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INTELLIGENT DISASTER MANAGEMENT ROVER

Narasimha N M (2VX23LVS04)

Under The Guidance of

Dr. Meghana Kulkarni,
Chairperson, Dept. of ECE, VTU Belagavi

Under the Co - Guidance of

Ms. Aishwarya Payannavar,
Assistant Professor, Dept. of ECE, VTU Belagavi

MTech in VLSI Design and Embedded System
Department of Electronics & Communication Engineering
Visvesvaraya Technological University "Jnana Sangama", Belagavi– 590018

I. Abstract: An AI-powered robotic vehicle for disaster response specifically after earthquakes is being developed by this project using the Internet of Things. The Rover uses deep learning and image processing to identify people in collapsed areas and it shares live video and real-time GPS data via an Internet of Things dashboard. Its rocker-bogie mechanism and AI navigation allow it to maneuver through debris-filled terrain. It also delivers essentials like food and medicine and enables remote healthcare. This intelligent all-terrain rover reduces human risk increases situational awareness and speeds up rescue efforts through automation and real-time monitoring.

II. Introduction: Natural disasters and conflicts still affect communities around the world often striking without warning and leaving devastation in their wake. To ensure environmental preservation and public safety effective protocols must be established both before and after such incidents. Robots are currently used in hazardous inspections and security surveillance but their potential for disaster response is still untapped. When searching for survivors and assessing dangerous situations during emergencies like earthquakes gas leaks or bomb explosions rescuers frequently risk their lives. In these circumstances every second matters and quick decisions under extreme pressure are required. In this case mobile robots can be helpful. Through their ability to enter unstable structures find trapped victims and provide real-time updates they help firefighters and medical teams respond more swiftly and safely. Intelligent robotic systems are universally needed because disasters like floods in river belts cyclones in coastal areas or terrorist attacks in urban areas are not specific to any one place. AI-powered capabilities enable such robots to significantly reduce risks save lives and support rescue teams in the direct circumstances.

III. Problem Statement: Reaching victims of natural disasters like earthquakes floods or wildfires as soon as possible can mean the difference between life and death. Building a robotic vehicle that can drive through dangerous terrain recognize people in need and instantly communicate its location is the aim of this project. With features like GPS cameras and sophisticated sensors the rover is designed to go where human rescuers might consider it too risky. By combining AI and IoT technologies it aims to spe ed up rescue operations reduce risks and ultimately save more lives when every second matters.

IV. Objective of the project:

• To create a robotic vehicle that can be sent out on its own in disaster areas and that can look around to find and document people.
• To enable precise human identification by the robot in disaster-affected areas through the use of image processing and deep learning.
• To make IoT-based communication possible which will enable the rover to transmit the GPS location of victims it has identified straight to a control panel. In order to enable the robot to carry and drop necessities like food or medication, when necessary, a remote payload delivery system should be added.
• To develop an adjustable rocker-bogie chassis to ensure mobility over rough terrain and to create an Internet of Things (IoT)-enabled web application that shares real-time data from the robot making it accessible from anywhere in the world.

V. Literature Survey: Numerous studies have been conducted on robotic systems for disaster management concentrating on environmental monitoring wireless communication victim detection and autonomous navigation. The deployment of a low-cost low-power robotic system intended to direct rescue teams during emergency situations utilizing wireless sensor networks is covered in the paper by Raghad Dardar [1]. This study emphasizes how crucial affordability and energy efficiency are especially for large-scale or resource-constrained deployments. Albert W. Y. Ko along with Henry Y. K. Lau [2][3] offer several strategies for successful rescue operations with a focus on combining search dogs' acoustic sensors for victim detection and camera-mounted probes. Their research emphasizes the necessity of multi-modal systems that supplement conventional rescue techniques with robotic capabilities. The same is true of Trupti B. Bhondve [4] presents a robotic monitoring system that analyses human body conditions and transmits critical data for emergency response using a camera module and multiple sensor units. Ryuji Sugizaki and Tsuyoshi Suzuki [5] investigate a novel idea in which wireless sensor networks (WSNs) are autonomously deployed and restored using mobile robots. In post-disaster situations where infrastructure might be damaged or non-existent this is especially important. In addition, Kamol Chuengsatiansup [6] investigates a team-based strategy for rescue operations involving numerous robots outfitted with a variety of sensors such as CO_2 sensors digital compasses laser range finder's thermopile arrays and microphones. The ability of these robots to function in both autonomous and teleoperated modes allows for a variety of deployment options. A thorough analysis of collective intelligence and emergent behaviour in autonomous robotic swarms is given by D. Kurabayashi [7] who also highlights the potential of cooperative multi-agent systems to improve search effectiveness and coverage. Parallel to this Kuntze and Helge-Bjoern [8] talk about the initial results of the SENEKA project which is cantered on mobile robots' situation-responsive networking for dynamic disaster management.

VI. Working Principle:

Developing a tiny AI-powered rescue robot that can help with disaster relief and emergency response is the aim of this project. The robot which uses a rocker-bogie mechanism can maneuver through partially collapsed buildings and confined spaces that are too dangerous or difficult for human rescuers to reach. It can enter tight spaces thanks to its small size and ingenious design which also allows its onboard AI to process data from multiple sensors. By using its camera to detect human shapes and thermal signatures the robot can use deep learning to identify victims who are unconscious or injured even in low-visibility situations like smoke or darkness. By immediately recording the victims GPS location upon detection and transmitting it to the Internet of Things-based control center the robot assists rescue teams in responding quickly. The project methodology is strategically designed to support government agencies and rescue teams in disaster-affected areas by deploying an AI-enabled robotic vehicle that can navigate autonomously detect humans in real time and provide remote medical assistance. In addition to victim detection the robot uses AI-driven navigation and obstacle avoidance to safely traverse unpredictable environments. It also has health monitoring sensors that measure SpO_2 pulse and body temperature. Via the Internet of Things platform these sensors send the data to doctors allowing for quick remote diagnosis. A 360-degree surveillance system keeps an eye out for hazards like gas leaks fires and unstable buildings ensuring that teams are always aware of potential threats. All data including video feeds sensor readings alerts and diagnostics are transmitted to a web and mobile dashboard giving rescuers and medical personnel complete control over the robot from any location. By combining Internet of Things connectivity with deep learning AI navigation this intelligent self-governing robot can improve the effectiveness and security of disaster response operations while also saving lives.

Hardware Requirements:

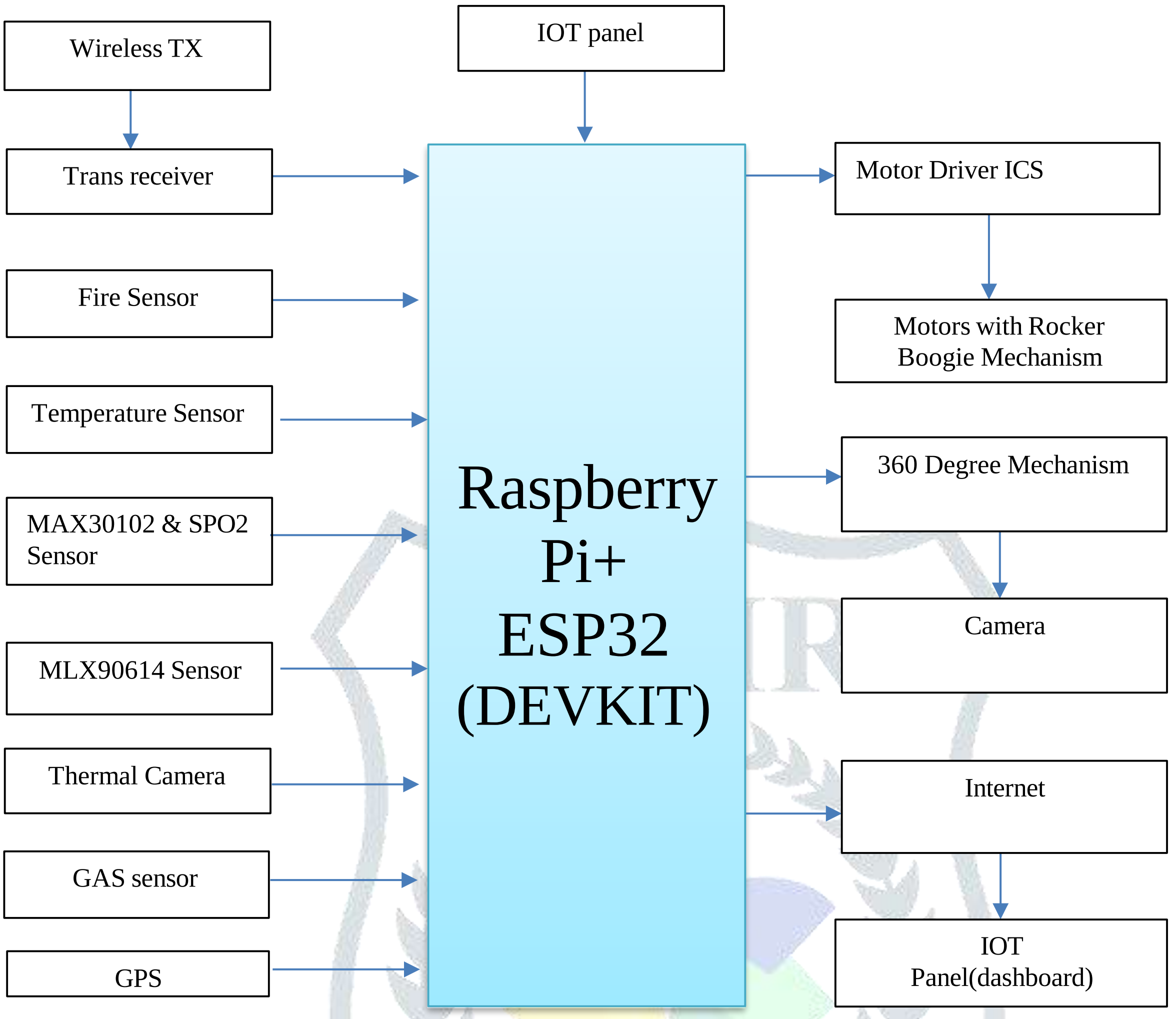
- Raspberry Pi
- ESP 32 Module
- Thermal Camera
- Temperature sensor
- UBLOX Neo 6m GPS module
- MAX30102 Pulse and SPO2 Sensor
- MLX90614 Sensor
- Wireless Trans receiver Modules
- Wireless Camera
- ERW Steel Pipes
- Wheels
- DC Gear Drives
- DC motor Driver
- Power Supply
- Joystick module
- Ultrasonic sensor
- Fire Sensor
- Buzzer
- LCD display

Software Requirements:

Programming Language: C++, Python

Development Tools: Arduino IDE
Python Thonny
Brackets IDE
PHP my Admin
WAMP Server

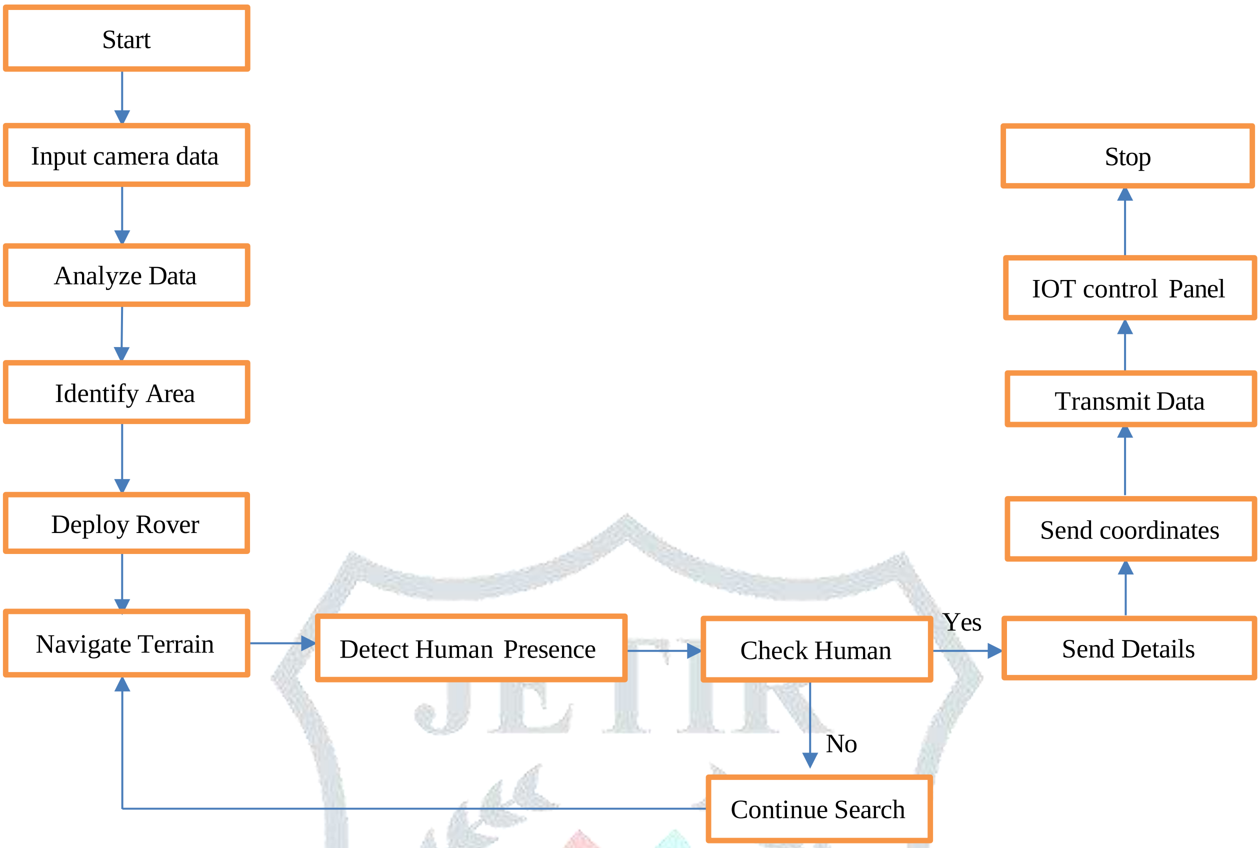
Block Diagram:



F(a)

The goal of this project is to create an Internet of Things-controlled rover that can identify people in emergency situations as the block diagram illustrates. Because the rover is small it can maneuver through tight spaces and get to places that might be challenging for human rescuers to reach. It has a wireless camera built in which allows operators to watch disaster areas in real time by sending live video to the control station. In order to notify rescue teams, the rover uses deep learning and image processing to detect human presence and record GPS coordinates. The rover and identified victims' precise real-time location updates are provided by the integrated GPS module. The IoT panel can be used to activate the rover which will then move independently throughout the area of interest while looking for people. It automatically stops when it detects a person and records their GPS coordinates for the rescue crew. It also has a payload delivery system that can deliver vital supplies such as food and medication to areas affected by disasters. From any location in the world search and rescue teams can remotely monitor and operate the rover thanks to an Internet of Things (IoT)-based control panel application that shows all of the data gathered. The rocker-bogie mechanism that the robot is built with allows it to move smoothly over both smooth and rough terrain. This block diagram demonstrates the integration of sensors processors and communication systems to operate the intelligent disaster management rover. The Raspberry Pi with ESP32 which serves as the systems main controller is at its core. It gathers information from a number of onboard sensors such as a thermal camera temperature sensor gas sensor fire sensor and health monitoring sensors (MAX30102 for pulse and SpO_2 and MLX90614 for body temperature). The precise location of the rover and any victims found is provided by a GPS module and remote communication is enabled by a wireless transceiver. After data is gathered it is processed and decisions are made by the Raspberry Pi + ESP32. For instance, it can record information and issue alerts in the event of a fire gas leak or human presence. In order for the rover to traverse uneven terrain it also regulates the motor driver ICs that supply power to the rocker-bogie wheels. While real-time video and sensor data transmission are made possible by the onboard internet connection full-area surveillance is provided by a 360° camera mechanism. The IoT panel also known as the dashboard receives all processed data at the end and allows rescue teams to track the rover's discoveries from any location in the world. They are able to effectively plan rescue operations by using this dashboard which provides them with GPS coordinates hazard alerts live video and victim health readings. The rover is a dependable disaster response tool because of its integration of sensors AI processing and IoT.

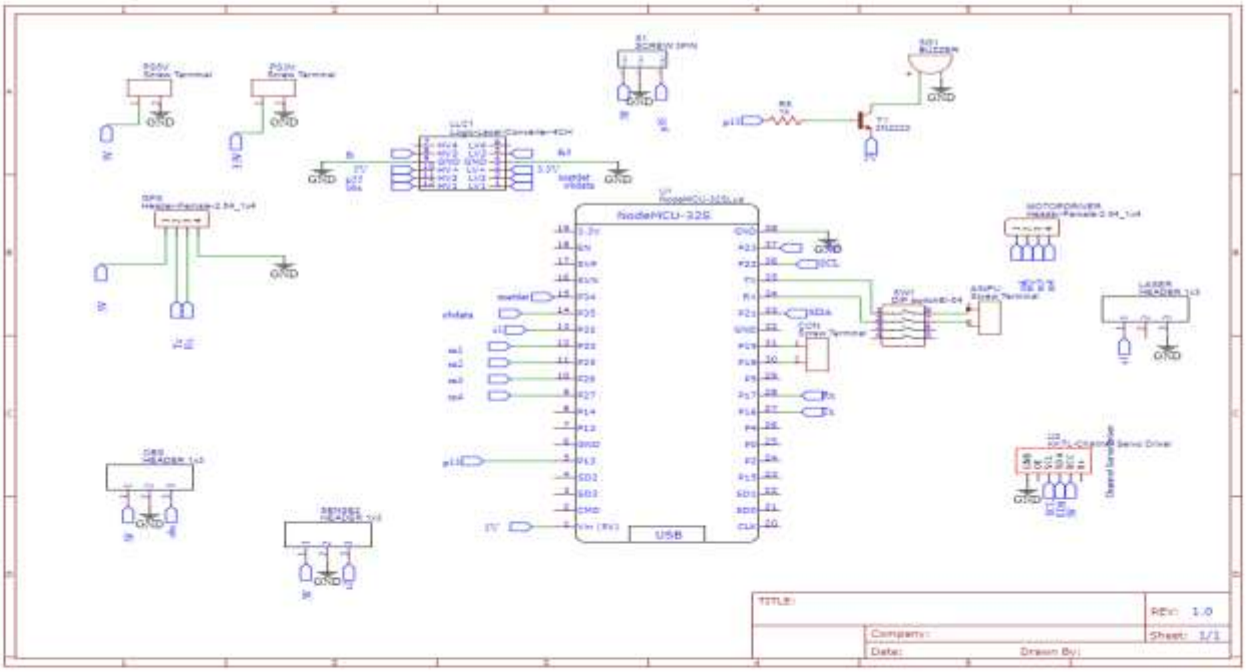
Flow Chart



F(b)

In the flow chart the intelligent disaster management rover's operation is explained. In order to determine potential locations where people might be trapped it first records live video from its onboard camera which is subsequently processed by AI. The rover is launched and starts using its sensors and rocker-bogie mechanism to navigate the terrain after identifying an area of interest. It can travel over uneven and rough terrain which makes it appropriate for disaster areas like rubble or buildings that have collapsed. The rover constantly searches its surroundings for signs of human habitation as it moves. The rover resumes its search if no one is discovered. The system confirms a person's status including whether they are conscious or unconscious when it detects their presence. Following confirmation, the rover logs information and gets it ready for transmission. By taking this step, false alerts are reduced and rescue teams are only given accurate information. Following verification of the information the rover records the victims GPS coordinates and sends the location and detection data to the IoT control panel. This data is then instantly available to rescue teams enabling them to make prompt decisions about what to do next. The rover is a dependable tool for enhancing the speed precision and safety of disaster response operations because the process does not stop until the mission is finished. Thermal and RGB cameras ultrasonic gas fire and biomedical modules are the first sensors to gather real-time data from the disaster environment before the Intelligent Disaster Management Rover starts operating. Using neural networks to analyse temperature pulse and SPO_2 data from the MAX30102 and MLX90614 sensors as well as deep learning models for victim detection the Raspberry Pi/Jetson Nano processes this data. Ultrasonic sensors enable autonomous navigation and SLAM-based mapping at the same time. The ESP32/Arduino controls low-level sensor inputs and motor control guaranteeing smooth rover movement. Rescue teams can monitor analyse and control the rover with manual override options on an Internet of Things dashboard that receives all processed data including victim location health status hazard alerts and live video. This makes it possible for search and rescue efforts in disaster areas to be quick precise and secure.

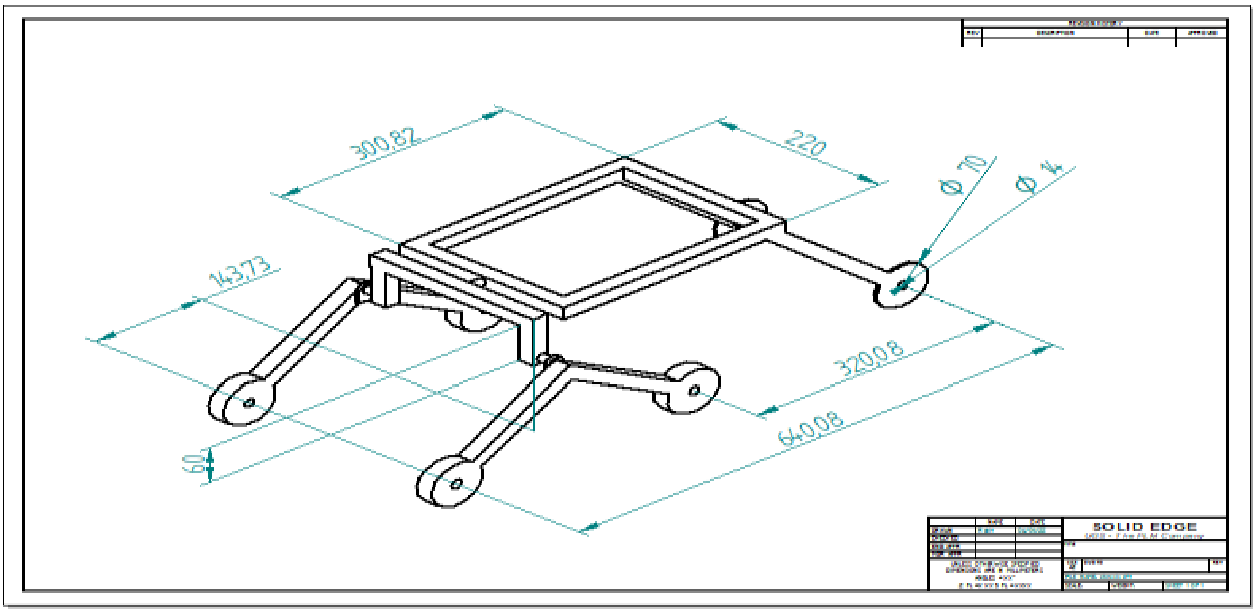
VII. Implementation: The core of practically all contemporary electronic devices is the printed circuit board or PCB. PCBs are what make electronics work from basic devices like digital clocks to intricate robotic systems. They serve as electrical signal conduits guaranteeing that every part interacts and functions as planned. It is crucial to select the appropriate PCB type because various designs have distinct functions. Today three types of PCBs are commonly used. Single-sided PCBs are easy to use and reasonably priced because they have a fiberglass base with a single copper coating on one side. Double-sided PCBs provide greater flexibility for intricate circuits by using the same fiberglass base but having copper coatings on both sides. To handle complex high-density designs like those found in contemporary communication and artificial intelligence systems multi-layer PCBs go one step further by stacking multiple layers of copper and fiberglass.



F(c)

Four essential layers make up each PCB. The substrate which is the foundation and typically made of fiberglass provides skeleton-like strength and rigidity. The copper layer sits on top of this and functions similarly to the body's nervous system by transmitting electrical signals between components. This is covered with the solder mask a polymer layer that acts as skin-like protection for the copper and stops short circuits. In order to show crucial labels part numbers and instructions for assembling or troubleshooting the circuit the silkscreen layer is lastly printed on the surface. When combined these layers give the PCB its strength dependability and effectiveness for robotic disaster management and other applications.

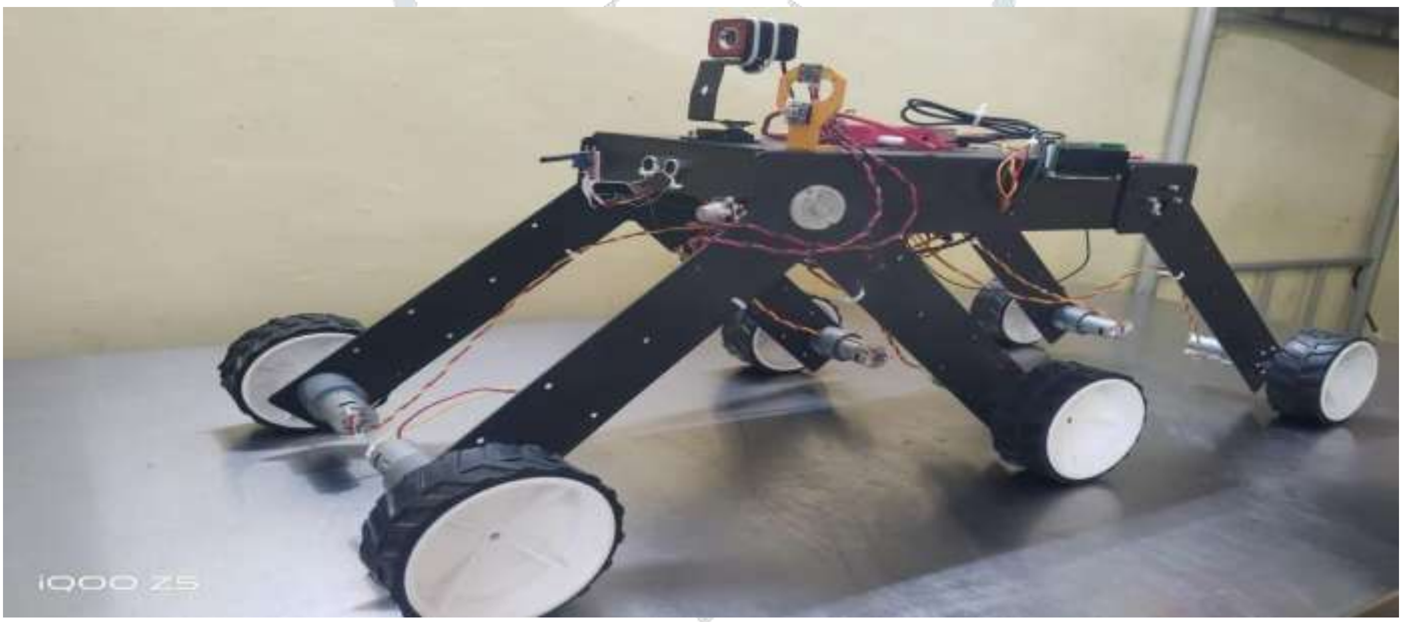
Mechanical Structure design: The 3D modelling of the mechanical structure of the rover is as shown below. The rover is made all terrain using rocker boogie mechanism, so that it can easily traverse over all the terrains.



F(d)

Fabricated and Assembled Mechanical Structure

The mechanical framework of the rover was constructed with a rocker-bogie mechanism a suspension system well known for its ability to glide over rough and uneven terrain. Because of its design the rover can stay steady when negotiating obstacles slopes or rubble which makes it perfect for disaster management situations. On each side two sets of wheels support the central chassis one set is fixed (the bogies) while the other is mounted on pivoting arms (the rockers). Because of this configuration the rover can naturally tilt and flex maintaining traction and ground contact on all wheels. The rover's rocker-bogie mechanism disperses its weight to keep the system balanced and moving forward when it comes into contact with obstacles like rocks slopes or debris. This keeps things from toppling over and guarantees stability even in erratic situations. It is dependable and effective due to its versatility in handling difficult terrain without the need for intricate active suspension technology. The same mechanism which is used here for terrestrial applications like search and rescue disaster recovery and exploration is trusted in some of the most sophisticated robotic vehicles in the world including NASAs Mars rovers. Incorporating the rocker-bogie design allows the rover to confidently traverse disaster-affected areas guaranteeing dependable performance in situations where human rescuers encounter challenges or danger. The ESP32 serves as the primary controller in this project managing all of the rovers' fundamental functions. In addition to controlling the motors servos and buzzer it has direct connections to sensors such as pulse temperature flame gas PIR and ultrasonic sensors. It is ideal for real-time control and alerts sent via wireless modules or Wi-Fi because of its lightning-fast signal response. This makes the ESP32 the robots' hands and nerves always ready to sense and respond at a moment's notice. However, the brain work is handled by the Raspberry Pi. It links to the rover's camera and uses AI models to identify dangers like gas leaks or fires detect people and analyse their posture (standing falling hands up). The Raspberry Pi can run deep learning models that need higher performance and process images because it has more processing power than the ESP32. Because it can handle complex tasks that go beyond simple sensor readings the Pi becomes the systems intelligence centre. The Raspberry Pi and ESP32 work well together to create an intelligent disaster management rover when they are combined. Smooth hardware control and quick reactions are guaranteed by the ESP32 while real-time video and sensor data analysis by the Raspberry Pi adds intelligence. When combined they enable the robot to not only navigate through challenging terrain but also to recognize people gather health information and transmit precise GPS-based alerts to the Internet of Things control panel for rescue coordination.



F(e)

The AI inference in this project functions as the rover's brain assisting it in making prompt and astute decisions during rescue operations. After the rover records video with its onboard camera the system analyzes the frames to identify human body landmarks and shapes including the location of the arms shoulders and head. Rather than requiring rescuers to manually watch the video feed the AI model instantly analyzes the data to determine whether a person is present and in what state whether they are standing sitting falling or requesting assistance. Here the deep learning model that has been trained makes the decisions. It predicts the most likely state of the individual along with a confidence level by comparing live camera data with what it has already learned during training. For instance, the system may confidently identify someone as fallen if they are lying motionless. Upon confirmation of a detection the rover logs the individuals GPS location and transmits it to the Internet of Things control panel. This guarantees that the rescue crew is aware of the victim's location and condition right away. Because of its capacity to comprehend and respond instantly the rover is transformed from a simple moving vehicle into an intelligent disaster management assistant. The rover uses artificial intelligence (AI) inference to speed up detection lessen the workload for human operators and guarantee that vital alerts are sent promptly. By fusing independence precision and quick decision-making this technology saves lives in difficult situations where every second counts.

VIII. Results:

During testing the robotic vehicle operated well utilizing the rocker-bogie mechanism to successfully navigate confined spaces and uneven terrain. In addition to precisely detecting the presence of people both standing and sitting it also recorded critical health indicators like body temperature pulse and SpO_2. The system consistently detected dangers like gas leaks and fires sending out alerts in a timely manner. The IoT-based control panel was able to monitor and coordinate in real time thanks to the seamless transmission of all gathered data including GPS location live video feed and sensor readings. These findings show that the rover has the potential to be a dependable and knowledgeable helper in rescue and disaster management missions.

IX. Conclusion:

In summary this project demonstrates how a robotic vehicle can significantly enhance rescue and disaster response efforts. The rover's combination of sophisticated sensors wireless communication and fundamental medical diagnostic tools allows it to tackle real-world problems that rescuers encounter in hazardous situations. It is an invaluable tool in situations where every second counts because of its capacity to navigate over uneven terrain identify dangers find people who are trapped and even track vital signs. IoT integration guarantees that rescue teams receive real-time access to all data including victim locations medical records and hazard alerts. This helps responders see the situation clearly before entering dangerous areas which also enhances coordination. In general, the rover's successful conception and deployment demonstrate its capacity to save lives and lessen the effects of natural disasters on local populations. Through the integration of robotics artificial intelligence and the Internet of Things the system illustrates how technology can offer disaster management solutions that are safer quicker and more intelligent.

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