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Guardianbot: An Iot-Integrated Rescue Robot for Life-Sign Detection in Post-Disaster Scenarios

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ABSTRACT

Natural catastrophes and calamities such as building collapse, post-tsunami, earthquakes are some of the most disastrous situations mankind faces and, in such circumstances, rescuing survivors is the most critical job. The swarm robots in the present project are governed by a centralized system where all the bots connect to a common IoT cloud. Through this connection, they communicate and store all the accumulated data. The bots also utilize several sensors such as GPS location tracker, an ultrasonic sensor for obstacle and edge detection for maneuvering purposes, LM35 temperature sensor. The current system is also developed with a unique novel hybrid 6-wheel design which will facilitate easy maneuvering over rough terrain. In disaster rescue operations, the timely detection of live human presence is crucial for optimizing search and rescue efforts. This paper introduces a Smart System for Live Human Detecting Robot designed for disaster response scenarios. Leveraging the Internet of Things (IoT) technology, the proposed system enhances the capabilities of rescue robots by providing real-time data on the presence of live humans in disaster-stricken areas. The system integrates advanced sensors and IoT devices to detect vital signs and human movements, enabling efficient and rapid identification of survivors. This innovation aims to improve the overall effectiveness of disaster rescue operations, ensuring a swifter response and increased chances of saving lives. This paper discusses the design and development of swarm robotics, which can be employed in such disasters to search for survivors and for various research purposes.

I. INTRODUCTION

Swarm robotics, a subset of multi-robotics, involves the coordination and communication of numerous robots in a decentralized manner to achieve a common goal. Drawing inspiration from the behaviors of insects like birds, bees, and ants, these simple swarm robots operate based on local rules. In comparison to a complex singular robot, a large number of these robots exhibit robustness and efficiency in performing intricate tasks. In the context of search and rescue missions, swarm robotics proves particularly effective, as the collective can efficiently cover affected areas, assist each other in case of breakdowns, and communicate via the cloud for seamless coordination[1].

The implementation of swarm robotics for search and rescue is demonstrated in various scenarios. One application involves swarm robots following firefighters in a building, navigating lower areas with lower smoke and temperature to aid in finding humans and guiding firefighters. Another swarm robot, equipped with a robotic arm, maneuvers on small rocks and wreckage via Bluetooth control from a mobile device. Blue Swarm 2.5 focuses on cost-effectiveness[3], incorporating sensors for obstacle detection, collision avoidance, and heat signature detection from survivors. An all-terrain robot with a robotic arm is proposed for surveillance tasks, utilizing cameras, thermal imaging, ultrasonic sensors, and autonomous terrain mapping.

Several challenges and considerations arise in the development of swarm robotic systems. The issue of area coverage is addressed through the use of swarm robotics, but potential drawbacks include the lack of an edge detection system, which could lead to disasters in search missions with steep terrains. Rescue operation systems utilizing GPS tracking face challenges such as irrelevant data from PIR sensors and random traversal, potentially leading to repeated search areas and wasted time. Various robots designed for rescue operations [2] incorporate features like thermometers, lifting arms, RF communication, and even an Android app for control.

In summary, the integration of swarm robotics with nanoscience, nanotechnology, nanorobots, and computer science showcases a diverse range of applications in the medical and rescue domains. While these innovations present solutions to complex challenges, careful consideration of ethical, technical, and practical aspects remains crucial for their successful implementation in real-world scenarios [4].

Various robots have been developed for autonomous search and rescue missions, employing advanced technologies for improved efficiency. One approach involves the use of thermal array sensors to detect body heat and autonomously navigate into search areas to locate human survivors. Despite its effectiveness in locating survivors, the reliance on signal strength for location tracking introduces potential inaccuracies. Another robot is designed specifically for autonomous exploration and mapping tasks, focusing on areas with a high probability of locating victims while minimizing conflicts during exploration. This emphasizes resource allocation for optimized efficiency in search and rescue operations [4].

Innovative designs for robots with specialized capabilities have been introduced. A robot with a wheel-legged system is highlighted for its ability to carry heavy weights and implement real-time transformations in the field, facilitating maneuvering in rough terrains [5]. Another wheel-legged design showcases three different states: rotation center lift, leg motion, and a normal wheel state, demonstrating feasibility for various applications. An alternative approach utilizes a 4*4 high-power wheel system and a robotic arm to manipulate obstacles instead of avoiding them, providing a unique solution for navigation in challenging environments [1].

In the realm of industry applications, a method is described wherein fixed temperature sensors in industrial environments can be moved using a robot to detect temperatures in different locations. Additionally, the utilization of DTMF technology is discussed for controlling and communicating sensor data and devices, with data processing handled by an Arduino UNO. The development of an IoT robot aims to enhance safety in coal mines by sensing toxic gas levels and temperature [2], alerting workers to potentially hazardous conditions. Another IoT robot is designed to assist the elderly in performing basic tasks, incorporating features such as face detection, live streaming home surveillance, and Bluetooth remote control.

The potential of swarm robotics in search and rescue for first responders is explored, discussing the evolution of the Blue Swarm and introducing various robot models such as Scout, Scout Walker II Beam, and Crawler Robot. A survey on existing swarm robot methodologies is conducted, experimenting with five advanced algorithms for exploration. The results indicate that the Robotic Darwinian Particle Swarm Optimization (RDPSO) algorithm outperforms several other algorithms in terms of efficiency and effectiveness. These developments underscore the diverse applications and continuous advancements in robotic technologies for search, rescue, and various specialized tasks.

Objectives:

The smart system for a live human detecting robot in disaster rescue operations using the Internet of Things (IoT) has several key objectives aimed at enhancing the efficiency and effectiveness of rescue operations during disasters [2].

Live Human Detection:

The primary objective is to develop a robot equipped with advanced sensors and technologies to detect and locate live humans in disaster-stricken areas. This involves the integration of sensors capable of detecting vital signs, such as heat signatures or movements, to ensure the timely identification of survivors [3].

IoT Integration:

Utilize IoT technologies to enable seamless communication between the robot and a centralized control system. This involves incorporating sensors, actuators, and communication modules that can relay real-time data to the control center, allowing for swift decision-making and coordination of rescue efforts [4].

Autonomous Operation:

Implement autonomous navigation and operation capabilities to enable the robot to navigate through challenging terrains or environments without direct human control. This involves developing algorithms and systems that allow the robot to make decisions based on its surroundings and the data collected through sensors [5].

Remote Monitoring and Control:

Facilitate remote monitoring and control of the robot by rescue teams. This objective aims to provide real-time video streaming, telemetry data, and control functionalities through the use of IoT technologies. Remote monitoring ensures that rescue teams have a comprehensive view of the disaster site without physically being present [4].

Survivor Condition Monitoring:

Integrate sensors capable of monitoring the health and condition of survivors once detected. This includes sensors for measuring vital signs, assessing the environmental conditions, and providing relevant data to rescue teams for informed decision-making [3].

Obstacle Avoidance and Navigation:

Develop robust algorithms and systems for obstacle avoidance and navigation to ensure the robot can navigate through debris, rubble, or challenging terrain without getting stuck. This enhances the robot's capability to reach survivors in difficult-to-access locations [5].

Scalability and Adaptability:

Design the SMART SYSTEM to be scalable and adaptable to different disaster scenarios. The robot should be capable of handling various types of disasters, including earthquakes, floods, or fires, and be easily deployable in different environments and conditions [2].

Energy Efficiency:

Focus on optimizing the energy consumption of the robot to ensure prolonged operation during rescue missions. This involves incorporating energy-efficient components, power management systems, and possibly renewable energy sources to enhance the robot's endurance [3].

Human-Robot Interaction:

Develop interfaces and communication systems that facilitate effective interaction between the robot and rescue teams. This includes features that allow operators to provide specific instructions, receive status updates, and control the robot remotely [4].

By achieving these objectives, the smart system aims to contribute to more efficient and technologically advanced disaster rescue operations, ultimately increasing the chances of successfully locating and rescuing live humans in critical situations [5].

II.LITERATURE SURVEY

The literature survey on the "Smart System for Live Human Detecting Robot for Disaster Rescue Operation Using IoT" encompasses a broad exploration of research related to disaster rescue, IoT applications, smart systems, live human detection, and the integration of these technologies in rescue robots[3].

In the context of disaster management and detection, the project type -1 aims to leverage IoT-based wireless sensor techniques to detect and manage specific types of disasters. The paper highlights the increasing importance of total automation in various aspects of human life, citing IoT as a boon with applications in smart cities, agriculture, industrial control, security, and medical applications. The integration of IoT is seen as a key enabler for complete automation[1], reducing human efforts through machine-to-machine interactions.

The type-2 focuses on wireless sensor networks for disaster management, emphasizing their self-organization and self-configuration capabilities. The author proposes using this network to minimize loss of life during disasters by collecting data to make informed decisions for rescue teams. Techniques for Landslide Detection, Forest Fire Detection, Tsunami Detection, and Microcontroller-based Earthquake Detection are discussed. The two-layer approach involves data collection from sensors, transmission to a gateway using ZigBee components, and sending alerts through text messages or SMS for timely evacuation[1].

The type-3 introduces a robot for detecting human presence in disaster scenarios, controlled using an earthquake phone. The robot utilizes PIR sensors and DTMF tones for operation, making it remotely controllable from anywhere in the world. The author suggests applications beyond rescue operations, such as military use for detecting unwanted presence. The robot is equipped with sensors like ultrasonic, PIR, temperature, and oxygen sensors to detect obstacles, motion, and potential fires during rescue operations[2].

In the type-4 an inexpensive autonomous robot is proposed for distress situations. The model integrates RF technology and an ARM7 controller with sensors like PIR, IR, and temperature sensors. The IR camera is recommended to enhance the project's effectiveness. The fifth paper presents the hardware and software implementation of an earthquake-controlled robot, showcasing results from various sensors in graphical and tabular formats. Both papers highlight the potential of affordable robots in minimizing loss of life during disasters[3].

Firstly, the survey delves into the domain of disaster response and rescue operations. Various studies highlight the critical challenges faced by emergency responders during disasters, emphasizing the need for advanced technologies to enhance the efficiency and effectiveness of rescue missions. The survey underscores the urgency of employing innovative solutions to address the complexities of disaster scenarios, where time-sensitive actions are paramount[4].

The role of IoT in disaster rescue operations is a central theme in the literature survey. Researchers emphasize the integration of IoT technologies to enable real-time communication and data exchange between rescue robots and control centers. This integration facilitates remote monitoring, decision-making, and coordination, thereby optimizing the overall effectiveness of rescue efforts. Studies showcase how IoT can be leveraged to create a connected and responsive ecosystem, allowing for seamless communication and control in dynamic disaster environments[5].

The survey delves into the concept of a "Smart System" for disaster rescue robots, highlighting the importance of developing intelligent and adaptive systems. Smart systems are designed to autonomously navigate through disaster-stricken areas, employing advanced algorithms and sensors to detect live humans. These systems prioritize adaptability, scalability, and energy efficiency to ensure robust performance in diverse disaster scenarios, aligning with the evolving needs of emergency response teams.

Live human detection emerges as a critical objective in the literature survey, emphasizing the development of rescue robots capable of sensing vital signs and human presence in disaster-affected areas. Researchers explore various sensor technologies, including thermal arrays and movement detectors, to enhance the robot's ability to locate survivors accurately. The incorporation of autonomous navigation further contributes to the robot's efficacy in navigating complex terrains and debris during search and rescue missions.

The survey recognizes the significance of vital signs monitoring in disaster scenarios. Researchers propose integrating sensors that monitor survivors' health conditions[3], providing crucial data to rescue teams for informed decision-making. This aspect ensures that the rescue robot not only detects human presence but also assesses the well-being of survivors, contributing to a comprehensive and life-saving approach in disaster response[1].

In summary, the literature survey reveals a multifaceted exploration of disaster rescue robotics, IoT applications, smart systems, live human detection, and vital signs monitoring. The integration of these technologies is poised to revolutionize disaster response[3], offering more efficient, connected, and adaptable solutions to mitigate the impact of disasters on human lives[2].

III. EXISTING SYSTEM

The existing systems for live human detecting robots in disaster rescue operations using IoT have witnessed significant advancements, leveraging a combination of technologies to enhance efficiency and effectiveness. These systems typically incorporate IoT components for real-time communication, smart sensors for live human detection, and autonomous navigation features for effective disaster response. The integration of these elements creates a connected and responsive ecosystem, allowing rescue robots to operate in dynamic and challenging disaster environments[4].

In the existing systems, IoT technologies play a crucial role in enabling seamless communication between the rescue robot and centralized control centers. Remote monitoring, decision-making, and coordination are facilitated through the exchange of real-time data, providing rescue teams with valuable insights into the disaster scenario. The utilization of smart systems allows for autonomous navigation, enhancing the robot's ability to navigate through complex terrains and locate live humans efficiently[5]. Additionally, these systems often incorporate vital signs monitoring, ensuring a more comprehensive approach to assessing the well-being of survivors[3].

Drawbacks of Existing System

Despite the advancements, existing systems for live human detecting robots in disaster rescue operations using IoT face certain drawbacks and challenges[2] that researchers and developers are actively addressing:

Limited Scalability:

Some existing systems may face challenges related to scalability, especially in large-scale disasters. The ability to deploy a sufficient number of robots to cover extensive disaster areas without compromising efficiency remains a concern[1].

Energy Consumption:

The energy efficiency of these systems is a critical consideration. Operating in disaster-stricken environments may require prolonged operation, and ensuring an adequate and sustainable power source for the rescue robots remains a challenge.

Sensor Limitations:

While the integration of sensors is crucial for live human detection, some existing systems may face limitations in the types of sensors employed. Issues such as sensor range, accuracy, and adaptability to different disaster scenarios may impact the overall effectiveness of the system.

Communication Reliability:

The reliability of communication between the rescue robot and control centers is essential for real-time decision-making. Challenges such as signal interference, connectivity issues, or delays in data transmission can hinder the effectiveness of the system.

Adaptability to Diverse Environments:

Disaster scenarios vary widely, and existing systems may encounter challenges in adapting to diverse environments such as earthquake-ridden areas, flooded regions, or fire-stricken locations. Ensuring that the system remains effective across different disaster types is an ongoing consideration[3].

Cost Constraints:

The cost of developing and deploying sophisticated robotic systems with IoT capabilities can be a limiting factor. Balancing the need for advanced technology with cost-effectiveness is crucial for widespread adoption and implementation.

As the field of disaster rescue robotics using IoT continues to evolve, addressing these drawbacks is essential to ensure the development of robust, scalable, and adaptable systems that can effectively respond to a variety of disaster scenarios. Ongoing research and technological innovations aim to overcome these challenges and further enhance the capabilities of live human detecting robots in disaster rescue operations.

IV. PROBLEM DISCUSSION

The concept of employing a smart system for live human detection in disaster rescue operations through IoT technology is full of potential, offering innovation and promise. However, its implementation is accompanied by numerous challenges. Two critical factors affecting the system's performance are reliability and accuracy. False positives, where non-human objects are mistakenly identified as humans, can lead to unnecessary alarms, while false negatives pose a serious risk by failing to detect actual humans in need during rescue operations[1].

Environmental factors further compound the challenges. Disasters create harsh conditions, introducing debris, smoke, water, and other obstacles that can compromise the accuracy of sensors and data transmission. Limited visibility due to poor lighting conditions or environmental factors like dust and fog may hinder the system's effectiveness in identifying live humans[4].

Power consumption emerges as a significant concern, especially in disaster-stricken areas where obtaining a stable power supply is challenging. Efficient power management is crucial for the continuous and reliable operation of IoT devices. Communication issues also loom large, with the system heavily relying on real-time communication between devices. In disaster-stricken areas, damaged or unreliable communication infrastructure can impact overall system performance, introducing latency that may affect the timeliness of rescue operations[5].

The scalability of the system presents logistical challenges, requiring careful planning, coordination, and logistics for the deployment and maintenance of numerous devices in disaster-stricken areas. The associated costs, both in terms of development and deployment, are substantial, potentially limiting the widespread adoption of this technology in disaster management[4].

Privacy and ethical concerns add another layer of complexity. Continuous monitoring for human detection raises privacy issues, necessitating a delicate balance between the need for rescue operations and respecting individuals' privacy rights. Ensuring data security is crucial to prevent unauthorized access or misuse of the information collected by IoT devices.

Integration with existing systems, such as disaster management and rescue operations frameworks, poses complexity and may require standardization. Maintenance and durability are additional challenges, as devices deployed in disaster-stricken areas must withstand harsh conditions, and regular maintenance may be difficult, impacting the overall reliability of the system. Finally, regulatory challenges related to compliance with local and international regulations on data privacy, surveillance, and disaster management add a layer of complexity to the implementation process.

Addressing these multifaceted challenges demands a multidisciplinary approach, bringing together expertise in IoT, robotics, disaster management, and regulatory frameworks. Only through such a comprehensive approach can the successful implementation[1] of a smart system for live human detection in disaster rescue operations be ensured.

V. PROPOSED SYSTEM

The proposed mobile rescue robot aims to operate in disaster and earthquake-stricken areas, assisting in the identification of live and injured individuals while facilitating rescue operations. This innovative system seeks to detect and respond to natural disasters promptly, potentially saving lives and minimizing losses, even in the absence of a large number of rescue operators. Comprising a mobile rescue robot and earthquake control, the system utilizes a sensor unit, microcontroller, motor driver unit, and transmission unit to enhance its capabilities.

The Earthquake rescue robot incorporates sensors such as ultrasonic, oxygen, temperature, and PIR (Passive Infra-Red) sensors to monitor environmental conditions in disaster areas. These sensors feed real-time data to the ATmega328 microcontroller, a low-powered, low-cost microcontroller commonly used in projects and autonomous systems. The microcontroller plays a central role in gathering sensor data in real-time, transmitting information to the control room's CPU, receiving commands from a mobile app, and facilitating the robot's movement during rescue operations.

The robot's driver unit manages the robot's movement in the x-axis and y-axis using a conveyor belt-type mechanism and four DC motors. The robot's ability to navigate through debris and rugged terrain is facilitated by positive and negative pulse edges, enabling forward, backward, left, and right movements. The transmission unit, employing a Bluetooth module, transmits data from the microcontroller to the receiver. At the receiver end[5], displayed on a PC or app, real-time data and weather parameters aid in locating humans, facilitating prompt rescue operations. The applications of this system extend to forest fire detection, human body detection under debris, sensing unwanted presence for security purposes, and weather monitoring, showcasing its versatility and potential impact on various scenarios.

Advantages of Proposed System

The proposed project showcases versatile applications, with one significant use being forest fire detection. Equipped with sensors, including a temperature detector, the robot can detect rising temperatures indicative of a potential fire. Upon reaching a predetermined threshold[3], the temperature sensor triggers an alarm. Additionally, the system incorporates a smoke detector to identify the presence of smoke and combustible oxygen, while the humidity sensor further aids in recognizing hot weather or fire conditions. The robot, designed for mobility in forests, remains vigilant and can alert authorities to potential fire outbreaks.

Another critical application involves human body detection under debris, applicable in incidents such as earthquakes, tsunamis, or airplane crashes. Utilizing infrared radiation emitted by the human body, the robot employs a PIR sensor to ensure the detection of human presence even in challenging scenarios[5]. To navigate obstacles, an Ultrasonic sensor is used, allowing the robot to sense entities using ultrasonic waves. This capability has the potential to save numerous lives by aiding in the rescue of individuals trapped under debris during emergencies.

The project extends its utility to security operations by employing the PIR sensor for sensing unwanted human presence. This feature can be utilized for various security purposes, such as detecting intruders in a room or near the main door. The system can alert homeowners in real-time, enabling timely responses and the possibility of contacting law enforcement to prevent theft or robbery. Moreover, the integration of a camera with the PIR sensor enables parents to monitor their children, enhancing overall security within a household[1].

Beyond these applications, the project proves valuable for weather monitoring both indoors and outdoors. With precise sensors, it facilitates the maintenance of proper indoor air quality index. This adaptability makes the system not only a tool for emergency response but also a useful asset for everyday environmental monitoring, showcasing its broad range of applications and potential impact[4].

V. MATERIALS AND METHOD

The project involves the use of various components, each serving a specific purpose in creating a disaster management system. One critical component is the battery, converting stored chemical energy into electrical energy. Batteries are categorized into primary (disposable) and secondary (rechargeable) [5]. The capacity of a battery depends on factors such as discharge conditions and the rate at which it is discharged. The project utilizes LM35 as a temperature sensor, measuring temperature and humidity, and MQ2 as an oxygen sensor, detecting various combustible gases. The PIR sensor is employed for motion detection.

The LM35 temperature sensor operates within a range of -40 to 80 degrees Celsius, providing accurate readings with a quick response time. The MQ2 oxygen sensor is sensitive to combustible gases, operating on a 5V power supply and offering both digital and analog outputs. The PIR sensor, functioning as a motion sensor, detects infrared rays emitted by the human body. Each sensor plays a crucial role in environmental monitoring during disasters.

The ESP32, an open-source electronic platform, serves as the microcontroller, operating at 5V with 14 digital I/O pins. The project also incorporates a Bluetooth module (HC-05) for wireless communication. The L298N motor driver handles the movement of the robot. The project's future work involves the implementation of swarm robots for search and rescue operations, utilizing RF communication for interconnection and thermal cameras for survivor detection. The integration of IoT technology, sensors, and communication modules creates a comprehensive disaster management system with real-time monitoring and alert capabilities.

VI. IMPLEMENTATION

Implementation is the stage, which is crucial in the life cycle of the new system designed[3]. The implementation phase is starting at process installing software and hardware and requirements. Installation hardware is setting up the PC desktop hardware requirements specification.

Hardware Implementation:

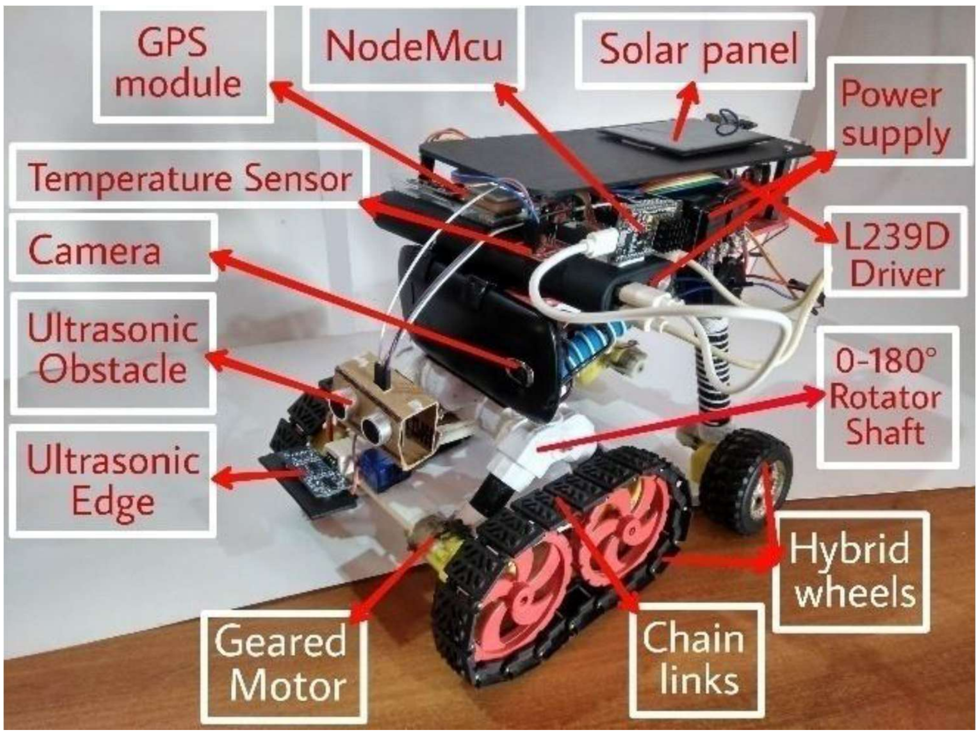

Fig 1: Hardware Implementation

Body

The body of the robot is CAD designed using the Autodesk Fusion 360 software. And 3D printed using a biodegradable poly lactic acid (PLA) 3D printing filament. The 3D printed parts are then assembled together[1].

NodeMcu

It is used as the processor of the swarm robots as it is smaller in size inexpensive and has the capability of connecting to the internet via the inbuilt ESP8266 Wi-Fi module. Shown in image 3.It has several GPIO pins and has storage of 4MB runs on XTOS and it is energy efficient, which is essential in swarm technology. All the sensors and IO devices such as Ultrasonic sensor, GPS module,L239D, and temperature sensor is connected to the NodeMcu[5] and the IO is processed. Two Node Mcu is used due to lower number of IO pins. The CPU has 80Mhz frequency.

Power supply

The entire project is drawn from three different sources one 13000mah power bank for NodeMcu, sensors.And a separate9V power supply for the L239D driver and 6300RPM geared motors robot movement as it requires 9 volts. A 6v solar panel is installed on top of the robot which recharges the rechargeable batteries during the search operation[5], power from the solar panel ensures that the robots will sustain in the field of operation for a longer period of time.

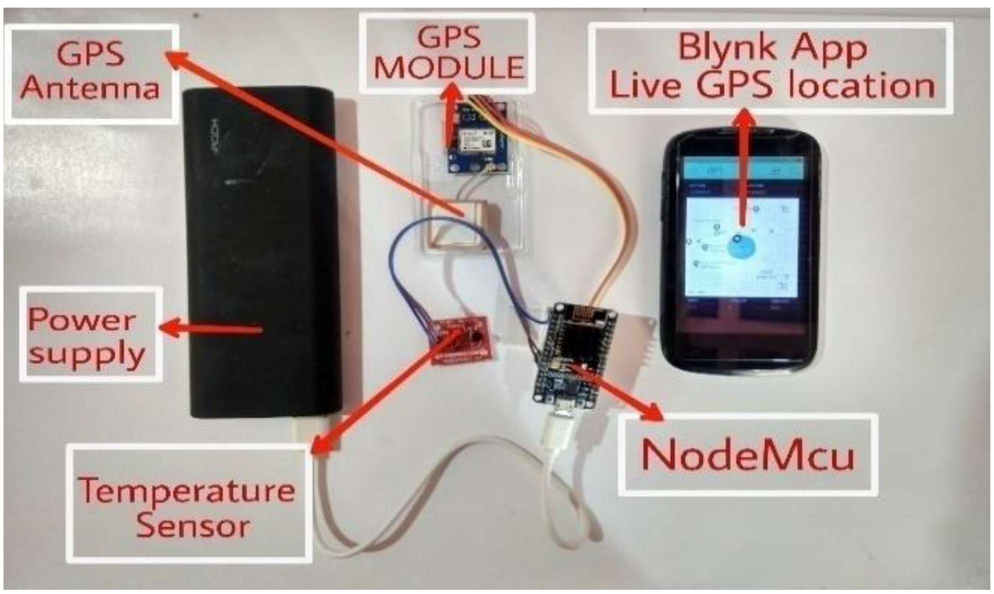

Fig 2: GPS Module And Temperature Sensor

GY-GPS6MV2 GPS module

It is used for location tracking. The module has a Ceramic antenna which can connect to several satellites to determine the exact location and also has EEPROM to save configuration data when there is no power supply. This module is used in this project to track the location of the robot in the search area, and also to identify the survivor's location. These location data are sent to the cloud for analysis[4].

Temperature sensor

LM35 temperature sensor is attached to the Node Mcu in order to accumulate live temperature data. This sensor can detect temperatures from -55 degree 150 degrees. The raw input data is collected from the IO pin. The formula below is used to convert raw data to accurate temperature value[3].

Temperature = (5.0 * input data * 100.0) / 1024

This data can be used by the rescue team during a search operation to check if the temperature is too high inside buildings if any fire explosion has occurred, Shown in figure 3.

Ultrasonic sensor

HC-SR04 used in this project is capable of emitting 40000Hz ultrasound. As shown in the figure 4 the trigger pin in the sensor will emit ultrasound and the waves will reflect back when it strikes an object and the reflected waves is received back by the echo pin and the time duration of sent wave and received wave is calculated and the time is converted to distance, Formula used to calculate distance is distance = (duration/2) / 28.5 where distance and duration are initialized to 0 initially[1]. the threshold is set to 30cm distance and area of propagation is above 5-6 cm above ground level.Obstacles that are 5-6cm in height from ground level is moved over by the hybrid wheel system.This data is used to detect objects in front of the robot while moving. The robot makes use of the ultrasonic sensor data to avoid obstacles and continue searching operation without crashing into any objects[1]. The robot moves around the obstacle instead of taking a random path as designed in[5], this optimizes the search process and reduces the time to search and excludes redundant search[3]. A second ultrasonic sensor with same configuration is used to detect edges in the search area. The same principle is used as the obstacle avoidance, but the sensor will be facing the floor and as soon as the distance measured is greater than7cm the robot detects it as an edge. And the robot will change its path avoiding the edge[4].

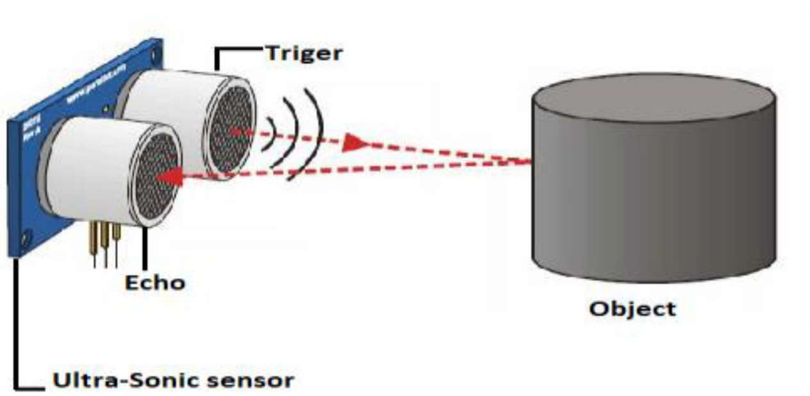

Fig 3: Obstacle Detection & Edge Detection

L239D motor driver

L239D H-Bridge motor driver is used to drive the geared motors. The H-bridge will allow the DC current to flow in both directions.Which will allow the motors to rotate in both the directions [2], this mechanism is used to make the robot move left, right and straight back. The left row of three wheels are connected as one connection to the L239D and similar to the right row of wheels, the robot moves forward when the H-Bridge powers both left and right as high, it moves back when it's powered low, to move left only the right set of wheels are powered high, for right all left wheels are powered high, As shown in the table 1.

TABLE 1. Digital control signals for L239D driver

Commands	***Inputs****(Right wheels)*	***Inputs****(Left wheels)*
Front	*1*	*1*
Back	*0*	*0*
Left	*1*	*0*
Right	*0*	*1*

Hybrid wheel system

This system unique novel 6 wheel is design shown in figure 5 is designed in such a way that the front section wheels are capable of swinging from 0 to 180 degrees with the help of a rotator shaft, helping in climbing small rocks and obstacles while the back wheels provide support.6 300RPM geared motors are used for movement. Front two wheels are connected with each other using chain links which makes the robot hybrid of both tanker wheel system and normal rovers, the hybrid wheels can maneuver over obstacles which are at the height of 5-6 cm, and the obstacles that are higher than 5-6 cm is detected by the obstacle sensor and ensures the robot takes a different path.The rotator shaftis also equipped with two suspension springs which will help in moving and reduce damages on the electronics, also will ensure the robot is stable while climbing over small objects[1].

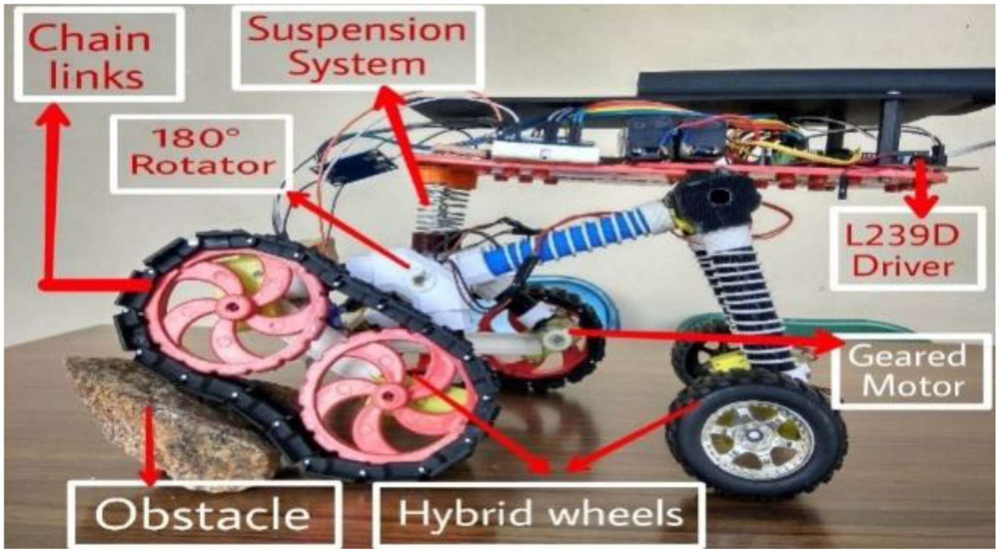

Fig 4: Hybrid wheel system

Software Implementation

Arduino IDE is usedto program the swarm robot using embedded cpp language. Google firebase cloud service is used to store and view all the data sent by the NodeMcu and sensors. To connect to the Google firebase host connection link and secure authentication id is included in the code which is provided by the firebase cloud. And to communicate with the cloud the NodeMcu ESP8266 needs to be connected to a WIFI network[3].The robots use the firebase cloud as a platform to communicate with each other and to receive the area to be searched and dived the area among them self. In the receiving end, both rescue team and the operation team can view the results provided by the swarm robots[5].

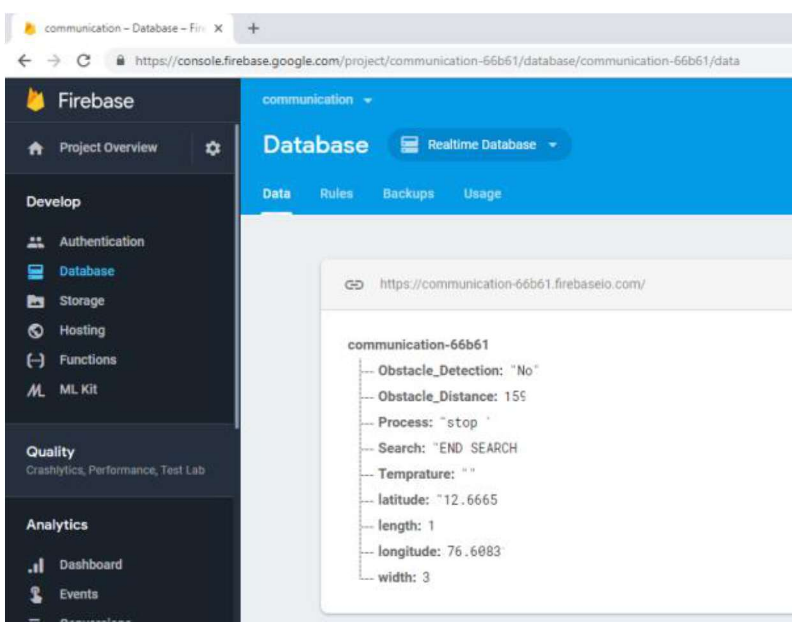

Fig 5: Google Firebase

Blynk

An android app called Blynk is used to view the live GPS data provided by the swarm robot, Location can also be viewed in the google cloud live database. Shown in figure 6. Using the data sent by GY-GPS6MV2 GPS module[1], the blynk app will also show the direction in which the robot is moving and the number of satellites it is connected to provide the GPS data and also it provides the live location of the robot in a map. Depicted in figure 5.

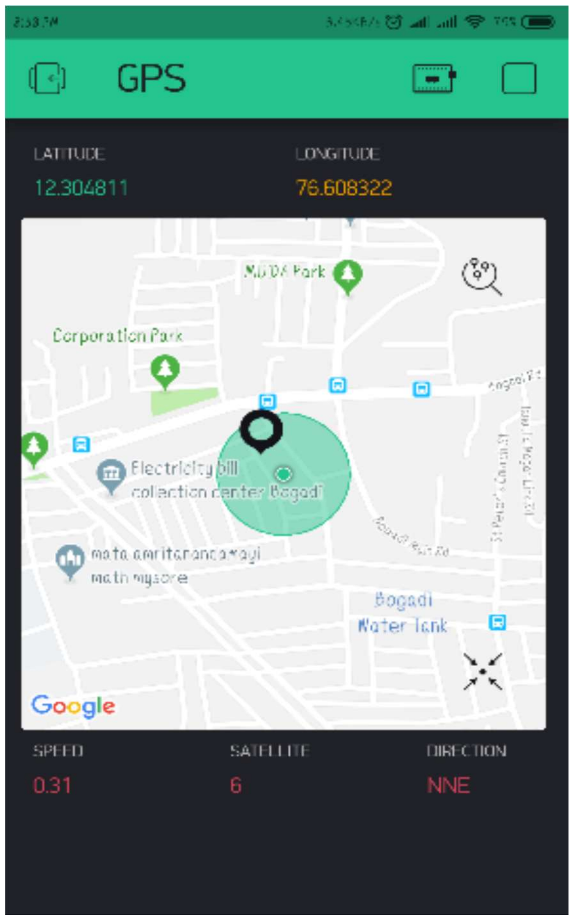

Fig 6: GPS live tracking using Blynk App

Camera

To view the live scenario and to locate the survivors of the disaster-prone area, an old android mobile with an IP webcam mobile app is used for the viewing purpose. The live feed can be viewed by a computer, mobile or tabs by entering the IP address provided by the app[1]. Both the rescue team and the operations team can view this live feed from the camera. The operations team can also toggle the led flash remotely by the IP camera web interface. Shown In figure 6. The process of detecting survivors is to be done by the operations team by looking into the live feed of the camera[3].

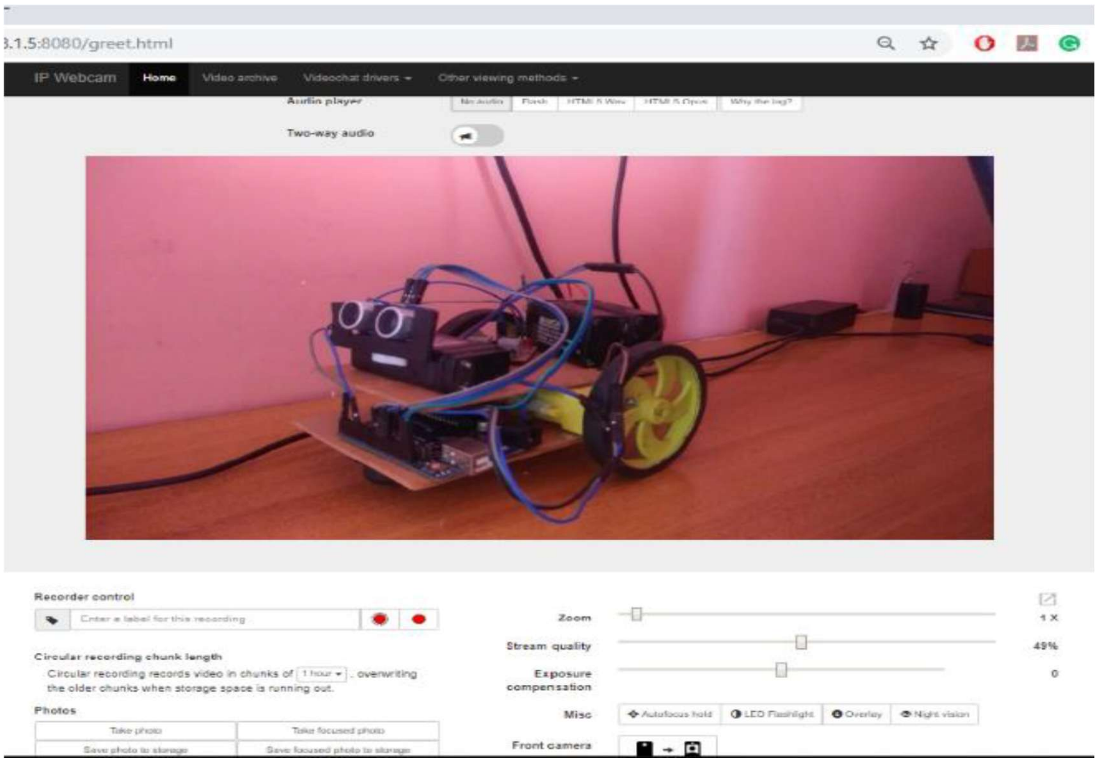

Fig 7. View from IP camera web interface

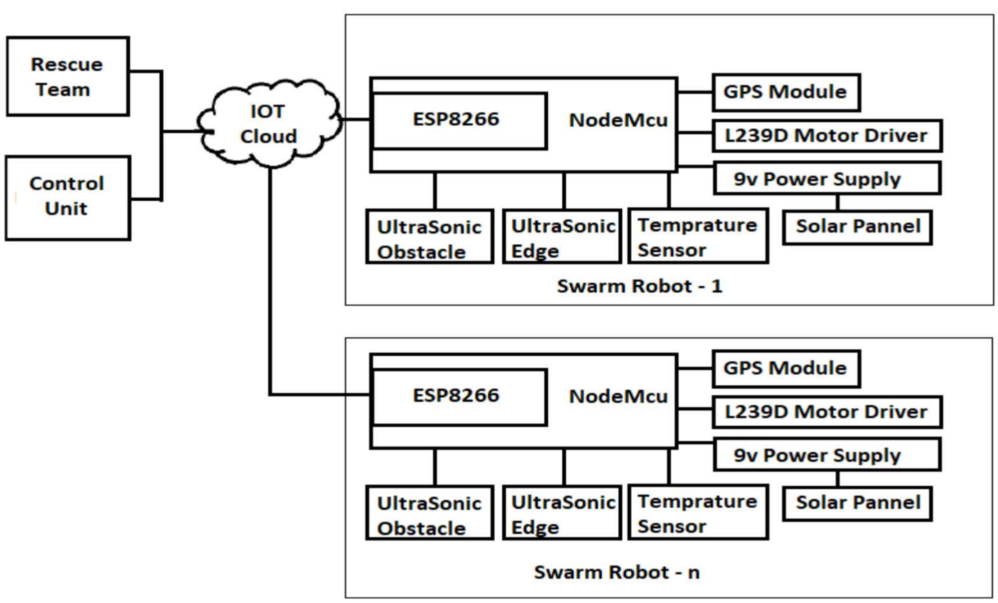

Fig 8. View from IP camera web interface

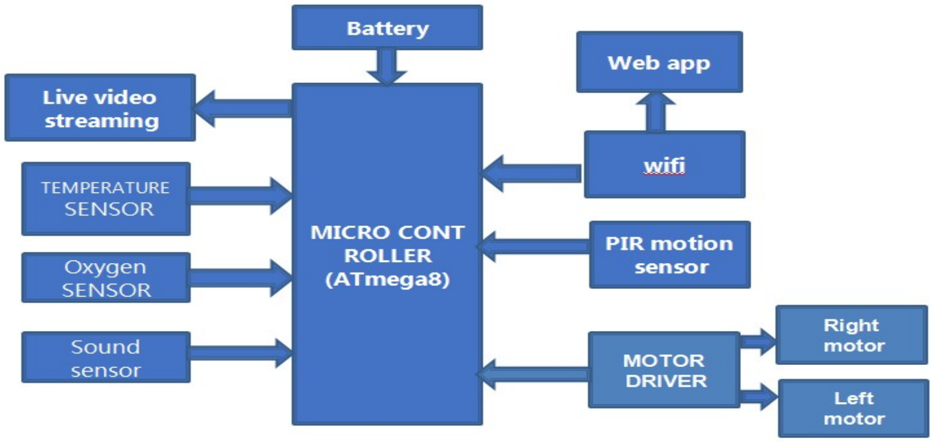

Fig 9:Block Diagram

Algorithm

Step 1: Input area perimeter to the swarm robot

Step 2: Robot divides the area and start searching

Step 3: If obstacle detected change direction

Step 4: If edge detected change direction

Step 5: Find temperature of area and transmit it to the firebase cloud database.

Step 6: Find live location of robot and transmit location to the firebase cloud database.

Step 7: If robot damaged assign nearest robot the task of damaged robot.

Step 8: If human survivor found in camera retrieve live tracking location.

VII. RESULTS AND DISCUSSION

The proposed method highlights the swarm robot's effectiveness in navigating through rough terrain, utilizing a hybrid wheel system that facilitates movement over small obstacles like stones, sand, and grass. The ultrasonic sensor, with a 30cm detection threshold, plays a crucial role in preventing collisions by providing data for calculating the optimum path. This feature ensures that the robot can efficiently cover the entire area in search of survivors[3]. However, a drawback arises with the second ultrasonic sensor, which detects edges within a 7cm threshold. The high-powered robot moving at a faster speed poses a challenge, as the sensor's detection speed is not sufficient to promptly identify edges, necessitating a reduction in the robot's power to ensure accurate edge detection[1].

The temperature sensor proves to be a valuable component, providing accurate data for the search operation. On the other hand, the camera module, with a video capture rate of 30fps and VGA resolution, faces challenges due to the constant movement of the robot[1], causing disturbance and an unacceptable frame rate. The recommendation is to employ higher-quality cameras with better resolution and fps rates to enhance the live feed from the disaster area. These improvements would contribute to the overall efficiency and performance of the swarm robot in disaster response scenarios[2].

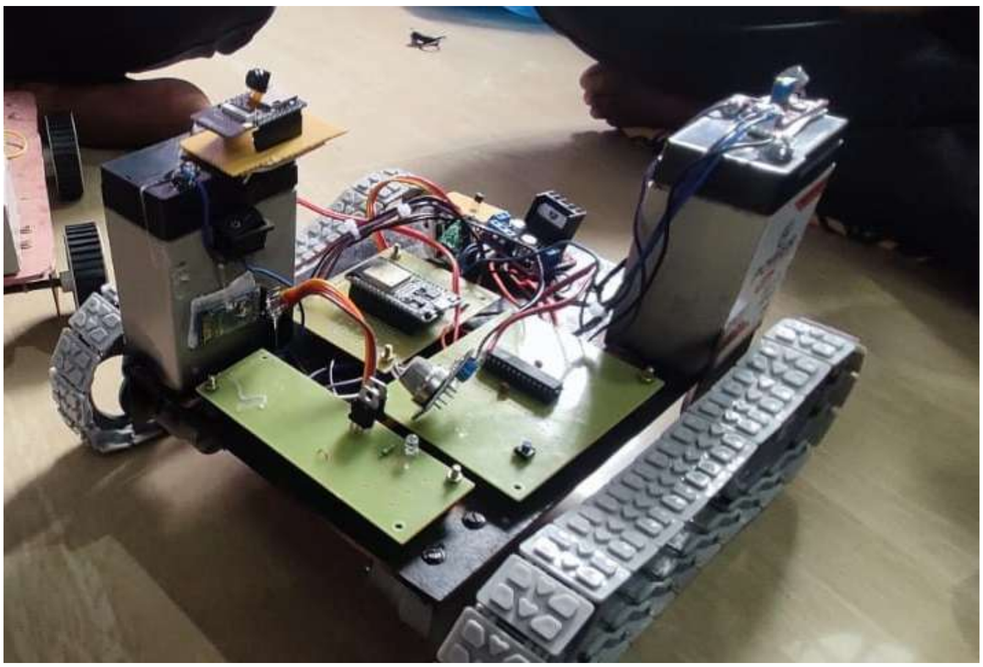

Fig 10: Disaster Rescue Robot

VIII. CONCLUSION

The successful implementation of the swarm robot was marked by its effective functionality in response to the assigned area and perimeter. Tasked with a search operation, the robots demonstrated their capability to navigate the designated space while avoiding obstacles. Simultaneously, the rescue team efficiently utilized live feeds from the robot-mounted cameras to detect victims within the operational area. This approach to search and rescue operations proves invaluable in terms of time-saving, particularly during the critical phase of a search operation. The efficiency of the operation is expected to increase with a higher number of swarm robots, showcasing the scalability and potential for rapid execution.

The hybrid wheel system employed by the robots played a pivotal role in their maneuverability, enabling them to navigate diverse terrain and overcome various obstacles seamlessly. This adaptability is crucial in disaster-stricken areas where the landscape may be littered with small objects and challenging topography. Looking ahead, the potential for further improvement [4] includes interconnecting the robots via RF communication in scenarios where Wi-Fi connectivity is unavailable in the disaster area. This enhancement would enable seamless data exchange among robots, facilitating communication between the swarm and enabling the closest robot to relay critical information to the rescue or operations team[1].

IX. FUTURE SCOPE

IoT, as an emerging technology, holds the promise of revolutionizing daily life by minimizing human effort and intervention. The integration of IoT into various systems, as demonstrated in our project, brings forth an automated solution capable of detecting fires, rescuing people trapped under debris, sensing human presence, and even monitoring weather conditions. By establishing connections between devices, IoT facilitates seamless communication and coordination, significantly reducing the need for direct human involvement. This advancement is particularly crucial in scenarios where time is of the essence, such as disaster management, where swift and timely actions can save numerous lives. The project's use of IoT underscores its potential to enhance efficiency and effectiveness in diverse applications[1].

The project's applicability extends beyond disaster management, finding relevance in security issues where the detection of unwanted human presence is essential. Whether in restricted military areas, medical rooms, unauthorized entry into homes, or secure locations like banks and company premises, the IoT-based system offers a robust solution for monitoring and alerting. The choice of ESP32 as the project's baseline further enhances its practicality by simplifying the interfacing of components, contributing to the overall effectiveness of the system. As IoT continues to evolve, its integration into various domains promises to bring about a future characterized by increased automation and improved response capabilities in critical situations.

For future iterations, the integration of thermal cameras stands out as a promising enhancement. Rather than relying on manual detection, thermal cameras could be utilized to identify survivors more efficiently. This advancement would not only expedite the rescue process but also enhance the accuracy of locating individuals in need. Overall, the successful implementation of the swarm robot, coupled with these potential improvements, underscores its significance in advancing search and rescue capabilities in disaster scenarios.

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