Journal for Educators, Teachers and Trainers
The PROFESIOLab electronic, peer-reviewed, open-access Magazine

ISSN 1989-9572

DOI: 10.47750/jett.2023.14.04.34

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Journal for Educators, Teachers and Trainers, Vol. 14 (4)

https://jett.labosfor.com/

Date of reception: 15 June 2023
Date of revision: 04 July 2023
Date of acceptance: 05 Aug 2023

Dr. P Rama Koteswara Rao1, M Suneel1, Dr I V Prakash1 (2023). AI-Powered Smart Borewell Rescue Bot: Rapid Underground Saver. Journal for Educators, Teachers and Trainers, Vol. 14(4)406-421

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AI-Powered Smart Borewell Rescue Bot: Rapid Underground Saver

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ABSTRACT

Our borewell rescue robot is designed to enhance the efficiency and safety of rescue operations in deep, narrow borewells where human access is limited or unsafe. Equipped with an ESP32 microcontroller, powerful DC motors, a camera module, and a mechanical gripper, the robot is built to navigate tight spaces and perform precise rescue operations. By integrating advanced technology, it minimizes risks and reduces the time required for manual efforts. The robot's camera module provides a live video feed, enabling rescuers to assess the situation remotely while allowing experts to guide the operation in real-time. This collected data plays a crucial role in making informed decisions during rescues. Beyond emergencies, the robot's multifunctional design also makes it suitable for geological exploration and other confined-space applications. Its adaptability, coupled with cutting-edge technology, ensures it remains a reliable and effective solution for borewell rescues, mitigating risks while expediting the rescue process.

Keywords: Time Efficiency, Borewell Rescue Robot, DC Motors, Robust Design, ESP32 Microcontroller

1.INTRODUCTION

Lately, more kids are accidentally falling into big holes in the ground called bore wells, especially in rural parts of India. This happens because the holes in villages are larger compared to the ones in cities, which makes them riskier. People in villages dig these holes to get water from the ground when regular wells don't work well due to not enough water, using up too much, or not filling up properly. These holes, known as bore wells, go really deep into the ground to find water. Sometimes, when these holes don't have water, the people who dug them leave them without closing them up properly, making them dangerous, especially for kids. These abandoned bore wells can be deeper than 300 feet, and over time, the insides might collapse. When a child accidentally falls into such a hole, it's hard to figure out where exactly they are because it's dark and deep. The usual ways of rescuing them involve drilling new holes nearby and using complex tools. But now, there's a simple solution. A rescue tool with a strong light and a sensor to measure distances is sent down into the hole using a pulley. The child gets oxygen so they can breathe during the rescue. Once the child is found, a special arm temporarily holds their head, and a plate guided by the tool's camera locates the space around the child. A cable is then carefully passed through this space, and an airbag is inflated under the child, stopping them from going down any further. This clever method reduces the chance of the child getting hurt during the rescue. The whole system is pulled up with the pulley, making sure the rescue is safe and successful. This way of rescuing kids from bore wells is a practical answer to the complicated problems these incidents bring, using both smart tools and a careful plan to keep children safe. A smart rescue system is designed to help when kids fall into big holes in the ground. The system uses a bunch of toolsto make sure the rescue goes well.

Problem Statement

The problem statement revolves around the frequent incidents of children accidentally falling into uncovered bore wells, especially in rural parts of India. The key issues are outlined as follows:

1. **Borewell Design and Abandonment:**
    - Bore wells in villages are often larger in diameter compared to those in cities, making them more hazardous for children.
    - Lack of proper closure and abandonment of bore wells by drillers afterunsuccessful attempts or when water is not found pose serious risks.
2. **Groundwater Dependency and Exploration:**
    - Villagers heavily depend on groundwater, leading to the constant drilling of borewells to meet water needs for farming or domestic purposes.
    - Open wells, which are more accessible, are not always viable due to factors likeover-exploitation, less recharge, or seasonal variations in groundwater levels.
3. **Unattended and Collapsed Bore Wells:**
    - Abandoned bore wells, which can be deeper than 300 feet, may not be sealed properly, and over time, the insides may collapse.
    - Lack of monitoring or regular checks contributes to the potential dangers thesebore wells pose to unsuspecting children.
4. **Complexity in Traditional Rescue Methods:**
    - Conventional methods of rescuing children from bore wells involve drilling parallel holes and using geophysical tools.
    - These methods are complex, time-consuming, and may not be suitable for all situations, especially when the child is stuck at significant depths.
5. **Safety Concerns During Rescues:**
    - Traditional rescue methods may pose risks to both the child and the rescuers.
    - The dark and confined spaces within bore wells make it challenging to accurately assess the child's position, increasing the potential for injuries during rescue attempts.
6. **Need for Innovative and Safe Rescue Solutions:**
    - There is a pressing need for innovative and efficient rescue solutions that can quickly

and safely extricate children from bore wells.

- The development of a smart rescue system, combining technology and a careful plan, aims to address these challenges and provide a reliable and safe method for borewell rescues.

7. **Public Awareness and Preventive Measures:**

- Lack of public awareness and education regarding the dangers of uncovered bore wells.
- There is a need for initiatives to inform communities about the risks and preventive measures, such as proper closure of bore wells.

2.LITERATURE SURVEY

M. V. RAVI, NEHAL THAKUR, B. N. RACHANA 2020: Methods to keep child alive in a bore should take in to consideration the lack of oxygen, increased temperature and humidity, which produces hyperthermia. These problems are addressed with fresh air delivery or without delivery of oxygen. The remotely controlled robot will go down the borewell and perform the action. The rescue system is operated through PC using wireless camera and Bluetooth technology.

RAJARATNAM D.R.P, LAKSHMI RAJ TILAK R 2018: The Bore Well Rescue Robot is capable of moving inside the well and performs operations according to the user commands. The proposed model is designed to provide the child with two level of safety achieved by using robotic holding at the top and safety airbag at the bottom. The robot is operated by the human manually and monitor in computer. According to the observations made continuously using CCTV camera.

GIRDHARAN M 2016: It takes nearly 30 hours to dig the parallel pit, by that time the child would have died. There is possibility of injuries to the child inside the well. The mechanical system moves inside the uncontrolled bore well. Camera connected to pc to check the position of the child. Entire System is hooked with rope. This kind of system can release trapped baby from the bore well securely within lesser time.

MRS. V SARITHA, P. AISHWARYA 2022: Rescue of trapped child from bore well is very risky and difficult process when compared to the other accidents. It takes more than a day to save the child. Here, the child who is stuck inside the hole is to be saved by the clipper which pick and place the child with the help of remote controller. The clipper is left inside manually by the rope tied up at its hands. It also consists of camera which is affixed to the clipper whichis used for monitoring the child. By this camera we get the visuals of the child and their condition.

JAYA SUDHA M, SARAVANAN 2019: At present, the rescuing task is accomplished by the method for burrowing a parallel pit close to the bore well with the same depth of the child and makes a passage that interfaces with the two wells. It takes about 30 hours to burrow the new.well. The protection system is with the guide of setting an air sack at the base of the passage and recovers the child at the base of the passage and recovers the child at any rate of gripper disappointment.

MOINUDDIN SHAIK, BHARGAVA REDDY KAKU NURI 2021: In this project, a new method has been introduced for a practical, safe, time saving rescue with less manpower. Here the system utilizes the associated work of wireless technology with mechanical setup for the rescue. Various technically efficient gadgets are combined in the setup. To ensure the medical safety of the victim the system has been aided with oxygen supply and water sprinkler along with many sensors to detect temperature, heart beat and presence of gas.

SHIVAM BAJPAI, ABHINAV SINGH 2019 S: The rescue team tries to approach the victim from a parallel well that take about 20-60 hours to dig. This complicated process makes 70% of the rescue operations fail. The design of handling system is made in such a way that the baby/victim never gets hurt and the robot itself provides some pretreatment to make the baby survive.

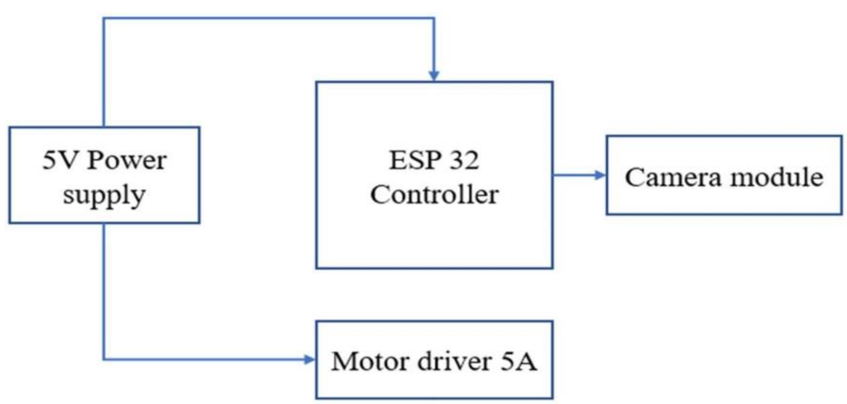
LAWRENCE DANIELA VINO LEE R 2017: To assist in such rescue operations, we tend to propose a robotic system capable of moving underneath the bore well supported with user commands equipped with a robotic arm, high power LED, high-resolution camera, and sensors like ultrasonic, temperature and gas sensor. The device system is interfaced with the at mega 328 controllers. Robotic arm is designed uniquely where it operates with 4-point gripping system in which each pair is controlled separately in order to increase the precision of the grip.

S. GOPINATH, T. DEVIKA 2015: The sensor systems are interfaced with the ARM8 processor. A camera along with an LED light is used to visualize the victim as well as it helpsto operate the system by control unit. The vacuum cup is used to adjust the child position. The arm movement of the robot is controlled by stepper motor. Once child is perfectly picked by robot, BLDC motor is used to lift up the child from borewell.

3. PROPOSED SYSTEM

3.1Working operation

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.



(a)

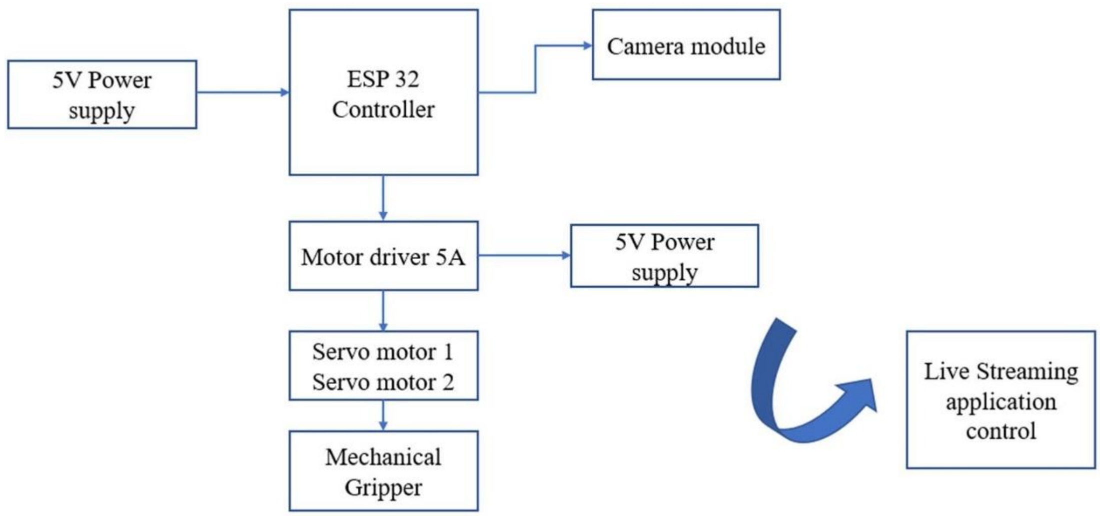


Figure 1: Block diagram of proposed borewell rescue robot. (a) external hardware. (b) internal hardware.

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 designed to navigate through narrow and confined spaces, such as borewells, using its compact and sturdy structure. High torqueDC motors are integrated into the robot to provide precise and powerful locomotion, enabling it to traverse challenging terrains. The ESP32 microcontroller acts as the control center, receiving input commands from the remote-control device and translating them into motor movements. The robot's movements are controlled based on the operator's commands, allowing it to navigate through the borewell while avoiding obstacles.

Step 2: Live Video Transmission: A camera module is attached to the robot chassis, capturing live video footage of the surrounding environment. The camera module is connected to the ESP32 microcontroller, which processes and transmits the video feed to the remote-control device. The live video transmission enables the rescue team to have real-time visual feedback of the borewell interior, helping them assess the situation and make informed decisions.

Step 3: ESP32 Microcontroller and Control System: The ESP32 microcontroller serves as the central control system for the robot, coordinating its various components and functionalities. It establishes a wireless communication protocol, such as Wi-Fi or Bluetooth, to enable real-time control and data transmission between the robot and the remote-control device. The microcontroller receives commands from the operator through the remote-control device and sends corresponding signals to the motor drivers, controlling the robot's movement. It also receives and processes the video feed from the camera module, ensuring its transmission to the remote-control device.

Step 4: Mechanical Gripper Integration: A mechanical gripper system is designed and implemented to facilitate the safe retrieval of individuals trapped in the borewell. The gripperis integrated onto the robot chassis and connected to the ESP32 microcontroller for control. When a trapped individual is located, the operator can remotely command the robot to position the gripper and securely grasp the person. The gripper's mechanism is designed to provide a firm and stable hold on the individual, enabling them to be lifted out of the borewell safely.

Hardware modules

- CNC laser cutting
- CNC metal bending
- High torque DC motors
- ESP 32 controller
- 10A motor driver
- Camera Module
- Power supply
- Borewell casing pipe
- 3D printed brackets, clamps and sloid parts

Software modules

1. Catia V5
    - Mechanical design
        - Parts design
    - Sketcher
    - Assembly design
    - Drafting
    - Generative sheet metal design
2. Arduino IDE

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. 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.

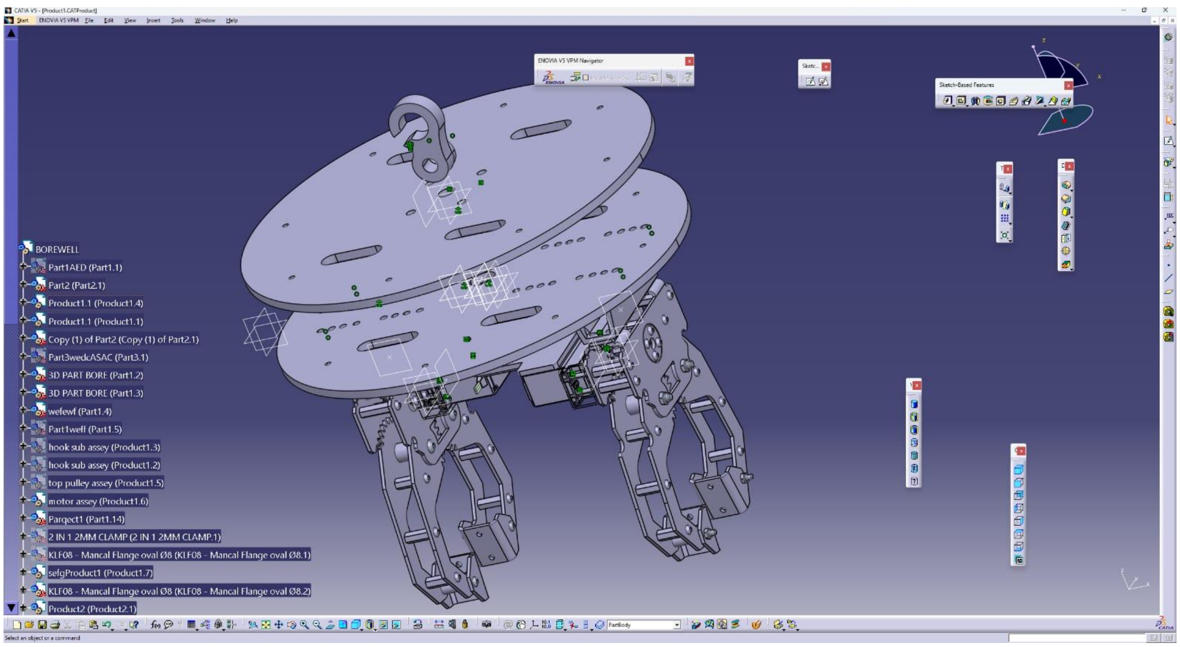
Connect the 5v power supply unit to the robot's electrical system, ensuring proper wiring and polarity. Implement any necessary voltage regulation or current limiting mechanisms to protect the components from power fluctuations or overloading. Test the power supply system, ensuring stable and reliable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

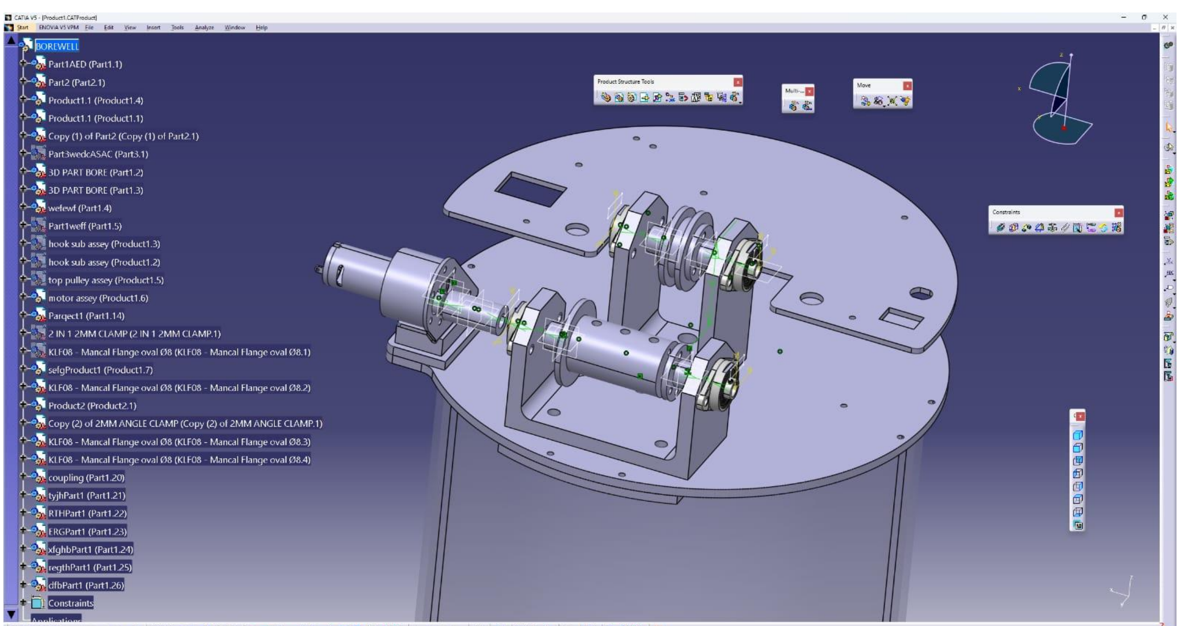
Cut the borewell casing pipe to the desired length, allowing it to fit through the borewell openings. Securely attach the robot structure, components, and modules onto the borewell casing pipe, ensuring structural stability and integrity. Test the overall assembly's robustness and stability, ensuring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

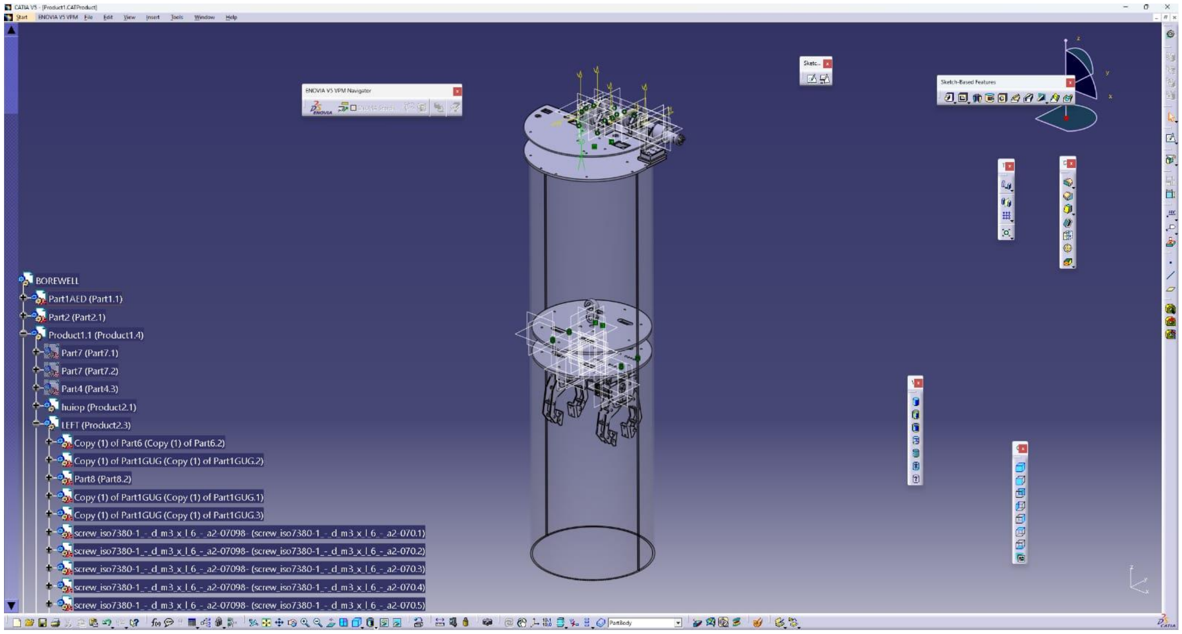
Prepare the 3D printer by loading the appropriate filament material and configuring the printing parameters. Initiate the printing process, allowing the 3D printer to produce the desired components layer by layer. After printing, remove the 3D printed components from the printer, ensuring their dimensional 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

3D-Modelling Design



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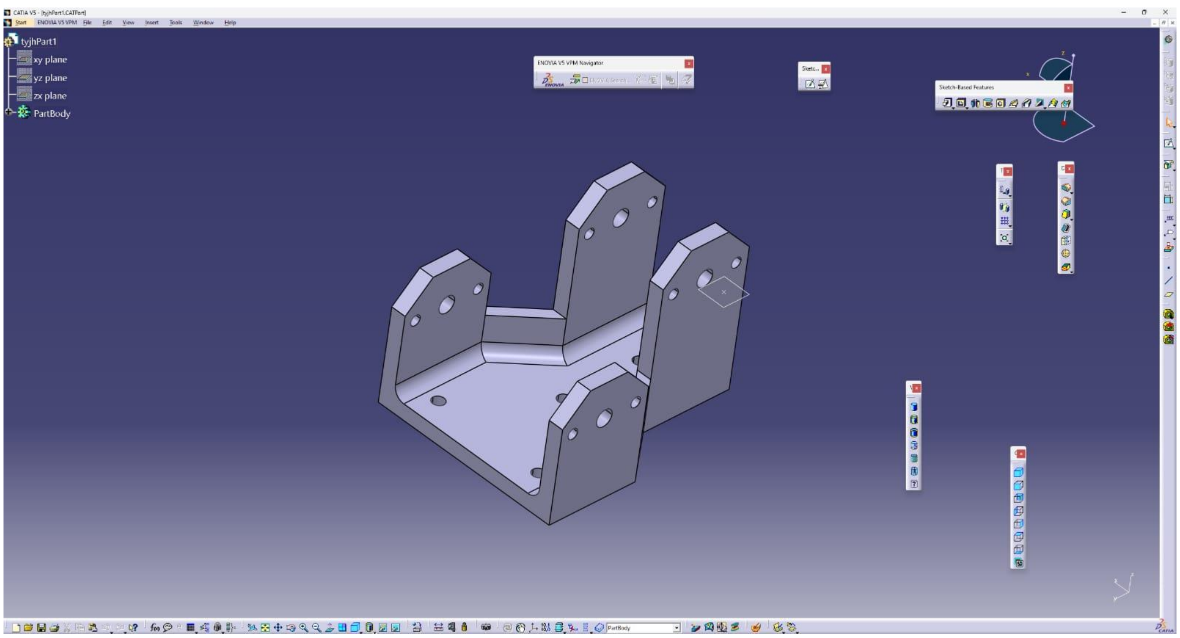
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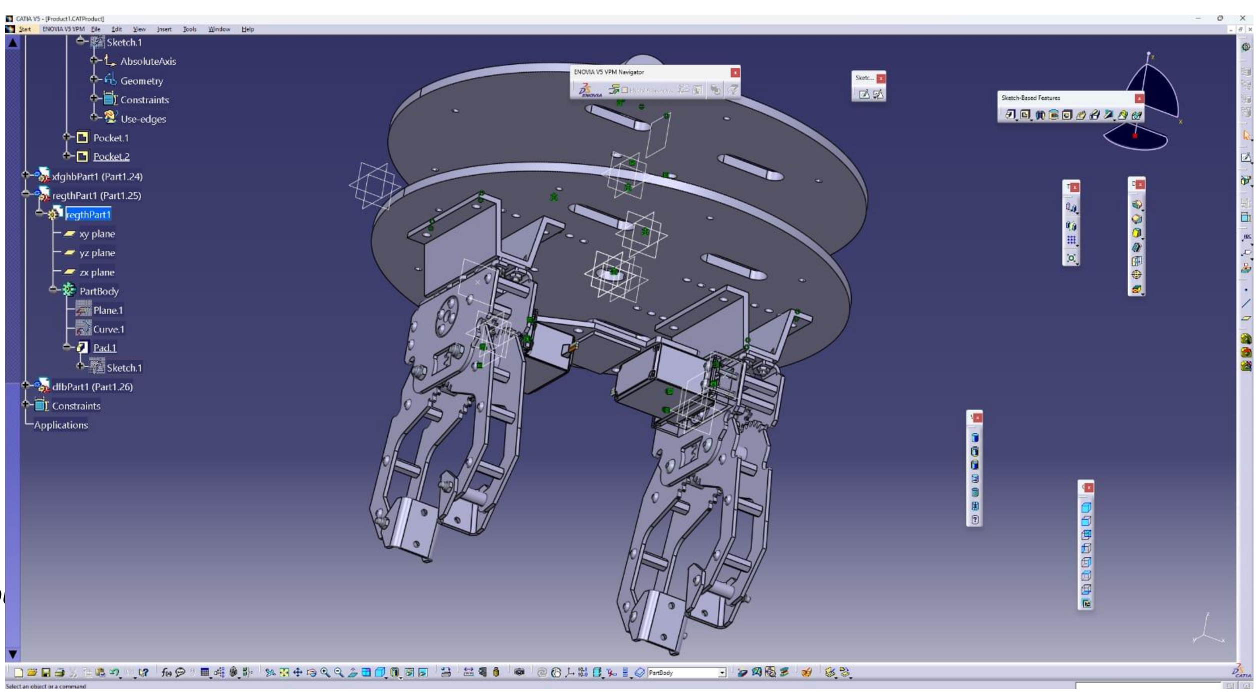
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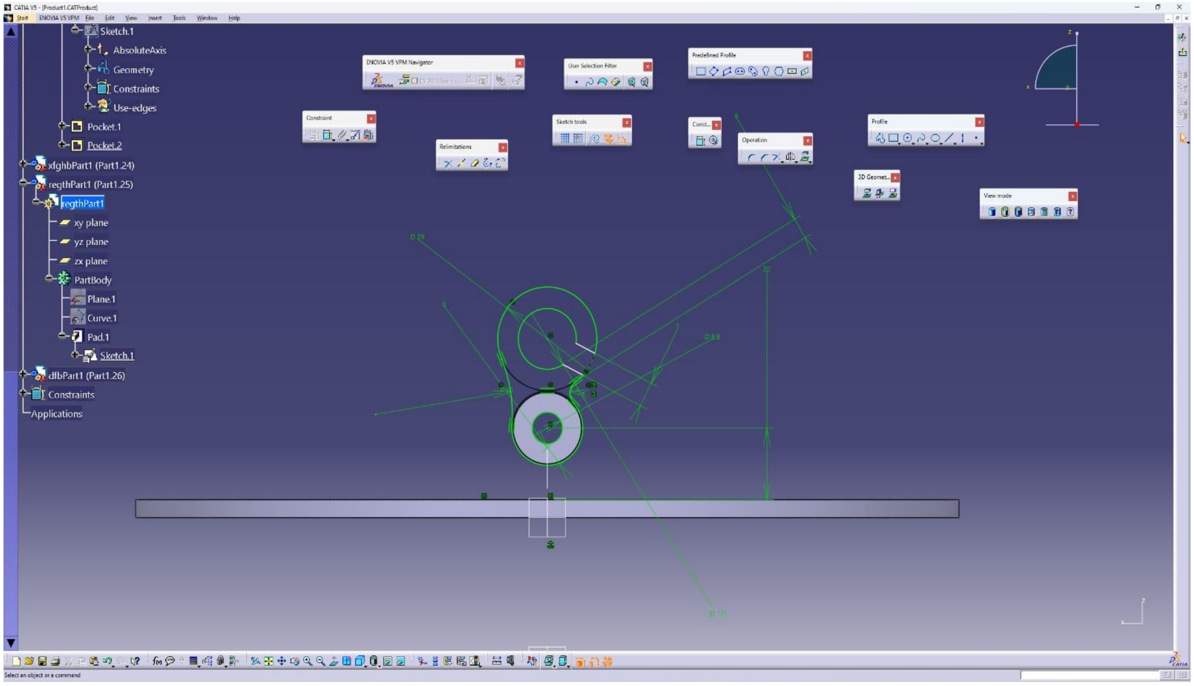
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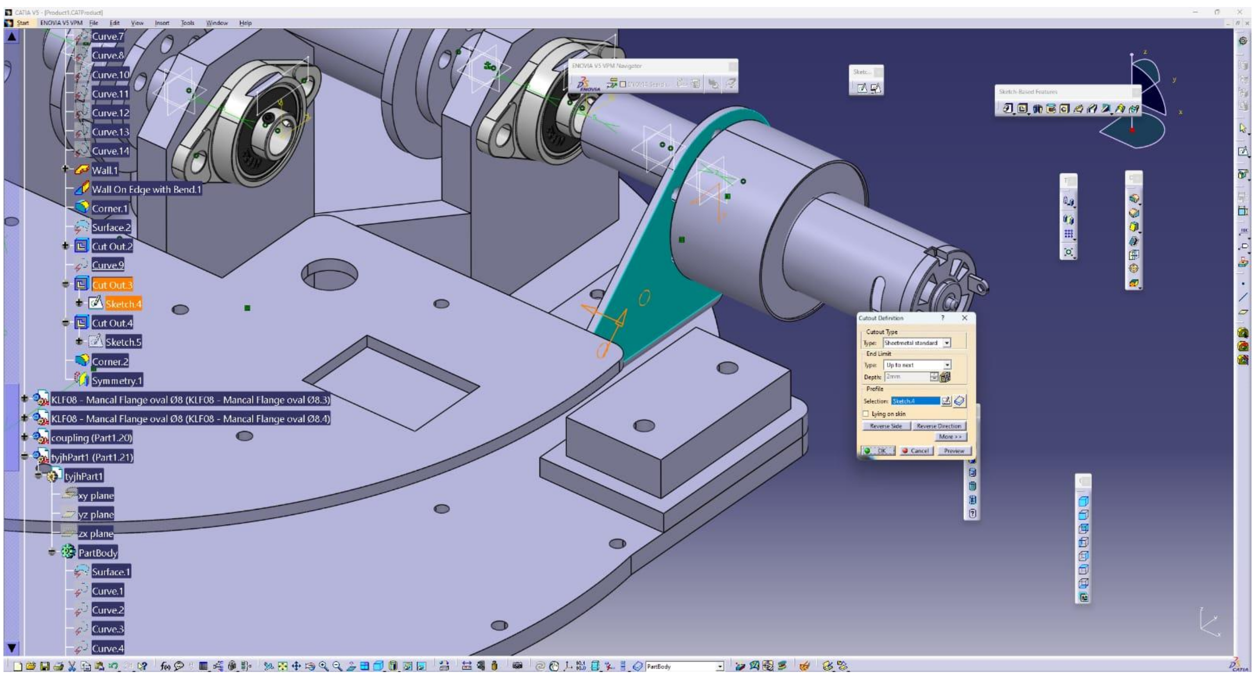
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Curve.12
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Curve.14
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Corner.1
Surface.2
Cut Out.2
Curve.9
Cut Out.3
Sketch.4
Cut Out.4
Sketch.5
Corner.2
Symmetry.1
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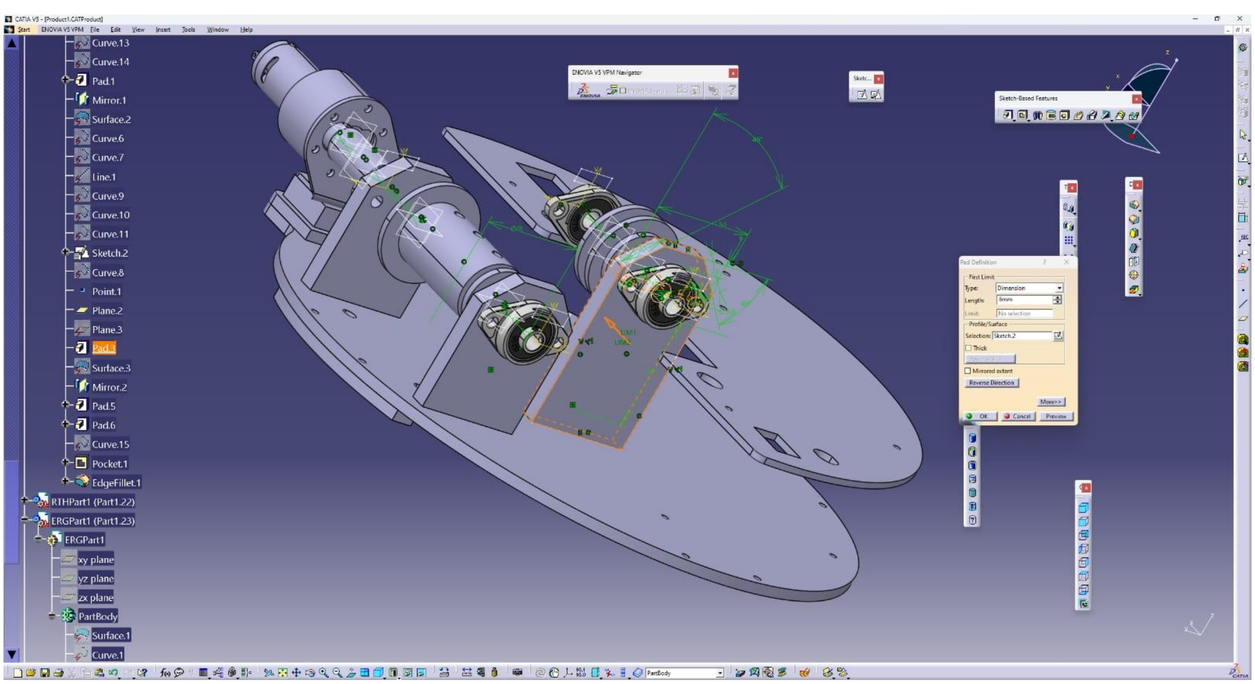
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Surface.2
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Curve.8
Point.1
Plane.2
Plane.3
Pad.2
Surface.3
Mirror.2
Pad.5
Pad.6
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Pocket.1
EdgeFillet.1
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Surface.1
Curve.1
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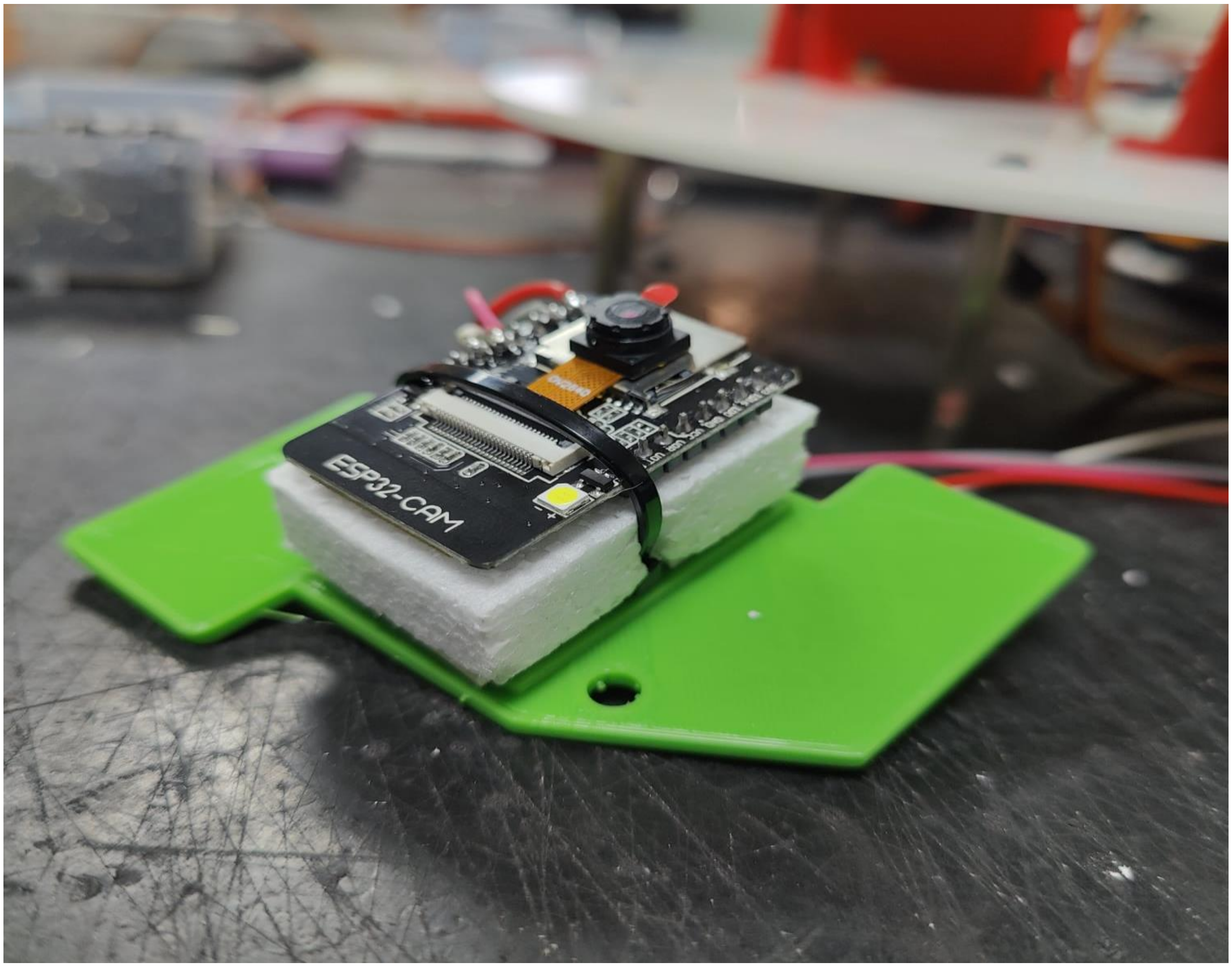
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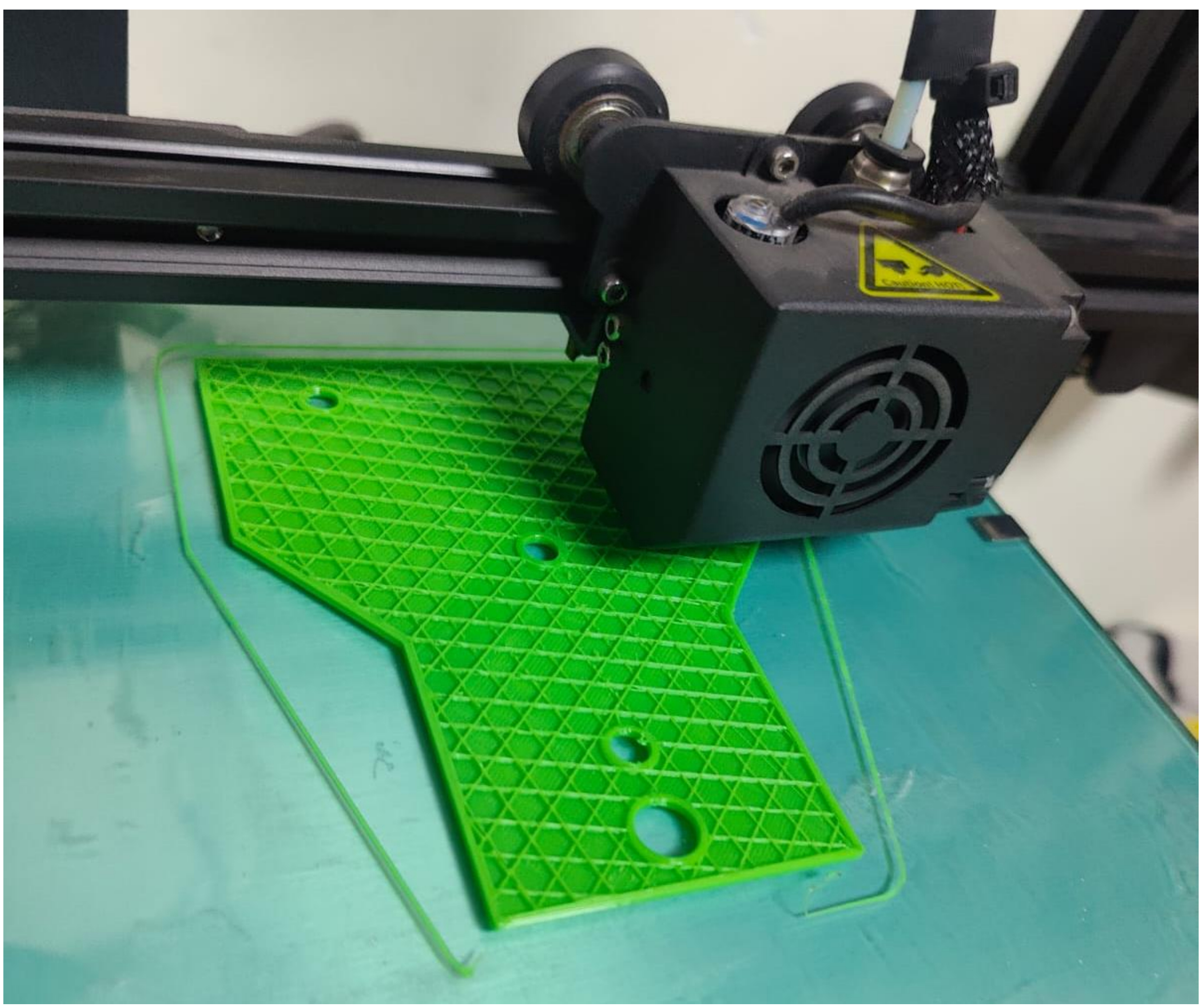

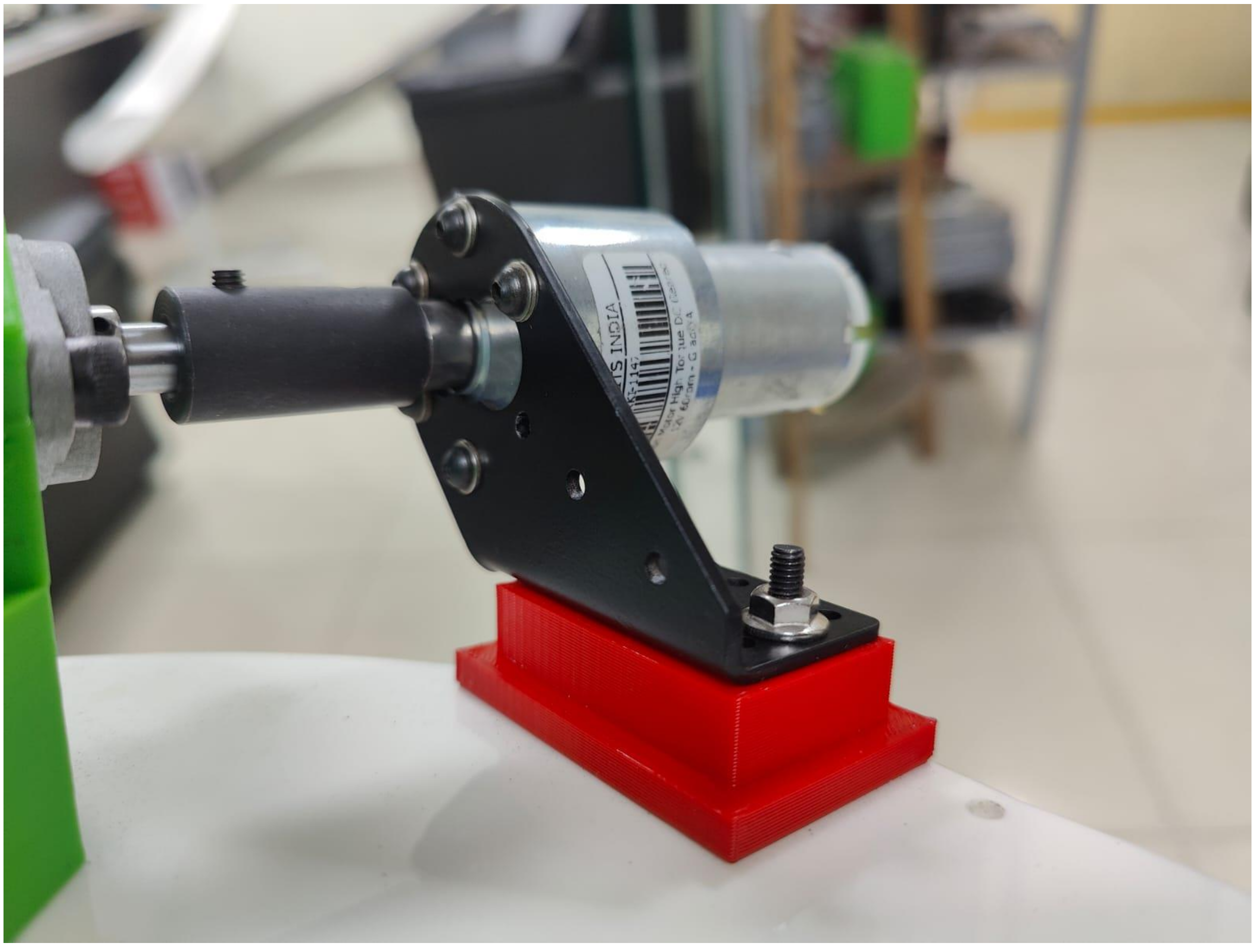

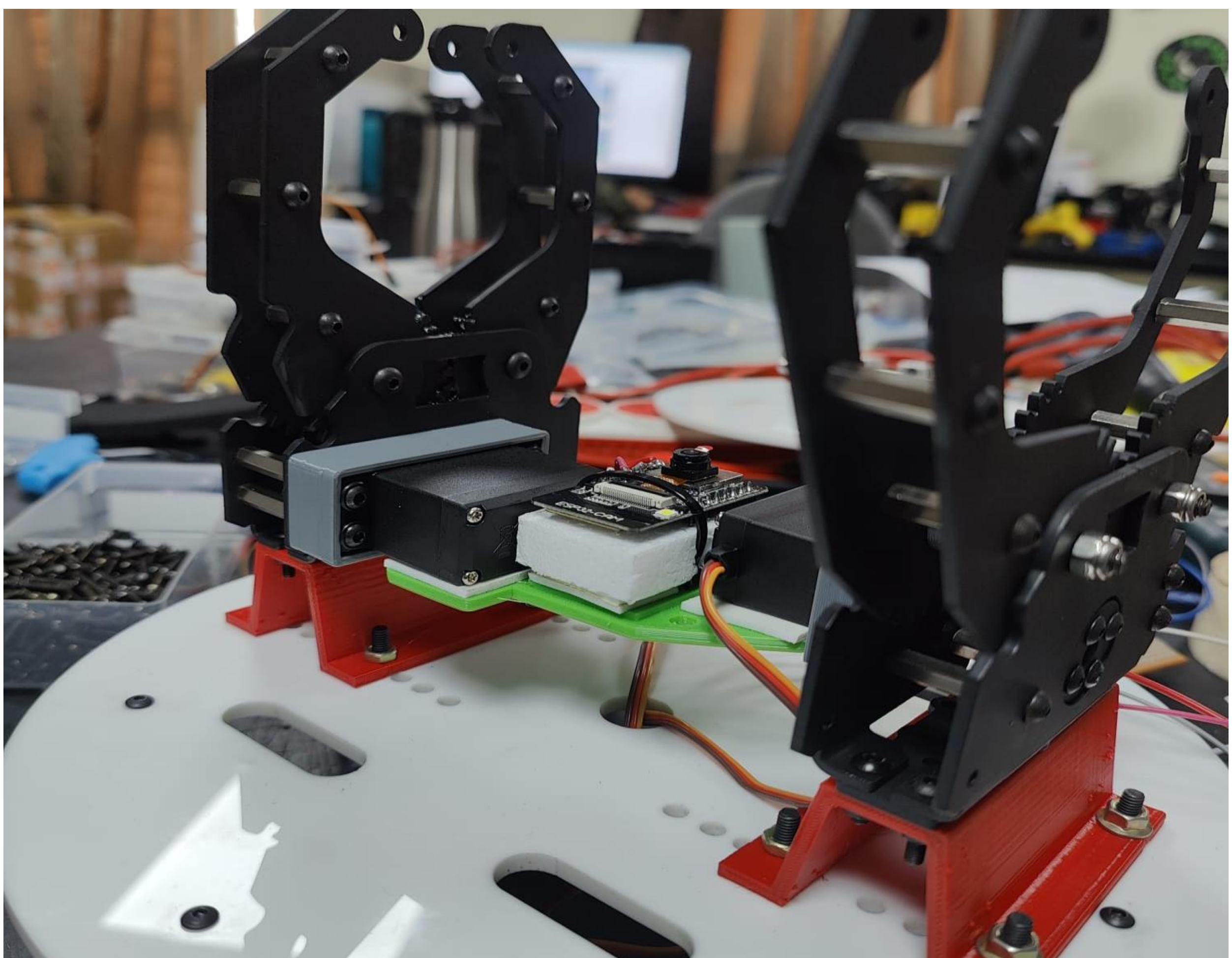

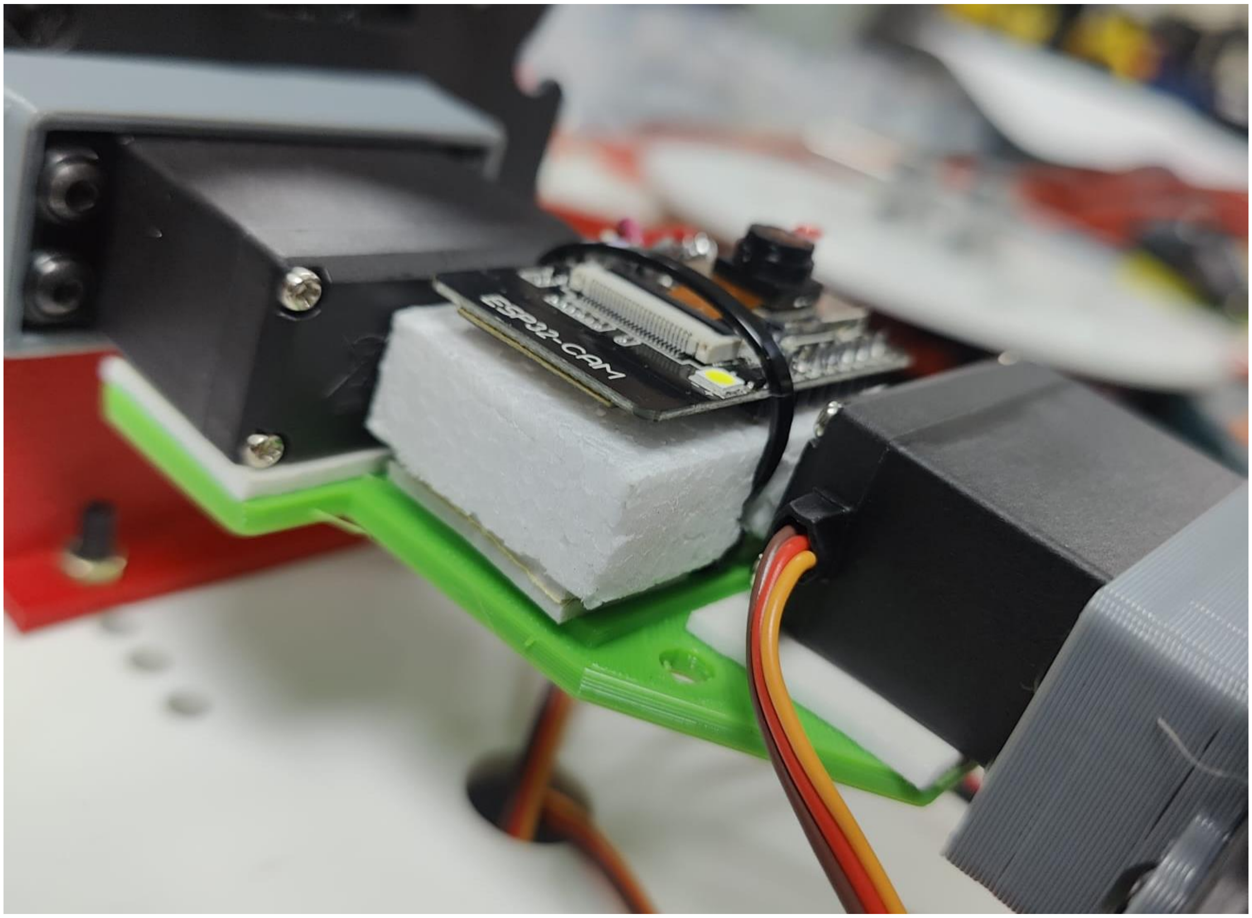
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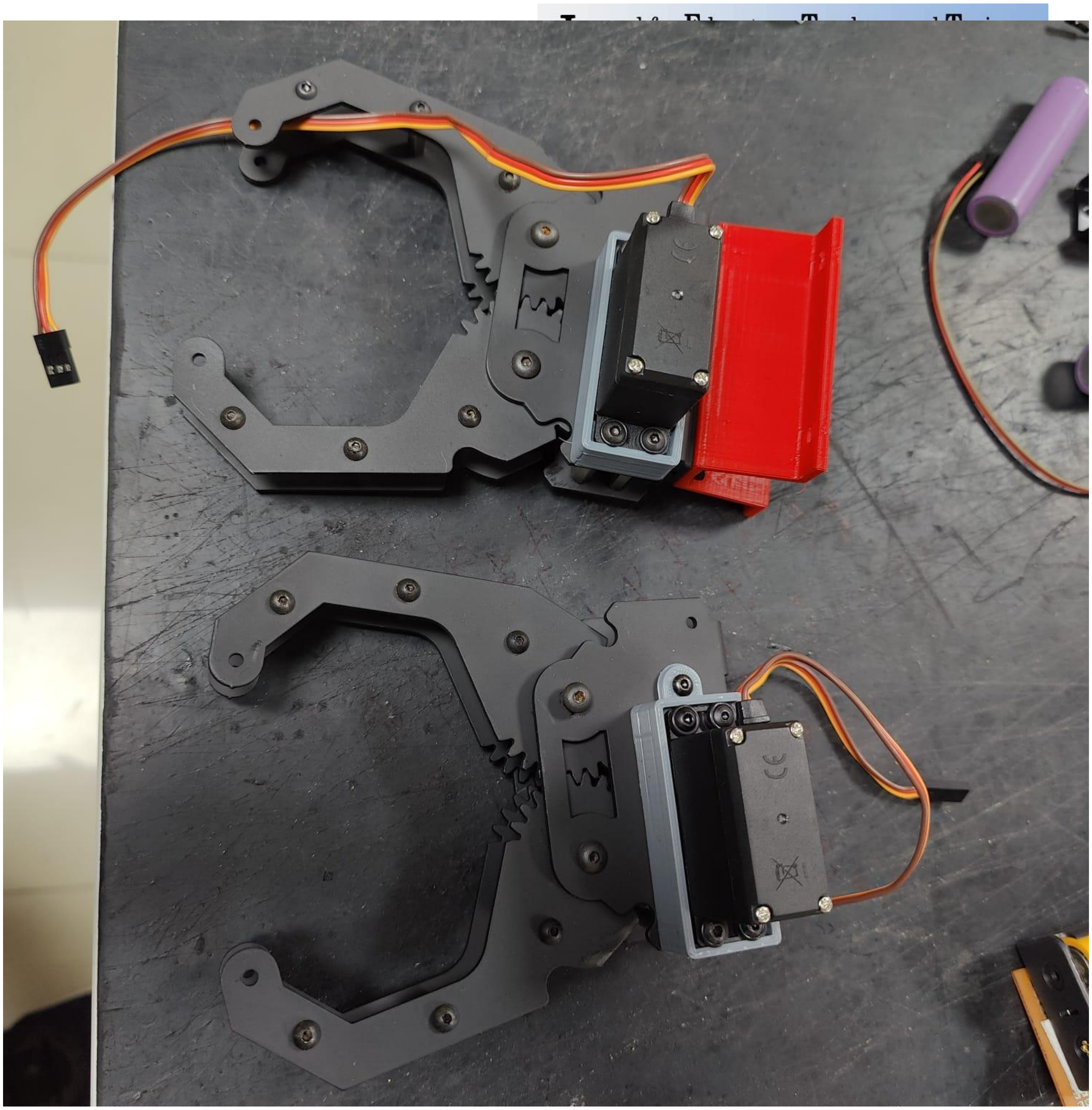

CONCLUSION

The development of a borewell rescue robot marks a significant advancement in addressing the challenges associated with rescuing individuals trapped in underground borewells. The robot, equipped with an ESP32 microcontroller, powerful DC motors, a camera module, and a mechanical gripper, serves as a specialized tool tailored for borewell environments. One of the critical motivations behind this project is the increasing incidence of accidents, particularly involving children, falling into abandoned borewells, which pose significant risks due to their depth and narrowness. Traditional rescue methods involving manual efforts and complex tools are often inefficient and time-consuming. The borewell rescue robot offers a solution by leveraging technology to enhance both the efficiency and safety of rescue operations. The robot's design focuses on maneuverability within tight spaces, crucial for navigating the confined environment of borewells. With its powerful DC motors, the robot can move effectively through the narrow passages of borewells, reaching individuals trapped at considerable depths. The integration of a camera module allows for live video feed transmission, enabling rescuers to assess the situation accurately and make informed decisions remotely. This feature is particularly valuable in scenarios where direct human access is limited or unsafe. Furthermore, the mechanical gripper enhances the robot's capabilities by enabling it to perform precise rescue operations, such as holding the individual's head temporarily and manipulating objects within the borewell environment. This versatility ensures that the robot can adapt to various rescue scenarios, providing a reliable and effective solution to borewell emergencies. The use of an ESP32 microcontroller facilitates seamless communication and control of the robot's functions, ensuring optimal performance during rescue operations. Additionally, the integration of WiFi connectivity enables remote monitoring and control, allowing rescuers to operate the robot from a safe distance while providing real-time assistance.

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