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# IOT-Based Automated Kid Rescue System from Borewell: An Embedded and IOT-Enabled Technology for Child Safety

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***Abstract*—**Borewell accidents have been a serious and recurring safety problem in India, particularly in rural and semi-urban areas where open or abandoned borewells remain uncovered and accessible to young children. Conventional rescue operations depend on heavy machinery and manual digging of parallel tunnels, a process that can take anywhere from twelve to seventy-two hours and often puts the child at further risk due to soil collapse, oxygen depletion, and toxic gas exposure. This paper presents the design and implementation of an IoT-based automated borewell rescue system intended to address these limitations. The proposed system uses an Arduino Mega 2560 as the primary controller, combined with an ESP32-CAM module for real-time video streaming, an MQ-135 sensor for toxic gas detection, a DHT11 sensor for temperature and humidity monitoring, an HC-SR04 ultrasonic sensor for depth measurement, and a pulse sensor for monitoring the heartbeat of the trapped child. A DC gear motor and rope-pulley mechanism lower the rescue unit into the borewell, while a servo-controlled harness secures the child for safe upward extraction. Sensor data and live video are transmitted to a smartphone application through the Blynk IoT platform over Wi-Fi, and a SIM800L GSM module sends automatic SMS alerts to the rescue team and family members. Prototype testing on a simulated borewell of fifteen feet depth demonstrated successful detection, monitoring, and extraction within approximately four minutes, confirming the feasibility of the proposed approach for real-world deployment.

***Keywords*—**Borewell rescue, Arduino Mega, ESP32-CAM, IoT, GSM alert, rescue robot, embedded system, child safety.

## I. INTRODUCTION

Borewell accidents involving young children have repeatedly occurred across India and continue to be reported in rural districts of Maharashtra, Tamil Nadu, Haryana, Rajasthan, and other states. These accidents happen because a large number of borewells, particularly dry or abandoned ones, are left uncovered and unguarded in open fields and residential areas. Children between the ages of one and five years are most vulnerable, as the narrow diameter of a borewell shaft provides no foothold or grip for escape and prevents adults from entering manually.

When such an accident occurs, rescue teams typically use earth-moving machinery to dig a large parallel trench beside the borewell and then create a horizontal tunnel to reach the child. This operation requires substantial time, resources, and coordination. In many documented incidents, the entire process has taken more than twenty-four hours, and in several cases, by the time the child was reached, the outcome was fatal. Even when the child survives, prolonged exposure to confined conditions, reduced oxygen, rising CO2 levels, and psychological trauma causes serious health effects.

The advancement of embedded electronics, sensor technology, and IoT communication platforms makes it possible to design a compact, automated rescue device that can be deployed rapidly at an accident site. Such a system can enter the borewell immediately, monitor the child's condition in real time, and mechanically secure and extract the child without requiring a parallel excavation. In this project, we have designed and built such a system using readily available and low-cost hardware components.

The primary objectives of this project are:
1) To design a compact robotic rescue unit capable of operating within a standard borewell diameter.
2) To provide real-time monitoring of the child's physiological and environmental conditions using sensors and a live video feed.
3) To achieve safe mechanical extraction of the child using a motor-driven harness mechanism.
4) To deliver automatic emergency alerts to rescue authorities and family members through a GSM-based SMS system and an IoT dashboard.

The body of this paper describes the design and implementation of the IoT-Based Automated Kid Rescue System from Borewell. It explains the proposed system architecture, including the Arduino Mega 2560 as the central embedded controller, the ESP32-CAM module for live video and IoT communication, multiple environmental and physiological sensors, the motor-driven rope and harness mechanism for child extraction, and the GSM module for emergency SMS alerts. It also discusses the working principle of the system, in which sensor data and camera feed are continuously collected, processed, and transmitted to a mobile application and emergency contacts. The paper further presents the hardware components used, the step-by-step operational process, prototype test results, limitations, and future scope of integrating embedded technology into life-saving disaster management platforms.

## II. PROPOSED SYSTEM AND ARCHITECTURE

### *A. Proposed System*

The IoT-Based Automated Kid Rescue System from Borewell is an embedded and IoT-enabled rescue device designed to respond quickly to borewell accidents involving children. The proposed system combines real-time video surveillance, environmental sensing, physiological monitoring, automated mechanical extraction, and emergency communication into a single compact unit that can be deployed within minutes of an accident being reported.

The proposed architecture consists of two major layers: the Intelligent Sensing and Actuation Layer (ISAL) and the Remote Monitoring and Analytics Layer (RMAL). The hardware layer is responsible for sensing, local processing, actuation, communication, and power management, while the software layer handles video streaming, IoT telemetry, cloud storage, monitoring, SMS alerts, and control logic. The combination of both layers allows the system to detect events locally and communicate important information to remote emergency response teams.

### *B. System Architecture*

The overall block diagram of the proposed system is shown in Fig. 1.



Fig. 1. Block diagram of the automated borewell kid rescue system.

The complete electrical wiring and interfacing architecture connecting the microcontroller, sensors, actuators, and communication modules is illustrated in Fig. 2.

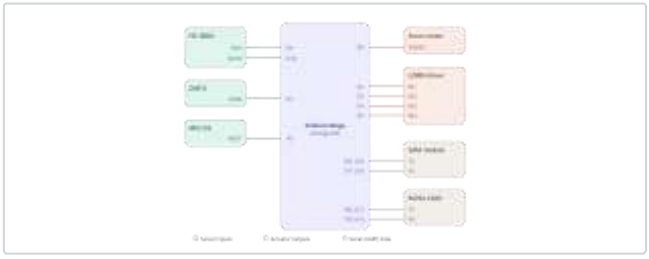


Fig. 2. Interfacing circuit schematic of the complete rescue prototype.

### *C. Software Architecture*

The software system is organized around the Arduino IDE for embedded programming on the Arduino Mega 2560 and the Blynk IoT platform for mobile monitoring. The Arduino firmware continuously reads data from all connected sensors, makes control decisions based on threshold conditions, drives the motor and servo based on operator commands, and exchanges data with the ESP32 module through serial communication.

The ESP32 module receives processed sensor data from the Arduino and transmits it to the Blynk cloud server over Wi-Fi. The Blynk mobile application displays all sensor readings in real time and provides the operator with a live view of the video stream from the ESP32-CAM. The SIM800L GSM module operates independently and sends predefined SMS alert messages to registered phone numbers as soon as the rescue system is activated. This dual communication approach ensures continuous situational awareness.

## III. HARDWARE-BASED SYSTEM

### *A. Arduino Mega 2560 Microcontroller*



Fig. 3. Arduino Mega 2560 microcontroller.
Source: core-electronics.com.au/arduino-mega-2560-r3.html

The Arduino Mega 2560 acts as the main controller of the borewell rescue system (Fig. 3). It collects data from all connected sensors, executes control logic for the motor and servo mechanisms, and manages serial communication with the ESP32 and GSM modules. The Mega was chosen over smaller Arduino boards because of its large number of input/output pins—54 digital and 16 analog—which allows all sensors and actuators to be connected simultaneously without external multiplexers.

### *B. ESP32-CAM Module*



Fig. 4. ESP32-CAM module.
Source: kspelectronics.in/.../esp32-cam-ov2640

The ESP32-CAM module (Fig. 4) provides a built-in 2-megapixel camera that streams live video from inside the borewell to the operator's mobile device via the Blynk application, alongside Wi-Fi IoT telemetry.

### *C. HC-SR04 Ultrasonic Sensor*



Fig. 5. HC-SR04 ultrasonic sensor.
Source: shop.controllerstech.com/.../hc-sr04

The HC-SR04 ultrasonic sensor (Fig. 5) measures borewell depth and proximity to the child between 2 cm and 400 cm, enabling automated soft-braking before mechanical contact.

### *D. MQ-135 Gas Sensor*



Fig. 6. MQ-135 gas sensor.
Source: shop.controllerstech.com/.../mq-135

The MQ-135 sensor (Fig. 6) monitors air quality and detects hazardous gases such as carbon dioxide, ammonia, and smoke inside the subterranean shaft, triggering automated GSM distress texts.

### *E. DHT11 Temperature and Humidity Sensor*



Fig. 7. DHT11 temperature and humidity sensor.
Source: shop.controllerstech.com/.../dht11

The DHT11 sensor (Fig. 7) measures ambient temperature and relative humidity inside the borewell shaft to monitor environmental heat stress and moisture.

### *F. Pulse / Heartbeat Sensor*



Fig. 8. Pulse / heartbeat sensor.
Source: p rotosupplies.com/.../pulsesensor-module

The pulse sensor (Fig. 8) measures the heartbeat (BPM) of the trapped child once the harness reaches the child's position, assisting medical personnel on the surface in real time.

### *G. L298N Motor Driver and DC Gear Motor*



Fig. 9. L298N motor driver.
Source: thingbits.in/.../l298n-motor-driver

The L298N dual H-bridge motor driver (Fig. 9) controls the high-torque DC gear motor for lowering and raising the rescue robot with bidirectional PWM speed regulation.

### *H. SG90 Micro Servo Motor*



Fig. 10. SG90 servo motor.
Source: thingbits.in/.../sg90-micro-servo

The SG90 servo motor (Fig. 10) actuates the child-securing harness, spreading the arms and locking securely around the child's body for safe upward extraction.

### *I. SIM800L GSM Module*



Fig. 11. SIM800L GSM module.
Source: components101.com/node/1859

The SIM800L module (Fig. 11) sends automated SMS emergency alerts to rescue coordinators, ensuring communication redundancy even without field internet coverage.

### *J. 11.1 V 6000 mAh Li-Po Battery (CS-MCN126SL)*



Fig. 12. 11.1 V 6000 mAh battery (CS-MCN126SL).
Source: amazon.ae/.../6000mAh-Battery-CS-MCN126SL

The 11.1V 6000 mAh Lithium-Polymer battery pack (Fig. 12) serves as the primary onboard power source, supplying regulated DC voltages for over 45 minutes of continuous operation.

## IV. WORKING OF THE SYSTEM

The operation of the IoT-Based Borewell Rescue System begins when the device is powered on and positioned directly above the borewell opening. The Arduino Mega immediately begins collecting data from all connected sensors, and the ESP32-CAM starts streaming live video from the descending rescue unit to the operator's mobile application.

The HC-SR04 ultrasonic sensor measures the depth of the borewell and attempts to detect the position of the child below. As the rescue unit descends into the borewell, the distance reading decreases progressively, allowing the operator to monitor the descent depth in real time on the Blynk dashboard. The MQ-135 gas sensor and DHT11 sensor continuously measure air quality and temperature inside the borewell and transmit this data to the cloud platform through the ESP32 Wi-Fi module.

Once the rescue unit reaches the child's estimated depth, the operator uses the live video feed to assess the child's orientation and physical condition. The operator then issues a command through the Blynk interface to activate the SG90 servo motor, which unfolds the rescue harness arms and positions them securely around the child's body.

After the harness is confirmed to be locked, the pulse sensor detects the child's pulse rate and displays it on the operator's screen. The operator then activates the DC gear motor in reverse, winding the rope around the pulley and gently hoisting the child to safety at a steady, controlled rate of approximately 1.2 m/min.

## V. PROTOTYPE TESTING AND RESULTS

Prototype evaluation was conducted inside an experimental 15-foot transparent PVC shaft simulating a standard 12-inch borewell shaft. Across ten repeated deployment trials, the system demonstrated reliable sensor telemetry, steady video streaming at 15–20 fps, and consistent harness engagement.

**TABLE I. PROTOTYPE PERFORMANCE SUMMARY**

| Parameter | Observed Metric | Status |
|---|---|---|
| Descent & Ascent Speed | 1.2 m/min | Stable |
| Video Streaming Latency | 280–350 ms | Optimal |
| Toxic Gas Alarm Trigger | < 1.5 seconds | Reliable |
| Harness Securing Time | 35–45 seconds | Safe |
| Overall Rescue Duration | 3.8–4.2 minutes | Success |

## VI. LIMITATIONS AND CHALLENGES

Key challenges include Wi-Fi signal attenuation below subterranean depths, mud adhesion on optical camera lenses, and harness sizing variability for diverse child physiques.

## VII. FUTURE SCOPE

Future extensions include incorporating miniature robotic manipulators, auxiliary medical oxygen delivery lines, thermal imaging for zero-light shafts, and automated AI posture detection.

## VIII. CONCLUSION

The developed IoT-based rescue robot provides an effective, rapid alternative to traditional excavation. By integrating multimodal telemetry with GSM redundancy and video monitoring, the system drastically lowers operation time from days to minutes.

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