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DESIGN AND FABRICATION OF BOREWELL CHILD RESCUE SYSTEM

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ABSTRACT

Borewells are narrow and deep cylindrical excavations used for various purposes, such as water extraction or geological exploration. Accidental falls or entrapments in borewells pose significant challenges for rescue operations due to limited access and potential hazards. Therefore, developing a specialized robot for borewell rescue can enhance the efficiency and safety of such operations. This project presents the development of a borewell rescue robot equipped with an ESP32 microcontroller, high torque DC motors, a camera module, and a mechanical gripper. The robot is designed to navigate and perform rescue operations in narrow borewell environments, where human access is limited or hazardous. The objective is to create a robust and efficient robot capable of reaching and retrieving individuals trapped in borewells, thereby reducing the risks and time associated with manual rescue operations.

Keywords: Borewell rescue system, Robotics, Internet of Things, ESP32 controller, 3D modelling.

1. INTRODUCTION

The historical roots of the gripper-based borewell rescue robot can be traced to various global incidents emphasizing the pressing need for a more effective solution. Notable examples include the 2006 episode in Kurukshetra, India, where a 5-year-old boy endured nearly 50 hours trapped in a borewell. Similarly, the 2019 case in Tamil Nadu, India, garnered international attention as a 2-year-old boy's rescue operation unfolded. These incidents served as catalysts, compelling researchers, engineers, and organizations to develop a specialized robot geared towards mitigating the risks associated with borewell accidents. The urgency to find innovative approaches stemmed from the high-profile nature of these incidents, highlighting the importance of swift and efficient rescue methods.

Borewell accidents, especially involving children, trapped in narrow borewells, persist as a recurring issue in various global regions. Rescue efforts face formidable challenges due to the confined spaces and challenging access points inherent in such incidents. Conventional rescue methods often encounter limitations in safely and effectively extracting individuals from deep borewells. The evolution of advanced robotic technologies has brought about a revolution in multiple industries, notably in search and rescue operations. Among these innovations is the gripper-based borewell rescue robot equipped with live streaming capabilities. This article seeks to offer an overview of this remarkable robotic system, highlighting its background, significance, the imperative need it addresses, and the historical context that propels its development.

Significance

The gripper-based borewell rescue robot with live streaming addresses the limitations of conventional rescue techniques by utilizing advanced robotic capabilities. It offers several significant advantages:

- Enhanced reach and access: The robot's gripper mechanism allows it to navigate through narrow borewell shafts and confined spaces, reaching areas where humans cannot operate easily.
- Improved safety: By deploying the robot, human rescuers can reduce their exposure to potential risks associated with entering unstable borewell structures or encountering hazardous substances.
- Real-time situational awareness: The live streaming feature enables rescuers, authorities, and even concerned individuals to observe the rescue operation remotely, providing valuable information and updates.
- Efficient and precise operations: The robot's gripper mechanism provides a controlled and accurate grip on the individual, facilitating their safe extraction from the borewell.

2. LITERATURE SURVEY

Rishab et al. (2023) presented a mechatronic puppet-based robotic hand system specifically designed for life-saving applications. The paper likely discusses the design and development of the robotic hand, including its mechanical structure, actuation mechanisms, and control system. The authors might have also explored the application of this robotic hand in scenarios such as search and rescue operations, where the dexterity and adaptability of the hand can be crucial in saving lives.

Kavyasree et al. (2023) presented likely discuss a comprehensive system for rescuing children trapped in borewells using a robotic platform. The paper might cover the design, development, and functionalities of the rescue robot. This could include aspects such as mobility, sensing capabilities, manipulation mechanisms, and communication systems. The authors may also discuss the challenges associated with borewell rescue operations and how their proposed robotic system addresses those challenges.

Thota et al. (2023) likely discuss an innovative child rescue system that utilizes Arduino microcontrollers. The paper might cover the design and implementation of the system, highlighting the role of Arduino in controlling various components such as sensors, actuators, and communication modules. The authors may also present experimental results and discuss the effectiveness of their proposed system in borewell rescue scenarios.

Simi Simon et al. (2023) published a paper on borewell rescue robot work presented in this paper describes the Robot used to rescue the children from unused borewells. This system monitors the trapped child through Infra-red water proof cameras and high-resolution TV monitor. This system uses Ultrasonic Sensors and temperature sensor. APR module is attached to Robot which is used to communicate with the child. This system lacks with gas sensor to monitor harmful gas and provide oxygen.

Nish Mohith Kurukuti et al.,(2023) proposed a design to enlarge or adjusted as per the diameter of Borewell. Ultrasonic Sensor used to measure the distance from Robot wheel to borewell Wall and Logitech C270 camera is used to provide visual information to operator. Servo motor is used to control Robot Arms and DC motors to actuate the wheels of the motor. The Robotic system would adjust to the borewell size with help of Rack and Pinion mechanism to grab and hold the child. This system lacks with gas sensor and oxygen supply.

Ramkumar et al. (2022) proposed an IoT-based system for rescuing children who have fallen into borewells. The paper likely discusses the architecture of the system, which might involve sensors and communication devices connected through the Internet of Things (IoT). The authors might have also explored the integration of real-time monitoring, data analysis, and communication technologies to facilitate efficient and timely rescue operations.

Gopinath et al. (2022) proposed a system for rescuing children from borewell. The system uses a camera with LED for visualizing the victim. Temperature sensor, pressure sensor, gas sensors are used and are interfaced with ARM8 processor. The presented work does not include UDM sensor which has been incorporated in our work and thermistors are replaced by LM35 temperature sensors which gives better accuracy.

Kavianand et al. (2022) published a paper on smart child rescue system which uses a PIR sensor to detect the motion of the child trapped in a borewell. The sensor is placed at the top of the borewell pipeline and the signals detected are sent to the raspberry pi controller. An alert message is sent to the nearby fire station and also the contractor in charge using the interfaced GSM module. This system lacks in measuring the distance of victim from borewell and temperature inside and does not use robot arm for immediate rescue of child.

Sui et al. (2021) focus on the design, characterization, and application of an enveloping soft gripper. The paper might discuss the unique features and advantages of the gripper design, its material properties, and its ability to handle high loads. The authors may also present experimental results and applications where the gripper demonstrates its effectiveness in various tasks, including robotic rescue operations.

RenugaDevi et al. (2021) published present an IoT-based system for detecting unclosed borewell holes using automated drone-operated cameras. The paper might cover the architecture of the system, including the deployment of drones equipped with cameras and IoT-enabled communication. The authors may discuss the image processing techniques employed to detect unclosed borewell holes and how real-time alerts are generated to prevent accidents in remote areas.

Manish Raj et al.,(2021) published a paper in which where it used mechanical system and two arms and camera to rescue the child. this system lacked with sensors such as temperature sensor, gas sensor, PIR sensor.

Arthika et al.,(2021) presented a paper which mainly aims to rescue children from Borewell and designed to have adjustable diameter robot and continuously monitoring of child by having Camera. The system measures the distance of child by infrared transmitter and receiver and temperature by temperature sensor. The presented work does not include gas sensor to detect toxic gases present inside the borewell so that corrective actions can be undertaken on time to save the child.

Karthik et al. (2020) published an investigation and analysis of child rescue systems specifically designed for open borewells. The paper might discuss different approaches and technologies employed in such systems, including sensing methods, communication systems, and robotic mechanisms. The authors may also present case studies or simulations to evaluate the effectiveness and limitations of existing rescue systems.

Akash et al. (2020) presented the design and development of a specialized robot for rescue operations targeting borewell victims. The paper might cover aspects such as the mechanical structure of the robot, its mobility mechanisms, sensing capabilities, and control system. The authors may also discuss the challenges faced in rescue operations and how their robot addresses those challenges.

Aravind N Kaimal et al., (2020) proposed a method which combines multiple techniques in the rescue operation of children trapped in borewell. Here they combined the function of robotic arms along with camera and sensor detections for the rescue task. The robot was directed about the child's position based on the results obtained from camera. Then it would be extended towards the child and upon reaching the child it positions itself using protective casing. Using balloon technology, the child is safely landed over the balloon cushion which would be extended to raise the child and to avoid further falling. Next the whole system would be lifted up along with the victim above the ground level. This method's prototype was successfully implemented and found to give satisfactory results.

Palwinderkaur et al., (2020) proposed a system which is designed to rescue children trapped inside non operative borewells within short time. This system works based on wireless communication concept and the commands are given by the user. This system has power supply, gear motors, camera and microcontroller as the components. Gear motors are connected to Robot which uses three wheels with Rubber grip which fit exactly to the walls of the hole so that the Robot moves down easily without sliding and the arm of Robot is used to Pick the child from the borewell. This system does not provide oxygen supply and does not use temperature sensor.

Nitin Agarwal et al., (2019) have designed a system that involves manual operation to rescue a sufferer from a borewell. The system uses a robotic module with camera and teleoperation system. Along with the robotic arm the setup is equipped with LED light, live streaming camera and mic for interaction with the victim.

Prakash Bethapudi et al., (2019) developed a structure to save the lives got struck in borewell. The system has a sensor over the borewell to sense and produce alarm sound if anyone got slipped into the borewell. Eventually it also sends alert message to the people concerned and emergency numbers for rescue. This is an automated system which has a carrier fixed at 5 feet inside the pit to lift up the victim once the fall was detected. This carrier was furnished with soft cushion, light and toys for the safety and comfort of the kid rescued.

Sara Anjum et al., (2018) described about a procedure to provide assistance for the victims of open borewell. Here instead of conventional methods the modern system is adapted using Delta robotics, which is familiar for its high-speed potency along with temperature sensor and wireless camera. The experimental setup provides good result with respect to time consumed.

Surya Saravana Pandiyan et al., (2018) devised a prosthetic rescue robot which can be used for different types of rescuing tasks. Here the PBRS system is accompanied by multiple sensors for the safe rescue of the victim. This system with mild modification can also be used for detection of fissures or breaches in boilers, pipelines etc.

Shivam Bajpai et al., (2017) suggested a alternative method to save children who got trapped in borewell. The traditional way of digging parallel hole near the borewell is replaced by using robotic system in the borewell itself. The system is designed in such a manner that it gives pre-treatment for the child while rescue operation is being carried out. The setup consists of 3 mild steel rods positioned in triangular form with pulley, hanging disc operated by D.C motor, VGA camera and hanging balloon arrangement. Using this arrangement, the child will be safely rescued by the team without consuming long hours and large amount of manpower.

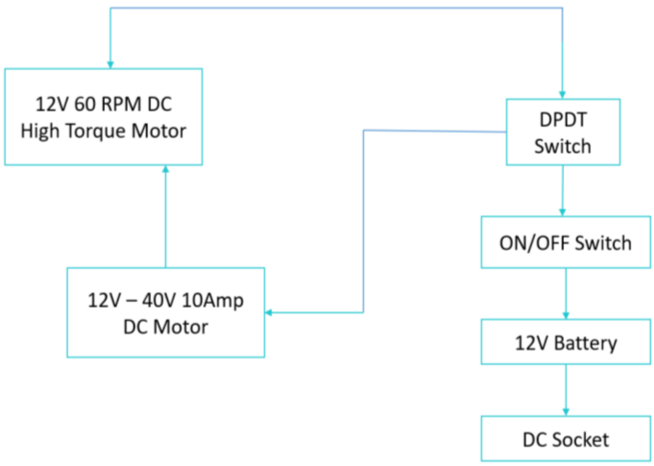
3. PROPOSED METHODOLOGY

Figure 1 shows the proposed block diagram. The robot's working operation involves the operator remotely controlling its navigation, receiving live video feed, and utilizing the mechanical gripper to perform rescue operations.

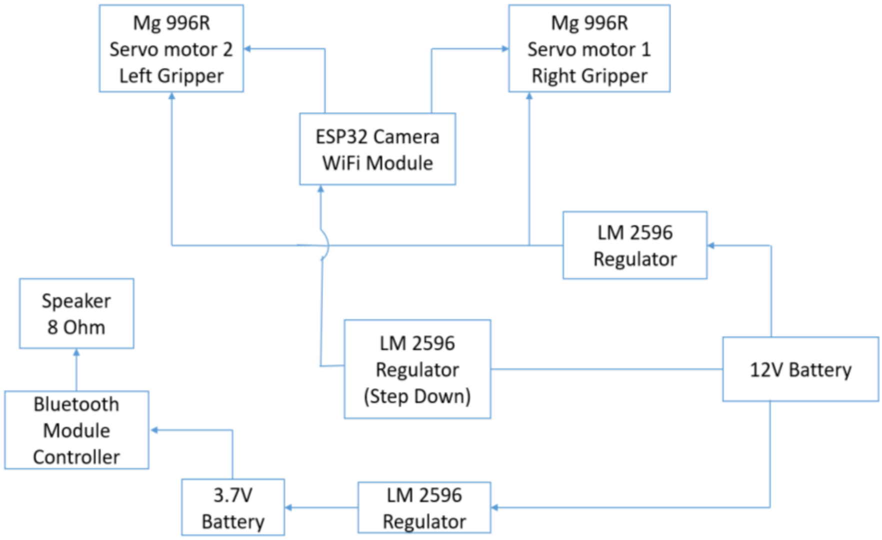
The ESP32 microcontroller acts as the central control system, coordinating all the components and facilitating wireless communication with the remote-control device. The integration of high torque DC motors, a camera module, and a mechanical gripper enhances the robot's capabilities for efficient and safe borewell rescue operations. The step wise analysis is illustrated as follows:

Step 1: Robot Navigation

The borewell rescue robot is meticulously engineered to through confined spaces like borewells, leveraging its compact and robust structure. Precision and robust locomotion are facilitated by the integration of high torque DC motors, allowing the robot to navigate challenging terrains. The ESP32 microcontroller acts as the command center, translating input directives from the remote-control device into motor movements. The robot's movements are precisely controlled based on operator commands, facilitating navigation through borewells while avoiding obstacles.



(a)



(b)

Figure 1: Block diagram of proposed borewell rescue robot. (a) Upper hardware. (b) Lower hardware

Step 2: Live Video Transmission

A camera module is affixed to the robot chassis, capturing live video footage of the surroundings. Linked to the ESP32 microcontroller, the camera module transmits the processed video feed to the remote-control device. This real-time video transmission empowers the rescue team with live visual insights into the borewell interior, aiding in situational assessment and informed decision-making.

Step 3: ESP32 Microcontroller and Control System

Serving as the central control hub, the ESP32 microcontroller coordinates the various components and functionalities of the robot. It establishes wireless communication, such as Wi-Fi or Bluetooth, facilitating real-time control and data transmission between the robot and the remote-control device. The microcontroller interprets operator commands, directing signals to motor drivers for precise control of the robot's movement. Additionally, it processes the video feed from the camera module, ensuring seamless transmission to the remote-control device.

Step 4: Mechanical Gripper Integration

A mechanical gripper system is devised and implemented to facilitate the secure retrieval of individuals trapped in borewells. Integrated onto the robot chassis, the gripper is linked to the ESP32 microcontroller for controlled operation. Upon locating a trapped individual, the operator can remotely command the robot to position the gripper and securely grasp the person. The gripper's design ensures a stable and secure hold, facilitating the safe extraction of individuals from borewells.

Step 5: Remote Control Interface

The remote-control device serves as the operator's interface for commanding and controlling the borewell rescue robot. Utilizing wireless communication with the ESP32 microcontroller, the interface features a user-friendly control panel. This allows the operator to send directional commands, control the mechanical gripper, and monitor the live video feed from the camera module. The intuitive design ensures effective robot operation, even for non-expert users during rescue missions.

Step 6: Power Management

Efficient power management is essential for prolonged rescue operations. The ESP32 microcontroller is responsible for monitoring and managing the power consumption of the entire system. This involves optimizing the usage of high torque DC motors, camera modules, and other components to maximize battery life. The microcontroller may implement sleep modes and energy-efficient algorithms during periods of inactivity, ensuring prolonged operational capability for borewell rescue missions. Through the integration of these steps, the borewell rescue robot emerges as a comprehensive and adaptable solution for navigating, inspecting, and executing rescue operations in confined spaces, offering emergency response teams a valuable tool for effective and reliable use in challenging scenarios.

Methodology

Utilize a CNC (Computer Numerical Control) laser cutting machine to precisely cut various components of the robot structure from metal sheets. Prepare the design files for the robot structure, ensuring proper dimensions and compatibility with the borewell openings. Load the metal sheets onto the CNC laser cutting machine and set up the cutting parameters, such as laser power and cutting speed. Execute the cutting process, allowing the CNC machine to accurately cut the desired shapes and structures for the robot components. After the cutting process, remove the cut metal pieces and perform any necessary finishing operations, such as deburring or sanding, to ensure smooth edges.

Utilize a CNC metal bending machine to shape and bend the metal components, such as brackets or clamps, required for the robot assembly. Prepare the design files with precise measurements and bending angles for the specific metal components. Load the metal pieces into the CNC metal bending machine and set up the bending parameters, including bend angle and bend radius. Initiate the bending process, allowing the CNC machine to accurately bend the metal pieces according to the specified design. After bending, remove the bent metal components from the machine and ensure their dimensional accuracy and structural integrity.

Mount the DC motors onto the robot chassis using brackets or mounting plates, ensuring secure and stable attachment. Connect the DC motors to the motor driver circuitry, providing power and control signals for their operation. Program the ESP32 microcontroller to control the DC motors, sending appropriate signals to the motor driver circuitry to control their speed and direction. Test the DC motors' functionality and ensure their proper integration with the overall robot control system.

Set up the ESP32 microcontroller as the central control unit of the robot. Develop the necessary software and firmware to program the ESP32, enabling it to receive commands from the remote-control device, control motor movements, and manage communication. Establish a wireless communication protocol, such as Wi-Fi or Bluetooth, to enable seamless communication between the robot and the remote-control device. Program the ESP32 to process incoming commands, translate them into motor movements or gripper actions, and send appropriate signals to the respective components. Test the ESP32 controller's functionality and ensure its integration with the other modules of the robot system.

Connect the motor driver module to the ESP32 microcontroller and the high torque DC motors. Ensure proper wiring and connections between the motor driver module, the ESP32, and the DC motors, following the manufacturer's guidelines. Program the ESP32 to send control signals to the motor driver module, enabling it to regulate the power supply and control the speed and direction of the DC motors.

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Test the motor driver's functionality, ensuring smooth and accurate motor control as per the commands received from the ESP32 microcontroller.

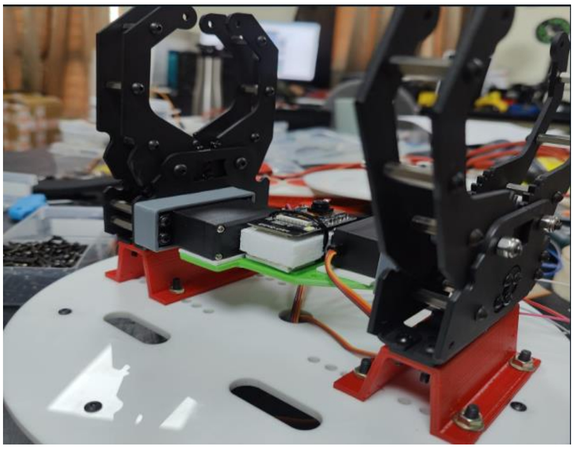
Mount the camera module onto the robot chassis, ensuring a clear and unobstructed view of the borewell environment. Connect the camera module to the ESP32 microcontroller, ensuring proper wiring and compatibility. Develop the software and firmware to capture and process video feed from the camera module. Program the ESP32 to receive video input from the camera module, process the captured frames, and compress them for transmission. Establish a wireless communication protocol between the ESP32 and the remote-control device to transmit the video feed in real-time. Test the camera module's functionality, ensuring the proper capture and transmission of live video feed from the borewell environment to the remote-control device.

Connect the 5v power supply unit to the robot's electrical system, ensuring proper wiring and polarity. Implement any necessary voltage regulation or current limiting mechanisms to protect the components from power fluctuations or overloading. Test the power supply system, ensuring stable and reliable power distribution to all modules of the robot.

Cut the borewell casing pipe to the desired length, allowing it to fit through the borewell openings. Securely attach the robot structure, components, and modules onto the borewell casing pipe, ensuring structural stability and integrity. Test the overall assembly's robustness and stability, ensuring that the robot can effectively navigate through the borewell using the borewell casing pipe as its guide.

Prepare the 3D printer by loading the appropriate filament material and configuring the printing parameters. Initiate the printing process, allowing the 3D printer to produce the desired components layer by layer. After printing, remove the 3D printed components from the printer, ensuring their dimensional accuracy and structural integrity. Assemble the 3D printed components onto the robot structure, ensuring proper fit and functionality. Test the 3D printed components, verifying their strength and compatibility with the overall robot system.

4. RESULTS AND DISCUSSION



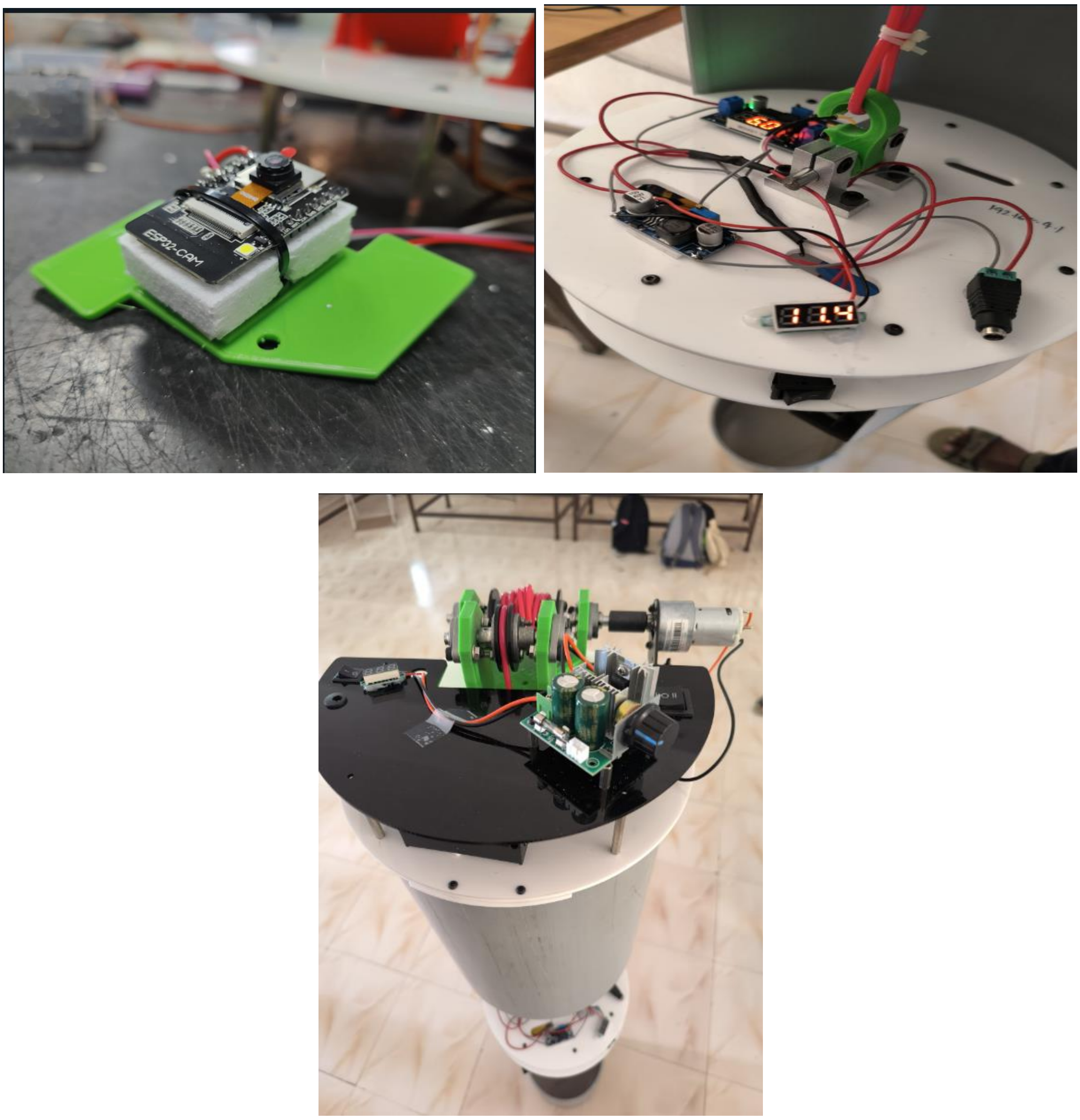


Figure 2: Hardware setup of borewell rescue system.

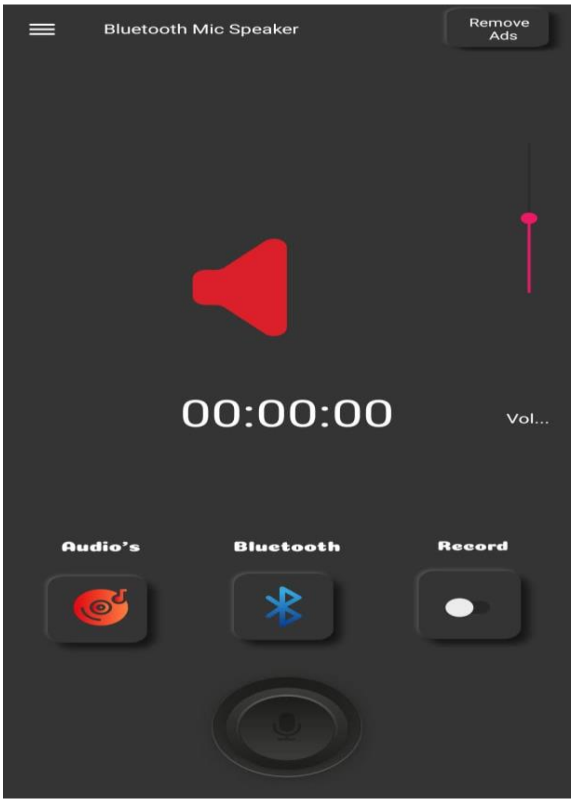


Figure 3: Bluetooth speaker for voice operations.

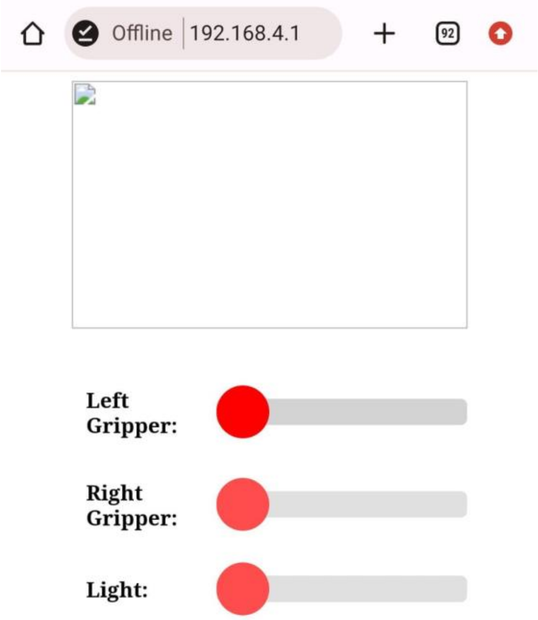


Figure 4: Control mechanism of proposed borewell rescue system.

5. CONCLUSION

In conclusion, the development of a specialized borewell child rescue robot equipped with state-of-the-art features such as the ESP32 microcontroller, high torque DC motors, a camera module, and a mechanical gripper represents a significant leap forward in enhancing the efficiency and safety of rescue operations in narrow borewell environments. Its compact and robust design enables it to navigate through confined spaces, providing access where human intervention may be limited or perilous, while the integration of high torque DC motors ensures precise locomotion even in challenging terrains. Acting as the central control system, the ESP32 microcontroller facilitates seamless coordination among its components and wireless communication with the remote-control device. The addition of a camera module offers real-time video transmission, granting the rescue team crucial visual insight into the conditions within the borewell, while the mechanical gripper system enables the secure retrieval of trapped individuals, mitigating risks during rescue operations. By harnessing these advanced technologies, this specialized robot holds immense promise in reducing the risks and time associated with manual rescue efforts, ultimately enhancing the effectiveness of borewell child rescue missions.

REFERENCES

[1] Rishab, S. K., D. S. Thinoj, and H. Umesh Prabhu. "Mechatronic Puppet Based Robotic Hand System For Life Saving Application." *2023 9th International Conference on Electrical Energy Systems (ICEES)*. IEEE, 2023.

[2] Kavyasree, A., Bhargavi, B., Shabbar, M., Neerajapatel, U., & Vucha, M. (2023, May). Borewell child rescue robot system. In *AIP Conference Proceedings* (Vol. 2492, No. 1). AIP Publishing.

[3] Thota, Bhavana, et al. "Innovative Child Rescue System from Borewell using Arduino." *2023 International Conference on Innovative Data Communication Technologies and Application (ICIDCA)*. IEEE, 2023.

[4] Simi Simon, Minna Jose, Mariya Jessy Gogy, Vismaya K D, Swathi Mukundan, "Borewell Rescue Robot", International Research Journal of Engineering and Technology, issue 3, 2023.

[5] Nish Mohith Kurukuti, Mahesh Jinkala, Purushotham Tanjeri, Somasekhar Reddy Dantla and Mallikarjuna Korrapati, "A Novel Design of Robotic System for Rescue in Borewell Accidents", International Conference on Robotics and Automation for Humanitarian Applications, 2023.

[6] Ramkumar, M., Jana, K., Babu, J., & Bharathi, G. (2022, December). IoT-based Child Rescue System from Borewell. In *2022 6th International Conference on Electronics, Communication and Aerospace Technology* (pp. 456-459). IEEE.

[7] S. Gopinath, T. Devika, L. Manivannan, Suthanthira Vanitha, "Rescue Child from Borewell using Embedded System", International Research Journal of Engineering and Technology, issue2,2022

[8] Kavianand G, Gowri Ganesh K and Karthikeyan P," Smart Child Rescue System from Borewell (SCRS)", Department of Electronics and Communication Engineering, Panimalar Engineering College, Chennai, 2022.

[9] Sui, Dongbao, et al. "An Enveloping Soft Gripper with High-Load Carrying Capacity: Design, Characterization and Application." *IEEE Robotics and Automation Letters* 7.1 (2021).

[10] RenugaDevi, S., et al. "IoT based detection of bore-well unclos Chandrasekaran, Natarajan, and Roopa Purushothaman. *Bridgital Nation: Solving Technology's People Problem*. Penguin Random House India Private Limited, 2019.ed holes using automated drone operated cameras in a remote area." *Journal of Physics: Conference Series*. Vol. 1767. No. 1. IOP Publishing, 2021.

[11] Manish Raj, P. Chakraborty and G. C. Nandi "An Approach Towards Rescue Robotics in Borewell Environment" International Conference on Communication and Signal Processing,2021.

[12] S. Arthika, S. Chidambara Eswari, R. Prathipaand, D. Devasena, "Borewell Child Fall Safeguarding Robot", International Conference on Communication and Signal Processing, April 2021.

[13] Karthik, S., et al. "Investigation and analysis on child rescue system from open bore well." *IOP Conference Series: Materials Science and Engineering*. Vol. 912. No. 2. IOP Publishing, 2020.

[14] Akash, B., et al. "Design and development of robot for rescue operations for bore-well victims." *2020 International Conference on Futuristic Technologies in Control Systems & Renewable Energy (ICFCR)*. IEEE, 2020.

[15] Aravind N Kaimal, Bijith P.B, Midhun C Baiju, Muhammed Suhail K.S(2020)," Borewell Child Rescue System", International.

[16] Palwinderkaur, Ravinderkaur and Gurpreetsingh, "Pipeline Inspection and Borewell Rescue Robot", International Journal of Research in Engineering and Technology,2020.

[17] Nitin Agarwal, Hitesh Singhal, Shobhit Yadav, Shubham Tyagi, Vishaldeep Pathak (2019), "Child Rescue System from Open".

[18] Dr. Prakash Bethapudi, Gandhi Netaji, (2019), "Smart Rescue System from Borewell", Journal of Advanced Research in Child Rescue System Through The Borewell and Their Safety Measures.

[19] Sara Anjum, Shreyas Hosur, Shrimanth, Sumithra P S, Dr Gayathri S (2018)," Assistance for Borewell Victims", International Rescue System for Safety Precaution as Borewells.

[20] Surya Saravana Pandian, Karthikeyan Sundarasamy (2018)," Multi-Purpose Prosthetic Bore Well Rescue Robot System" Created and Inherited the precautions and Sequence For the Systems.

[21] Rajesh, Singuru, Gamini Suresh, and R. Chandra Mohan. "Design and development of multi-purpose prosthetic bore well system-an invincible arm." *Materials Today: Proceedings* 4.8 (2017).

[22] Shivam Bajpai, Abhinav Singh, Ravi Shankar Rai, Ashwani Sharma, C.K Jha (2017), "Design and Fabrication of Borewell Rescue Robot", International Journal of Engineering Science and Computing.