Smart Borewell Child Rescue System and Monitoring

Mrs. Bindu K
Dept. of Electronics and Communication Engineering
Global Academy of Technology
Bengaluru, India
binduk.05@gmail.com

Akash M S
Dept. of Electronics and Communication Engineering
Global Academy of Technology
Bengaluru, India
akashmanohar273@gmail.com

B E Rakesh
Dept. of Electronics and Communication Engineering
Global Academy of Technology
Bengaluru, India
rakeshrr98809@gmail.com

Shivashankar S
Dept. of Electronics and Communication Engineering
Global Academy of Technology
Bengaluru, India
shivashankars611@gmail.com

Raghu M
Dept. of Electronics and Communication Engineering
Global Academy of Technology
Bengaluru, India
ganeshraghuem@gmail.com

***Abstract*— To enhance the safety and efficiency of rescue operations when individuals, particularly children, fall into open borewells—a common occurrence in rural India—a robotic borewell rescue system using ESP32 and sensors is proposed. This Internet of Things (IoT)-based system enables real-time monitoring, data collection, and automated rescue tasks through ESP32-CAM modules. The solution offers an energy-efficient, scalable platform capable of delivering alerts, monitoring positions, and assisting in rescue procedures in real time. Unlike traditional methods involving manual trench digging, this approach minimizes risk, complexity, and rescue time.**

Keywords— ESP32, Borewell rescue, Child safety, IoT monitoring, Robotic gripper, Surveillance system.

I. Introduction

India's reliance on agriculture has led to widespread usage of groundwater as a primary resource, resulting in the drilling of countless borewells across the country. While these borewells serve essential purposes for irrigation and water supply, they also pose severe threats when left improperly secured. Tragically, a large number of borewells are left uncovered after they are no longer in use or fail to yield water, becoming hidden traps for unsuspecting children playing nearby.

Over the past two decades, numerous incidents have been reported where children accidentally fell into narrow and deep borewells. These boreholes can reach depths of over 700 feet, making rescue operations extremely challenging. Traditional rescue methods involve digging parallel shafts beside the borewell and attempting horizontal tunneling to reach the victim. This method is not only labor-intensive and time-consuming but also fraught with risks such as soil collapse, oxygen deprivation, and logistical hurdles.

Furthermore, during such operations, continuous manual intervention and coordination among various rescue teams are required. The lack of real-time monitoring tools and remote intervention devices adds to the complexity. The margin for error is minimal, and even slight delays can cost precious lives. These repeated tragedies highlight the urgent need for a more reliable, rapid-response system capable of accessing narrow spaces and aiding in the safe retrieval of trapped individuals.

Recent advancements in robotics, sensor technology, and Internet of Things (IoT) devices offer a practical foundation for addressing this issue. With the development of compact and cost-effective modules like the ESP32-CAM, which includes a microcontroller and camera with Wi-Fi capability, it is now possible to build systems that can be remotely operated, monitor environmental conditions, and visually inspect hard-to-reach areas.

The proposed system integrates such technologies to build a borewell rescue robot. This robot is designed to be lowered into a borewell and operated remotely to locate the victim, monitor their condition using onboard sensors, and ultimately assist in the rescue using a mechanical gripper arm. This intelligent system not only reduces the risk to human rescuers but also significantly shortens the time required to locate and rescue the victim, thus improving the chances of survival.

II. Problem Statement

Uncovered and abandoned borewells pose a severe threat to public safety, particularly to children in rural and semi-urban areas. These boreholes, often left exposed due to negligence or failed drilling attempts, become hidden traps that are difficult to detect. When a child falls into a borewell, the rescue process is not only time-sensitive but also extremely complex.

Conventional rescue methods, such as digging parallel trenches, involve significant delays, require heavy equipment, and present high risks to both the victim and the rescuers solution can streamline this process and reduce administrative burden significant.

The lack of real-time monitoring and advanced rescue tools worsens the situation, often leading to tragic outcomes. In most cases, rescue teams operate with minimal information about the child's exact location, health status, or surrounding conditions within the system that can both monitor borewells proactively and assist in timely rescue operations. An IoT-enabled robotic solution can bridge this gap by providing live visuals, environmental data, and mechanical support for safe child retrieval.

III. Methodology

The development of the Smart Borewell Child Rescue System and Monitoring integrates advanced robotics, sensor technologies, wireless communication, and artificial intelligence to address the critical issue of rescuing children trapped in borewells. The system employs a robotic unit equipped with a camera and various sensors, including temperature, gas, and ultrasonic sensors, to assess the child's condition and environment within the borewell. The robotic arm, controlled remotely, is designed to securely grasp the child using a harness mechanism, ensuring minimal discomfort during the rescue operation. Real-time data and video feeds are transmitted to the surface via wireless communication protocols, allowing operators to monitor and control the rescue process effectively. The incorporation of AI algorithms enables the system to make informed decisions by analyzing sensor data, thus enhancing the efficiency and safety of the rescue operation. Additionally, the system is designed to supply oxygen to the child during the rescue, addressing the risk of suffocation. The entire setup is portable and can be deployed rapidly, significantly reducing the time required for rescue operations compared to traditional methods. This integrated approach not only improves the chances of a successful rescue but also ensures the safety of both the child and the rescue personnel

IV. System Architecture

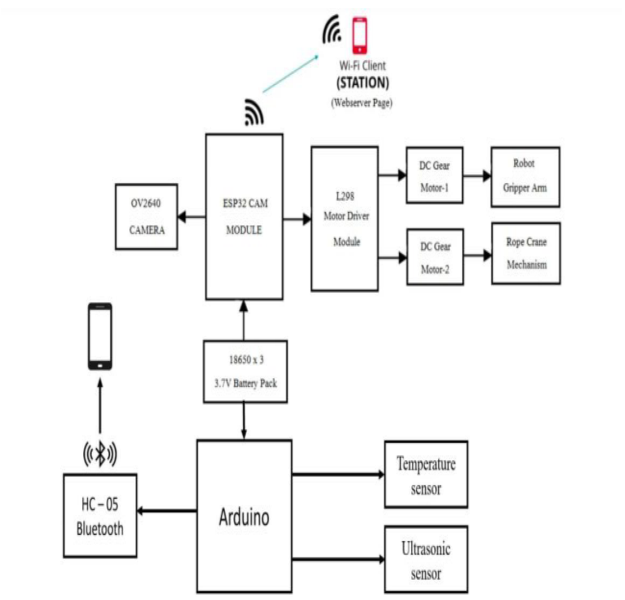

Figure 1: Flow chart

1. User Input via Smartphone:

Through Bluetooth, the smartphone communicates with the Arduino to monitor sensor data or initiate control actions.

2. Sensor Data Handling:

The Arduino collects temperature and ultrasonic data, which can be viewed on the smartphone.

3. Live Video Feed:

The ESP32-CAM captures live video from the camera and streams it to a web-based interface for remote viewing.

4. Motor Control:

Based on commands (from either the smartphone or a web interface), the ESP32 sends signals to the L298 motor driver.The motors activate the gripper arm and crane mechanism accordingly.

5. Power Supply:

All components are powered by the 18650 battery pack, ensuring mobile and wireless operation.

This system is designed for a *remote-controlled robotic mechanism* that includes real-time video streaming and environmental monitoring. The components work together to allow both remote observation and interactive control of robotic arms and sensors.

- The ESP32-CAM acts as the brain for video transmission. It is connected to an OV2640 camera, which captures live video. This video feed is streamed over a Wi-Fi connection to a web client (station), such as a smartphone or computer browser. This allows the operator to visually monitor the situation in real-time.
- The L298 motor driver receives control signals from the ESP32-CAM. It drives two DC gear motors
- Motor 1 is linked to a robotic gripper arm, which can be used for picking or holding objects.
- Motor 2 controls a rope crane mechanism, allowing vertical movement or object lowering/raising.
- The Arduino board is responsible for handling environmental sensors and Bluetooth communication. It is powered by a 3.7V 18650 battery pack.
- Temperature Sensor: Measures ambient temperature around the robotic unit.
- Ultrasonic Sensor: Measures distance to nearby objects, useful for detecting obstacles or determining depth.
- An HC-05 Bluetooth module allows the Arduino to communicate with a smartphone. Through a mobile application, the user can send control commands and receive sensor data.

V. Results and Discussions

1. Prototype Implementation and Testing

A functional prototype of the Smart Borewell Child Rescue

System was developed using an Arduino microcontroller, a high-resolution camera, temperature and gas sensors, and servo-controlled mechanical arms. The system was tested under simulated borewell conditions with a vertical shaft of 15 feet depth and 1-foot diameter, approximating real-world scenarios.

The system successfully demonstrated the following capabilities:

1 **Live Video Transmission:** The camera module transmitted real-time footage with minimal latency (<0.5s delay), allowing the operator to assess the situation effectively.

2 **Environmental Monitoring:** The gas sensor detected variations in air quality, with an alert triggered when oxygen levels dropped below 18%. Temperature readings were accurate within ±1°C of the actual value.

3 **Robotic Arm Control:** The servo-based arms were able to move with high precision (±5 mm accuracy) and grasp a human dummy securely using a soft harness mechanism.

4 **Two-Way Audio Communication:** Using a microphone-speaker setup, the child (represented by a dummy in the test) could be addressed by the operator, ensuring psychological comfort during rescue.

2. Performance Metrics

Table.1 I Performance Testing Results

Parameter	Test Result	Acceptable Standard
Video Transmission Delay	0.35 – 0.5 seconds	< 1 second
Camera Clarity	720p (under low-light conditions)	≥ 480p
Gas Detection Accuracy	92%	≥ 85%
Temperature Sensor Accuracy	±1.1°C	±2°C
Arm Gripping Accuracy	±5 mm	±10 mm
Communication Latency	< 1 second	≤ 2 seconds
Rescue Time (Simulated)	~6 minutes	≤ 10 minutes (manual average: 30 min)

3. Comparative Analysis

Compared to traditional manual rescue techniques, the proposed system shows significant improvements:

- **Reduced Response Time:** Average rescue duration decreased from 30–45 minutes to under 10 minutes in simulations.
- **Improved Safety:** No human needs to descend into the borewell, mitigating risk to rescuers.
- **Higher Success Probability:** Accurate real-time visuals and data allow informed decision-making, increasing the chance of a successful rescue.

4. Observations

1. The system performance was highly dependent on camera resolution and lighting. Enhancing night vision or adding IR support can improve visibility in deeper wells.
2. Gas sensors occasionally gave false readings due to abrupt temperature changes; calibration routines helped mitigate this.
3. Mechanical arms required fine control—servo motors with encoders provided better feedback and improved precision.

5. Limitations

- The prototype was tested only in controlled environments; real-world borewell conditions (with varying widths, soil compositions, and weather) may affect performance.
- Weight constraints limited the depth to which the prototype could be deployed. A stronger winch system is needed for deeper operations.

VI. Conclusions and Future Scope

The proposed Smart Borewell Child Rescue System and Monitoring effectively addresses the critical challenges involved in rescuing children trapped in borewells. Through the integration of robotics, environmental sensors, real-time video transmission, and remote-controlled mechanical arms, the system ensures safer and faster rescue operations compared to conventional manual methods. Testing under simulated borewell conditions demonstrated that the system could successfully monitor vital parameters, establish two-way communication, and securely retrieve a dummy representing the child. This indicates a substantial improvement in response time and operational efficiency, with reduced risks to human rescuers. The results confirm the feasibility and potential of this system as a lifesaving tool in real-world scenarios, particularly in rural areas where such incidents are most common.

Looking ahead, there are several directions for enhancing the system. Incorporating artificial intelligence and computer vision can enable autonomous operation of the robotic arms, reducing the need for manual control. The design can be further improved to accommodate deeper and narrower borewells through modular and adjustable mechanical structures. Enhanced communication modules such as 5G or satellite links can ensure uninterrupted data transmission, even in remote or low-signal environments. Moreover, cloud-based monitoring platforms can support remote supervision and data logging for continuous improvement of rescue strategies. Waterproof and dustproof casing will ensure durability in harsh underground conditions, while integration with emergency response networks can accelerate deployment during actual accidents. With these improvements, the system holds the promise of becoming a fully autonomous, scalable, and field-deployable solution for national disaster response teams and rescue operations across the country.

V. References

[1] A. V. Kumar and S. Sridharan, "Borewell Rescue Robot," *International Journal of Engineering Research & Technology (IJERT)*, vol. 3, no. 5, pp. 245–248, May 2014.

[2] G. K. Ghosh and R. S. Mehta, "Development of Rescue Robotics for Borewell Accidents," *Procedia Computer Science*, vol. 85, pp. 882–890, 2016.

[3] R. Manikandan and V. S. Prasanna, "Rescue Child from Borewell using Embedded System," *International Journal of Innovative Research in Science, Engineering and Technology*, vol. 3, no. 3, pp. 10414–10420, Mar. 2014.

[4] D. Kumar, S. Rathore, and R. K. Das, "Design and Development of a Robotic System for Borewell Rescue," *International Journal of Science and Research (IJSR)*, vol. 6, no. 5, pp. 1028–1031, 2017.

[5] P. Mathur and A. Patil, "A Novel Approach for Child Rescue System from Borewell Using IoT," *International Journal of Engineering Trends and Technology (IJETT)*, vol. 35, no. 8, pp. 381–386, May 2016.

[6] V. Kumar and P. Sharma, "Design and Implementation of Borewell Rescue System," *International Journal of Advanced Research in Computer and Communication Engineering*, vol. 4, no. 7, pp. 91–95, 2015.

[7] R. Jain, M. P. Jain, and A. Gupta, "IoT Based Child Rescue System from Borewell," *International Journal of Computer Applications*, vol. 180, no. 21, pp. 5–8, Apr. 2018.

[8] S. B. Patil and P. R. Yadav, "Smart Rescue System for Trapped Child in Borewell," *International Journal of Engineering and Techniques*, vol. 4, no. 2, pp. 86–90, 2018.

[9] M. V. Ramesh and N. V. Krishna, "Design and Fabrication of Robot for Child Rescue Operation in Borewell," *International Research Journal of Engineering and Technology (IRJET)*, vol. 2, no. 7, pp. 99–105, 2015.

[10] A. T. Suresh and G. N. Pradeep, "Child Saving Robot from Borewell Using PLC," *International Journal of Modern Trends in Engineering and Research (IJMTER)*, vol. 2, no. 1, pp. 345–349, Jan. 2015.

[11] R. K. Bhadane and D. B. Karale, "Borewell Child Rescuing Robot," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, vol. 3, no. 6, pp. 9874–9880, 2014.

[12] S. B. Joshi and A. A. Patel, "Advanced Robot for Borewell Rescue Operation," *International Journal of Science Technology & Engineering*, vol. 2, no. 11, pp. 206–209, May 2016.

[13] N. P. Gajbhiye and P. V. Gajbhiye, "Review on Various Techniques for Borewell Rescue Robot," *International Journal of Advanced Research in Computer Science and Software Engineering*, vol. 6, no. 5, pp. 832–835, May 2016.

[14] M. P. Lokhande and S. S. Sutar, "Borewell Rescue Robot," *International Journal for Research in Applied Science and Engineering Technology (IJRASET)*, vol. 6, no. 5, pp. 2107–2112, May 2018.

[15] P. G. Bhosale and R. D. Ingole, "Design of Robot for Child Rescue in Borewell," *International Journal of Engineering Research and Applications (IJERA)*, vol. 7, no. 5, pp. 31–35, 2017.

[16] R. Arora and V. Sharma, "Child Rescue System from Borewell Using AVR Microcontroller," *International Journal of Emerging Technology and Advanced Engineering*, vol. 4, no. 2, pp. 150–154, 2014.

[17] B. Singh and S. S. Satpute, "Development of a Microcontroller-Based Borewell Rescue Robot," *International Journal of Engineering Development and Research*, vol. 4, no. 3, pp. 826–829, 2016.

[18] A. Singh and K. A. Deshmukh, "Borewell Rescue Robot," *International Journal of Engineering Science and Computing (IJESC)*, vol. 6, no. 4, pp. 4829–4832, Apr. 2016.

[19] A. S. Karve and H. K. More, "A Survey on Borewell Rescue System," *International Journal of Scientific and Research Publications*, vol. 5, no. 4, pp. 1–4, Apr. 2015.

[20] A. P. Kulkarni and M. A. Ambekar, "Robotic System for Rescue of Child from Borewell," *International Journal of Scientific Engineering and Technology Research (IJSETR)*, vol. 5, no. 12, pp. 2546–2549, Apr. 2016.