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Water Level Monitoring and Management of Dams using IoT

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***Abstract*: Dams are one of the major water sources for irrigation, electricity generation etc. in India. Dams play a vital role since the time of colonialism. Lack of proper dam management system have been causing several losses including the recent floods. Inspired by the existing rural and socio-economic problems, an innovative and feasible automatic control system can be developed for dam management purposes. This paper also proposes a novel idea of collecting and sharing real-time information about water levels to the people living nearby its bank. Highly precise water level monitoring system and timely report to the locality is also developed. When the water level crosses the threshold condition, alert messages will be sent to the people and the shutters will open automatically, retaining water to its normal level. Timely warnings to every person living in the locality and timely opening of shutters can thereby reduce the risks of loss of life and prevent disasters. Hence, automation of dam system using Arduino, ultrasonic sensor, GSM module and motor, creates a new eye for both the Government as well as the people in the locality for creating mitigation plans.**

***Keywords*: Arduino, Buzzer, Dam, GSM, Real-time information, Ultrasonic sensor, Water level management.**

1. Introduction

Dams are the major sources of water supply to cities; they also play a vital role in flood control and can assist river navigation. Most of the dams are built to serve more than one purpose and their benefits are manifold. It is necessary to implement some sort of communication between the metering systems and computer models to provide support in managing the complex systems. In India nearly 4000 major/medium dams are constructed and many more are in a pipeline. Normally, the range of dam storage capacity of 185 billion cubic meters of water with a surface area of 5,580km (93.4TMCft). During rainfall, for every 9.6mm the rise of water level increases by 0.3ft. In the recent analysis by the BC dam safety annual report, from the year 2011-2016 number of dam incidents, dam alerts and dam failures are decreased respectively. With the growing interest in Internet of Things has become a right choice for the pre-alert system for monitoring the rise in the water level in dams. The risk rate of sudden flood occurrence opened up a way for the way the need of the real-time dam water level monitoring and prior alerting system which ensures the public safety.

2. Literature review

Various efforts have been made until now in monitoring water level and accordingly controlling dam gate. The contribution of work in this area is mentioned below,

1) IoT based water supply monitoring and controlling system

Water is a basic need of every human being. Everyone needs to save the water. Many times with lack of monitoring, overflow of the water takes place. Overflow of tanks can occur because of this lots of water wasted. Another thing is because of overflow in the pipelines with more pressure there is possibility of pipeline damage. Leakage detection is one more problem. All these problems are because of lack of monitoring, manual work and less man power. In this paper a survey of Aurangabad city and field survey have been done, to understand water supply distribution and related problems with the system. After taking a survey they observed that all the work is manual and need a better technology to make proper distribution. [1]

2) Wireless disaster monitoring and management system for dams

This paper suggests architecture to control gate by monitoring high density and then communicate in real time. Considering the recent events that took place on June 2013, a destructible situation has taken place due to heavy rainfall and cloud bursting at various places. Many dams were out of knowledge on various parameters about the flow and discharge from the nearer dams which were affected earlier and due to lack of communication among these dams, lead to considerable damage of property and life.[3]

3) Dam gate level monitoring and control

The main objective of this paper is to control the water Level in dam which was implemented using IoT (Internet of Things). The design implementation and control of the programmed monitoring system was developed by this project. The cradle of the project is based on methodology of IOT. For best results, the principle operation of the automatic gate control arrangement is subjected to dry running under various possible circumstances, with Proteus as the platform for working.[4]

4) Raspberry Pi based water monitoring and alert system

This paper deals with the automatic control of a river system. The system is a cascade of single input-single output (SISO) systems, and can be considered as a single input-multiple output (SIMO) system, since there are multiple outputs given by

intermediate measurement points distributed along the river. A generic robust design synthesis based on internal model controller (IMC) design is developed for internal model based controllers. The robustness is estimated with the use of a bound on multiplicative uncertainty taking into account the model errors, due to the nonlinear dynamics of the system. Simulations are carried out on a nonlinear model of the river. The industry has always focused to devise engineering methodologies for establishment and modification of relatively easier controlling and automation methods for any scrupulous process. This paper presents the design and implementation of a control system by means of microcomputers and data transmission networks. To verify the principle operation of the Controlling design to be presented a miniature model is experimentally tested using a PC-based system.[5]

5) IoT based water level monitoring system for lake

In this paper they have introduced the idea of water level monitoring and management for lake water storage source for villages. More specifically, they have introduced the raspberry-pi as controller for water level sensing and controlling in a wired and wireless environment. Furthermore, it can indicate the amount of available water in the lake. This system is based on GSM technology. Moreover, cellular phones with relative high computation power and high quality graphical user interface became available recently. From the user's perspective it is required to reuse such valuable resource in a mobile application. Finally, paper has proposed a web and cellular based monitoring service protocol for monitoring available water in lake.[6]

3. Existing system

Dams did not have any automation systems. Dam gates were only controlled manually. A person was allotted to operate the dam gates. The water level of dams was only measured using a scaling measure fitted at dam ends. The person who is responsible for monitoring water level monitors and intimates when to open or close dam gates to the person who is responsible for opening the dam gate. Intimations about opening or closing of dam gates weren't given to the people who live nearby the dam banks. The disadvantages include

- Needed human resource for operating dam gates.
- Continuous monitoring of water level of dam required.
- People do not know about opening of dam gates that may result in loss of livelihood.

4. Proposed system

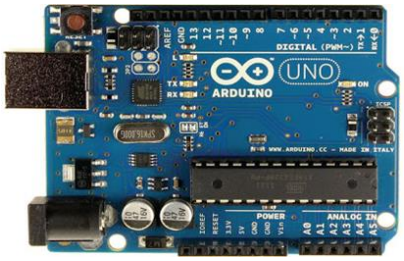
The ultrasonic sensor is used to measure the water level. As the water level reaches the first sensor message is displaying in LCD for the admin. when water level reaches the second sensor, dam gate is opened half and an alert message is displayed in LCD to admin. As the water level reaches third sensor, beyond a critical level, the GSM will inform the residents near the dam that the shutter will open soon. The motor interfaced with the Arduino will be initiated and opens the shutter after providing a final warning message. As the water level reduces, the motor will close the shutters and gets back to normal stage.

The components used are

- Arduino Uno
- Ultrasonic Sensor
- Servo Motor
- GSM Sim 800A
- Node MCU

1) Arduino Uno

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts.



2) Ultrasonic sensor

Ultrasonic ranging module HC-SR04 includes ultrasonic transmitters, receiver and control circuit. The basic principle of work:

1. Using IO trigger for at least 10us high level signal
2. The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
3. IF the signal back, through high level, time of high output IO duration is the time from sending ultrasonic to returning.

Test distance =

(high level time × velocity of sound (340m/s)/2

3) Servo motor

A servo motor is an electrical device which can push or rotate an object with great precision. If you want to rotate and object at some specific angles or distance, then you use servo motor. It is just made up of simple motor which run through servo mechanism. If motor is used is DC powered then it is called DC

servo motor, and if it is AC powered motor then it is called AC servo motor. We can get a very high torque servo motor in a small and light weight packages. Doe to these features they are being used in many applications like toy car, RC helicopters and planes, Robotics, Machine etc.

4) GSM Sim 800A

This is an ultra-compact and reliable wireless module. The SIM800A is a complete Dual-band GSM/GPRS solution in a SMT module which can be embedded in the customer applications. Featuring an industry-standard interface, the SIM800A delivers GSM/GPRS 800/1800MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mm x 24mm x 3mm, SIM800A can fit in almost all the space requirements in user applications, especially for slim and compact demand of design.

5) Node MCU

Node MCU is a development board which runs on the ESP8266 with the Espressif Non-OS SDK, and hardware based on the ESP-12 module. The device features 4MB of flash memory, 80MHz of system clock, around 50k of usable RAM and an on chip Wi-Fi Transceiver.

5. Architecture diagram

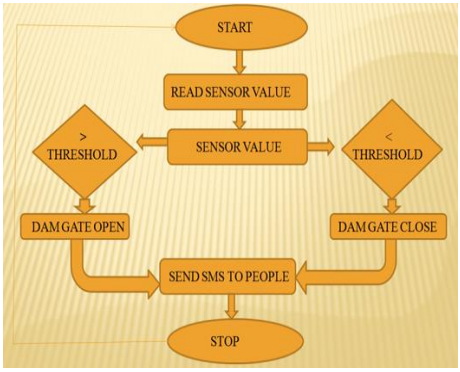


Fig. 1. Flow diagram of dam water monitoring and management system

Figure 1, Shows the flow of the process in monitoring and management of dam.

- The sensor senses the water level and compares with the setup threshold value.
- If the sensor value is greater than threshold value, dam gate is opened and SMS is sent to people nearby.
- If the sensor value is less than the threshold value, dam gate is closed and SMS is sent to people nearby.

6. Component diagram

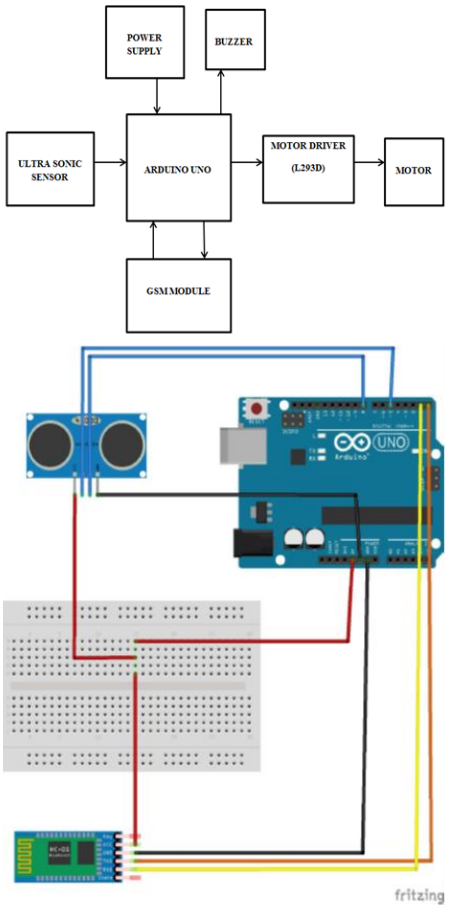


Fig. 2. Setup of water level sensor

Figure 2 shows the connection of Arduino Uno and ultrasonic sensor with the breadboard.

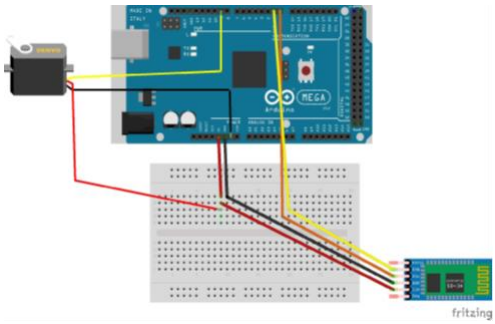


Fig. 3. Setup of the motor controlling gate mechanism

7. Modules

- Component Module
- GSM Module

A. Module description

Component module

1) Determining the Level of Water

In this stage getting the data on the level of water using ultrasonic sensors is done. The ultrasonic sensors are interfaced with a micro controller which transfers the data to a local base station using far field/near field communication.

Components required: Ultrasonic sensors, Arduino.

B. GSM MODULE

1) Short Range Communication

In this stage we deal with transferring the data at shorter distances i.e., nearby areas. The distance might range from few hundred meters to one or two kilometres. The short data transfer modules like Bluetooth or XBee are interfaced with the Arduino and used to transfer the data.

Components required: Bluetooth module / XBee module.

2) Long Range Communication

In this stage we work on transferring the data to long distances of order of several hundred kilometers. These helps us in gathering the data from all the nodes to a central base station which in turn reads the data and send the commands based on it. The technologies required to achieve this are yet to be finalized. Some types of communication which can be used for such purposes are LoRa, NB-IoT.

- LoRaWAN is a Low Power Wide Area Network: (LPWAN) intended to provide long range connectivity for wireless battery operated Things in a regional, national or global network. LoRaWAN meets the key requirements of Internet of Things such as secure bidirectional communication, mobility and localization services.
- Narrow Band IoT (NB-IoT) is a category of Low Power Wide Area Network (LPWAN) technology standard developed to enable a connection using cellular LTE bands between wide range of devices and services. NB-IoT is a narrowband radio technology designed specifically for the Internet of Things (IoT) applications. NB-IoT focuses primarily on indoor coverage, low cost, long battery life, and enabling a large number of connected devices.

8. Result

The prototype of the proposed idea has been implemented using Ultrasonic sensor, GSM, Arduino micro controller and servo motor. The first stage of the implementation was to determine the level of water using ultrasonic sensor. The ultrasonic sensor was mounted on top of a water container to determine the distance between the top of the container and the surface of the water. If the distance goes below a certain point it indicates that the water level in the container has reached a threshold value that is setup and the GSM module sends message to inform the concerned authorities as well as the residents near the dam warning them that the shutters will open soon. After that the shutters are opened by servo motor. When the water level goes below the threshold value that is setup the shutters are closed.

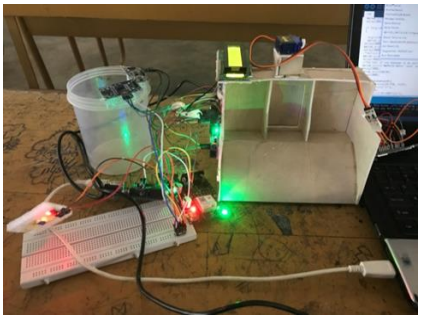


Fig. 4. Dam gate in closed state

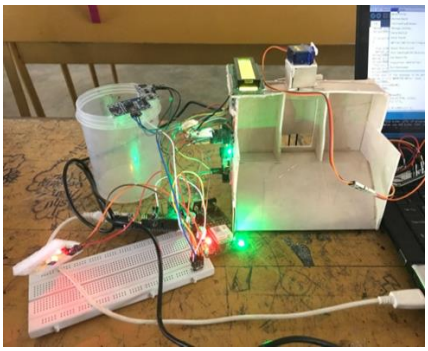


Fig. 5. Dam gate in partially open state

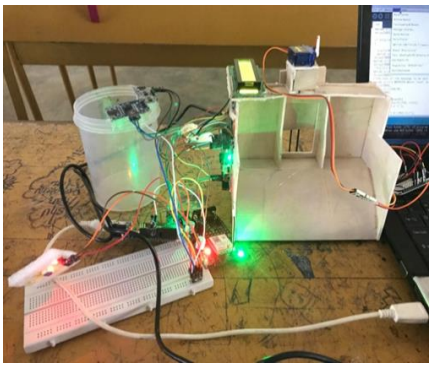


Fig. 6. Dam gate in fully open state

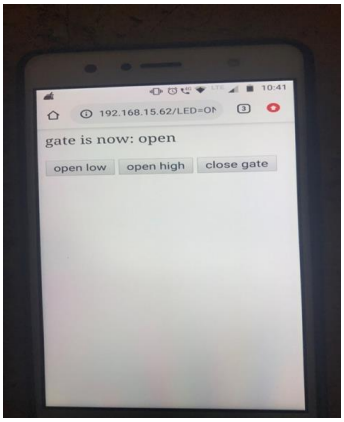


Fig. 7. Dam gate control on mobile- dam in open state

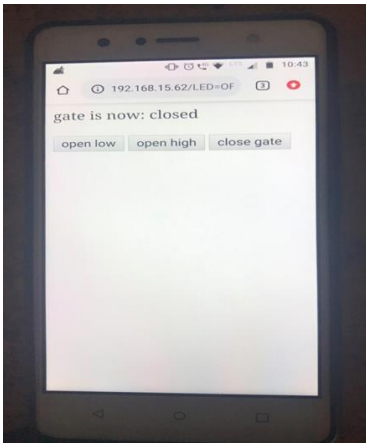


Fig. 8. Dam gate control on mobile-dam in closed state

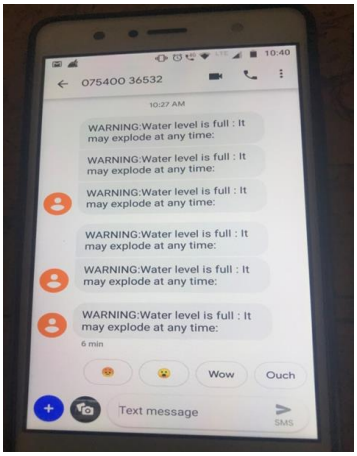


Fig. 9. Alert message on mobile when dam gate is opened fully

9. Conclusion

This paper presents an overview on water level monitoring and management of dams using IoT.

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