River Guard:Smart Bathing Alertand Safety System for Tourists

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ABSTRACT

This project presents a smart river-side monitoring and control system designed to integrate real-time performance tracking, environmental monitoring, and safety management into a single connected platform. The system continuously measures rotational motion generated by flowing water and calculates its speed for live display and remote monitoring. It also evaluates changing water levels to help assess river conditions and support timely decision-making. All collected data is transmitted to an online interface, enabling continuous supervision from any location.
In addition to monitoring functions, the system incorporates safety and automation features to enhance protection and operational control. It detects human presence near restricted areas and instantly sends alert notifications to authorized personnel to prevent potential accidents. A controllable gate mechanism is included to regulate water flow, which can be operated manually or remotely. By combining monitoring, alert systems, automation, and IoT connectivity, the project provides a reliable and intelligent solution for river-side management and safety enhancement.

I.INTRODUCTION

Water is one of the most essential natural resources for sustaining life, supporting agriculture, generating energy, and maintaining ecological balance. Rivers play a significant role in supplying freshwater for domestic consumption, irrigation, and industrial activities. However, effective monitoring and management of river systems remain a major challenge due to increasing population, rapid urbanization, and climate changes that affect water availability and river conditions. Traditional river monitoring methods rely mainly on manual inspection and periodic measurements, which are often inefficient and unable to provide continuous real-time information about water conditions and system performance [1], [4].

With the advancement of modern technologies, the Internet of Things (IoT) has emerged as a powerful solution for environmental monitoring and resource management. IoT-based systems enable sensors and embedded devices to collect data continuously and transmit it to remote monitoring platforms through wireless communication. These systems provide real-time supervision, automated alerts, and improved decisionmaking capabilities, which are essential for efficient water resource management and safety monitoring [9]—[11].

Monitoring the performance of water-driven mechanical systems is also important in river-based energy generation and water management applications. The rotational speed produced by flowing water can indicate the operational efficiency of such systems. At the same time, monitoring river water levels is crucial for detecting abnormal conditions such as sudden water rise, which may lead to flooding or infrastructure damage. Integrating these monitoring features with IoT technology enables authorities to observe system performance remotely and respond quickly to potential hazards [5], [8].

This paper presents a Real-Time River Performance and Water Level Monitoring System that integrates environmental monitoring, safety detection, and automated control into a single intelligent platform. The proposed system continuously measures the rotational motion generated by flowing water and calculates its speed for performance analysis. It also monitors variations in water level and transmits real-time data to an online platform for remote monitoring. In addition, the system enhances safety by detecting human presence near restricted areas and sending instant alert notifications to authorized personnel. A controllable gate mechanism is also incorporated to regulate water flow through manual or automated operation. By combining IoT connectivity, real-time monitoring, safety alerts, and automated control mechanisms, the proposed system aims to improve operational efficiency, environmental awareness, and public safety in river-side infrastructures.

II. LITERATURE SURVEY

Current water monitoring systems use various technologies to observe environmental conditions, water levels, and resource usage. Many researchers have developed systems using Internet of Things (IoT), wireless sensor networks, and embedded platforms to improve monitoring efficiency. Kumar et al. proposed an IoT-based water level monitoring system that uses sensors to measure water levels and transmit the collected data to a remote server for real-time monitoring and management of water resources [1]. Patel et al. developed a smart water monitoring system using IoT devices that continuously collect environmental data and provide remote access through web-based platforms for efficient water management [2]. Moorthy et al. designed a real-time water quality and level monitoring system that integrates multiple sensors with IoT connectivity to monitor environmental parameters and transmit the data for remote supervision and analysis [3]. Karthik et al. introduced a river monitoring system based on wireless sensor networks that uses distributed sensors to continuously observe river conditions and send data to a central monitoring station for further processing [4].

Kumar et al. proposed an IoT-based flood monitoring and alert system that detects rising water levels and sends early warning notifications to authorities, helping to reduce flood-related damage and improve disaster management [5]. Nandhini et al. developed a water level monitoring and flood detection system using Arduino and IoT technology, where sensors continuously measure water levels and generate alerts when the level exceeds a predefined threshold [6].

Hasan et al. developed a smart flood monitoring system using IoT technology that integrates sensor networks with cloud-based platforms to provide real-time monitoring and early warning alerts [13]. Silva et al. proposed a smart water monitoring system that uses IoT sensors to collect environmental data and transmit it to remote servers for real-time observation and analysis of water resources [14].

Although several monitoring systems have been developed for water level detection, water quality monitoring, and flood detection, many existing systems focus on only a single parameter. They do not integrate mechanical performance monitoring, human safety detection, and automated flow control in a single platform. The proposed system addresses these limitations by combining real-time river performance monitoring, water level detection, safety alert mechanisms, and automated gate control using IoT technology.

III. IMPLEMENT ATION

A. System Architecture

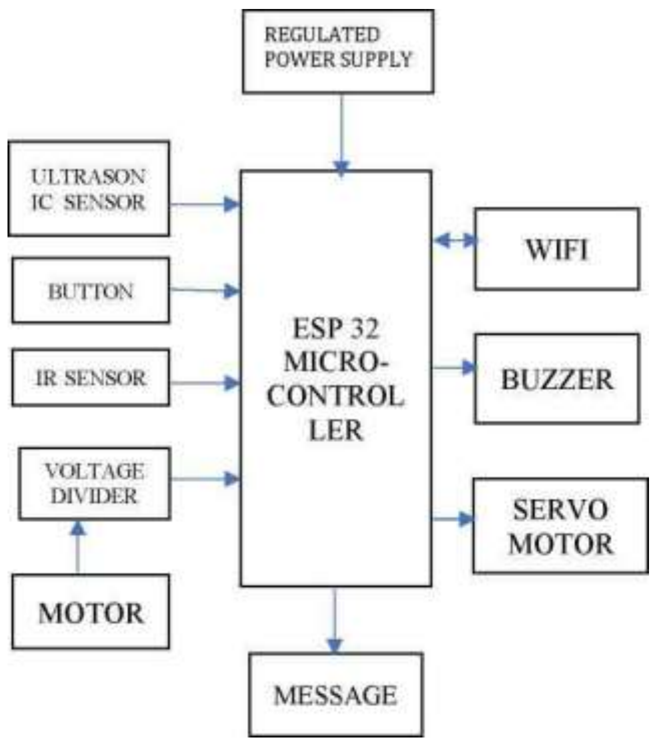
The proposed Real-Time River Performance and Water Level Monitoring System is designed to monitor river conditions, mechanical performance, and safety parameters using an IoT-based architecture. The system integrates multiple sensing modules, a processing unit, and a communication interface to provide real-time monitoring and automated control.

The ESP32 microcontroller acts as the central processing unit of the system. It receives input signals from different sensors such as the rotational speed detection module, ultrasonic water level sensor, and human presence detection sensor. The collected data is processed by the controller to calculate the rotational speed of the water-driven mechanism and determine the river water level.

The processed information is displayed locally and also transmitted to a web-based monitoring platform through a Wi-Fi communication module. This allows authorities to remotely monitor the system status and environmental conditions. In addition, the system includes a gate control mechanism operated through a servo motor which can regulate water flow. The gate can be controlled either automatically by the system or manually through a control switch.

For safety purposes, the system uses an IR-based human detection sensor to identify human presence near the riverbank or restricted zones. When a person is detected, the system generates an alert notification that is transmitted to authorized personnel via the communication module.

The integration of sensing, processing, communication, and control modules enables continuous monitoring, automated response, and improved safety management in river-side environments.



B. Hardware Components

1) ESP32 Microcontroller: The ESP32 microcontroller functions as the main processing unit of the system. It collects sensor data, performs calculations related to rotational speed and water level, controls the gate mechanism, and manages wireless communication. The ESP32 is widely used in IoT applications due to its built-in Wi-Fi capability, high processing speed, and low power consumption.

2) Rotational Speed Detection Module:
The rotational speed detection module is used to monitor the rotation of the water-driven mechanism. It generates pulse signals corresponding to each rotation of the shaft. These pulses are counted by the microcontroller to calculate the rotational speed in real time. This information helps evaluate the performance of water-driven systems such as turbines or mechanical devices operating near the river.

3) Ultrasonic Water Level Sensor: The ultrasonic sensor is used to measure the distance between the monitoring device and the water surface. By calculating this distance, the system can determine the current water level in the river. Continuous monitoring of water level helps detect sudden increases in water depth and provides early warning of potential flooding conditions.

4) Human Presence Detection Sensor: An IR sensor is used to detect the presence of a person near the monitored river area. The sensor emits infrared radiation and measures the reflected signal to determine whether an object or human is present. When a person enters the restricted zone, the system immediately triggers an alert notification to ensure safety.

5) Gate Control Mechanism: The system includes a servo motor-based gate control mechanism used to regulate water flow. The gate can open or close depending on system commands. This mechanism enables automated water management and helps maintain safe water levels.

6) Manual Control Switch: A manual control switch is provided to allow users to operate the gate mechanism directly. This feature acts as an override system that ensures reliable operation during maintenance or emergency situations.

7) Communication Module :The communication module uses the built-in Wi-Fi capability of the ESP32 to transmit system data to a remote web server. The data is stored in a database and can be accessed through an online monitoring interface. The module also sends alert notifications to authorized mobile devices when abnormal conditions or safety events are detected.

C. Software Implementation

The system software is developed using Embedded C programming language and implemented through the Arduino IDE development environment. The software continuously reads sensor inputs, processes the collected data, and controls system outputs.
The measured rotational speed and water level values are transmitted to a web server through a Wi- Fi connection. The server uses PHP for backend processing, HTML and CSS for the user interface, and a MySQL or flat-file database to store system data. The web interface allows remote monitoring and analysis of realtime river conditions.

D. Algorithm

The working algorithm of the proposed system is described as follows:
Initialize the microcontroller and connected sensors.
Start monitoring the rotational speed detection module.
Calculate the rotational speed based on received pulse signals.

Measure the river water level using the ultrasonic sensor.
Check for human presence using the IR sensor. If human presence is detected, send an alert notification to authorized personnel.
Update system data to the web server through Wi-Fi communication.
Monitor gate control input and operate the servo motor accordingly.
Repeat the monitoring cycle continuously for real- time operation.

IV. RESULTS AND DISCUSSION

The proposed **Real-Time River Performance and Water Level Monitoring System** was developed and tested to evaluate its ability to monitor rotational performance, measure water level variations, detect human presence, and transmit real-time data to a remote monitoring platform. The system integrates multiple sensors with an ESP32 microcontroller and IoT communication to ensure continuous observation and control.

A. Rotational Speed Monitoring

The rotational speed detection module was tested by connecting it to a water-driven rotating mechanism. As water flow increased, the sensor generated pulse signals corresponding to the rotational movement. These pulses were processed by the ESP32 microcontroller to calculate the rotational speed in real time.
The calculated speed values were displayed through the monitoring interface and updated continuously. The results showed that the system was capable of accurately detecting changes in rotational speed and providing reliable performance monitoring for water-driven mechanisms.

B. Water Level Measurement

The ultrasonic sensor was used to measure the distance between the monitoring device and the water surface. The sensor transmitted ultrasonic waves and measured the time taken for the reflected signal to return, which was then used to calculate the water level.
During testing, the system successfully detected variations in water depth and updated the values in real time. This feature allows the system to monitor river conditions continuously and can assist in identifying abnormal increases in water level that may indicate potential flooding risks.

C. Human Presence Detection and Safety Alerts

The IR sensor was tested to detect the presence of a person near the monitored riverbank area. When a person entered the detection zone, the sensor triggered a signal to the ESP32 microcontroller.
The system immediately generated an alert notification and transmitted it through the communication module to the connected monitoring platform. The results confirmed that the system was able to detect human presence quickly and send timely alerts, improving safety near restricted river areas.

D. Gate Control Operation

The gate control mechanism was implemented using a servo motor. The gate could be operated through both automated commands and manual input using a control switch. During testing, the servo motor responded correctly to control signals from the microcontroller and adjusted the gate position accordingly.
This functionality enables efficient regulation of water flow and provides flexibility through manual override when necessary.

E. Remote Monitoring Through IoT Platform

The ESP32 microcontroller transmitted sensor data to a remote web server using Wi-Fi connectivity. The transmitted data included rotational speed, water level measurements, and system alerts.

The web-based monitoring interface successfully displayed real-time system information, allowing remote supervision from any location. This feature demonstrates the capability of the system to provide continuous monitoring without requiring physical presence at the river site.

F. Overall System Performance

The testing results indicate that the proposed system performs efficiently in integrating multiple monitoring and control functions. The combination of rotational speed measurement, water level monitoring, safety alerts, and remote connectivity creates a comprehensive solution for river-side management.

The system provides real-time information, improves safety through automated alerts, and reduces the need for manual supervision. Therefore, the proposed solution demonstrates significant potential for applications in river monitoring, water resource management, and environmental safety systems.

V. CONCLUSION

This paper presented the design and implementation of a **Real-Time River Performance and Water Level Monitoring System** that integrates environmental monitoring, safety management, and automated control into a single intelligent platform. The proposed system uses an ESP32 microcontroller along with multiple sensors to monitor the rotational performance of a water-driven mechanism, measure river water levels, and detect human presence near restricted areas.

The system successfully provides real-time monitoring by collecting sensor data and transmitting it to a web-based platform through IoT connectivity. This allows authorities or users to remotely observe system performance and environmental conditions without requiring constant physical supervision. The integration of an ultrasonic sensor enables continuous monitoring of water depth, which can help detect abnormal water level variations and support early warning mechanisms.

In addition, the inclusion of an IR-based human detection module enhances safety by identifying human presence near hazardous riverbank locations and immediately sending alert notifications to authorized personnel. The servo motor-based gate control mechanism further improves system functionality by allowing both automated and manual regulation of water flow.

Overall, the proposed system demonstrates an efficient, low- cost, and reliable solution for river-side monitoring and management. By combining real-time data acquisition, IoT communication, automated alerts, and flow control mechanisms, the system improves operational efficiency, environmental awareness, and public safety. The developed system can be effectively applied in river monitoring, water resource management, irrigation systems, and smart water infrastructure projects

VI. FUTURE WORK

The proposed Real-Time River Performance and Water Level Monitoring System provides an effective solution for monitoring river conditions, mechanical performance, and safety parameters. However, the system can be further improved by incorporating additional advanced features to enhance its functionality and reliability.

In future work, the system can be integrated with a dedicated mobile application to allow users and authorities to monitor river conditions directly through smartphones. This would provide instant access to real-time data, alerts, and system status from any location. In addition, cloud-based data storage can be implemented to maintain long-term historical records of water levels and rotational performance for further analysis.

Advanced data analytics and machine learning techniques can also be applied to the collected data in order to predict water level changes and identify abnormal patterns in river behavior. This predictive capability can help in early flood detection and improve disaster management strategies.

Another potential improvement is the integration of additional environmental sensors, such as water quality sensors, temperature sensors, and rainfall sensors. These sensors would allow the system to provide more comprehensive environmental monitoring and support better water resource management.

Furthermore, the system can be expanded to support multiple monitoring stations along a river network, enabling centralized monitoring and control from a single platform. This would allow authorities to manage larger river systems more effectively and respond quickly to changing environmental conditions.

By incorporating these enhancements, the proposed system can evolve into a more advanced smart river monitoring and management platform capable of supporting sustainable water resource management and improved public safety.

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