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Automated Open Borewell Closing System to Prevent Accident Against Any Child or Living Being Fall into Open Borewell

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Abstract

Open borewells pose a grave danger to humans and animals, particularly children, due to their typically uncovered and unattended state. This paper presents an automated borewell closing system using IoT-based sensors and actuators. There have been many unfortunate events of animals and children getting trapped in neglected or orphaned borewells in India. These incidents lead to prolonged and highly intricate rescue operations, which usually have a low success rate. In an effort to mitigate this persistent public safety threat, we present an IoT-based Borewell Safety System capable of real time observation and automatic sealing of exposed borewells. This system is shielded by the ESP32 microcontroller, incorporating multiple sensors and modules into a singular unit like an ultrasonic sensor for proximity sensing, LDR sensor for light, ambient, servo motor for closing the borewell, and GSM module for sending alerts. The moment motion or proximity is sensed near the borewell, the ESP32 passes an instruction to the servo motor to protect the lid and at the same time sends an SMS to the emergency contacts stored in the system. This system is made for continuous operation with features of energy efficiency and expansion. A multi-use apparatus which can be implemented in both rural and urban settings the system has enhanced affordability while also effectively diminishing the frequency of life threatening accidents.

Keywords: *Borewell Safety, IoT, Ultrasonic Sensor, ESP32, GSM Module, Servo Motor, LDR Sensor, Accident Prevention.*

1. Introduction

Across India, the reliance on groundwater has made borewells an important feature of infrastructure, particularly in rural and semi-urban areas with limited municipal water supply. Most borewells are drilled for domestic and agricultural purposes as they allow access to underground water. Unfortunately, there is a serious safety concern due to the large number of borewells that are drilled every year. Many borewells are left unsealed or inadequately covered once they dry up or become non-functional. This negligence poses risk to public safety, especially to children and animals who can easily fall prey to these open vertical shafts. As some borewells may be narrow, deep, and dark, rescuing individuals stranded inside become extremely difficult. Numerous rescue missions in India have ended The borewells that cannot be seen from afar are often highlighted from afar, and those in the vicinity show no signal toward it, forming the illusion that one is not straggling. They appear deceptively simple, and there is no wave of instant-aid whenever there's extreme emergency. Loss of Visible and Quantitative Scope fades away along with a myriad of numb skeletons in the rest of the world. Dislocation of these covers can cause dangling and lack of movement from afar and result in extremely hazardous and delicate situations. Dislocation can also render them incapable of shielding the helpless. Risking safety becomes a thing of the past however, and extend marking do not do any positive to changing border control. Losing Control over monitors shifts markings from gains to protecting the globe. Some erstwhile control signals mark shifting borders and do not wait for automatic sequences which gives bureaucracy the false mark of freedom. Using

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wooden and metal covers can be a chosen primary modality, granting document, but unfortunately their use is limited and indicates a failure to thoroughly analyze alternatives devoid of world imagination.

2. Related Work

Several researchers and developers have attempted to address the borewell hazard through robotics and alert systems. Manual borewell covers are still widely used but often displaced or ignored. Some projects use infrared or ultrasonic sensors to detect movement within borewells, while others focus on post-accident rescue techniques using cameras and robotic arms. However, these methods largely lack the capability to act autonomously and prevent accidents before they occur. Few systems integrate both detection and prevention. Our system advances the state-of-the-art by integrating motion detection, automated closure, environmental monitoring, and GSM alerting—all in one modular, reusable platform.

3. Methodolgy

The proposed system is designed to continuously monitor the area around an open borewell and automatically take preventive action in case of any detected threat. It employs an embedded system integrated with IoT[1] components to perform real-time sensing, decision-making, and alerting functions. The entire methodology can be broken down into several key modules[2]

3.1.System Architecture

The architecture consists of the following main components: ESP32 Microcontroller – Acts as the brain of the system, processing input from sensors and controlling output actions[3] like motor activation and SMS alerts. It supports integrated Wi-Fi and Bluetooth, offering future expansion capabilities. Ultrasonic Sensor (HC-SR04) – Mounted at the mouth of the borewell, it detects any object or person approaching within a specified range (typically 10–20 cm). Servo Motor (SG90) – Connected to a mechanical lid that closes the borewell when activated by the ESP32 based on sensor data.

LDR (Light Dependent Resistor) Sensor – Senses ambient light to ensure that LED indicators are automatically turned on in low-light conditions for better visibility. GSM Module (SIM800L/SIM900A) – Sends SMS alerts to pre-registered emergency contacts when movement is detected near or inside[4] the borewell. LEDs and Buzzer – Provide local audio-visual feedback to indicate borewell status or system activation.

3.2.Working Principle

- System Initialization: Upon powering up, the ESP32 initializes all modules and enters continuous monitoring mode[5].
- Motion Detection: The ultrasonic sensor constantly measures the distance to detect any object or movement near the borewell. If an object is detected within the danger zone (e.g., less than 10 cm from the sensor), the system identifies it as a potential fall risk[6].
- Automated Response: On detection, the ESP32 activates the servo motor, which rotates to close the borewell lid. This mechanism is designed to work smoothly and immediately to minimize the window of danger.
- Real-Time Alert: Simultaneously, the GSM module is triggered to send an SMS notification to pre-configured numbers (such as local authorities or borewell owners), alerting them of the event.
- Lighting and Status Indication: The LDR sensor checks the ambient lighting. If the environment is too dark (below a predefined threshold), the LED light is turned on automatically. A buzzer also sounds to warn nearby individuals.
- Looping Operation: The system continues to monitor and repeat this cycle, ensuring 24/7 surveillance and safety.

3.3.Software Implementation

The ESP32 is programmed using the Arduino IDE with C/C++ and relevant ESP32 libraries. Proteus

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or Tinkercad simulations may be used to validate the circuit design before physical implementation. GSM AT Commands are used to communicate between the ESP32 and GSM module for sending messages.

3.4.Safety and Testing

The model was tested in simulated environments to verify: Accuracy of object detection using the ultrasonic sensor. Timely actuation of the servo motor. SMS delivery through the GSM module. Lighting response under varying environmental conditions.

4. Results

The proposed system was implemented as a working prototype and tested under controlled environmental conditions to evaluate its effectiveness, accuracy, and reliability. The results were analyzed across multiple dimensions including motion detection accuracy, response time, SMS alert functionality, servo motor performance, and lighting automation using the LDR sensor.

4.1.Object Detection Accuracy

The ultrasonic sensor was tested at varying distances to evaluate how accurately it detects movement or objects near the borewell opening.

Observation:

The ultrasonic sensor was able to consistently detect objects within the 10–15 cm range. False positives were minimal due to threshold tuning in the code.

4.2.Servo Motor Actuation

The servo motor (SG90) was tested for its response time and consistency in closing the borewell lid.

Average Response Time: 0.6 seconds Rotation Angle: 0° to 90° for full closure

Cycle Time:

Less than 1 second from detection to full closure

Observation:

The motor performed smoothly under load and successfully closed the lid every time motion was detected, without jamming or misalignment.

4.3. GSM Alert System

The GSM module was tested using different network conditions.

Observation:

The GSM module successfully sent SMS alerts in all test cases. Delivery speed varied slightly depending on network strength, but there were no message failures.

4.4.LDR Sensor and LED Automation

Lighting was tested in different ambient light conditions.

Observation:

The LDR sensor accurately triggered the LED light in dark and low-light conditions, ensuring visibility around the borewell at all times.

4.5.Overall System Evaluation

The proposed system was tested in various conditions and performed effectively in all core functions. The ultrasonic sensor accurately detected motion near the borewell, and the servo motor responded within one second to close the lid, minimizing risk. The GSM module reliably sent SMS alerts to emergency contacts, with slight variations in delivery speed based on network strength. The LDR sensor successfully activated the LED light during low-light conditions, ensuring round-the-clock visibility. The system operated autonomously with low power consumption and required no manual intervention. Overall, it proved to be a reliable, fast, and cost-effective solution for real-time borewell safety in both rural and urban environments.

Conclusion And Future Work

The Automated Open Borewell Closing System presented in this project offers a proactive and reliable solution to a critical safety issue. By integrating embedded systems with IoT technologies, the system is capable of detecting movement near an open borewell, automatically closing the lid using a servo motor, and sending real-time SMS alerts through a GSM module. The inclusion of an LDR sensor also ensures functionality in low-light conditions. The system performed well in tests, demonstrating quick response time, high accuracy, and minimal power consumption. This solution significantly reduces

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the risk of accidental falls into open borewells and can be effectively deployed in both rural and urban areas. While the current system fulfills its primary objective, there is scope for further enhancement. Future versions of the project could integrate AI-based image recognition to differentiate between humans, animals, and non-living objects for more accurate responses. Solar-powered operation can be implemented to support remote rural installations and reduce dependency on external power sources. The system can also be extended to a centralized IoT dashboard to monitor multiple borewell sites in real time. With these advancements, the system can become even more intelligent, scalable, and adaptable for wider deployment.

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