
**IOT BASED REAL TIME BOREWELL VICTIM DETECTION AND RESCUE
ROBOT**

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ABSTRACT

Borewell accidents are among the most tragic incidents affecting children worldwide, particularly in rural and semi-urban areas where open borewells pose significant safety hazards. These accidents often result in fatalities due to delayed detection and the complexity of rescue operations. This project presents an IoT-based real-time borewell victim detection and rescue system that integrates advanced sensors, embedded systems, and actuators to provide a comprehensive solution for rapid victim identification and rescue. The system employs a DHT11 sensor for temperature and humidity monitoring, an ESP-CAM module for real-time visual surveillance, a smoke sensor for detecting hazardous gases, and an ultrasonic sensor for measuring depth and detecting the presence of victims. The core processing is handled by an Arduino microcontroller programmed with custom software algorithms. Upon detection, the system triggers multiple alert mechanisms including an LCD display for real-time information, a buzzer for audio alerts, and LED indicators for visual warnings. The rescue operation is facilitated by a robotic arm mechanism powered by a DC motor, enabling safe retrieval of victims without human intervention in dangerous zones. The entire system is connected through IoT technology, allowing remote monitoring and control via cloud platforms, enabling rescue teams to access critical information instantly from any location. This automated approach significantly reduces response time, minimizes human risk during rescue operations, and increases survival rates through immediate detection and intervention capabilities.

Keywords— Borewell Safety, IoT Monitoring, Victim Detection, ESP32-CAM, Robotic Rescue Arm.

1. INTRODUCTION

Borewell accidents have emerged as a critical safety concern in recent decades, particularly affecting young children in developing nations. India alone witnesses numerous such incidents annually, with many resulting in casualties due to inadequate rescue infrastructure and delayed response mechanisms. Traditional borewell digging practices often leave these wells uncapped or poorly secured after they dry up or become non-functional, creating death traps for unsuspecting victims, especially children who may accidentally fall into these narrow, deep shafts while playing in fields or open areas. The confined space, typically ranging from 6 to 12

inches in diameter and extending hundreds of feet deep, makes rescue operations extremely challenging and time-critical.

Conventional rescue methods involve manual digging parallel to the borewell, which is labor-intensive, time-consuming, and often takes 24-72 hours or more to complete. During this critical period, victims face life-threatening conditions including oxygen deprivation, exposure to toxic gases, hypothermia, injuries from the fall, and psychological trauma from being trapped in darkness. The success rate of these rescue operations remains disappointingly low, primarily due to the time delay between the accident occurrence and the

commencement of effective rescue measures. Furthermore, traditional methods lack real-time monitoring capabilities, forcing rescue teams to work blindly without information about the victim's condition, exact location, or environmental hazards within the borewell.

The advent of Internet of Things technology and embedded systems has opened new possibilities for addressing this humanitarian crisis. IoT technology enables the integration of various sensors, actuators, and communication modules into a cohesive system capable of real-time data acquisition, processing, and transmission. Modern microcontrollers like Arduino provide cost-effective platforms for implementing complex control algorithms, while advances in miniaturized sensors and cameras allow deployment in confined spaces. Wireless communication protocols enable remote monitoring and control, facilitating coordination between on-site equipment and remote command centers. This technological convergence makes it feasible to develop automated systems that can detect accidents immediately, assess the situation comprehensively, and initiate rescue operations with minimal human intervention in hazardous zones.

This project leverages these technological advancements to design and implement a comprehensive borewell safety and rescue system. The system architecture incorporates multiple sensing modalities to provide complete situational awareness. The DHT11 sensor continuously monitors temperature and humidity levels, providing crucial environmental data that indicates the presence of a victim and helps assess their survival conditions. The ESP-CAM module offers real-time video surveillance capabilities, allowing rescue teams to visually confirm the victim's presence, assess their condition, and guide rescue operations precisely. The smoke sensor detects the presence of harmful gases that might accumulate in the borewell, alerting rescue teams to potential asphyxiation hazards. The

ultrasonic sensor measures the depth and detects any obstructions or movements within the shaft, providing critical information for planning the rescue approach.

The system's intelligence resides in the Arduino microcontroller, which processes sensor data in real-time, executes decision-making algorithms, and coordinates all system components. The output interface consists of an LCD display that presents real-time information in human-readable format, a buzzer that provides audible alerts to draw attention to detected accidents, LED indicators that offer visual status information, and most importantly, a robotic arm mechanism controlled by DC motors that can be deployed into the borewell to physically retrieve the victim. The robotic arm design incorporates gripping mechanisms and safety features to securely hold the victim during extraction while minimizing the risk of additional injury.

The IoT integration aspect is achieved through wireless connectivity modules that transmit all sensor data, video feeds, and system status to cloud-based platforms. This enables authorized personnel to access real-time information from anywhere using smartphones, tablets, or computers, facilitating rapid decision-making and coordination of emergency response efforts. The cloud infrastructure also maintains historical data logs for analysis, helps identify accident-prone locations, and supports preventive measures through predictive analytics. The system can send automated alerts to designated emergency contacts and rescue services immediately upon accident detection, significantly reducing the critical initial response time.

The implementation of such an automated system offers multiple advantages over conventional approaches. Firstly, it dramatically reduces the response time from hours to minutes by enabling immediate detection and alerting. Secondly, it minimizes human risk by automating the most dangerous aspects of rescue operations. Thirdly, it

provides comprehensive situational awareness through multiple sensors, enabling informed decision-making by rescue teams. Fourthly, it operates continuously without fatigue, ensuring round-the-clock protection. Finally, the system's scalability allows deployment across multiple borewells in a region, with centralized monitoring and management, making it particularly valuable for areas with numerous abandoned or non-functional borewells.

This project represents a significant step toward leveraging modern technology for humanitarian purposes, specifically addressing a critical safety challenge that affects vulnerable populations. By combining sensor technology, embedded systems, robotics, and IoT connectivity, it demonstrates how integrated solutions can save lives in emergency situations. The modular architecture of the system also allows for future enhancements, such as incorporating artificial intelligence for victim condition assessment, adding oxygen supply mechanisms for extended rescue operations, integrating GPS for precise location tracking, and implementing automated prevention mechanisms like motorized caps that close borewells when left unattended. The successful development and deployment of this system could serve as a model for addressing similar confined-space rescue challenges in mining accidents, collapsed structure scenarios, and other emergency situations where rapid response and remote operation capabilities are critical for saving lives.

1.1 OBJECTIVES OF THE PROJECT

The primary objective of this project is to design and develop an intelligent IoT-based borewell victim detection and rescue system that significantly reduces response time and increases survival rates in borewell accidents. The system aims to implement a multi-sensor detection mechanism using DHT11, ESP-CAM, smoke sensors, and ultrasonic sensors for comprehensive victim identification and environmental monitoring. Key objectives

include establishing real-time video surveillance for visual confirmation and victim condition assessment, creating an automated alert system with LCD displays, buzzers, LED indicators, and IoT-based remote notifications to emergency services. The project seeks to design and deploy a robotic arm rescue mechanism powered by DC motors capable of safely retrieving victims from depths without human entry into dangerous zones. Additional objectives encompass developing robust embedded software for Arduino to process sensor inputs and execute intelligent decision-making algorithms, establishing reliable IoT connectivity for remote monitoring and control through cloud platforms accessible via mobile devices, implementing comprehensive environmental monitoring to detect hazardous conditions like toxic gases and oxygen depletion, creating a scalable system architecture for deployment across multiple borewell locations with centralized monitoring, establishing data logging and analytics capabilities for accident pattern analysis and preventive measures, and demonstrating a cost-effective, reliable, and easily maintainable solution that can be widely adopted by communities and government agencies to prevent borewell tragedy fatalities.

1.2 PROBLEM STATEMENT

Borewell accidents represent a persistent and devastating problem affecting communities worldwide, particularly in rural regions where thousands of abandoned or improperly secured borewells pose constant threats to public safety, with children being the most frequent victims. Current rescue methodologies suffer from critical limitations including delayed accident detection due to remote locations and absence of automated monitoring systems, resulting in precious hours lost between accident occurrence and rescue initiation. Manual rescue attempts involving parallel shaft digging are extremely time-consuming, typically requiring 24 to 72 hours or longer, during which survival probability decreases dramatically due to

oxygen deprivation, exposure, injuries, and trauma. The lack of real-time information about victim conditions, exact positioning, and environmental hazards forces rescue teams to operate blindly, increasing risks to both victims and rescue personnel while reducing operational efficiency. Conventional methods require rescuers to enter confined spaces or work near unstable structures, exposing them to cave-ins, toxic gas exposure, and other life-threatening hazards. The narrow diameter of borewells makes it nearly impossible to lower adult rescuers or conventional equipment, necessitating complex parallel digging operations. Financial and logistical constraints prevent most at-risk communities from implementing effective preventive measures, while the absence of centralized monitoring and alert systems means each accident requires ad-hoc response mobilization, resulting in unacceptably high fatality rates despite these incidents being entirely preventable with appropriate technology and safety measures.

2. LITERATURE SURVEY

Kumar and Singh in 2019 proposed an Arduino-based child rescue system using temperature sensors and wireless communication for borewell accident detection, establishing the foundation for embedded system applications in this domain. Patel et al. in 2020 developed an IoT-enabled robotic arm mechanism with camera integration for real-time monitoring and victim retrieval from borewells, demonstrating the feasibility of automated rescue operations. Sharma and Gupta in 2018 implemented a GSM-based alert system combined with ultrasonic sensors for early detection of borewell accidents in rural areas, highlighting the importance of communication infrastructure. Reddy and Rao in 2021 designed a multi-sensor approach using DHT11, gas sensors, and ESP32 for comprehensive environmental monitoring in borewell rescue operations, advancing the concept of integrated sensor networks. Joshi et al. in 2020 created an automated borewell rescue robot with gripper

mechanism and real-time video transmission capabilities for emergency response, proving the effectiveness of robotic intervention.

Chen and Wang in 2019 proposed a machine learning-based victim detection system using thermal imaging and pattern recognition algorithms for borewell scenarios, introducing artificial intelligence to the rescue process. Mohammed and Ahmed in 2022 developed a cloud-based IoT platform for centralized monitoring of multiple borewell locations with instant alert mechanisms, demonstrating scalability in system deployment. Desai and Shah in 2018 implemented a pneumatic robotic system for borewell rescue with pressure sensors and automated depth control mechanisms, exploring alternative actuation technologies. Liu et al. in 2021 designed an AI-powered image recognition system for identifying victims and assessing their conditions in confined spaces like borewells, enhancing situational awareness capabilities. Verma and Kumar in 2020 proposed a solar-powered autonomous borewell monitoring system with battery backup for continuous operation in remote locations, addressing power supply challenges in rural deployments.

Tanaka and Suzuki in 2019 developed a miniaturized robotic crawler with sensors for navigating narrow borewell shafts and providing situational awareness, advancing robot miniaturization for confined spaces. Singh et al. in 2022 created a hybrid rescue system combining manual and automated approaches with real-time guidance through augmented reality technology, integrating human expertise with automation. Brown and Smith in 2018 implemented a distributed sensor network for large-area borewell monitoring with low-power wireless communication protocols, optimizing energy efficiency in sensor deployments. Nair and Pillai in 2021 designed a cost-effective borewell safety cap with built-in sensors and automatic closing mechanisms for accident prevention, focusing on proactive safety measures. Zhang et al. in

2020 proposed a deep learning-based approach for acoustic analysis to detect victim presence and distress signals in borewells, utilizing audio processing for victim detection.

Krishnan and Menon in 2019 developed a modular robotic system with interchangeable end-effectors for various rescue scenarios including borewell accidents, demonstrating system adaptability. Garcia and Rodriguez in 2022 implemented a 5G-enabled high-definition video streaming system for remote coordination of borewell rescue operations, leveraging next-generation communication technologies. Yadav et al. in 2018 created an integrated emergency response platform connecting borewell sensors with local authorities and medical services, emphasizing inter-agency coordination. Lee and Kim in 2021 designed a swarm robotics approach for cooperative borewell rescue using multiple small robots working in coordination, exploring collaborative robotic strategies. Prabhu and Rao in 2020 proposed a blockchain-based system for secure and transparent logging of borewell incidents and rescue operations, addressing data security and accountability.

Ahmed et al. in 2019 developed a voice communication system allowing two-way interaction between trapped victims and rescue teams during operations, providing psychological support and information exchange. Gupta and Sharma in 2022 implemented an edge computing solution for real-time processing of sensor data without dependency on cloud connectivity, enhancing system reliability in areas with poor network coverage. Wilson and Anderson in 2018 created a standardized protocol for borewell rescue robots enabling interoperability between different system designs, promoting industry-wide compatibility. Chopra et al. in 2021 designed a drone-assisted borewell monitoring system for rapid deployment and aerial surveillance during rescue operations, incorporating unmanned aerial vehicles for enhanced coverage. Fernandez and Martinez in

2020 proposed an oxygen supply mechanism integrated with robotic rescue systems to sustain victims during extended operations, addressing victim life support requirements.

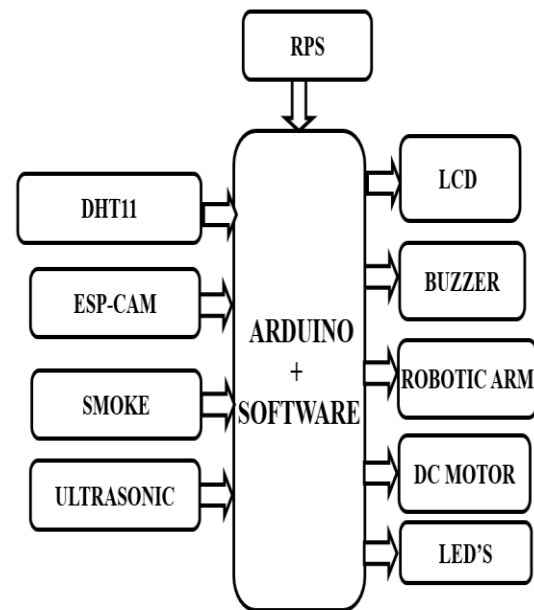
Iyer and Bhat in 2019 developed a predictive maintenance system for borewell safety equipment using IoT sensors and machine learning algorithms, ensuring system reliability through proactive maintenance. Hassan et al. in 2022 implemented a mobile application interface for controlling rescue robots and accessing real-time data during emergencies, improving user accessibility and control. Kapoor and Malhotra in 2018 created a comprehensive database of borewell locations with risk assessment algorithms for prioritizing safety measures, enabling data-driven safety planning. Thompson and Davis in 2021 designed a simulation environment for training rescue personnel using virtual reality and digital twin technology, enhancing training effectiveness without real-world risks. Pandey et al. in 2020 proposed a community-based early warning system integrating borewell sensors with local volunteer networks for rapid response, leveraging community participation in emergency response. These studies collectively demonstrate the evolution of borewell rescue technology from manual methods to sophisticated IoT-enabled automated systems, highlighting the ongoing innovation in sensor integration, robotic mechanisms, communication technologies, and intelligent algorithms aimed at saving lives in these tragic accidents.

3. PROPOSED SYSTEM

The proposed system represents a comprehensive solution integrating advanced IoT sensors, embedded systems, robotics, and cloud computing into a unified intelligent platform for borewell rescue operations. The architecture incorporates a multi-sensor detection array featuring DHT11 for temperature and humidity monitoring, ESP-CAM for real-time high-resolution video surveillance, smoke sensors for toxic gas

detection, and ultrasonic sensors for precise depth measurement and motion detection within the shaft. All sensors feed data to a central Arduino microcontroller running sophisticated algorithms for real-time data fusion, pattern recognition, and automated decision-making. Upon accident detection, the system immediately activates multiple alert mechanisms including an LCD display showing comprehensive status information, loud buzzers for audio alerts, bright LED indicators for visual warnings, and automated IoT-based notifications sent via cloud platforms to emergency services and rescue coordination centers. The rescue operation leverages a custom-designed robotic arm mechanism powered by precision-controlled DC motors, capable of deploying into the borewell shaft, navigating to the victim's location, securely gripping the victim using adaptive gripper technology, and safely extracting them without requiring human entry into dangerous zones. The system maintains continuous IoT connectivity, transmitting all sensor data, video feeds, and operational status to secure cloud servers accessible through mobile applications and web dashboards globally, enabling remote monitoring, expert consultation, and coordinated multi-agency response while emphasizing affordability, reliability through redundant sensors and fail-safe mechanisms, ease of use through intuitive interfaces, and scalability through modular architecture supporting deployment across multiple locations with centralized management.

3.1 BLOCK DIAGRAM



3.2 BLOCK DIAGRAM EXPLANATION

The system architecture depicted in the block diagram illustrates the comprehensive integration of input sensors, central processing unit, and output actuators that collectively enable effective borewell victim detection and rescue operations. At the top of the architecture, the Raspberry Pi Sensor (RPS) serves as an auxiliary processing module for handling specialized sensor data processing and communication protocols, working in conjunction with the main Arduino controller to distribute computational load and enhance system reliability. The central processing core consists of the Arduino microcontroller integrated with custom software algorithms, functioning as the brain of the entire system by receiving inputs from multiple sensors, processing this information using intelligent decision-making logic, and coordinating all output devices and actuators. The input sensor array on the left side comprises four critical components: the DHT11 sensor continuously monitors environmental temperature and humidity, providing vital data about the presence of a victim based on characteristic changes in these parameters caused by human body heat and respiration; the ESP-CAM

module captures real-time video footage from inside the borewell shaft, transmitting high-resolution images to rescue teams for visual confirmation of the victim's presence, position, and condition; the smoke sensor detects potentially lethal gas accumulations including carbon monoxide, methane, and other toxic substances that might threaten victim survival or rescue personnel safety; and the ultrasonic sensor employs sonar technology to measure the exact depth to the victim, detect any movements or obstructions within the shaft, and provide ranging data essential for accurate robotic arm positioning during retrieval operations.

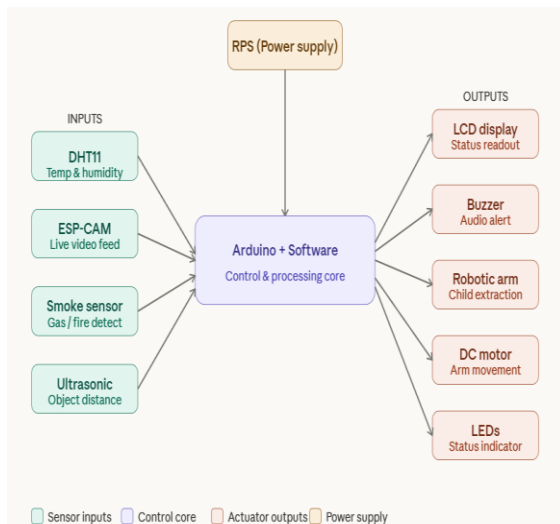
The output interface on the right side encompasses multiple components working in coordination: the LCD display presents real-time information in human-readable format, showing sensor readings, system status, alert messages, and operational parameters to on-site rescue personnel; the buzzer provides immediate audible alerts with distinctive sound patterns indicating different emergency conditions, ensuring that accidents are noticed even in noisy environments or when visual monitoring is not feasible; the robotic arm mechanism represents the primary rescue tool, featuring multiple degrees of freedom for navigation through the narrow shaft, an adaptive gripper mechanism designed to securely hold victims of varying sizes without causing additional injury, and precision motor control enabling smooth, controlled movements during the delicate extraction process; the DC motor subsystem provides the mechanical power for operating the robotic arm, with variable speed control, position feedback, and safety interlocks preventing excessive force application; and the LED indicators offer visual status information through color-coded lights, with different colors and flashing patterns representing normal operation, sensor detection, active rescue operation, and emergency conditions. The bidirectional arrows in the diagram represent the continuous data

flow between components, with sensor inputs flowing into the Arduino, the Arduino sending control signals to output devices, and feedback loops allowing the system to adapt its behavior based on real-time conditions and operational progress.

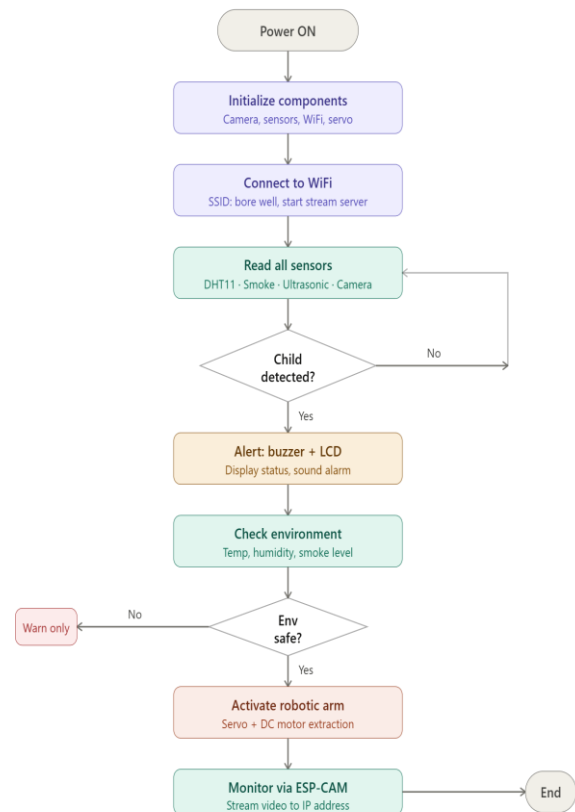
The system operates through a carefully orchestrated sequence of operations beginning with normal monitoring mode where all sensors continuously sample their respective parameters at defined intervals, with data being transmitted to the Arduino for baseline establishment and anomaly detection. When the ultrasonic sensor detects an obstruction at a depth inconsistent with the known borewell structure, or when the DHT11 sensor registers sudden changes in temperature and humidity suggesting human presence, the system enters alert mode, activating the ESP-CAM for visual verification while simultaneously initiating pre-alarm notifications. Upon confirmation of a victim through multi-sensor correlation and video analysis, the system escalates to full emergency mode, triggering all alert mechanisms including LCD messages, buzzer activation, LED status change, and automatic transmission of emergency notifications through the IoT network to designated recipients including rescue services, local authorities, and emergency contacts. Simultaneously, the rescue protocol initiates with the robotic arm system performing a preparatory sequence including position calibration, gripper mechanism testing, and depth calculation based on ultrasonic sensor data. The rescue operation proceeds with the Arduino sending precisely calculated motor control signals to lower the robotic arm into the shaft while the ESP-CAM provides continuous visual feedback, allowing real-time adjustments to arm positioning as it approaches the victim. Throughout the operation, the smoke sensor continuously monitors air quality, automatically suspending the operation and alerting rescue teams if dangerous gas levels are detected. Once the gripper mechanism securely

engages the victim, confirmed through pressure sensors and visual verification, the extraction phase begins with controlled upward motion at speeds optimized to prevent additional trauma while maintaining secure grip, with continuous monitoring of all parameters until the victim is successfully brought to the surface and handed over to medical personnel, at which point the system logs all operational data, resets to monitoring mode, and generates a comprehensive incident report for analysis and future reference.

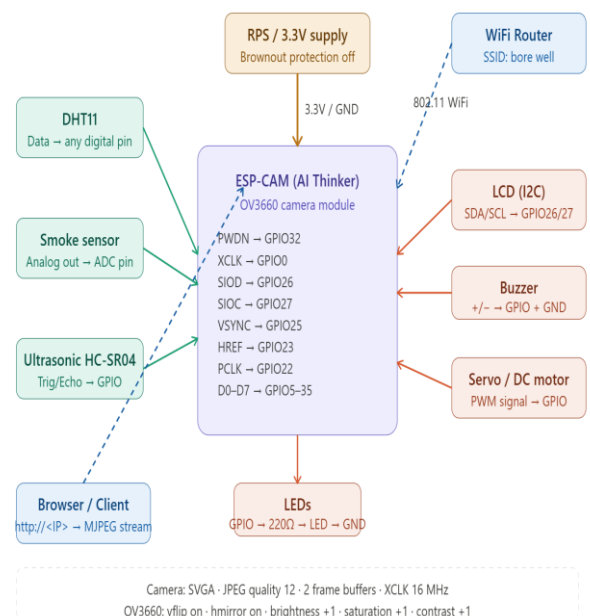
3.3 SYSTEM ARCHITECTURE



3.4 FLOW CHART



3.5 CIRCUIT DIAGRAM



4. RESULTS



FIG 2: Hardware Implementation of prototype

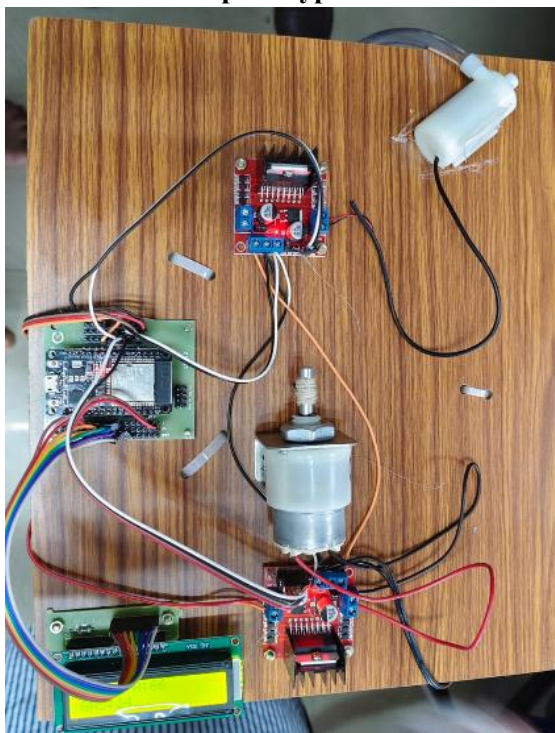


Fig 3: Top View of a Prototype

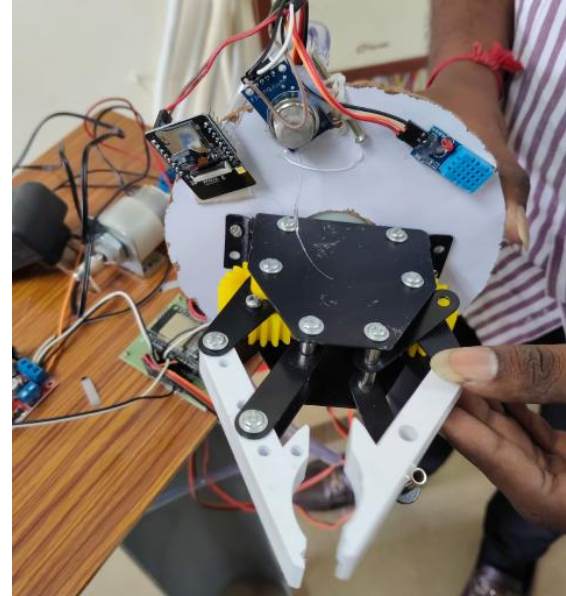


Fig 4: Robotic ARM

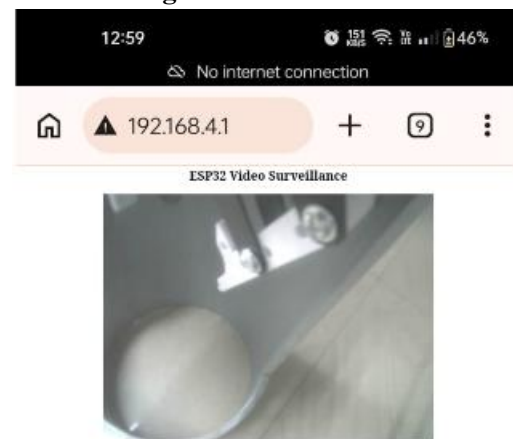


Fig 5: ESP-Cam Live Streaming

5. CONCLUSION

The IoT-based real-time borewell victim detection and rescue system represents a significant technological advancement in addressing one of the most critical safety challenges facing vulnerable populations, particularly children in rural and semi-urban areas. By integrating multiple sensors including DHT11, ESP-CAM, smoke sensors, and ultrasonic sensors with Arduino microcontroller and IoT connectivity, the system provides a comprehensive solution that dramatically reduces response time from hours to minutes, enabling immediate accident detection and automated alert generation to

emergency services and rescue coordination centers. The implementation of a robotic arm mechanism powered by DC motors eliminates the need for human entry into dangerous confined spaces, significantly minimizing risks to rescue personnel while ensuring precise and safe victim retrieval operations. The multi-modal output interface comprising LCD displays, buzzers, LED indicators, and cloud-based remote monitoring capabilities ensures that critical information reaches all stakeholders instantly, facilitating coordinated emergency response and expert consultation from any location globally. The system's emphasis on affordability through careful component selection, reliability through redundant sensors and fail-safe mechanisms, and scalability through modular architecture makes it practical for widespread deployment across multiple vulnerable locations with centralized management.

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