

A Bluetooth Robot for Borewell Rescue

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Abstract - The development of a Bluetooth-based robot for borewell rescue operations aims to enhance safety and efficiency in rescuing individuals trapped in deep wells. This research investigates the design, development, and deployment of a remotely controlled robot equipped with Bluetooth technology to navigate through narrow borewells. The robot's ability to reach confined and hazardous spaces, where human intervention is limited, is crucial for life-saving operations. Key features include an adjustable arm for grabbing and lifting, cameras for real-time monitoring, and sensors for detecting vital signs or environmental changes. Bluetooth communication allows seamless control from the surface, offering a safe distance between the operator and the rescue operation. This project analyzes various aspects such as mechanical design, mobility in restricted spaces, communication reliability, and power management. The primary aim is to create a reliable, cost-effective, and scalable solution that can be used in rural and urban settings where borewell accidents are prevalent. Research findings indicate that Bluetooth-based control systems, when integrated with appropriate sensors and robust design, can significantly improve rescue times and accuracy, minimizing the risks to both victims and rescuers.

Keywords: Bluetooth, robot, borewell rescue, investigation, research, design, sensors, safety, communication, mobility, life-saving.

INTRODUCTION

The increasing number of borewell accidents, especially in rural and urban areas, has raised significant concerns about safety and rescue operations. Each year, numerous cases are reported where individuals, particularly children, fall into deep borewells, often resulting in severe injuries or fatalities. Traditional rescue methods, which typically involve manual labor and heavy machinery, are time-

consuming, costly, and can sometimes lead to further danger for the trapped individual. To address these challenges, innovative technologies such as robotics and Bluetooth controlled systems have emerged as a promising solution for improving rescue operations. This research focuses on the development of a Bluetooth controlled robot specifically designed for borewell rescue. Bluetooth technology is particularly suitable for this application as it allows for wireless communication over short distances, ensuring a safe distance between the rescuer and the accident site while providing real-time control. The robot is designed to navigate narrow borewells, locate victims, and assist in the rescue process by using integrated cameras, sensors, and mechanical arms. Current research in this field has explored various robotic systems, but few have incorporated Bluetooth control, making this an area of significant potential.

EXISTING SYSTEM

The main objective of this project is to make it possible for a child fall inside bore well to rescue without any injury. This goal is achieved by controlling a robot to take of the child inside the bore well which is controlled by the person from outside. In existing system, a big hole is dug beside the bore well up to the depth where the child is stuck. A small delay in this resources accumulation may reduce the chances of saving child alive. If the area beside the bore hole contains rocks below certain depth, in such cases the chance of saving child alive is very low. Lack of oxygen inside the bore well and lack of light sources causes the major difficulty during the rescue operation. There is no such special equipment for rescuing the child trapped inside the bore well. There is no proper technique to rescue victims of such accidents. When the local arrangements do not work, army is called in.

In most cases reported so far, a parallel hole is dug up and then a horizontal path is made to reach to the subject's body. It is not only a time taking process, but also risky in various ways. Moreover it involves a lot of energy and expensive resources which are not easily available everywhere and in this process we always need big space around trapped bore that we can dig. Whatever may be the case the success ratio depends on lots of factors like availability of time taken for transportation of machinery to the situation, human resources and mainly the response time of various government organizations. In India according to the NCRB report of 2011 there are 5 average deaths per day in the license bore wells. At present there is no proper solution for this problem; in this paper the model of a robot arm which can be used for rescue operation is explained robot's various subsystems, including communication,

METHODOLOGY

Design and Implementation of Bluetooth-Controlled Robot for Borewell Rescue

The primary objective of this research is to design and develop a Bluetooth-controlled robot for borewell rescue, incorporating an STM32 controller, ESP32 CAM Bluetooth module, ultrasonic sensors, and servo motors. The system was designed to efficiently navigate the narrow confines of a borewell, detect the presence of trapped individuals, and perform rescue operations with minimal risk. The robot uses Bluetooth communication to allow remote control from the surface, ensuring safety for the operator. The STM32 microcontroller was selected for its processing power and versatility in controlling the various subsystems, including motor control, sensor integration, and communication protocols.

Components and Integration The robot system consists of the following key components:

STM32 Controller: The STM32 microcontroller is the heart of the robot, managing the operations of the sensor data processing, and motor control. The STM32 was chosen for its processing speed, which is essential for real-time operations in a rescue scenario.

ESP32 CAM Bluetooth Module: The ESP32 CAM module provides Bluetooth communication between the robot and the operator. This module was selected for its wireless connectivity, allowing the operator to control the robot from a safe distance and receive real-time video feeds via its onboard camera.

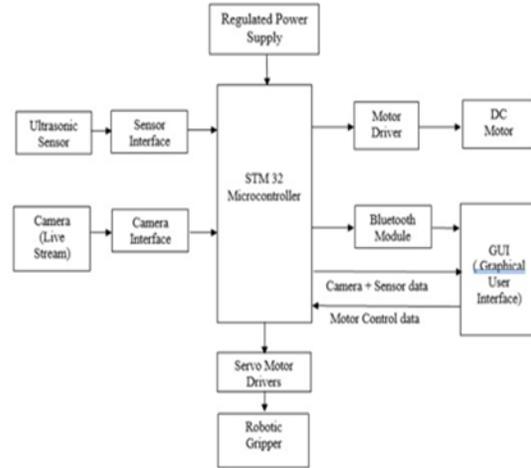


Fig. 1. Block Diagram

Ultrasonic Sensor: An ultrasonic sensor is integrated into the robot for proximity detection. This sensor helps the robot navigate through confined spaces and detect obstacles or changes in the borewell environment, such as the presence of trapped victims.

Servo Motors: Servo motors were used for precise control of the robot's movement and mechanical arm. These motors facilitate the lifting and manipulation of objects, which is essential for rescuing a trapped individual.

System Testing and Evaluation

The system was subjected to rigorous testing under simulated borewell conditions. Various factors were evaluated, including the robot's mobility in confined spaces, communication reliability, and sensor accuracy. During testing, the robot was remotely controlled using a mobile application linked to the ESP32 CAM Bluetooth module. Data on system performance, including motor responsiveness, Bluetooth communication range, and sensor detection efficiency, were collected and analyzed. Based on the results, iterative improvements were made to ensure

that the robot could perform rescue tasks efficiently and safely in real-world borewell scenarios.

Analysis of Robot Performance

The performance of the robot was analyzed in terms of mobility, communication range, and sensor accuracy. The following key parameters were considered during the analysis:

Mobility: The robot's ability to navigate through confined borewells was analyzed using the servo motors and ultrasonic sensors. Testing indicated the robot could efficiently turn, move forward, and backward with ease, even on uneven surfaces.

Bluetooth Communication: The ESP32

CAM Bluetooth module was tested to ensure a stable communication range between the robot and the operator. The maximum effective range for Bluetooth communication was found to be up to 30 meters in open conditions, with slight interference in more confined borewell spaces.

Sensor Performance: The ultrasonic sensor's ability to detect obstacles and measure distances was evaluated. The sensor was effective in detecting objects within a 2-meter range with an accuracy of 5 cm. This ensured that the robot could avoid obstacles and accurately assess the borewell environment.

COMPONENTS USED

STM 32 Microcontroller

The STM32 controller is a series of high performance 32-bit microcontrollers developed by STMicroelectronics, based on the ARM Cortex-M architecture. Known for its versatility, the STM32 family offers a wide range of devices that cater to different application needs, from low-power to high performance requirements. These microcontrollers are widely used in embedded systems, robotics, automotive, and IoT applications due to their powerful processing capabilities, energy efficiency, and extensive range of built-in peripherals like ADCs, DACs, and communication interfaces (UART, SPI, I2C, etc.). The STM32 is also supported by a comprehensive set of development tools and software,

making it a popular choice for developers working on complex embedded projects.

ESP 32 CAM

The ESP32-CAM is a compact development board featuring the ESP32 chip, which integrates Wi-Fi and Bluetooth capabilities. It is designed specifically for applications that require low-cost and low-power wireless communication, while also offering a builtin camera module for image and video capture. The ESP32-CAM is ideal for IoT projects, security cameras, and remote monitoring systems due to its ability to stream video or take snapshots over Wi-Fi. It includes a variety of I/O pins for connecting additional sensors and modules, making it a versatile and cost-effective solution for wireless projects that require both connectivity and image processing.

Servo Motor

The SG90 servo motor is a small, lightweight, and affordable analog servo motor commonly used in robotics, RC models, and automation projects. It provides precise control of angular position, typically within a range of 0 to 180 degrees. The SG90 motor operates with a 3-wire connection (power, ground, and signal) and is controlled by varying the pulse width of the input signal. It is widely used for tasks that require controlled movement, such as controlling robotic arms, camera gimbals, or steering mechanisms, due to its compact size, ease of use, and cost-effectiveness.

Ultrasonic Sensor

The HC-SR04 is an affordable and popular ultrasonic sensor used for distance measurement in various projects. It operates by emitting a high frequency sound wave and measuring the time it takes for the wave to bounce back after hitting an object. This time is then used to calculate the distance between the sensor and the object. The HCSR04 is commonly used in robotics, obstacle avoidance systems, and automation, as it provides accurate distance readings (typically ranging from 2 cm to 400 cm) with simple interfacing via Arduino or other microcontrollers.

Bluetooth module

The HC-05 Bluetooth module is a widely used, low-cost, and easy-to-use Bluetooth serial communication module designed for wireless communication between devices. It supports both master and slave modes, allowing it to connect to various Bluetooth-enabled devices such as smartphones, laptops, or other microcontrollers. The HC-05 operates over the Serial Port Protocol (SPP), enabling data transfer through a simple UART (Universal Asynchronous Receiver/Transmitter) interface. It is commonly used in DIY projects, robotics, and IoT applications for wireless control and communication.



Fig.3 Prototype System

Motor Driver

The L298N motor driver is a popular dual HBridge motor driver IC used for controlling the direction and speed of DC motors and stepper motors. It allows for bidirectional control, enabling the motor to rotate in both clockwise and counterclockwise directions. The L298N can supply up to 2A of current per motor, making it suitable for small to medium-sized motors in various robotic and automation projects. The motor driver is controlled using logic-level inputs, typically from a microcontroller like an STM 32.

RESULTS

A prototype of our project was successfully designed and fabricated keeping in mind all the constraints and practical issues. The proposed system is tested and was found to perform satisfactorily within short time compared to traditional methods providing safety feature the biggest concern. Life supporting system including oxygen supply, assisting equipment like camera and lighting and other sensing elements were successfully installed and found to work smoothly. Overall our project was efficiently designed to perform with all the requirements and constraints based on our objectives.



Fig.2 Prototype System



Fig.4 Prototype System

CONCLUSION

The proposed system operation works better and can perform different works which will make the arm more secure and easier in operation. Since there is no need for a parallel hole for rescue purposes and the child is rescued through the existing hole itself, the rescuing time is reduced considerably. And there is no need of digging another parallel extraction pit that costs time. As a development of the system in the future, we can provide additional comfort facilities like cooling. Also, the whole system can be fully automated. And it is better to replace the rope pulley arrangement, with any other suitable safe method.

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