disaster Risk Reduction Management Committees. It is a two-way communication channel where the Local Volunteer Observers and telemeters send rainfall and water level data to the OPCEN 24/7 and where the OPCEN sends back corresponding alert signals through the vertical layers. *(Antonio, S., De Guzman, Y., Dolatre E., Flossman-Kraus, U., Mollen, A., Myano O., & Neussner, O. (2012) LFEWS (Local Flood Early Warning System))*

In De Guzman (2016), water level monitoring system was developed and deployed flood gauging instruments in critical flood prone areas throughout the Philippines for flood monitoring and forecasting. The standalone Water Level Monitoring System is equipped with solar panel and makes use of an ultrasonic sensor to measure the rate of change of water level using the principle similar to radar and sonar that gives real time data. The sensor calculates the time interval between sending the signal and receiving the echo to determine the water level. The information collected is then transmitted to a central server at a predefined interval, via SMS.

CBEWS for Floods (November 2006), set up a flood warning scheme in the municipalities of Dinalupihan and Hermosa in Bataan Province in order to help mitigate the disastrous effects of flooding in the said areas. The system is a non-structural flood disaster mitigating measure that encompasses hydrological monitoring (river stage observation), information exchange and a flood warning that is based on river stage and rate of rise, and the disaster preparedness and response phases as applied to a locality or a sub-basin area within the two towns. The system is composed of a set of staff gages (water level or river stage gages) installed strategically within the target area. The gages will be used as reference markers for the community to monitor and observe during times of inclement weather. Warning will be send via bells or alarm by the community personnel or volunteer and exchange of information is also via SMS.

The same with the other studies conducted for water level monitoring system with the same purpose of saving lives of people affected by the effects of climate change, severe flooding, this study utilized the use of Gizduino instead of Arduino as its microcontroller. Gizduino is a locally available Arduino clone that is much cheaper. They are electronics prototyping platforms based on flexible, easy-to-use hardware and software. It has an ability to control interactive objects and environments, and have limitless potential to do so. Gizduino is also fairly compatible with Arduino IDE.

In the study of Asaad Ahmed Zhang Jian Min, (2013) entitled Automatic Water Level Control System, Arduino was used to automate the process of water pumping in a tank and has the ability to detect the level of water in a tank, switch on or off the pump accordingly and display the status on an LCD screen. The system also monitors the level of water in the sump tank (source tank). If the level inside the sump tank is low, the pump will not be switched ON and this protects the motor from dry running. A beep sound is generated when the level in the sump tank is low or if there is any fault with the sensors.

Arduino was also used as microcontroller in the study of Azid (2015) entitled SMS based Flood Monitoring and Early Warning system. With tools such as credit top-up and storing contact numbers done via SMS, updates on the height of the water level would be texted upon users' request. The system provides timely information and alerts at-risk or threatened populace and relevant authorities by means of SMS when the level of water surpasses the user-defined threshold value.

Methodology

The researchers used developmental research. Developmental research, as opposed to simple instructional development, has been defined as the systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet the criteria of internal consistency and effectiveness.

This water level monitoring system is made up of the water level sensors installed in the rivers to detect the level of water in the river during the rain and thus it can predict before the river overflows. The sensor will send the information about the water level to the controlling program if it's already at risk. The controlling program will now send a message as a warning to the mobile numbers registered in it. In this case, the community will then be given enough time to prepare to move to a safer place before the water rises.

In this study, the researchers used Software Development Life Cycle (SDLC) process using the Rapid Application Development (RAD) Model. The SDLC is the process to develop or revise a software product. It consists of a series of planned activities depending on method to be used. RAD model refers to a software development methodology wherein the prototyping is fast in consequence of minimal planning. RAD model distributes the analysis, design, build, and test phases into a series of short, iterative development cycles. The phases of a RAD model are: Requirements Planning, User design, rapid Construction and Transition and Testing and Turn Over.

The first phase is the requirements planning stage. To be able to develop the sms-based water level monitoring system, the researchers conducted a research on the requirements needed for the development of the project. The researchers came up with using the Gizduino Microcontroller, an Arduino compatible microcontroller kit. It's a single board AVR microcontroller platform based on highly popular open source Arduino design. It can be used as well with AVR's tradional programming tools.

Hardware Requirements

Gizduino Specifications

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm

Gizduino Ethernet Shield

- IEEE802.3af compliant
- Low output ripple and noise (100mVpp)
- Input voltage range 36V to 57V
- Overload and short-circuit protection
- 9V Output
- High efficiency DC/DC converter: typ 75% @ 50% load
- 1500V isolation (input to output)
- Requires an Arduino board (not included)
- Operating voltage 5V (supplied from the Arduino Board)
- Ethernet Controller: W5100 with internal 16K buffer
- Connection speed: 10/100Mb
- Connection with Arduino on SPI port

Software Requirements

Arduino IDE 1.7. It supports all the Arduino boards including the newest Arduino Zero Pro, Arduino Yún and Arduino Due boards and the 9 Axes Motion shield.

Basic4Android (B4A. Visual Basic Language, Android 1.6 and Above

Supports all of Android core features including: SQL databases; GPS; Home screen widgets; Background services and broadcast listeners; Bluetooth (serial ports); USB host; Web services; Camera; XML, JSON and CSV; Views animations;

Multitouch gestures; Networking (TCP, UDP, FTP, SMTP and POP3); Push notifications (C2DM); Text to speech and voice recognition; AdMob ads; OpenGL; Graphics and charts; Sensors; Files I/O; Integrate with services such as: Dropbox, Google Analytics, Twitter and others; Objects serialization. Highly extensible with support for custom Java libraries. *(Arduino Uno 2015, from:http://digital.csic.es/bitstream/10261/127788/7/D-c-%20Arduino%20uno.pdf [May 2015])*

The next phase is the user design. Here, the researchers produced a system model, an outline of the system design. This outline is depicted through the flowchart below.

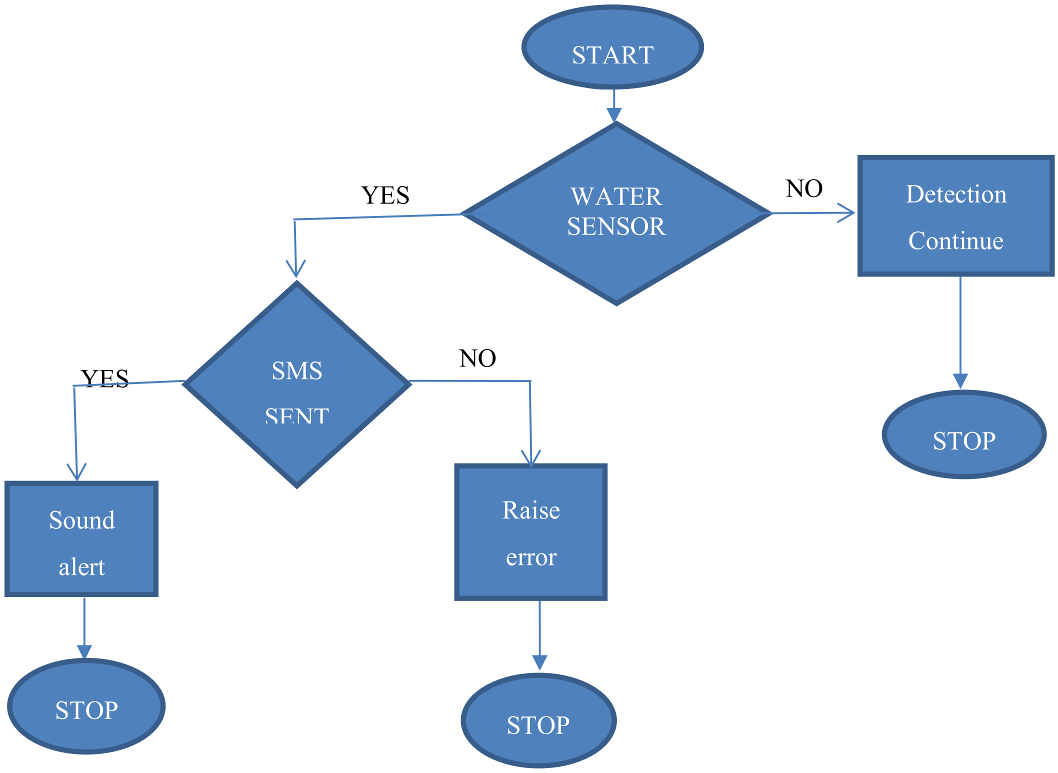

Figure 1. Proposed System Model

The next phase is the rapid construction. In this phase, the researchers developed the program to retrieve the result of the water level from the sensor and analyze the data and send an equivalent sms to the phone numbers registered in the sim card attached to the microcontroller. The final phase of RAD model is the testing and turnover, the overall testing time is reduced in RAD model as the prototypes are independently tested in the iterations. However, the data flow and the interfaces between all the components need to be thoroughly tested with complete test coverage.

Since most of the programming components have already been tested, it reduces the risk of any major issues.

Results and Discussion

In this study, the researchers have chosen to use a Smart Phone to implement the concepts of Mobile Computing considering that Smart Phones nowadays are becoming more and more mobile. Since, a Smart Phone is a mobile device that can be taken anywhere and as long as there is telecom network signal, and the Smart Phone and Gizduino belong to the same network. Communication is possible. *(Cauligi S. Raghavendra, Krishna M. Sivalingam, and Taieb Znati (2008). Wireless Sensor Networks.)*

The study was designed with this function in mind: allow sms to be sent to designated mobile phone numbers in cases where water sensor receives signals that water reached the critical level. The code for the Gizduino and Gizduino Ethernet Shield is a unified code covering all of the functions Gizduino is intended to apply. These functions are Data acquisition from the Water level Sensor, the Output send signals to the controller that sends SMS to designated mobile phone numbers. Global System for Mobile Communications (GSM) module is used for sending the mobile text messages.

The idea of using SMS based warning was utilized because mobile phones have outnumbered humans in 2016 according to the Zeenews India. *(http://zeenews.india.com/business/news/technology/mobile-devices-to-outnumber-humans-by-2016_51126.html?theme).* According to them, the growth of mobile Internet, video, data and smartphones predicted that there would be more than 10 billion mobile-connected devices by 2016, more than the estimated global population of 7.3 billion by United Nations and Asia Pacific region which is tipped to experience an 84 per cent growth in mobile phone ownership.

According to inquirer.net *(http://technology.inquirer.net/14162/philippines-cited-for-mobile-phone-use)*, the use of mobile phones in the Philippines has brought better information access for farmers, broader citizen engagement and link to traffic data for taxi drivers. The country also witnessed one of the first uses of text messaging as a medium for social change during the EDSA II revolt in 2001 that led to the ouster of then President Joseph Estrada.

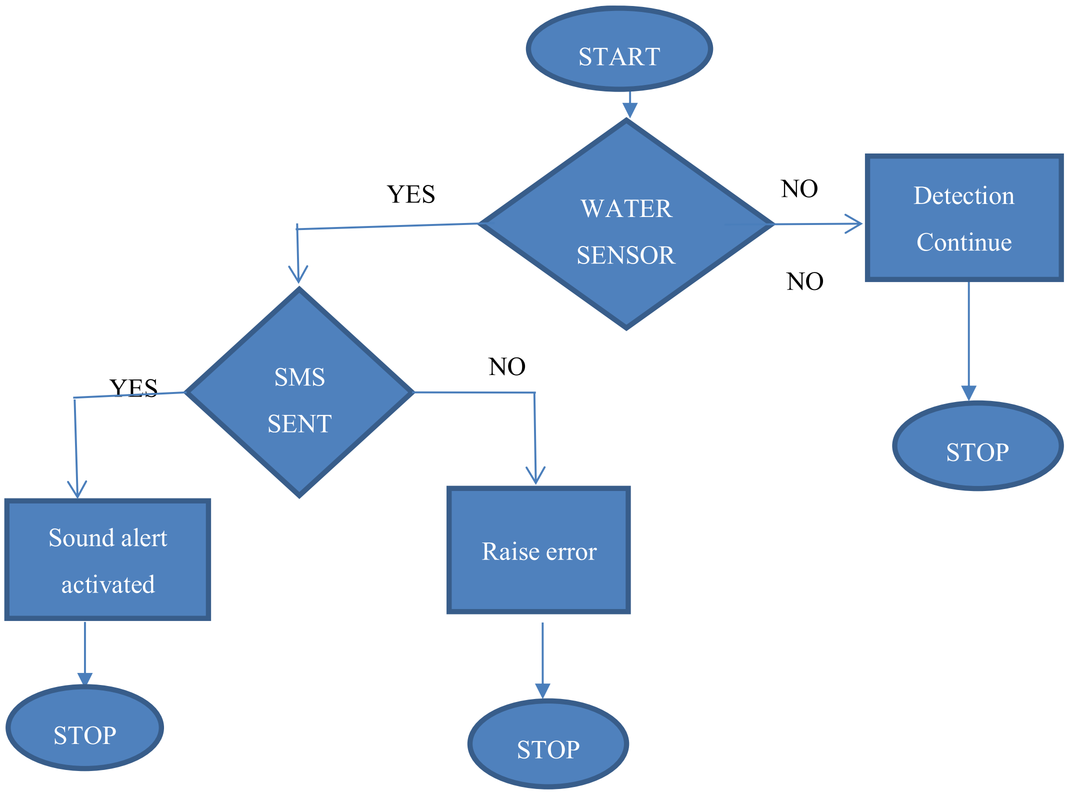

Figure 2. System Flowchart for WLM System

The simplified flowchart is shown in Figure 2. The system will start the moment the battery supplies the circuit with the electricity needed. Every component of the project is active the moment it is turned on. When the water level sensor is activated the water level is detected; otherwise, there will be waiting time to detect the water level

The Controller will then analyze the signal and it will activate the GSM module to send the necessary message. *(ThinkLab Training and Consulting (2013) The gizDuino Fundamentals: Getting Started (Windows and Mac). Retrieved from https://thinklab.ph/2013/07/31/the-gizduino-fundamentals-getting-started/ May 15, 2016)*

The GSM module contains saved numbers to where the message should be sent. The message will be automatically sent to the concerned/connected phone number that contains message/s regarding the water level; otherwise, there will be an error with regard to the sending of SMS.

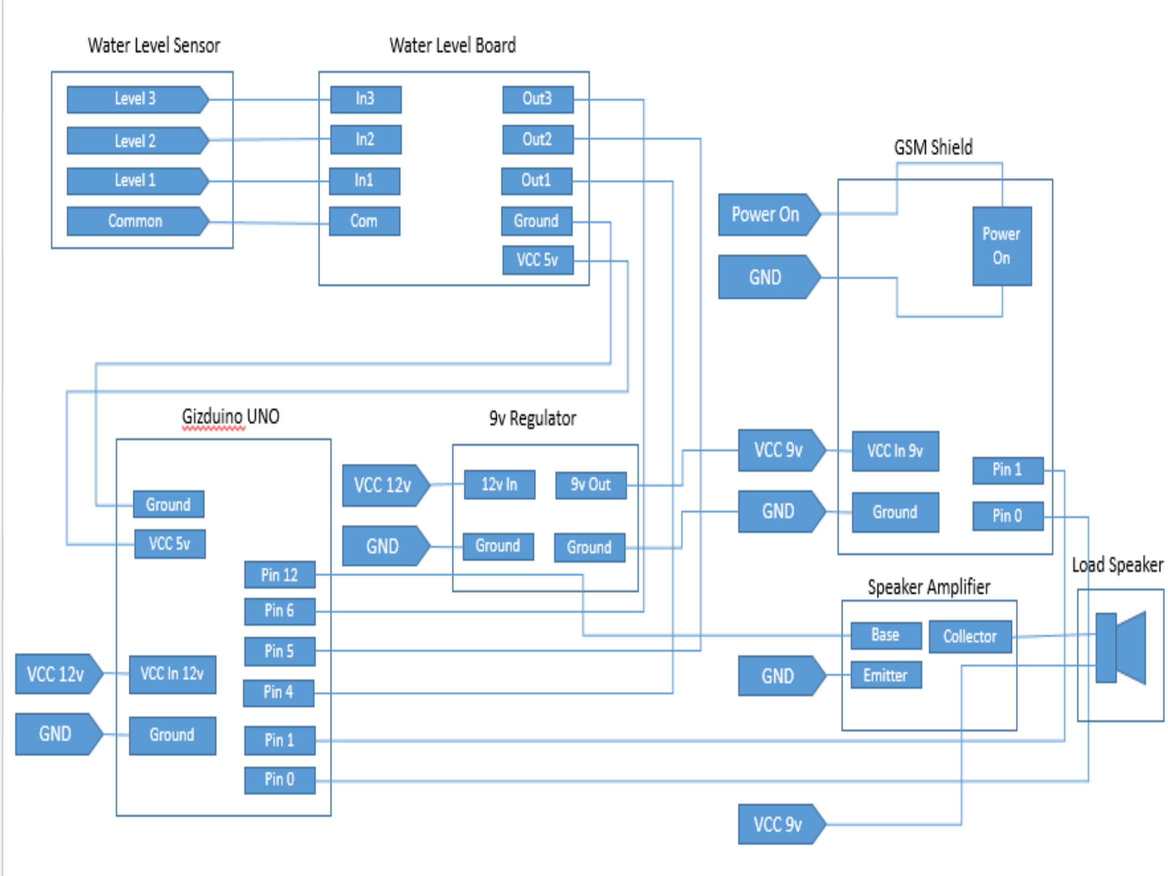

Figure 3. Water Level Sensor Block Diagram

Figure 3 shows the Water level block diagram. There are three levels that are indicated depending on the water level and critical aspect set by the user. There is also a common label which means that the sensor is ready to detect its particular level.

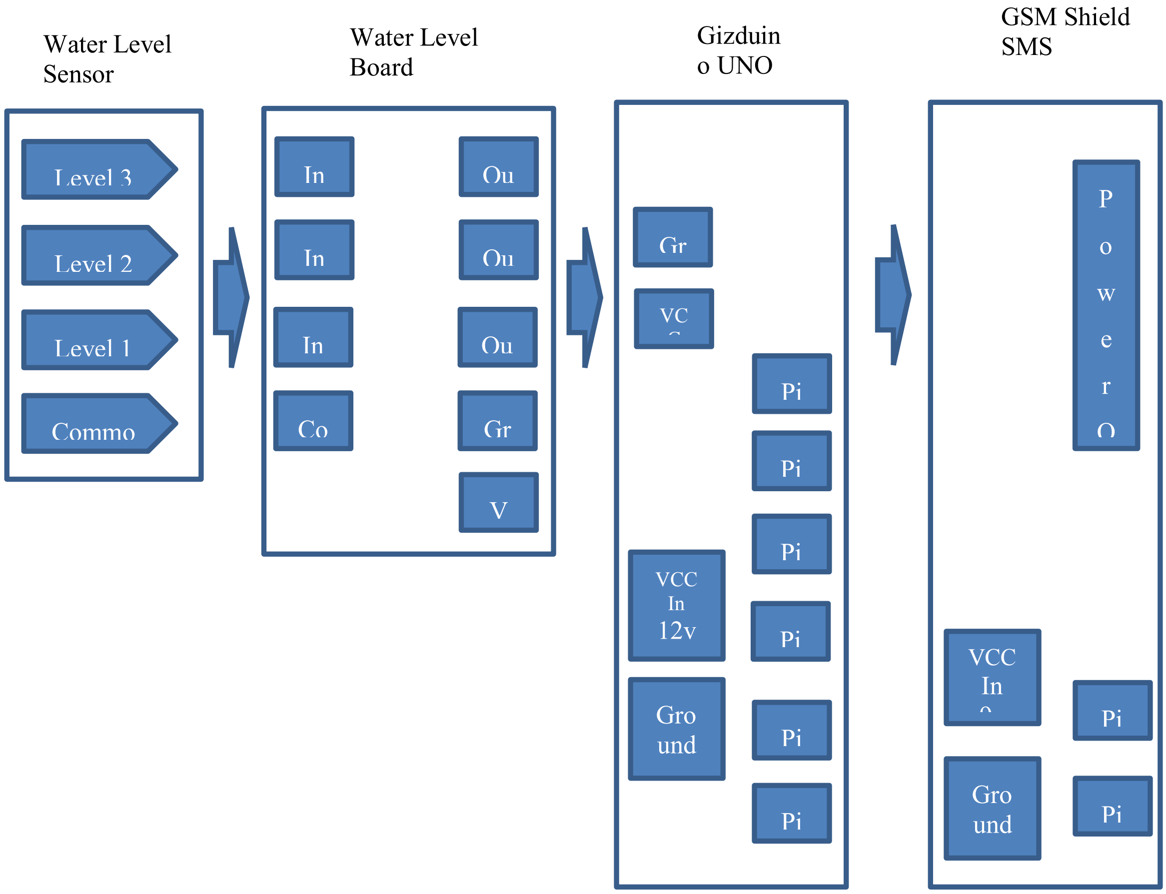

Figure 4. Water Level Sensor Process Flow

Testing

Blackbox and Integration Testing. There are two basics of software testing, the blackbox testing and whitebox testing. Black box testing is a testing technique that ignores the internal mechanism of the system and focuses on the output generated against any input and execution of the system. It is also called functional testing. White box testing is a testing technique that takes into account the internal mechanism of a system. It is also called structural testing and glass box testing. To validate the output of the mobile app water level monitoring system, the blackbox testing was used by the researchers.

An integration testing is performed to expose defects in the interfaces and in the interactions between integrated components or systems. In this study, the software developed as a user interface to the result of the water level obtained from the environment where the sensor is located, is integrated with the Arduino device which is connected to the sensor that detects the water level. This test verification is done to ensure correctness of the combined functionality after integration.

Testing Procedure. Here is the tested mobile app water level monitoring system using Arduino that uses 3 sensor probes as water level indicator with 3 leds and a simple controller that turns on a motor as indicated in Figure 4, that produces different variations of sounds as a warning when the water has reached the desired level .

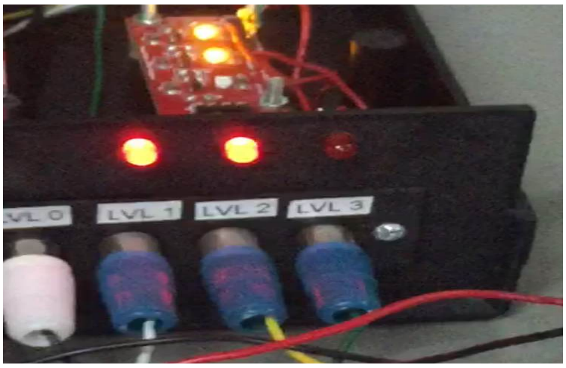

Figure 5. Water Level Led Indicator

The output of the sensor does not affect the type or kind of water it obtains. There is no need to test the mobile app water level monitoring device in a flooded area just to check the validity of the output. It will function according to what is expected of it even if the testing was done using a bottle of water with tap water in it. The objective is to test whether the sensor sends signals to the controller the moment the water reached each levels of the sensor.

As shown in Figure 5, the Arduino device has 3 sensor probes, white for Level 1, yellow for Level 2 and green for Level 3 which is the critical or the highest level of water. However, there is a common wire which is always at Level 0 and which must always stay at the lowest level of the water.

Figure 6. Water Level Sensor

To test the increasing level of water which will be obtained by the sensor, an empty bottle with the water level sensor inserted in it is used (Figure 7).

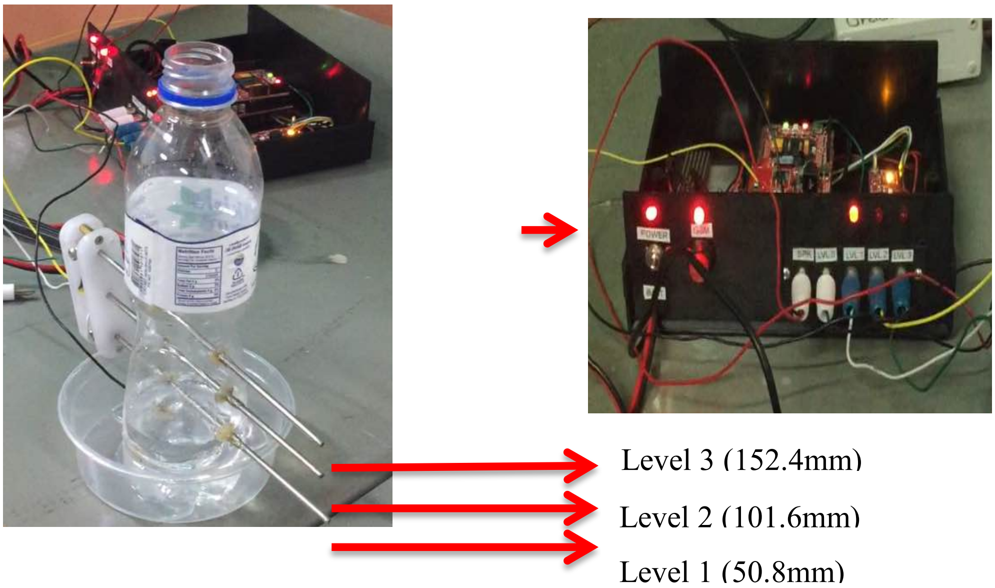

Figure 7. Improvised Water Level Tank for Testing the Water Level

Initially, the bottle was filled with water up to Level 1. The sensor will obtain the water level at Level 1 and will send to the controller. When the water level is increased at Level 2, it will send a signal to the controller to trigger an alarm and send an sms warning that the water level increased.

Table 1

Summary of Testing (Water Level Input 50.8 mm – 152.4mm deep)

Input	**Output**		
Water Level	**SMS**	**Alarm**	**Light Indicator (LED)**
Low Level – 50.8 mm deep	SMS sent	ON	ON
Medium Level – 101.6 mm deep	SMS sent	ON	ON
High Level – 152.4 mm deep	SMS sent	ON	ON

The table above shows the summary of input done on the first testing using different water level from 50.8 mm deep up to 152.4mm deep. The output shows that SMS, Alarm and Indicator Light turned on using the system.

Conclusions

This study has achieved its objectives and provides a system that could monitor the water level and report its level via SMS. It is developed with a capability to detect water level during floods. The microcontroller as central processor is connected to the water level sensor. A series of tests were conducted where it was found that the system was functioning well.

The researchers recommend the use of postpaid SIM cards to avoid disconnection of the line and in order to send messages continuously. It is also recommended that the system be implemented in Calumpang River here in Batangas City to serve as the monitoring system during typhoon so as to warn the public of possible evacuation when the critical water level is reached.

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