Dam Management Systems: Integrated Approaches for Structural Safety Monitoring, Water Resource Optimization, and Disaster Risk Reduction in Hydropower Infrastructure

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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 flood that struck in Kerala. 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: Water level management; Real-time information; Arduino; GSM; ultrasonic sensor.

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 of the hydro power plants. Generally, the dams are monitored through traditional surveillance techniques and the water management except the monitoring of level of water in some of the dams which is automatized. Management of water resources through dams becomes complex as the number of users depending on dams is huge and these users may have conflicting interests. This situation gets much complex with the fact that the available resources are limited with high possibilities of droughts and floods. This affects the densely populated areas. Dam monitoring is a tedious and long term process which has to be improved step by step.

A new system for dam water monitoring and management should be established which can provide water level in real time and can allow us to come to quick conclusions regarding the safety operations of the dams.

This system can be used to automatize the control of dams without human interference. This monitoring system is developed for measurement of water levels, and it is composed of ultrasonic sensor, micro-controller, GSM module and motor. The ultrasonic sensor measures the distance from the sensor to the surface of the liquid . This system proposes the development of water level monitoring system by integrating the GSM module to alert the people living near the banks through Short Message Service (SMS) when the water has reached the critical level. By doing so, people can migrate to safer places. The current dam control technology is manual wherein the handler operates the gate on command. This gives room for irregular water sharing between two properties, human error which can result in floods or unnecessary wastage of water. Our proposed system removes these possibilities incorporating automated dam control system.

2. MATERIALS AND METHODS

Basic block diagram for the proposed system is shown below.

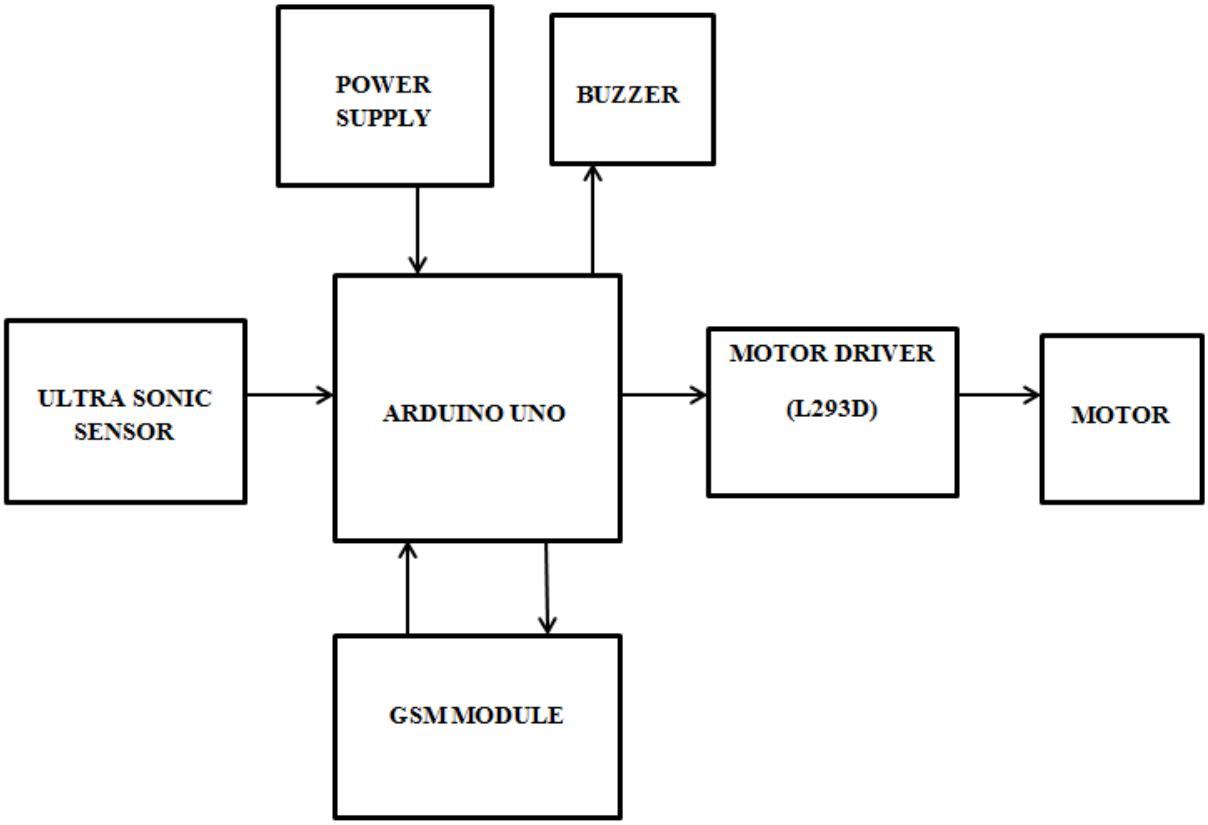

Fig 1 : Block diagram of the system

The above setup consists of Arduino Uno , ultrasonic sensor , GSM , a motor, motor driver. The ultrasonic sensor can be used to measure the water level . As the water level rises up, the GSM will inform the residents near the dam that the shutter will open soon. As the water level rises beyond a critical level that is predefined, the motor driver 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.

3. COMPONENT DESCRIPTION

3.1 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

3.2 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.

3.3 GSM module

This is an ultra-compact and reliable wireless module. The SIM900A 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 SIM900A delivers GSM/GPRS 900/1800MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mmx24mmx3mm, SIM900A can fit in almost all the space requirements in user applications, especially for slim and compact demand of design.

3.4 L293D motor driver

The L293D is quadruple high-current half-H drivers. It is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo- Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled, and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled, and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

3.5 DC motor

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings.

4. FLOW CHART

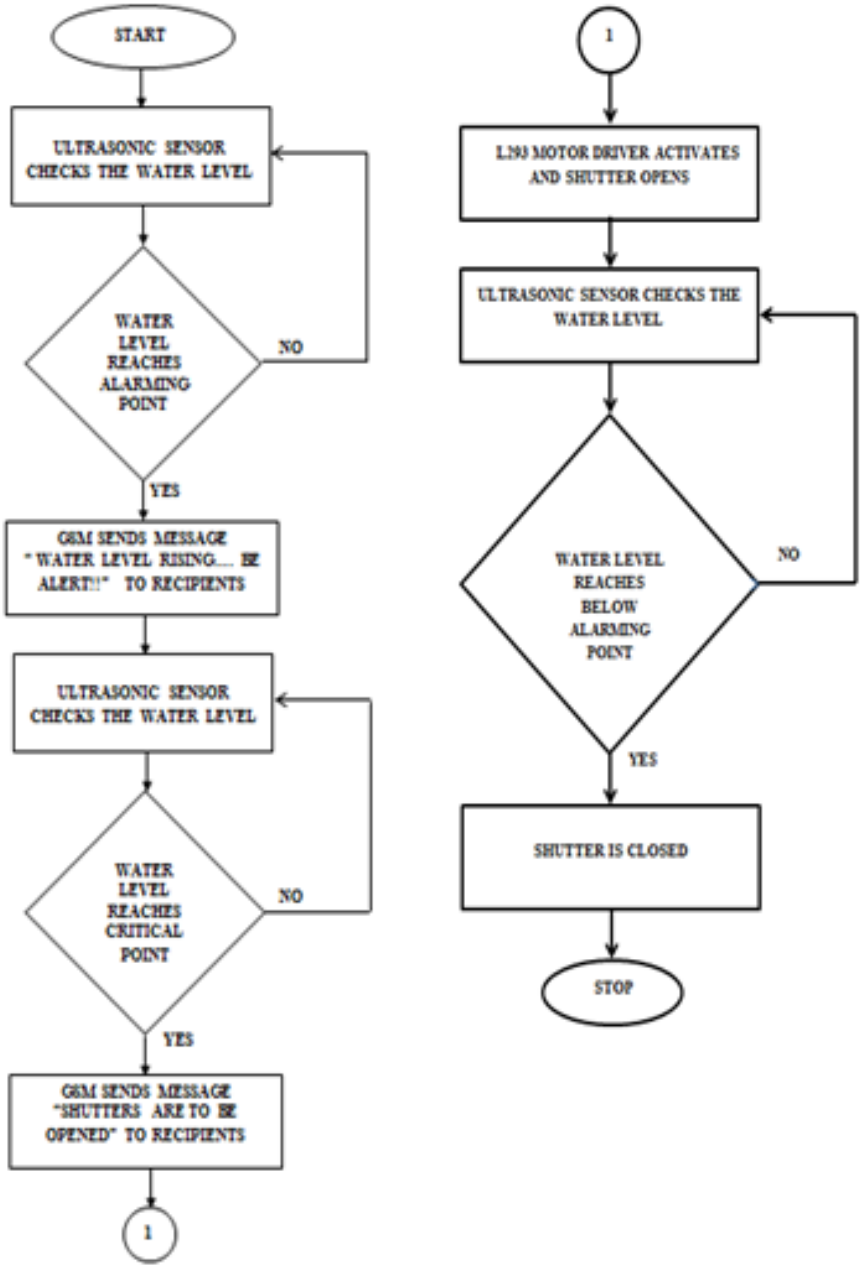

Fig 2: Flowchart of the proposed system

5. RESULTS AND DISCUSSION

A prototype of the proposed idea has been implemented using Ultrasonic sensor, GSM, Arduino micro controller and DC 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 an alarming point and the GSM module sends message to inform the concerned authorities as well as the residents near the dam that the water level is rising. When the water level reaches the predefined critical level, it sends another message to the same recipients, warning them that the shutters would be opened soon . After that the shutters were opened by DC motor that's driven by a motor driver. When the water level goes below the alarming point the shutters were closed.

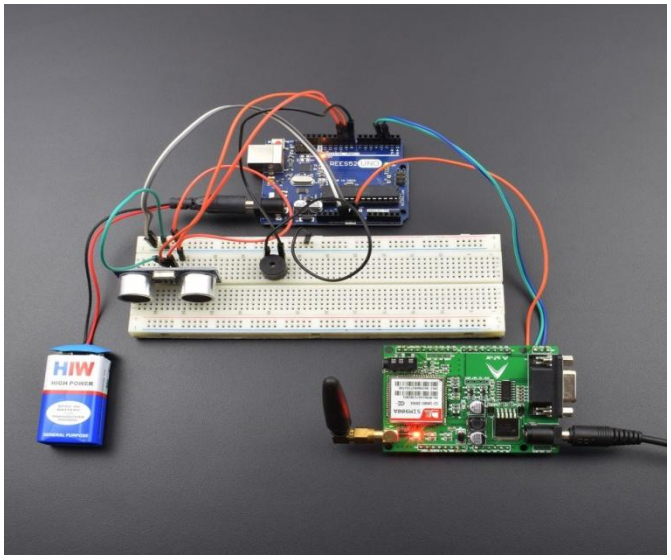

Fig 3: Circuit implementation of the proposed system

6. CONCLUSION

Recently we met with one of the most dreadful disasters of this era in Kerala. If there were any proper management system, the result would not be as happened.. Mechanisms that frequently inform the mob could be useful in many ways. So we expect that the proposed system be implemented.

7. ACKNOWLEDGEMENT

It gives us great pleasure in acknowledging the support and help of our principal Dr. Jaya V L and Dr.C. Gopakumar, our Head Of Department, and other faculties of the department of Electronics and Communication, who helped us directly or indirectly with the works of our project and gave us a chance to portray our skills and dedication through this project.

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