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SMART SYSTEM FOR CONTROLLING AND MONITORING WATER AND TURBIDITY LEVELS IN DAM RESERVOIR USING MICRO-CONTROLLER TECHNOLOGY

N.Savitha*, Saravanan.P, Nisha.R, Muthukumaran.N

Assistant professor, Department of ECE, A.R. Engineering, College, Villupuram.
*Corresponding author
vasanthisavi@gmail.com

ABSTRACT

A micro-controller-based technology has been developed for monitoring and controlling the water quality and quantity in dam reservoirs by using various sensors. This system is able to automatically detect and measure the changes in water and turbidity levels of incoming water for hydropower production. In this project, an Arduino UNO micro-controller and GSM Technology control the operations of the system through sending messages and regulating automatic water valves according to the instant status of the dam water. The developed prototype has four units: sensing unit, processing unit, displaying unit, and alerting unit. In the sensing unit, the ultrasonic sensor continuously monitors the change in water levels and the turbidity sensor takes turbidity measurements of incoming water. In the processing unit, the detected data are collected and fed to the microcontroller for further processing. This technology is expected to reduce the time and cost incurred during the hydropower plant operations by using a small amount of manpower and will facilitate fast information collection.

Keywords: Automation, Arduino Uno, Micro-controller,Sensors,Serialmonitor.

1. INTRODUCTION

Dam is a man-made structure designed to hold backwater for generating electricity, water supply, flood management or river flow diversion [1]. Dam and water reservoir are both built to regulate the flowing water and to store this latter for various purposes such as flood reduction, hydroelectric production, recreation, fisheries and irrigation. The most common problems encountered by the water reservoir and dams are mainly based on failure to fulfill the intended purpose which is to store water. Apart from water evaporation and water seepage, sedimentation and flooding have been reported to be serious problems for water reservoirs and dams. In hydropower production, the quantity and quality of water are monitored and controlled time to time but the use of manual and mechanical technologies result in the creation of hard-working conditions and it becomes more obvious during the rainy seasons where changes in both water quantity and quality are very important. The purpose of this research is to design a smart system for controlling and monitoring dam water reservoirs while alleviating both sedimentation and improper water allocation problems by using an Automated Microcontroller Technology.

2. LITERATURE REVIEW

Information of water quantity and quality is important in life-cycle of any dam reservoir in hydroelectric production. This smart system detects and takes the quick measurements of water and turbidity levels. It controls, monitors, and warns about any critical change in water level and turbidity of incoming water. This technological system reduces the time and cost incurred during the hydropower plant operations by using small amount of manpower, and facilitates fast information collection and process.

Previous Studies

Studies have been previously conducted at both global and regional scales and working systems have been developed to monitor and control water level and or water quality in dam reservoirs. An automated flood gate control system has been developed [2] where water level was monitored but water turbidity was not taken into consideration. Embedded water gate control systems using respectively C and Visual Basic, and Linear Predictive Coding(LPCs)were developed to control the water level where at the

highest water level the gate is allowed to open automatically but they do not provide the time at which the gate would close if the water level is at normal condition and they didn't consider water quality[3] [4]. It is clear that water level and water quality under turbidity in our case are crucial parameters to be considered while monitoring and controlling dam water reservoirs. Currently, smart systems for controlling and monitoring water quality consist of many sensors that measure various parameters such as temperature and humidity, pH levels, the turbidity in the water, and water level in the storage tank [5] but no combination of these parameters has been used for reducing sediments deposition in dam water reservoir. There is a lack of using smart technology in design and operations of dam water reservoirs while alleviating both sedimentation and improper water allocation problems. And the time of information dissemination and processing is very long which consequently leads to time delays. The purpose of this research is to design a Smart System for Control and Monitoring water levels and turbidity levels in the dam reservoir of a Pico Hydropower Plant by using Microcontroller Technology. A study of a system which is Water Level Monitoring and Dam Gate Control over Internet of Things (IoT), was developed [6]. The main objective of this IoT based methodology system was to control (open and close of gate) by detecting water level in the dam. In this system, water level values were detected at different level changes. Depending on the set water level values, the dam gate might close or open, the buzzer alarmed and using the Blynk application, the people in charge were receiving through phone SMS, Email and Twitter at the same moment [6].

In 2016, T.T.Yuvarani and R.Archana developed a system that uses GSM technology for monitoring, controlling and warning of dam water level, where they used microcontroller to compare the level in the dam using the water level sensor's threshold value. The Global System for Mobile Communication (GSM) module is utilized to relay dam level status to the control room [7]. In the project research work of [8], a system for remote monitoring of a dam was developed. In India, people developed the system of dam automation using IoT, where they used python to program Raspberry pi.The gates are under automation that uses a direct current (DC) motor to control them. In this system, water level sensors are also used to collect data in order to control the gates and they use turbidity sensors to measure the turbidity of water. It also displays the status of the dam and checks the cracks of walls, so the main purposes of the system were automatic dam gate control and corrosion detection [9].

In Indonesia, researchers developed an embedded system based for power plant monitoring and controlling. This system had the importance of monitoring the environmental conditions by using various sensors, PIC microcontroller was used to read data from the different sensors, GSM was used to send the status of the boiler to the user whether for instance the temperature inside the boiler increases to the threshold value. All values were displayed on the Liquid Crystal Display (LCD) display. In this system, they considered many parameters like water, temperature, gas, and pressure levels. The main purpose of this system was to monitor and control these parameters for power plants in order to prevent the power plant wastage which affects the persons who surround the power plant [10]. In the research of dam automation and application using IoT in India, the main aim was to measure three levels of water in dam where the sensor was used to sensor the water level and when it reaches the full level reservoir the dam gate opens automatically. A relay module was used to control the opening and closing of the gate by detecting water level in the dam. The only one parameter considered was a water level [11]. An embedded system with microcontroller based can control dam system and this has been done by developing a system for detecting the level of water and the inflow water change that provide the moment of gates to be controlled in real-time by using stepper motor [12].

1. MATERIALSANDMETHODS

In this project, the agile development methodology is used for a continuous iteration of development and testing of the viable prototype. An improvement is done for each complete stage of the system if it is found to be necessary. In our proposed system, both water level and turbidity level are monitored and when they reach to maximum levels, there is an automatic action to open or close the valve on the dam and the message is sent to the person in-charge by using GSM Module at the same time the buzzer alarms. The purpose of this project is to help the users to have the ability of remotely controlling and monitoring their dams without human interaction with the dam units. This system provides an easy way to check the information of valve function; in closing and opening. The user can control the dam from far or around and the buzzer provides an alarm when the water level goes high up. From the proposed system, the ultrasonic sensor and turbidity sensor detect water level and turbidity level respectively in the dam and then the sensed data is displayed through LCD.

Block Diagram and System Architecture

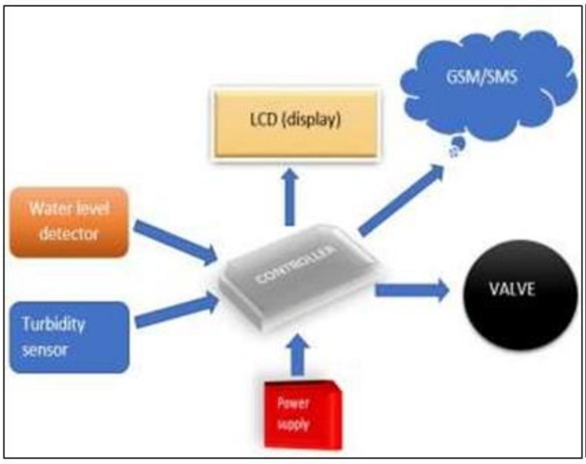

Figure1. a. Block Diagram

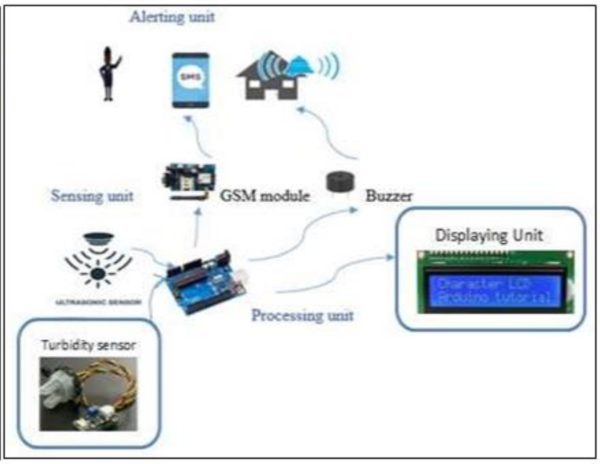

Figure1.b. System Architecture

The proposed system has four units including sensing unit, processing unit, displaying unit and alerting unit. In the sensing unit, the ultrasonic sensor continuously monitors the change in water levels and the turbidity sensor takes turbidity measurements of incoming water (Figure 1 (b)). In the processing unit, the detected data are collected and fed to the microcontroller for further processing. The processed data is viewed on a display unit which is LCD, and the alerting unit consists of the alarm to be generated and an SMS notification to be sent (Figure 1 (a)).

Flowchart

In the flowchart Figure 2, there is a pictorial diagram representation of an algorithm used to represent information processes for both system activity and connectivity. The activities and the connection order are shown by boxes of different kind and rows respectively. The flowchart diagram on figure below shows a by-step system operation from the start to the end.

The system was turned on and continued to run many iterations for all system components in operation and starting the initialization of set parameters. In this project study, the ultrasonic sensor and turbidity sensor were used to detect respectively water level and turbidity level in the dam water reservoir. These sensors continuously monitored the changes in water level and turbidity level and the data obtained from the sensors were sent to the micro-controller for processing and analysing. Afterward, each analysed data was compared to the required optimum. If water and turbidity levels exceed their respective thresholds, the abnormal conditions were detected, and a buzzer connected to the microcontroller was used to output an alarm for warning and notifying through Short Message Service (SMS) using the GSM module the responsible personnel to act accordingly.

The system circuit diagram, represented in Figure 3, visually demonstrates the electrical connections of the system components on the Arduino Nano board (microcontroller board). The Arduino Nano

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features a single-board microcontroller that gathers input data from various sensors and devices, processing it into useful outputs. With 22 input and output pins, including 14 digital pins and 8 analogue pins, the Arduino Nano accommodates diverse connections. For instance, the turbidity sensor data pin is linked to analogue pin A0, while the ultrasonic sensor's trig and echo pins are connected to digital pins 5 and 6, respectively. Pins for the LCD (RS, EN, D4, D5, D6, and D7) are connected to digital pins 3, 4, 9, 10, 11, and 12. The GSM module's transmitter and receiver pins are connected to pins 7 and 8 of the Arduino. Additionally, a wire from the valve is connected to pin 2, and a wire from the buzzer is connected to pin 13 of the Arduino. All components are powered by a 5V energy supply.

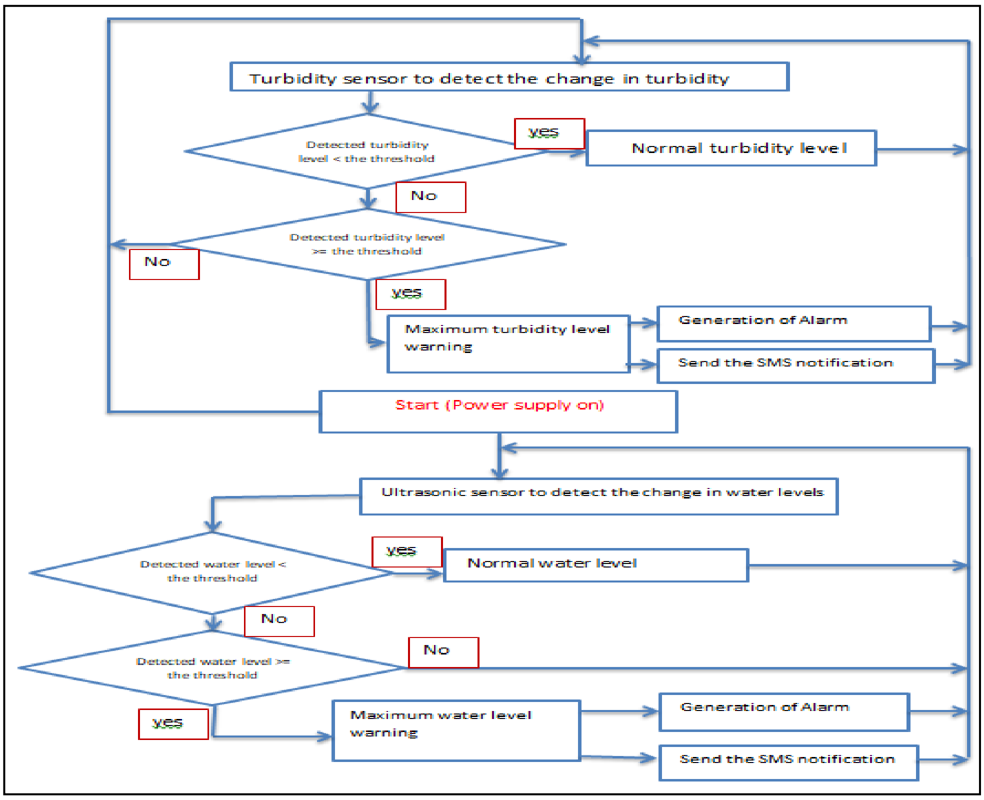

Figure 2 illustrates the flowchart depicting the development process of the system.

Throughout the system integration process, these units were interconnected, demonstrating their interaction and ensuring effective system functionality in alignment with the specified requirements.

Programming Languages and Software Used:

The system was developed using the C programming language within the Arduino IDE (Integrated Development Environment). C programming is widely used for its high-level functionality and general-purpose nature, contributing to efficient software development. Arduino IDE, an open-source software, is primarily based on C++ and C programming languages. It enables users to write and upload code to Arduino boards. The IDE supports various libraries based on the required sensors or

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components, with output displayed on the serial monitor window. The ATMEGA 238 microcontroller, housed within the Arduino board, was programmed using the C programming language.

Additionally, the Easy EAD software was utilized. Easy EAD is an online circuit drawing application known for its simplicity and ease of use. It offers a wide range of complex software libraries and links, making it suitable for designing printed circuit board (PCB) schematics and simulating electronic circuit diagrams, thus proving beneficial for this project.

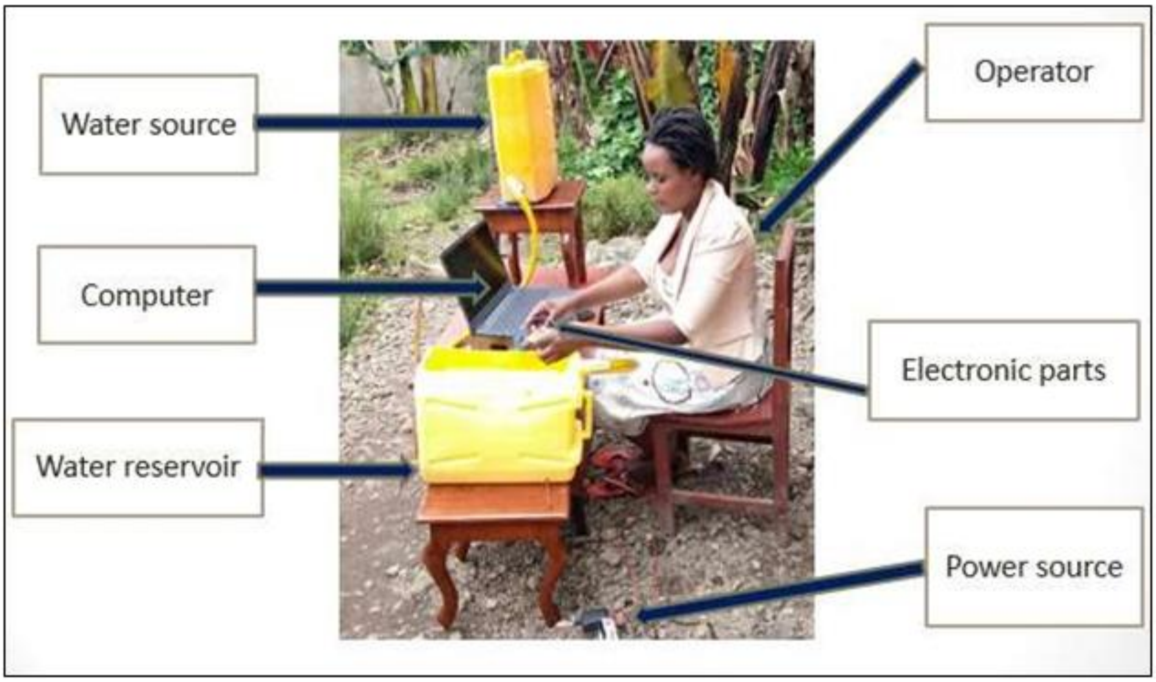

Figure4: Prototype development

Results and Discussion

Prototype Development

The prototype development process is illustrated in Figure 4.

Results

During the development and laboratory testing of our prototype, various hardware and software components were employed to measure water levels and turbidity. The setup consisted of two containers: one serving as a water source and the other as a dam water reservoir. Water flowed from the source to the dam reservoir through pipes equipped with valves. An ultrasonic sensor monitored the water level in the reservoir. When the distance between the sensor and the water surface reached 310 mm, indicating maximum capacity, the valve was shut off to prevent overflow. Simultaneously, an SMS notification was sent to the responsible person, and a buzzer sounded an alarm. Conversely, when the water level returned to normal, the valve reopened. If the water level decreased to 330 mm, indicating minimum capacity, the valve reopened to allow water flow from the source to the reservoir.

A turbidity sensor measured the turbidity of water in Nephelometric Turbidity Units (NTU). Safe drinking water typically has a turbidity level below 4 NTU. The sensor detected variations in turbidity levels, with a threshold set at 50 NTU. If the turbidity exceeded this value, indicating poor water quality, the buzzer sounded an alarm, and an SMS notification was sent. Both water level and turbidity measurements were displayed in real-time on an LCD screen and the serial monitor.

Table 1: Comparison of Water Level Measurements

No.	Water Level	Measurement of Water Level	Status in Dam Reservoir
1	Maximum	$\leq$ 310 mm	Bad condition, dam is full
2	Normal	330 mm $\leq$ x $\leq$ 310 mm	Normal condition, valve is switched on
3	Minimum	$\geq$ 330 mm	Bad condition, valve is on

Table 2: Comparison of Turbidity Level Measurements

No.	Turbidity Level Measurements in Water Dam	Status Description in Water Dam
1	$\leq$ 4 NTU	Good condition, safe for drinking
2	$\geq$ 50 NTU	Bad condition, potential sediment formation
3	< 50 NTU	Good condition, turbidity increasing but safe

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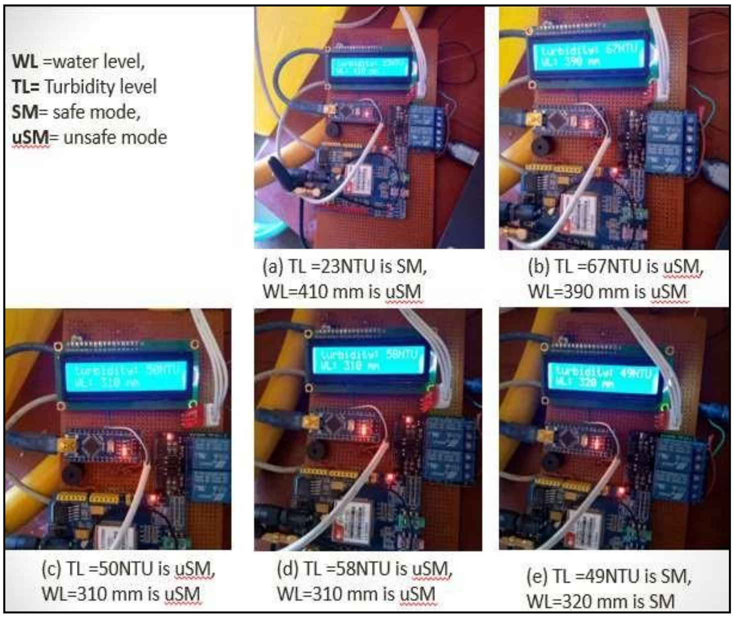

Figure5: Results from lab system testing