DESIGN AND DEVELOPMENT OF SMART IOT ENABLED BOREWELL SYSTEM

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College : *K S School OF Engineering and Management, Bengaluru*
Branch : *Department of Mechanical Engineering*
Guide : *Dr. Parashuram A Kutakankaeri*
Student(s) : *Mr. Surya N*
Mr. Chandu K S
Mr. Harish C
Mr. Suhas Patel P.

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Introduction:

In recent years, incidents of children falling into open or abandoned borewells have increased significantly, particularly in rural areas. These borewells are typically narrow and deep, making rescue operations extremely challenging. Traditional rescue methods, such as digging parallel pits, are time-consuming, risky, and often inefficient. Borewell accidents involving children remain a serious concern due to limited space, lack of oxygen, and difficulty in accessing the trapped victim. To address these challenges, this project proposes a Smart IoT-Enabled Borewell Child Rescue System. The system utilizes a robotic mechanism that can be lowered into the borewell to safely rescue the child. It is equipped with a camera for live monitoring, robotic arms for gripping, and wireless control for remote operation. This approach significantly reduces rescue time and enhances safety

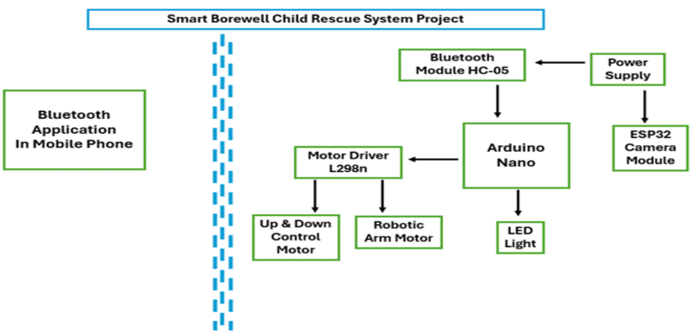


Figure 1: Design and Development of a Smart IoT-Enabled Borewell Child Rescue System

The proposed system is designed to locate the child, enable real-time communication, supply oxygen, and perform a safe rescue operation using robotic arms, thereby improving the efficiency and success rate of rescue missions.

Objectives:

1. To design a robotic system for rescuing children trapped in borewells.
2. To provide real-time video monitoring using ESP32-CAM.
3. To ensure safe gripping and lifting using a robotic arm.
4. To reduce rescue time and improve success rate.

Methodology:

1. **Requirement Analysis and Feasibility Study:**
   Before building anything, it’s vital to understand the problem in detail. Studying real borewell accidents helps define what the rescue robot must be capable of — such as fitting in narrow spaces, providing oxygen, and communicating with the trapped child. This step sets the foundation by listing what the robot must do and identifying technical challenges.
1. **Mechanical Design:**
   Since borewells are narrow and deep, the robot’s physical design must be compact and robust. CAD software is used to create a detailed 3D model that fits borewell dimensions, includes stabilizing arms to hold the robot steady inside the shaft, and features robotic arms to grip the child gently.
2. **Component Selection:**
   Selecting the right hardware components — like microcontrollers, cameras, motors, sensors, and batteries — is crucial. These parts must be reliable, lightweight, and compatible.
5. **Prototype Fabrication:**
   With designs and components ready, the physical prototype is assembled. Lightweight and durable materials like aluminium or plastic are used for structure and arms. Wiring the electronics correctly ensures the robot’s motors, cameras, sensors, and communication modules function as planned.
6. **Software Development:**
   The robot needs smart software to control all hardware components. Programming microcontrollers enables motor control for arms and stabilizers, video streaming, audio communication, and sensor data processing.

7. **System Integration:**

   Hardware and software are combined and tested as a whole. This ensures all parts communicate seamlessly, motors respond to commands, video and audio are clear, and sensors accurately report environmental conditions

8. **Testing and Calibration**

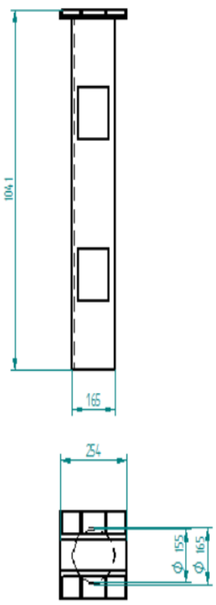
   Testing inside simulated borewells confirms the robot's capability to perform in realistic conditions. Calibration adjusts motor forces to avoid harming the child, stabilizers to hold position, and sensors to provide accurate data. This iterative process helps fine-tune the robot for safe and reliable rescue operations.

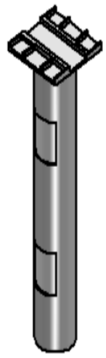
9. **Safety and Contingency Planning:**

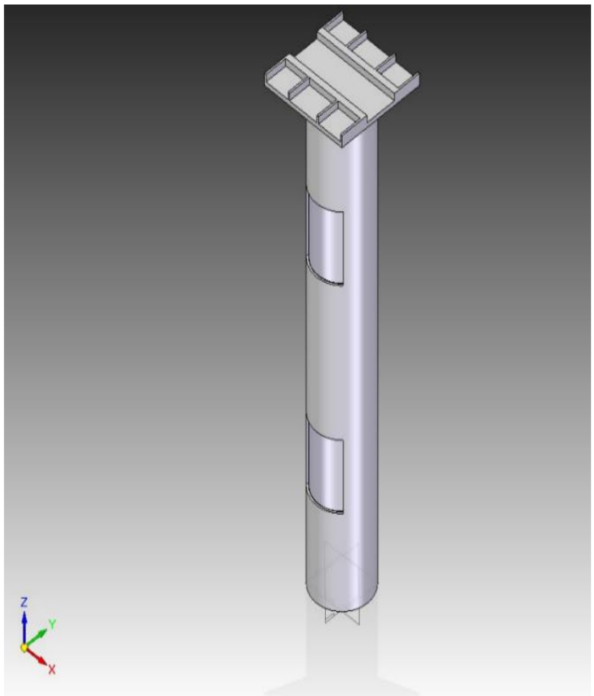
   Safety is paramount. Emergency stop functions and manual overrides ensure rescuers can intervene instantly if something goes wrong. Backup power systems prevent shutdowns during operation, and mechanical fail-safes ensure the robot won't injure the child even if a system fails.

10. **Deployment Strategy:**

    Finally, the project includes planning how to deploy the robot quickly and efficiently during an actual rescue. Training rescue teams, preparing operational checklists, and making sure the robot is transportable are important to ensure the robot can save lives when needed.







Result and Conclusion:

The Smart IoT-Enabled Borewell Child Rescue System was successfully designed and tested to address the critical issue of borewell accidents involving children. Experimental evaluation under controlled conditions demonstrated that the motorized mechanism enables smooth and stable vertical movement within confined spaces. The ESP32-CAM module provided clear real-time video streaming, while the LED lighting system ensured good visibility in dark environments, allowing accurate monitoring and positioning of the robotic unit.

The robotic arm, driven by servo motors, effectively demonstrated safe gripping capability without causing damage. The Bluetooth-based wireless control system enabled responsive and user-friendly operation through a mobile device. Integration of the Arduino Nano, motor driver, and supporting electronic components ensured proper coordination and reliable system performance during repeated trials, indicating consistency and operational stability.

In conclusion, the developed system proves to be an efficient, safe, and practical solution for borewell rescue operations. It significantly reduces reliance on traditional manual methods, which are time-consuming and risky. The project highlights the effective use of robotics and IoT in addressing real-world problems. With further enhancements such as improved gripping mechanisms and extended communication range, the system can be deployed in real-time rescue missions and has strong potential to save lives.

Future Scope:

The future scope of this project includes:

1. AI-based automation can improve efficiency and enable intelligent decision-making in the system.
2. Miniaturization will make the system compact, portable, and easier to deploy in real-time situations.
3. Advanced sensors can enhance accuracy, detection capability, and overall performance.
4. Telemedicine integration and government deployment can support remote assistance and large-scale public safety implementation.
5. Addition of oxygen supply system
6. Real-time GPS tracking and emergency alerts