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# A Review on Flood monitoring: Design, Implementation and Computational Modules

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**ABSTRACT**: Floods are most common and widespread of all natural disasters. It causes damages to houses, industries bridges resulting in loss of lives and property. Though it is not possible to control the disasters totally, by adopting suitable measures the flood damages can be minimised. In this paper, various flood monitoring techniques, their design and implementations were discussed.

**KEYWORDS**: GDU, GPRS, FFGS, GIS, WSNs

## I. INTRODUCTION

A bridge is an important element in a transportation system, and, its failure or defective performance will result in serious disruption of the traffic flow. It is well known that absolute safety is the criteria in building bridges as there are number of risks failures associated with the bridges. Its failure will result in loss of lives and property and also will affect people. Bridges constructed over rivers, seas and waterways are vulnerable to disasters such as flooding and tsunami, and they are facing unexpected loadings due to floods and tsunamis.

Being prepared for floods requires measurement and notification of water level, velocity, intensity of rain, weather and precipitation. The major components of the flood alert system are Monitor Water Level,

- Log Precipitation
- Calculate Water level
- Discharge
- Transmit Information
- Install and Maintain

The instant water-level monitoring techniques are mainly focused on the measurement of the relative height of the water surface which is highly a difficult task. Mainly there are four types of measuring sensors that are used for measuring water level: they are Pressure sensors, bubble gauges, float gauges, and non-contact radar gauges. But there are many issues that affect the sensor and its performance. However, pressure sensors have to be placed at the bottom of the river or surroundings, which requires high maintenance cost since they can be easily destroyed or buried by floods. Float gauges have to be stored in the water-level towers built in the center of the river, which can cause the problem of high construction costs and difficulties. Bubble gauges use extended measuring tubes to separate the main body from the water, but these extended measuring tubes need to be replaced when damaged by flood. Moreover, the extended tubes inside the river needs frequent maintenance. The non-contact sensors such as ultrasonic gauges or radar gauges are expensive and can be only set up across the river, which are usually road or railway bridges. Such techniques use acoustic or optical reflection principles to measure the height of the water surface. Hence, the reliability of the measurement can be easily affected by a number of factors, such as the angle between the radiation source and the water surface,illumination, fog, rain,air quality, humidity, water ripples, and the atmospheric conditions.

## II. RELATED WORK

A. *Real-time flood monitoring and warning system*

This system is composed of three major components: sensor network, processing/transmission unit, and database/ application server. The condition of water or water level in near real time can be monitored remotely by utilizing

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wireless sensors network that uses the mobile General Packet Radio Service (GPRS) communication in order to transmit measured data to the application server [1]. Also a middleware called VirtualCOM enables application server to communicate with the remote sensors connected to a GPRS data unit (GDU). The application server is a web-based system implemented using PHP and JAVA and MySQL as its relational database. Fig. 1showsthe structure of each monitoring sensor unit at the remote site. Thesensor module consists of an ultrasonic Doppler instrumentto monitor water level anda precipitation sensor, to measure the amount and intensity of rain.Users will able to view real-time water condition as well as the forecasting of the water condition directly from the web via web browser or via WAP.

Fig.1. Precipitation Sensor and its Installation [1]

A case study of a flood forecasting system for the Demer basin (UK) has been presented by TTate E.et al [2].This system also uses a web-based approach. Data is collected from hydrological observation stations in real time and processed with a cluster of server computers, and then the results are made available on client computers in the control room and via remote access. This gives operational managers fast, most accurate, real-time flood forecasting and facilitates the decision to issue an alert. However, this study did not discuss the dissemination of flood information to general public.

Another flood prediction system have reported bySharif, H et al is the use of remote sensing and geographical information system (GIS) to detect flooding in the Indus river basin and its tributaries in Pakistan[3]. The project uses digital maps of the river basin to show output from flood routing models so that the early flood warning level analysis can be done and warning signals can be issued to flood prone areas.

A flash flood guidance system (FFGS) has been implemented by the Mekong River Commission Secretariat (MRCS) in Vietnam to warn of flash floods [4]. The FFGS evaluates the possibility of a flash flood within a certain basin from the collected data, which includes rainfall, water level, weather report and the velocity of the river and the system creates maps indicating a risk flood area for hydrological authorities.

B. *Flood Monitoring using Wireless Sensor Network*

Wireless sensor networks (WSNs) are an emergent class of extremely dynamic environment consist of wide variety of applications, such as weather forecasting, habitat monitoring, precision agriculture etc. These sensor networks have limitations of system resources like communication range, battery power and processing capability. There is a crucial link between safety and survival of any transportation organization. It is essential that Railways, bridges and track on bridges are one of the weak links in ensuring the required level of safety during floods[5] .Thus it is important for system to enhance safety of track over bridges against any flash floods and inundation or water flow.
This system has been designed and installed in a way, that, when the water level on a bridgereaches to a particular water level then the rise in waterlevel will be sensed by the electromechanical float sensor and sends the signals providedto the Central Processing Unit (CPU), which activates the signal and triggers the GSM modemfixed at the signal location, which in-turn sends a predefined SMS, based on the waterlevel position, to predefined GSM/CDMA cell phones with otherparticulars of the bridge.In this system the sensor to be used are float sensor and ultrasonic sensor. Sensor nodes equipped with water level sensors are deployed in the upstream and downstream region of rivers in order to estimate the difference between them.Wireless sensor networks have been used for flood detection in Honduras, which is affected by heavy rain fall [6]. This system relies on volunteers and has limited technology.Sensors

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to measure river state consist of river level markings painted on bridges and water collecting rain gages. Fig. 2 shows the typical topology of the wireless sensor network. The network was designed as a two-tier architecture, a short-range communication link as a single-hop network within an 8 km range in the 900 MHz band and an inter-cluster communication network with a radio-range of up to 25 km in the 144 MHz band.

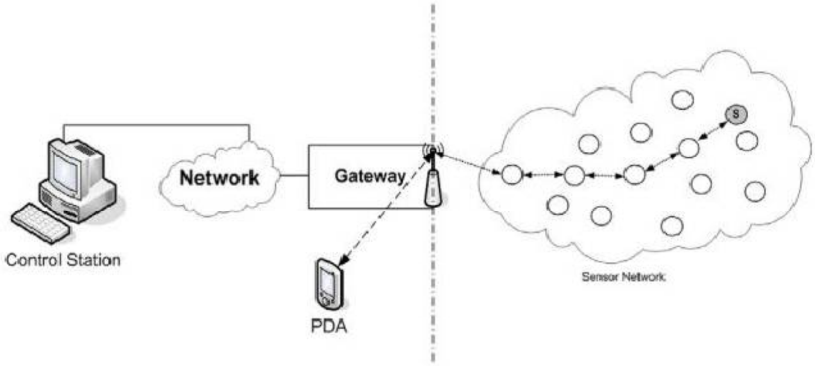


Fig.2. Topology of Wireless Sensor Network [5]

The authors of the paper did not address about data transmission or the warning approach used. However, they mentioned about the protection of the system from environmental and human damage, appropriate coverage of the area at risk and effective prediction as the main issues.

Krzhizhanovskaya, V et al. presented a prototype of an early flood warning system [7]. The system used sensor networks installed in flood defences such as dams and embankments to calculate dam and embankment failure and to simulate possible criteria's of flood propagation. All the relevant information and simulation results are fed into a decision support system that helps flood managers to make informed decisions in the case of an emergency situation.

C. *SMS based Flood Monitoring*

The main objective of this system is the ability to read the water level at each and every second, display it tothe supervisor and alert relevant authorities by means of an alarm and short message system (SMS) when the water level exceeds a predefined threshold. For sending mobile messages Global System for Mobile Communications (GSM) network has been used and Peripheral Interface Controller (PIC) microprocessor is used to read the input from the sensor and to display the result[8]. The measuring system is based upon the theory of pressure being applied to liquids. Furthermore, the collected data is useful for investigating and monitoring the cause of flooding with respect to time and weather patterns.

Here the water level of the flood is determined using the pressure sensors. For this system a mobile phone is used instead of GSM module. The advantages of using mobile phone over the GSM module are: the user will easily able to recharge mobile during emergencies in case where the charge goes low, The PIC is also used to check battery level of the system. As shown in Figure 3 when a pipe is placed vertically, with one end opened and other end immersed into the liquid the level in the pipe will be proportional to the level in the tank.If the upper end of the pipe is closed off and some volume of air is trapped and the pressure in the pipe will vary proportionally with the liquid level change in the tank, such that $P = D \times G \times H$ where P = Pressure, D= Density, G = Gravity and H= Height.

An SMS-based disaster warning system was proposed by Cioca, M. et al. aware citizens about flood in the Sibiu area of Romania [10]. In this system an SMS message was sent by the hydrology institute to authorities to ask for permission to issue a flood warning, and then the flood information alert is sent to public. It is interesting to note that before a flood alert can reach citizens, it must get through several steps.

Oprea, M. et al introduced a prototype of intelligent system for flood forecasting and real time alerts [9]. This system uses a microcontroller from the ARM family, and the study proposes sending of real-time hydrological data for decision making through radio communication.

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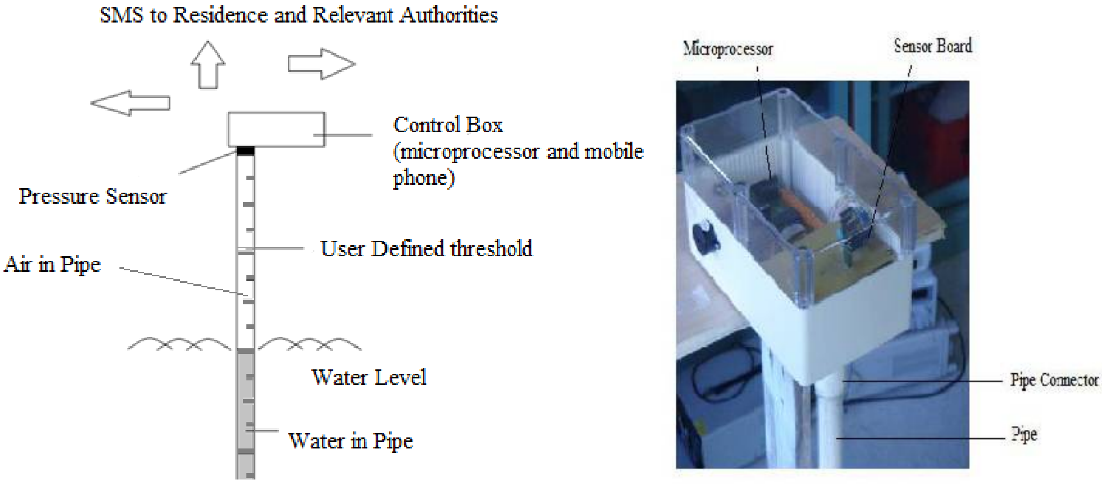


Fig.3.The Schematic diagramand sensing unit of the Flood level Monitoring system [8].

Each of the LMRB countries has its own flood warning systems, which are similar to each other and use a traditional approach for warning people. Parameters such as water level, water flows, precipitation and temperature, weather are collected from hydrological stations, and then the data is analyzed to predict and issue daily in flood forecasting bulletins. National television, radio broadcasting, telephone, facsimile, e-mail, websites and the newspaper network are also used to deliver flood information to the public. However, many people cannot able to receive any real time alerts as they do not have access to email and websites [11].

B. *Real Time Wireless Flood Monitoring System Using Ultrasonic Waves*

This system developed a real time wireless flood monitoring system by using the concept of the ultrasonic waves. This system can automatically sense the water level and then send this value to the control room through the wireless system to display it on LCD [12]. This project is developed by using ATMEGA32 microcontroller. The system consist of two parts, transmitter and receiver modules. The water level is automatically detected by the transmitter and then transmits it to the receiver. The distancebetween sensor and the water surface is detected by using ultrasonic sensor. Water level detection is performed without physical contact between the sensorand water surface. Ultrasonic sensors utilize the principle of sound reflection to measure the level of the water.The system employs the use of advance sensing technology in performing real time monitoring of water level. The developed system is composed of three major components: sensor network, transmitting modules and processing the data .The sensor network measures the water level data while the transmitting module is used to transmit measured data to the Receiver module where the data will be processed.

C. *Video Surveillance for Flood Disasters*

In this method video surveillance based flood monitoring and warning system is used. Beyond the current flood warning analysis and notification systems, which only rely on precipitation forecasts and water-level sensors, this system is capable of providing near real-time surveillance video and automated flood monitoring and warning-signals[14]. The key advantage of this system is the introduction of video surveillance concept, in which the flood overflow is considered as the monitoring object, and the risk level is determined on the basis of the number of preset warning points intruded by the flood object. Moreover it does not need any of the currently used water-level measuring techniques, such as suitable locations and structures like piers or embankments for setting up the rulers and various sensors such as Pressure, bubble gauge, float gauge.Fig 4 shows the example of a flood region detection, in which the white area denotes the flood region, foreground seed points are represented by black plus signs (+), background seed points are represented by yellow "x" symbols, and the user preset warning points are represented by green asterisk symbols (*).An image segmentation technique is used for removing the surrounding objects, such as buildings and the geographical background and adopts a Grow Cut method for region segmentation.GrowCut has two types of seed

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points: Foreground and background. Fig5 shows the detection of water level at each instant, in which white segments indicate the detectedwater area, while the black segments show the background object.

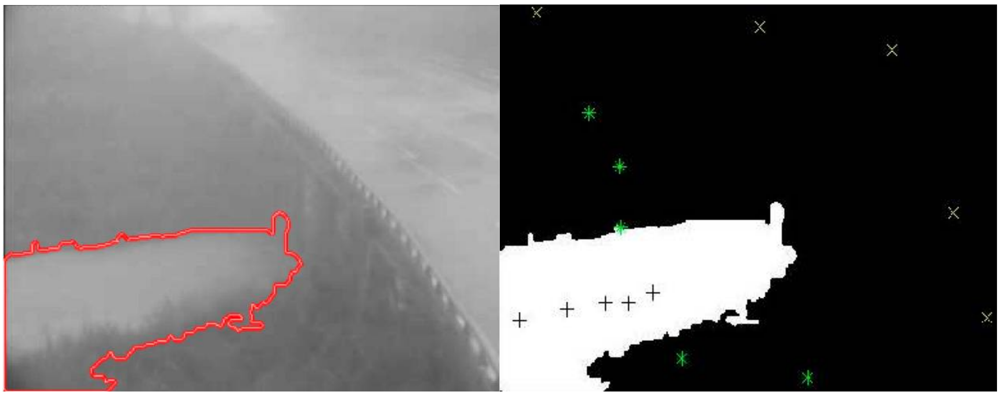

Fig.4. Example of Flood Region Detection [14]

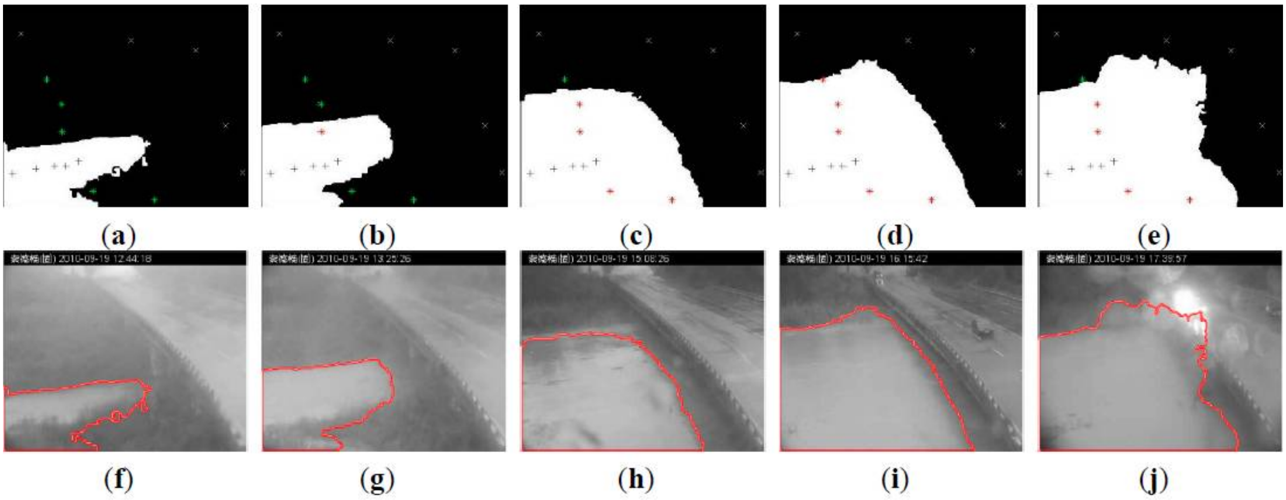


Fig.5. Detection of water level at each instant [14]

## III. CONCLUSION AND FUTURE WORK

The Video Surveillance for Flood Disasters based system providestimelier, fast and accurate flood warning information to disaster relief units and citizens, in order to reduce the negative impacts of the flood disasters.It also has other advantages, such as it avoids the common needs of a standard water-level ruler, flexibility in selecting location, and relatively a large field of view, when compared with other water-level measurement techniques. On the other hand while using sensors the problem arises with the selection of right sensor for measuring water level which may largely depends on the site and the data required by flood models.However, these works does not discuss the dissemination of flood information to general public. Therefore an application can be developed as a client server system using Android and web based Java in order to provide warning and alert to people during flood instant.

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