ISSN 2321 3361 © 2018 IJESC

Research Article Volume 8 Issue No.10

Floods Forecasting by Water Level Monitering

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Abstract:
The utmost thing when a disaster occurs is the circulation of information among the people. A deployment of devices enabled by IoT (Internet of Things) could bring benefits in terms of informing people opportunely for making decisions in face of any disaster. In this paper, we present a pilot project through a micro-model that is constructed to alert the people about the Floods. For such purpose and to prove our concept, we designed a water level sensing and water flow sensing model which is tested in a controlled environment. This micro-model is performed on a programmable electronic board (Netduino Plus 2), an Ultrasonic sensor and Water Flow Sensor. The information thus collected from both the sensors is transmitted and displayed to user. Finally, the micro-model is tested by experimental tests under a controlled environment and satisfactory results are obtained.

Keywords: Disaster Management, Floods, Flow Sensor, IoT, NetduinoPlus2, ThingSpeak, Ultrasonic sensor.

I. INTRODUCTION

According to Darwin's theory only the fittest of all living beings survive. But Human beings have also proved further that smartest of all living beings survive even in the worst environmental conditions. Several natural disasters are responsible for the extinction of different species on earth. Even today they pose a great threat to the world. Disasters droughts, volcanic eruptions and floods are not controllable but by taking some pre-disaster cautions the harm caused can be lessened. Floods have proved to be fatal since eras and still prove to be dangerous. Floods are the most common and widespread of all natural disasters. India is one of the highly flood prone countries in the world. Around 40 million hectares of land in India is prone to floods as per National Flood Commission report. Floods cause damage to houses, industries, public utilities and property resulting in huge economic losses, apart from loss of lives. Though it is not possible to control the flood disaster totally, by adopting suitable structural and non-structural measures the flood damages can be minimised. For planning any flood management measure latest, reliable, accurate and timely information is required.In such cases Evacuation is a pre-emptive move to protect life and property, where as rescue is a post-disaster phenomenon of helping people to move from areas that have been hit by disaster to a safer place. However, the situation of evacuation and rescue comes along with numerous unanswered queries in mind. Very often, due to lack of information or in haste the process of evacuation and rescue becomes difficult and painful.

There exists encouragement for researching preliminary solutions in this kind of disaster to mitigate and help in rescue operations. A variety of options are available for creating systems capable of warning vulnerable populations about an imminent threat of floods.

Because of the expensive cost of gauges to measure water level and the importance of developing warning systems for measuring levels in rivers that contribute to safeguard lives of citizens who inhabit regions in danger of flooding, we present a water level and water flow sensor working on an IoT platform.

II. BACKGROUND

Very recently it appeared the concept of Internet of Things (IoT) as a topic emerged in the wireless technology field. IoT describes the pervasive presence of a variety of devices such as sensors, actuators, and smartphones or mobile phones that through unique addressing schemes, are able to interact and Co-operate with each other to reach common goals [1]. In [2] is mentioned Internet of Things is a paradigm as a result of the convergence of three different visions: Internet-oriented visions (middleware), things oriented (sensors) visions and semantic-oriented (knowledge) visions. In previous works dealing with this term [3], [4]. Hence, it is possible to use the concept of IoT to provide communication capabilities toa device that could alert opportunely to a population before a natural disaster occurs. Before using sensors integrated into IoT ("Things"-oriented vision) some works have been proposed to disaster situations [5], [6], [7], [8]. Specifically "Things"-oriented vision works like [9], [10] where RFID technology is used. However, we are especially interested in those applications centered in disasters by floods. For example, a system for flood detection is ALERT [11]. This system uses remote sensors to transmit environmental data to a computer system. Various kind of sensors deployed in the ALERT system is rainfall, water level, and weather sensors. These sensors supply information to the centralized database system. Another example is found in [12], it is a landslide detection system using a WSN (Wireless Sensor Network). This system has enabled a more convenient early warning system and provides a system able to learn about the phenomena of natural disasters. Current emergency management and disaster recovery systems usually involve several parts such as a communication infrastructure and an information management system [13]. Forecasting flash flood by the overflowing of rivers is able to process, analyze (by means of rain gauge and stream gauge) and remotely sensed data to detect the occurrence of a flood. This system is the ideal solution, but it is expensive. A variety of hardware, software (including computer applications and programs), and communication capabilities are required to support and maintain this water level measurement system. Several studies have designed river level sensors using databases, processing raw data, extracting information and sending wirelessly this information to users. [14], [15],[16].

Another more previous works have studied similar issues such as [17], [18]. Because of climate change extreme rainfall is becoming more frequent often, therefore it causes heavy flooding. This causes the need to monitor constantly the river level, so these measurements must be safe and to have reliable sensors are essential. According to location characteristics, different measuring principles can be used. A water level measurement enables to know the amount of water that have a river, it also to know what level it can become dangerous because it may cause an overflow, therefore, cause floods. Saving level values can make predictions for future levels and behaviors in the water level of rivers, lakes, lagoons, ponds, and dams.

A. *Water Level Meters*

Different types of water level measurement systems are used in industry and research which is shown in Figures 1, 2, 3, and 4. These can find directly measuring the height of the liquid by drawing up to reference line, other measuring hydrostatic pressure, some more which are based on a float system whose displacement caused by the same liquid is quantified or also those that exploit the electrical properties of a liquid. Traditional systems for measuring water level have existed for decades. Next, we present the most typical ones.

1) Limnimeter Rule Meter*:*

Rule for graduating that is set in a river and used to read the fluctuations of the water levels. (See FIGURE 1).

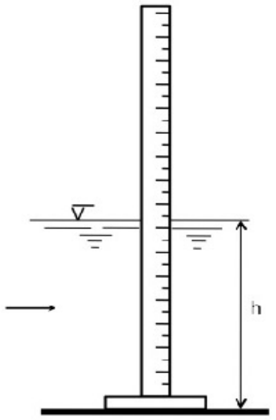

FIGURE 1. LIMNIMETER RULE METER

2) Liquid Level Meter: This device measures directly the height of liquid taking into account a reference of level measurement of a container. (See FIGURE. 2).

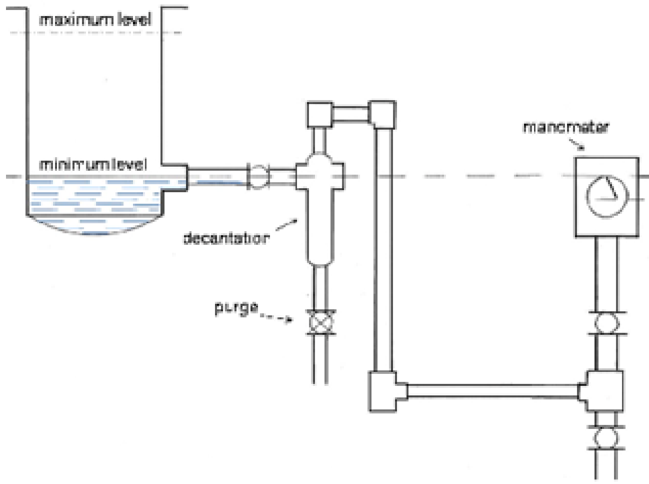

FIGURE 2. LIQUID LEVEL METER

3) Sounding Line Meter: It is a rod or ruler which is inserted into a reservoir, the water level is determined directly by measuring the length that is wetted by the liquid. (See FIGURE 3).

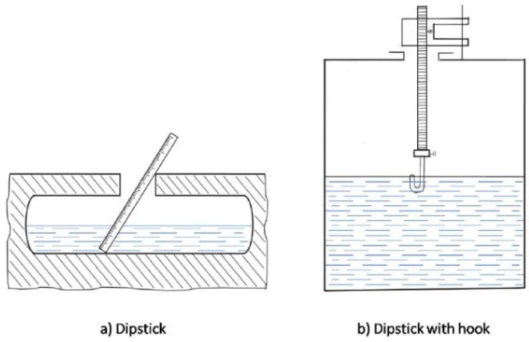

FIGURE 3. SOUNDING LINE METER

4) Mechanical Float Meter: It consists of a float located in the tank connected to the outside showing the liquid level with graduated scale. The connection can be direct, magnetic or hydraulic. (See FIGURE. 4).

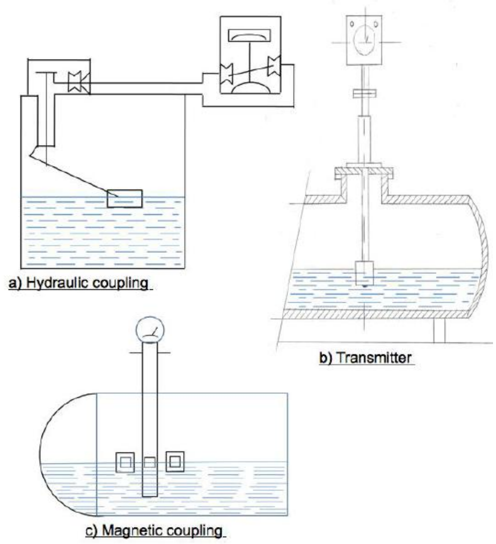

FIGURE 4 MECHANICAL FLOAT METER

B. Water Level Measurement Sensors

Right now exists sophisticated early warning systems capable of providing some protection from floods. These systems can be from heavy rain event detection via satellite sensors, rainfall gauge networks, radar networks, or some combination of the three, until atmospheric fine-scale models, to forecast the risk of flooding in rivers or water bodies a short time in the future. Currently, there are many modern level sensors to measure levels of water such as stated in the previous paragraph. Some kinds of sensors are shown In TABLE I.

TABLE I
LEVEL SENSORS WHICH DETECT THE LEVEL OF LIQUIDS

Point level detection of liquids	**Point level detection or continuous monitering**	**Continuous level measurement of liquids**
Mechanical and magnetic float	Ultrasonic	Magnetostrictive
Pneumatic	Optical interface	Resistive chain
	Microwave	Magnetoresistive
	Capacitance	Hydrostatic pressure
		Air bubbler
		Gamma ray

III. STRUCTURE AND DESCRIPTION

To test the performance of our water level measurement system, we have created a micro-model based on a prototype. In this way, we avoid waiting for torrential rains to watch how the water rises in a river. It seems an absurd idea to test our prototype directly on a river. Basically, the prototype has as function to be a flood alarm system, that consists in a water level meter connected to an audible alarm device in 24-hour operation. When the water level reaches the level marked a speaker alert (Siren) is triggered. The prototype also sends information about water level from the container to a web server and smartphones as well. As mentioned, there are different models and types of water level meters, including sensors based on different technologies. At this time, we design a solution based on a simple open circuit that closes when in contact with water that takes advantages of existing sensors, so we think that an implementation of water level system can send alert signals toward a web server or a software application installed on smartphones.

A. Water Level Design

To validate the idea and realize a Proof of Concept (POC), as noted earlier, we have designed a micro-model that emulates how the river stage rises. This micro-model consists of a water container, an electronic circuit, a Netduino board, a laptop, and a smartphone.

It is convenient to use an ultrasonic sensor for level measurement, a flow sensor for water flow speed measurement and wireless data transmission to connect the device to a server.

B. Equipment and Materials

In order to design the prototype the following materials and equipments were used.

1) Water Container: It enables to replicate a controlled environment.

2) Netduino Plus 2 board (See FIGURE 5): Netduino Plus 2 is an electronic platform to create our prototype since it calculates measurement and stores readings of levels.

This board has the following features:

- ST Micro 32-bit microcontroller
- Speed: 168 MHz, Cortex-M4
- Code Storage: 384 KB
- RAM: 100 + KB

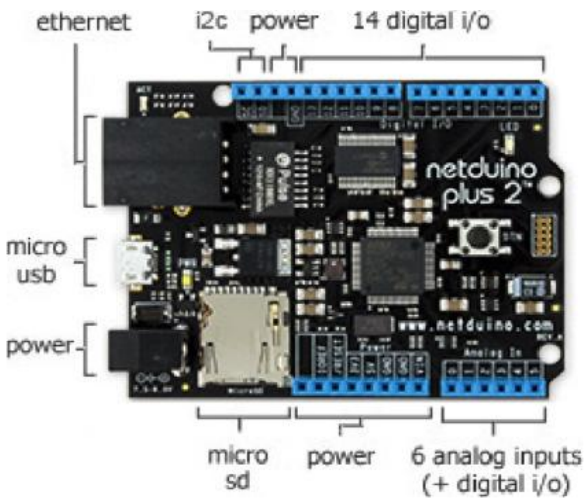

FIGURE 5 NETDUINO PLUS 2 BOARD

3) Ultrasonic Sensor: It is used for water level measurement.

4) Water Flow Sensor: It enables the water flow speed measurement.

5) GSM module SIM 900A: It enables the transmission of data onto the smartphone.

6) 16x2 LCD display.

7) 1 Laptop. - A computer to execute Microsoft C#, connect to netduino and to display the acquired data.

8) Microsoft Visual C# 2010 Express: Programming Language for running the water level system.

9) Smartphone: To receive messages when the water level and water speed is changing.

C. Architectural Design

The architecture of the prototype is as shown in the figure no .It consists of a large rectangular water container which is used to show the rising water level. An acrylic floating sheet is set to float on the water in the container. As the water level rises the sheet also rises. This sheet is used to reflect the ultrasonic waves emitted by the ultrasonic sensor. An outlet is added through which the water flows out. A valve along with an flow sensor is attached to the outlet pipe which moniters the water flow speed. Both the sensors are then connected to the netduino circuit where the data is collected and transferred onto the smartphones through GSM module. Also the data is displayed on the screen of desktop in the form of graphs.

D. Measurement and interpretation of obtained values during sensing

The rising water level is continuously monitored by the ultrasonic sensor. The flow of the water is calculated by the flow sensor. The readings obtained from ultrasonic sensor and flow sensor are collected at the netduino and send to a program where the data is processed for further display. The readings are send to user. Water level is sending in the form of percentage of water filled in the container and the speed of the water flow is displayed in liters per minute.

The messages are also displayed on the LCD Display where they are updated after every 15 seconds. Three levels of warnings are programmed viz;

1) If water level is between 60% to 75%, then first warning SMS is send. The message is of format:
"Water Level is above 60%"

2) If water level is between 75% to 85% then second warning SMS is send. The message is of format:
"Water Level is above 75%"

3) If the water level is greater than 85% then third warning SMS is send and the buzzer beep is started. The message send is of the format:
"Water level is above 85% Alert!!!"

4) If the water flow rises above 4L/min then alert message is send which is of the format:
"Water flow is very high".

The data gathered is also displayed in the graphical form on an IoT application known as ThingSpeak. ThingSpeak is an open source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates.

IV. TESTING AND IMPLEMENTATION

Netduino apps are written using C# language. After compiling the Netduino programming code, add some water in the container and the prototype is ready to be tested.

A. Testing prototype

As mentioned, a rectangular water container with a float is filled with water.An ultrasonic sensor is fixed on the rim of the container in such a way that the ultrasonic waves emerging out of the sensor fall upon the floating sheet and reflect back towards the sensor.When the water level rises the valve attached to the outlet pipe is opened and water is allowed to flow through flow sensor which takes the readings according to the speed of water flowing through it.

How we tested the prototype proposed in this paper is described in detail as follows:

1) The water container (empty and dry)is filled with water through a pipe. Gradually the water level rises and the levels are calculated and displayed in the form of percentages.

2) The program installed on the laptop triggers the audible buzzer signal and also sends 1st warning message to the user when the water level crosses 60% simultaneously the flow rate is also displayed.

3) When the water level crosses 75% 2nd warning message is send.

4) When the water level crosses 85% final warning message is send and the buzzer is triggered which indicates the water level is maximum.

5) Even if the water flow speed rises above 4L/min a warning message is send to the user.

In this way we tested our prototype once slowly being filled with water in the container; if the water level rises, warning messages are sent to both the laptop and the Smartphone.
Depending upon the results obtained from the readings if the flow of water is constant one can calculate the time in which the container will be full.

V. CONCLUSION

According to definitions of IoT, if we consider a sensor as an element of IoT which enables to communicate its current status and be published on Internet, then our proposal is very close to what we are intending to achieve within the concept of Internet of things.
Nevertheless, the real intent of the proposal is to achieve a flood early warning system. So far, we have only built a micro-model through a prototype that sends an audible signal and graphical messages towards Smartphones and laptop about the water level in a container.
This micro-model was developed based on a programmable electronic board (Netduino Plus 2), ultrasonic sensor, flow sensor, GSM module, ThingSpeak application. The information gathered from these sensors was then processed by a program written in C# language and via GSM module was transferred to Smartphones and laptop. This information was transmitted to an application through internet. After these users can graphically see the data, these data show the values of water levels and speed of water flow.
Subsequently, the prototype tests were conducted into a controlled environment, these tests consisted measuring the water level in a container with water, different levels were tested as per the written program, and such testing showed the expected results. Given these facts, if it is known through properly set standard levels it is possible to know exactly these calculations in a real scenario like a river. Hence, people can be opportunely informed when rising river levels, so inhabitants can make a decision and start preparing to evacuate their homes if necessary. Thus we can consider a warning system to alert residents of low-lying areas about changes in rivers.

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