Intellectual and remotely self monitored Flood Observatory System for high frequency flood prone locations


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Abstract: - One of the most devastating natural disasters in the world is flooding. Flooding is a great treat towards mankind in many ways especially in damaging agriculture land, residential areas and cities with high cost of lives. Flooding also has a great impact towards the economy of a country. Countries with a high frequency of flooding have to spend a large amount of money on flood mitigation plans. Most flood mitigation plans are expensive and only some plans can be implemented based on priority. Cost and safety are prime concerns and many researchers around the world were engaged to develop the most efficient ways of monitoring and innovating early flood warning system. This paper highlights one of a possible flood detection and warning system to efficiently monitor critical flood prone locations on a real time basis. A Flood Observatory System is developed to send water level or water rise information from remote flood prone locations, where human excess is limited due to distance and weather factors, to a more centralized location. The ability to receive real time information on water levels in flood prone locations would enable both government and private organizations to react to the imminent danger in an effective manner. When the real time flood information can be received instantly, public safety organizations and other emergency managers can effectively plan their resource deployment within the limited time of alert. The water rise information from flood prone locations could be used to save life’s and properties in many ways. This simple Flood Observatory System with stand-alone features could then be a practical flood alert system

Key-Words: - Intelligent flood monitoring system, programmable logic controller, flood observatory system, smart control application.

1 The Flood Observatory System

The Flood Observatory System is designed to be an intelligent system for monitoring flood at remote locations which has a high frequency of flooding. This system is fully automated and operates without human intervention at all time. The Flood Observatory System has many features which enable the monitoring station locations to be on alert before the flood water reaches the high level. This self operated system enables the monitoring station to be informed on any changes of water level at a certain location on real time basis. Flood prone locations require regular monitoring especially during rainy seasons since continuous rainfall can cause the flooding [1 - 3]. The Flood Observatory System can be implemented at locations of high potential flooding for effective monitoring.
The most valuable information given by this system is instant water rise information. This information is calculated by performing a simple mathematical operation consisting of water level and real time. If a system is capable of sending such information in real time to the monitoring station without human intervention and regardless of the weather, wise decisions could be made. Apart from alerting the monitoring stations, the system can also be used to trigger flood warning signs for road users, buildings and public areas instantly. The Flood Observatory System consists of a number of components working together to perform simple repetitive task [4]. The basic system requires water detection sensors to detect the water level, a control unit to process the information and a GSM modem to establish wireless communication between flood observatory system and the monitoring station [4 - 6]. The basic structure of the flood observatory system is shown in Fig. 1.

The water detection level is to be determined by the total number of sensors used in the system. The output of an RF receiver is connected to the main control unit to update the system in real time. The sensors are positioned at a certain location where water level measurement can best be obtained. One of the factors considered when positioning the sensor are weather conditions. During dry seasons the water level will remain low or at the safe zone and during rainy seasons the water level will rise drastically to high risk level.

Table 1 shows an example of flooding zone with alert/warning information.

<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe zone</td>
<td>All types of vehicle can use the road</td>
</tr>
<tr>
<td>Low risk zone</td>
<td>Heavy and light vehicle can use the road</td>
</tr>
<tr>
<td>Moderate risk zone</td>
<td>Only heavy vehicle can use the road</td>
</tr>
<tr>
<td>High risk zone</td>
<td>Road is closed for all vehicles</td>
</tr>
</tbody>
</table>

The Flood Observatory System consists of three main components which are connected to one another wirelessly via RF. The centralized control unit and display system can be placed at a distance away from the sensors situated in a remote high risk flooding locations.

2.1 Sensor unit

Sensors are the best device to use in an automation system especially for remote locations where human excess is limited. Wireless sensor technology is employed as the best alternative for detection from a distance. The sensor unit is designed to be located approximately 100 meters in radius from the centralized control unit.

The sensors are positioned at a certain location where water level measurement can best be obtained. One of the factors considered when positioning the sensor are weather conditions. During dry seasons the water level will remain low or at the safe zone and during rainy seasons the water level will rise drastically to high risk level.

The water level changes will be detected by the sensors and the information will be instantly transmitted to the centralized control unit via RF. The output of an RF receiver is connected to the main control unit to update the system in real time. Table 1 shows an example of flooding zone with alert/warning information.
The detection level which includes the minimum water detection level, highest water detection level and variance between each sensor are determined by the monitoring station management.

2.2 Controller unit

The controller unit for the Flood Observatory System detects the information of the sensors wirelessly if there are any changes in the water level. Wireless communications is established via an RF transmitter and receiver in real time based on the detection, a programmable logic controller (PLC) process the data ... The control unit will then send the information to the monitoring station via the short messaging system (SMS).

The communication between the Flood Observatory System and the monitoring station is established by using a GSM modem to send real time water level information and to receive special commands from the monitoring station [4, 6]. The PLC is connected with a GSM modem and perform communication as programmed in the system [5]. One of the developed Flood Observatory System prototype is shown in Fig. 2.

![Fig. 2. The prototype of a Flood Observatory System](image)

The control unit is also programmed to perform basic calculations on the next water level prediction based on real time sensor detection. The water rise prediction time can then be transmitted to the monitoring station as programmed. The water rise prediction is the comparison between the water level from one zone to another zone. The prediction message will be instantly transmitted once the water level increases from one zone to another. The number of zones is determined by the management in the monitoring system is based on the frequency of water rise in a monitored location.

2.3 Display and warning indication unit

Apart from sending real time water information the Flood Observatory System is capable of displaying warning signs if required. For example a running text display unit is connected to the control unit to display and alert road users on safety during flood.

The display unit will display a few sets of information which are very useful to road users to avoid damage to their vehicles. The display system is designed to be placed at a distance of approximately 100 meters in radius from the control unit. Apart from the text display unit, the control unit can also be connected to a nearby traffic light as a warning system for the flood prone locations. The traffic light system can be used to indicate the road conditions during flood. The system is capable of determining whether the road is safe for users as the water level changes.

3 Operation of a Flood Observatory System

The system operates with sensors which are located on the river bank or any location where the water level measurement is required. For the prototype unit shown in Fig. 2, there are four sensors connected to the system.

As the water level changes, the detection on the sensor will increase according to where the sensors are placed. The sensors will send the detected information wirelessly to the control unit. The control unit will determine which input port is to be used to indicate the water level.

Based on the detected port, the PLC will send the information to a communication interface to transmit the water level information in sms format to the monitoring station management. The Flood Observatory System can be programmed to transmit sms to the monitoring station management on all water change information i.e. changes in a fixed level periodically during normal operations [4].
Fig. 3 shows an example of sensors used in the Flood Observatory System prototype with detection criteria.

![Sensor position of the Flood Observatory System with the various level of risk zone](image)

The Flood Observatory System is also capable of responding with the monitoring station management at any time. When the GSM modem receives a SMS command from the management, it sends the information to the communication interface [7, 8]. The SMS will then be converted a signal and send to PLC. The PLC will read the code sent and run a system check on the current water level placed at a distance away and sends an instant reply message to the management on the latest water level information [8, 9].

**4 Advantages of Flood Observatory System**

The new revolution in alerting both the remote station personnel and users on real time water level information using Flood Observatory System is an effective and efficient technique. Instant alerts on water level change using SMS is the most common technology that humans are engaged with during working hours and during their leisure time [7 - 9]. In addition to that the remote station personnel’s are also capable of checking real time water level status just by sending a SMS to the Flood observatory System. The control system embedded on the flooding location will instantly respond the users of the current status.

The advantages of Flood observatory System compared to the conventional system (manual data collection by humans) is shown in Table 2.

**Table 2. Factors on water level monitoring by conventional system**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Conventional system</th>
<th>FOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive real time water level alerts</td>
<td>No</td>
<td>Automatic</td>
</tr>
<tr>
<td>Display instant warning sign</td>
<td>No</td>
<td>Automatic</td>
</tr>
<tr>
<td>Request remote location water level information</td>
<td>Manual</td>
<td>Instantly</td>
</tr>
<tr>
<td>Initial cost of installation</td>
<td>Daily basis</td>
<td>RM 3000</td>
</tr>
</tbody>
</table>

The conventional system is still widely practiced in most countries. The management has to depend on manually collected data from the flood prone locations periodically. This method is not only expensive but impractical during bad weather conditions.

There are some sophisticated software’s for monitoring the water level change from a distance [10 - 14]. Custom made software’s are only practical on a one to one basis, whereby the monitoring station management can only monitor a single station at one time. The system also requires internet connections and not practical for remote locations.

The system has a few factors within the capability of a Flood Observatory System, but the only difference is in the costs for initial investment and also for long run maintenance.

The advantages of the Flood Observatory System comparing to software based system are shown in Table 3.
Table 3. Factors on water level monitoring by software base system

<table>
<thead>
<tr>
<th>Factors</th>
<th>Software system</th>
<th>FOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receive real time water level alerts</td>
<td>Automatic</td>
<td>Automatic</td>
</tr>
<tr>
<td>Display instant warning sign</td>
<td>No</td>
<td>Automatic</td>
</tr>
<tr>
<td>Request remote location water level information</td>
<td>Instantly</td>
<td>Instantly</td>
</tr>
<tr>
<td>Initial cost of installation</td>
<td>Very costly</td>
<td>RM 3000</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Very costly</td>
<td>Cheap</td>
</tr>
<tr>
<td>Upgrading the system</td>
<td>Require professional and costly</td>
<td>Cheap</td>
</tr>
</tbody>
</table>

5 Conclusion

The Flood Observatory System is an intelligent system which is capable of sending real-time water level information from a remote location to a monitoring station which could be at a distance away, regardless of time. The system also features alerts unit to display warnings and alerts to the users via text displays or traffic light system in the event of flooding.

One of the special features of the Flood Observatory System is that it is self-monitoring. Self-monitoring ensures that the system performs efficiently and reliably for the monitoring station in the event of system failure, which includes sensor unit and power supply unit.

The implementation cost is invaluable to the efficiency and usefulness of the system towards mankind. The practicality of the system helps to minimize overheads due to floods and also prevents catastrophe at flood prone locations.

A system for flood monitoring and alert system was developed especially for critical flood prone remote locations to ensure mankind safety and savings to all sectors.

6 Future works

Sensors are important elements in the Flood Observatory System. Further studies on wireless sensor technology will be required. Precise and accurate detection of water level will improve the data collection system for the monitoring station.

The flood alert information’s can be displayed on liquid crystal displays (LCD) for road users and for safety reasons could be placed at strategic locations.

A possible means of power supply for the sensors and centralized control unit is via solar cells. The Flood Observatory System will be easy to install and maintained if it is powered by solar cells. The use of solar energy will also provide cheaper source of power to the entire system to operate especially if the system is placed in a remote location. For sustainability the circuits and control unit should be designed to consume minimum power during operation.

7 Acknowledgment

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8 References


