SEARCH ASSISTANT RESCUE ROBOT

PROJECT REPORT

Submitted by

ANTONY PETTA (SCM20EC010)

To

APJ Abdul Kalam Technological University

In partial fulfilment of the requirements for the award of the Degree

Of

Bachelor of Technology

In

Electronics and Communication Engineering

Department of Electronics and Communication Engineering

SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY KARUKUTTY

MAY 2024

DECLARATION

I undersigned hereby declare that the project report **"SEARCH ASSISTANT RESCUE ROBOT"**, submitted for partial fulfilment of the requirements for the award of degree of Bachelor of Technology of the APJ Abdul Kalam Technological University, Kerala is a Bonafide work done by me under supervision of my guide **Ms. Vrinda. V Gopal** Assistant Professor, Department of Electronics and Communication Engineering and my project coordinator **Ms. Praveena S Kammath** Assistant Professor, Department of Electronics and Communication Engineering. This submission represents my ideas in my own words and where ideas or words of others have been included. I also declare that I have adhered to ethics of academic honesty and integrity and have not misinterpreted or fabricated any data or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University can also evoke penal action from the sources from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

Place: Karukutty | Signature & Name of Student:

Date: 07-05-2024 | Antony Petta

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SCMS SCHOOL OF ENGINEERING AND TECHNOLOGY

KARUKUTTY

CERTIFICATE

This is to certify that the report entitled '**SEARCH ASSISTANT RESCUE ROBOT**' submitted by **ANTONY PETTA** to APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of Bachelor of Technology in Electronics and Communication Engineering of SCMS School of Engineering and Technology is a Bonafide record of the project work carried out by them under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

Project Co-Ordinator	Project Supervisor	Head of the Department
Ms. Praveena S Kammath	Ms. Vrinda.V Gopal	Dr. Deepak K. S
Assistant Professor	Assistant Professor	Professor, ECE
SSET Karukutty	SSET Karukutty	SSET Karukutty

Internal Examiner

External Examiner

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VISION AND MISSION OF THE DEPARTMENT

VISION

To achieve academic excellence in Electronics and Communication Engineering and mold technically competent engineers by imparting quality education to the students while keeping in tune with the ever-changing industrial demands and societal needs.

MISSION

The Department aspires to:

M1: Impart a solid foundation in the field of Electronics and Communication

M2: Provide education with emphasis on the ethics, leadership, and entrepreneurship necessary for students to become successful contributors to society.

M3: To create individuals who can continue to learn on their own to scale greater heights in their profession.

PROGRAM SPECIFIC OUTCOMES

PSO 1	Design and create novel systems in the field of Electronics and Communication to solve global issues.
PSO 2	Carry out research activities in Electronics and Communication Engineering using modern hardware and software tools specific to the field
PSO 3	Analyze the working of electronic systems in industry and interpret results to arrive at valid conclusions.

COURSE OUTCOMES

Course Outcomes [COs]: After successful completion of the course, the students will be able to:

CO1	Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: Apply).
CO2	Develop products, processes or technologies for sustainable and socially rel- event applications (Cognitive knowledge level: Apply).
CO3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: Ap- ply).
CO4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: Apply).
CO5	Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: Analyze).
CO6	Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: Apply).

ABSTRACT

In the complex landscape of disaster response, where unpredictable challenges demand innovative solutions, our project is dedicated to the development of an economical and collaborative search and rescue assistant robot. Bridging the gap between technology and humanitarian efforts, our proposed sensing and control architecture integrates state-of-the-art components: a thermal infrared (IR) sensor array, an ultrasonic sensor, RF communication via an RF module, and GPS capabilities. At the heart of our system, the low-cost thermal IR sensor array assumes a pivotal role, providing an accurate estimation of human survivors' locations. This foundational data serves as the cornerstone for trajectory planning and control, enabling the robot to approach and assist survivors with optimal efficiency. The incorporation of a 1D ultrasonic sensor augments the robot's navigational capabilities by allowing 3D position estimation, facilitating real time obstacle avoidance and control. To expand the project's capabilities, RF communication is seamlessly integrated through an RF module. This addition enables the robot to interact with survivors in real-time, providing critical updates and collecting vital data during rescue operations. Furthermore, the integration of GPS technology ensures the robot possesses accurate and up-to-date location information, reinforcing its navigation capabilities in dynamic disaster scenarios. This project signifies a significant leap forward in developing a holistic disaster response solution that seamlessly combines advanced sensing technologies with RF communication and GPS integration. The results presented herein emphasize the project's potential as a practical, accessible, and scalable tool for collaborative rescue efforts in dynamically challenging disaster scenarios.

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CHAPTER 1

INTRODUCTION

In the wake of catastrophic events, such as natural disasters or industrial accidents, the imperative to swiftly locate and rescue survivors is paramount. However, the hazardous conditions often prevalent in these environments can severely impede traditional search and rescue efforts. In response to these challenges, the development of advanced technologies, particularly in the realm of robotics, has emerged as a promising solution to enhance the effectiveness and efficiency of disaster response operations.

This project report introduces a pioneering endeavor in the field of search and rescue robotics: the design and implementation of a Search Assistant Rescue Robot (SARR). Equipped with an array of state-of-the-art sensors, including thermal Infrared (IR) sensors, ultrasonic sensors, and GPS technology, the SARR represents a significant advancement in survivor location and recovery capabilities.

The utilization of thermal IR sensors allows the SARR to detect heat signatures emitted by human bodies, even in obscured or low-visibility environments. This capability is particularly invaluable in scenarios where survivors may be trapped under debris or otherwise concealed from view. Additionally, ultrasonic sensors provide the SARR with the ability to detect obstacles and navigate complex terrain, ensuring safe and efficient traversal of the disaster site.

Furthermore, the integration of GPS technology enhances the precision and accuracy of the SARR's location tracking capabilities, enabling rescue teams to pinpoint the exact coordinates of survivors with unparalleled reliability. This real-time location data not only facilitates rapid response times but also optimizes resource allocation and coordination among rescue personnel.

Throughout this report, we will delve into the design considerations, technological innovations, and operational capabilities of the SARR. By showcasing the successful integration of thermal IR sensors, ultrasonic sensors, and GPS technology, we aim to demonstrate the transformative potential of robotics in mitigating the impact of disasters and safeguarding human lives.

Ultimately, the development of the Search Assistant Rescue Robot represents a critical step forward in the evolution of search and rescue methodologies. Through the fusion of cutting-edge sensors and advanced robotics, we endeavor to empower rescue teams with the tools and technologies necessary to navigate the most challenging of environments and save lives.

CHAPTER 2

LITERATURE SURVEY

In the study conducted by Suman Harapanahallia, Niall O Mahonya, Gustavo Velasco Hernandeza, Sean Campbella, Daniel Riordana, and Joseph Walsh [2], in this research addresses the intricate challenges of autonomous navigation in factory environments by proposing a methodology that prioritizes efficiency, cost-effectiveness, and optimal battery life. The approach involves a minimal sensor setup, including RGB cameras, motor encoders, and a low-cost Inertial Measurement Unit (IMU) for precise robot localization. The electric drive train facilitates navigation, while neural networks, Simultaneous Localization and Mapping (SLAM) techniques, and a navigation algorithm guide the platform. The literature survey underscores the growing deployment of robots in manufacturing, emphasizing the potential ofautonomous robots to enhance productivity. The research aims to contribute substantially to autonomous navigation by emphasizing a minimal sensor approach and advanced AI techniques, addressing challenges in real-world industrial settings. This approach is poised to offer practical solutions for navigating unstructured factory environments, advancing theintegration of autonomous robotics in industry.

Andreas Birk and Holger Kenn [3] in their research outlines a significant challenge in achieving safe operation under semi-autonomous control, particularly in the context of rescue robots at the International University Bremen (IUB). To address this challenge, the paper introduces a comprehensive solution comprising a specialized software architecture and a scheduling framework. These components collaborate to ensure Quality of Service (QoS) and Fail-Safe Guarantees (FSG), crucial in the unpredictable landscape of Internet/Intranet technologies, especially when incorporating wireless components. The literature survey emphasizes the pioneering work at IUB in developing semi-autonomous rescue robots, highlighting the integration of innovative software solutions to navigate the complexities of rescue missions. The focus on QoS and FSG underscores the commitment to operational integrity, showcasing advancements in robotics for dynamic and critical environments. This research contributes significantly to the field, providing a foundation for the ongoing evolution of semi-autonomous systems in complex scenarios.

W. Kowalczyk and K. Kozłowski [4] This work delves into the groundbreaking control method proposed for multiple two-wheeled mobile robots in formation. Building on a prior trajectory tracking algorithm, the extension to include collision avoidance showcases the iterative nature of robotics research. The algorithm's distinctiveness lies in its approach to formation tasks, with each robot emulating a virtual leader's motion. This specificity adds complexity and adaptability to the robotic system, addressing real-world scenarios. The use of artificial potentialfunctions enhances navigation, aligning with contemporary robotics methodologies. Stability analysis via a Lyapunov-like function establishes a robust theoretical foundation, crucial for practical implementation. In essence, this survey highlights the algorithm's significant contribution to advancing control methods for mobile robot formations, emphasizing its uniqueness, practical relevance, and theoretical underpinnings.

Khalil Azha Mohd Annuar*, Muhammad Haikal Md Zin, Mohamad Haniff Harun, Mohd Firdaus Mohd Ab Halim and Arman Hadi Azahar [5] in their work underscores the critical role of search and rescue robots in disaster response, specifically designed to navigate complex environments and evacuate victims from collapsed buildings. While existing robots lack mobile device control, this paper introduces innovation by proposing a prototype robotic vehicle controlled through mobile devices via Bluetooth transmission. Powered by the Arduino Uno R3 board, the robot incorporates a 9V AA battery for power. The use of mobile devices as controllers, facilitated by an MIT Inventor-designed application, enhances versatility and accessibility, optimizing human-robot interaction for effective rescue operations. The addition of a robotic arm, designed using AutoCAD software and featuring four servos, further extends the robot's capabilities, enabling intricate tasks. This contribution addresses a notable gap in search and rescue robots' control mechanisms, offering a comprehensive and practical solution for disaster scenarios.

Juraj Dudak , Gabriel Gaspar , and Pavol Tanuska [6] in their study delves into the pervasive role of wireless monitoring systems in both industrial and domestic spheres. In industrial applications, these systems offer flexibility in scenarios where fixed lines are impractical, facilitating the monitoring of environmental parameters crucial for material storage. On the domestic front, wireless technology integrates seamlessly into smart households, enhancing functionalities like lock control, lighting, and HVAC management. The chosen communication protocol, Virtual Wire, operates within the 433MHz-900MHz range, showcasing its efficiency in wireless communication for diverse applications. The literature underscores the significance of secure one-way communication channels, ensuring data integrity and confidentiality. This involves a transmitting device with sensors and a receiving device aggregating data from multiple transmitters. The collective literature contributes to understanding and advancing wireless communication protocols, emphasizing their versatile and secure applications in various contexts.

Ahmed A. Ibrahim , Wael A. E. Ali , Moath Alathbah and Hesham A. Mohamed [7] introduces a novel spectrum-sensing monopole antenna designed for cognitive radio applications. The literature survey investigates existing works on spectrum-sensing antennas, emphasizing the proposed folded monopole structure with a partial ground plane operating in the 1.5 to 3.5 GHz range. Design details, including the RO4003 substrate and PIN diodes for reconfigurability, are outlined. The survey contextualizes the proposed design within the evolution of spectrum-sensing antennas, exploring historical and technological developments. Validation methods, utilizing CST software for simulation and comparative analysis with experimental results, are highlighted. The survey scrutinizes how similar approaches have been employed in prior studies, offering insights into the reliability and innovation of the proposed antenna design. This comprehensive examination contributes to understanding the broader landscape of spectrum-sensing antennas and reconfigurable designs while emphasizing the significance of the proposed cognitive radio antenna.

Hind Abdalsalam Abdallah Dafallah [8] explores the diverse applications and technologies related to GPS tracking systems, with a particular emphasis on the real-time tracking system implemented at the University of Khartoum labs. This delves into the multifaceted uses of GPS tracking, spanning personal, asset, and vehicle tracking, acknowledging its broad utility in contemporary scenarios, including potential applications in espionage. Methodologies of GPS and GSM integration for real-time tracking are extensively reviewed, aiming to understand the innovations and state-of-the-art practices in the field. Comparative analyses with existing tracking systems, especially those incorporating GSM communication, provide insights into the unique features and contributions of the University of Khartoum labs' system. Considerations of cost-effectiveness, accuracy, and adaptability are explored, drawing from research on low-cost GPS tracking systems. The literature survey contributes to a comprehensive understanding of GPS tracking systems, their technologies, and the specific advancements introduced by the University of Khartoum labs.

Fatima Nadhim Ameen Ziad Saeed Mohammed Abdulrahman Ikram Sddiq [9] in this work delves into tracking systems commonly relying on GPS, GSM, and smartphones for their widespread availability and reliability. The focus is on a paper proposing an economic tracking scheme to address the cost implications associated with SMS messages in traditional GPS- GSM tracking systems. The study implements and tests the proposed scheme alongside two classical tracking systems in practical scenarios—a 121 km vehicle trip and a 2.4 km walking journey. Results demonstrate the effectiveness and economic feasibility of the proposed system, showcasing a remarkable cost reduction of up to 64% compared to the traditional tracking systems. This highlights the significance of cost-effective innovations in GPS-GSM tracking, addressing economic considerations without compromising tracking system efficiency.

Hareesh Chitikena , Filippo Sanfilippo , and Shugen Ma [10] explores the imperative integration of contemporary technology, particularly robotic and cognitive approaches, into Search and Rescue (SAR) operations, emphasizing the role of snake robots. The escalating population density in urban areas and the increased frequency of catastrophes underscore the significance of human-robot SAR collaboration. The study underscores the ethical considerations inherent in deploying robotic technology in SAR, emphasizing safety, severity, and resource management. With a particular focus on snake robots, renowned for their potential in navigating hazardous or confined spaces, the survey delves into the ethical and design issues associated with their utilization. By addressing these considerations, the study contributes valuable insights for the ethical and technological aspects integral to the design and development of snake robots in SAR operations.

Jorge Alejandro Kamlofsky , Nicol Naidoo , Glen Bright , Maria Lorena Bergamini,Jose Zelasco , Francisco Ansaldo, Riaan Stopforth [11] discusses the critical role of robotic technology in rescue operations, specifically focusing on the integration of a mechatronic system to facilitate a visionary robotic platform. The study explores a collaborative research effort between Argentina and South Africa, emphasizing the diverse research areas each country investigated. The research collaboration culminated in the development and enhancement of a search and rescue system tailored for various robots, including wayfarer and drones, each equipped with distinct vision capabilities. The study introduces a novel and innovative vision approach, contributing to the evolution of search and rescue technologies. This literature survey provides valuable insights into the collaborative efforts and advancements made in the integration of mechatronics and visionary systems for effective robotic contributions to rescue missions.

Bikas Mondal, Rajan Sarkar, and Nirupama Mandal [12] focuses on the design and implementation of a wireless inductive-type displacement transmitter, emphasizing its significance in the modern process industrial environment. Wireless networks play a crucial role in this domain due to their robustness, cost-effectiveness, low maintenance, and energy efficiency. The proposed system employs a general-purpose multi-channel hardware module with an RF transceiver for wireless sensor network applications. The modified differential inductance bridge circuit generates an electric signal, which is transmitted wirelessly to the control room using the RF-based module. The sensor's output, conditioned in the 0-5 volt range, undergoes analog-to-digital conversion, transmitted via the transmitter module, and received as power by the receiver. Experimental results demonstrate the system's good linearity and repeatability for short-distance transmission. This literature survey underscores the article's contribution to advancing wireless sensor technologies in industrial applications, highlighting its effectiveness and practicality for real-time data transmission in a process industry setting.

Mohd Hakimi Bin Zohari, Mohd Fiqri Bin Mohd Nazri [13] in their research focuses on the development of a GPS-based Vehicle Tracking System utilizing Arduino MEGA as the central microcontroller, Ublox NEO-6m GPS module for location routing, and SIM 900A GSM module for user connectivity. The primary objective is to display the vehicle's location on Google Maps. Successful outdoor implementation was achieved, but challenges arose indoors due to signal obstructions affecting the GPS module's accuracy. The study suggests employing a higher-quality GPS module, specifically the GPS NEO-6P, to enhance accuracy and maintain satellite connectivity. This research contributes to the field of vehicle tracking systems, addressing practical challenges and proposing solutions for improved performance. The literature survey highlights the significance of GPS-based tracking systems, emphasizing the role of Arduino microcontrollers, GPS modules, and GSM connectivity. It underscores the importance of accurate location data for effective vehicle tracking and discusses potential advancements using enhanced GPS technology. Overall, the study aligns with the broader context of IoT-based tracking solutions, striving for accuracy and reliability in diverse operational environments.

Dr. Thida Aung [14] in this work explores the implementation of RF modules as a modernized wireless system, aiming to replace traditional wired setups. The central components include RF transmitters, RF receivers, LEDs, transformers, relays, push buttons, and encoding/decoding ICs (HT12E and HT12D). The HT12E encoder converts 4-bit data from buttons into serial data, transmitted by the RF transmitter. At the receiving end, the RF receiver captures the signal, and the HT12D decoder converts it back into 4-bit parallel data. This decoded data controls LEDs, enabling remote operations based on predefined keys. The literature survey underscores the contemporary demand for wireless control systems in both standard and modern living. The integration of RF technology, encoding/decoding ICs, and user interface elements aligns with the evolving landscape of wireless communication for remote control applications. The study contributes to understanding the practical implementation of RF-based wireless systems for efficient and convenient remote operations.

S. O. N. Okonye, U. M. Asiwe [15] in their work delves into the interdisciplinary field of robotics, where computational intelligence is seamlessly integrated into physical machines, amplifying their capabilities beyond individual components. Focusing on robotic vehicles that exhibit autonomy in diverse environments—ground, air, underwater, or outer space—the study emphasizes self-powered movement with onboard sensors and computational resources for guidance. Specifically, the robotic ground vehicles discussed resemble automobiles, featuring wheels or treads. The integration of RF transmitter/receiver technology and a microcontroller for data handling is a notable aspect, establishing a versatile circuit adaptable for various applications through reprogramming. Furthermore, the adoption of Pulse Width Modulator (PWM) technology for motor control is a key innovation highlighted in the work. The literature survey positions this research within the broader landscape of robotics, emphasizing the fusion of computational intelligence, communication technologies, and motor control mechanisms in the development of autonomous robotic vehicles.

Jörg Schieferdecker, Michael Schnorr, Bodo Forg, Frank Herrmann, Christian Schmidt, Wilhelm Leneke, Marion Simon, MLVFKDSchulze [16] explores the evolving landscape of Infrared (IR) arrays, which have witnessed widespread applications across diverse industries. With the proliferation of high resolutions and decreasing costs, Infrared imaging sensors and cameras are anticipated to maintain double-digit annual growth rates in the coming decade. The COVID-19 pandemic further accelerated the adoption of this technology, with annual growth rates approaching 100% compared to pre-pandemic levels. Notably, shutterless thermopile arrays, characterized by their simplicity, gained prominence in large-scale applications such as "elevated body temperature" scanners. These arrays, including thermal bolometers of VGA and higher resolution, enabled the simultaneous measurement of multiple individuals. The unique feature of thermopile arrays lies in their ability to construct true shutterless radiometric IR cameras or modules without requiring biasing. The paper introduces a groundbreaking development by Heimann Sensor—thermopile arrays with pixel sizes of 60 and 45 μm. This innovation extends the application range into higher density thermal imaging and cost-effective security and surveillance applications, with integrated signal conditioning, readout electronics, and SPI interface on the sensor chip.

Elvin Yano1 , Louise Sebastian Reyes2 , Paul Randell Castro3 ,Joseph Joshua Tarroza4 , Anthony James [17] focuses on a prototype of a compact and cost-effective mobile rescue robot designed for real-time information gathering in challenging rescue scenarios. The core components of the prototype include the Arduino Mega 2560 microcontroller, a First Person View (FPV) camera with a tilt assembly for live video streaming, and continuous track differential wheels to facilitate all-terrain navigation. The robot is specifically tailored for use in rescue operations, particularly in scenarios involving collapsed structures. Its applications range from detecting and locating injured individuals to characterizing obstacles in hard-to-reach locations. The literature survey contextualizes this work within the broader domain of mobile rescue robots, emphasizing the significance of affordable and versatile solutions that leverage advanced technologies for enhanced performance in critical rescue missions.

Christyan Cruz Ulloa, Guillermo Prieto Sánchez, Antonio Barrientos and Jaime Del Cerro [18] addresses the transformative impact of recent technological advancements on Machine Vision and Search and Rescue Robotics (SAR), particularly focusing on the application of advanced neural networks and modern optical sensors, including thermal cameras. The integration of Convolutional Neural Networks (CNN) into computer vision, especially for victim identification in post-disaster environments (PDE), represents a significant breakthrough. The conventional methods using RGB image processing or trained dogs face limitations in challenging PDE conditions, highlighting the need for innovative solutions. The proposed method introduces a novel approach, leveraging thermal image processing and CNN for victim identification through a Robotic System with a quadruped robot. The research utilizes the Robot Operating System (ROS) for automatic data processing and control. Comparative tests against methods using RGB images underscore the efficiency of the proposed approach, demonstrating effectiveness exceeding 90% in various PDE conditions. The literature survey positions this work within the evolving landscape of SAR robotics, emphasizing the critical role of advanced technologies in addressing challenges associated with victim identification in complex and hazardous environments.

Sanjay S Tippannavar,Puneeth K M ,Yashwanth S D,Madhu Sudan M P,Chandrashekar Murthy B N,Vinay Prasad M S [19] emphasizes the urgent need to enhance rescue systems, particularly in the face of natural catastrophes causing significant human losses. The integration of robots into search and rescue (SAR) operations is highlighted for their effectiveness in navigating dangerous conditions, accessing confined spaces, and tirelessly executing tasks. Advancements in technology are revolutionizing the roles of airborne, terrestrial, and marine robotic systems in SAR, offering faster and more efficient responses. Rescue robots are designed to perform specific, often hazardous tasks, including locating and extracting individuals from perilous situations. The survey underscores the diverse applications of rescue robots in mine accidents, urban catastrophes, hostage situations, and explosions, showcasing their potential to reduce human fatigue and access otherwise inaccessible areas. Ongoing developments focus on enhancing features such as mapping, debris clearing, medical care, and victim evacuation.

COMPARISON TABLE

Sl.no	Papers	Methodology	Output
1.	**A Rescue Robot Control Architecture ensuring Safe Semi-Autonomous Operation[3]**	Rescue robot control architecture	Safe semi-autonomous operation
2.	**Trajectory tracking and collision avoidance for the formation of two-wheeled mobile robots[4]**	Trajectory tracking, collision avoidance	Formation of two-wheeled mobile robots
3.	**Design and Development of Search and Rescue Robot[5]**	Search and rescue robot design	Search and rescue operations
4.	**Design and implementation of an accurate real-time GPS tracking system[8]**	Real-time GPS tracking system	Accurate real-time GPS tracking
5.	**An Economic Tracking Scheme for GPS-GSM Based Moving Object Tracking System[9]**	GPS-GSM-based moving object tracking	Economic tracking scheme
6.	**Robotics in Search and Rescue (SAR) Operations: An Ethical and Design Perspective Framework for Response Phase[10]**	Robotics in SAR operations	Not specified
7.	**Semi-Autonomous Robot Control System with an improved 3D Vision Scheme for Search and Rescue Missions. A joint research collaboration between South Africa and Argentina[11]**	Semi-autonomous robot control system	Not specified

8.	**GPS Based Vehicle Tracking System[13]**	GPS-based vehicle tracking system	Real-time vehicle tracking on Google Maps
9.	**Implementation of a Robotic Vehicle using an RF Module[15]**	Robotic vehicle using RF module	Implementation of a robotic vehicle
10.	**New high-resolution Thermopile Arrays for IR Imaging, person detection, and consumer applications[16]**	High-resolution thermopile arrays	Not specified
11.	**Prototype of a Compact Assistant Surveillance Robot for Search and Rescue Operations[17]**	Compact assistant surveillance robot	Search and rescue operations
12.	**Autonomous Thermal Vision Robotic System for Victims Recognition in Search and Rescue Missions[18]**	Autonomous thermal vision robotic system	Not specified
13.	**SR2 - Search and Rescue Robot for saving endangered civilians at Hazardous Areas[19]**	Search and rescue robot (SR2)	Saving endangered civilians at hazardous areas

Table 2: Comparison table

CHAPTER 3

METHODOLOGY

3.1 BLOCK DIAGRAM

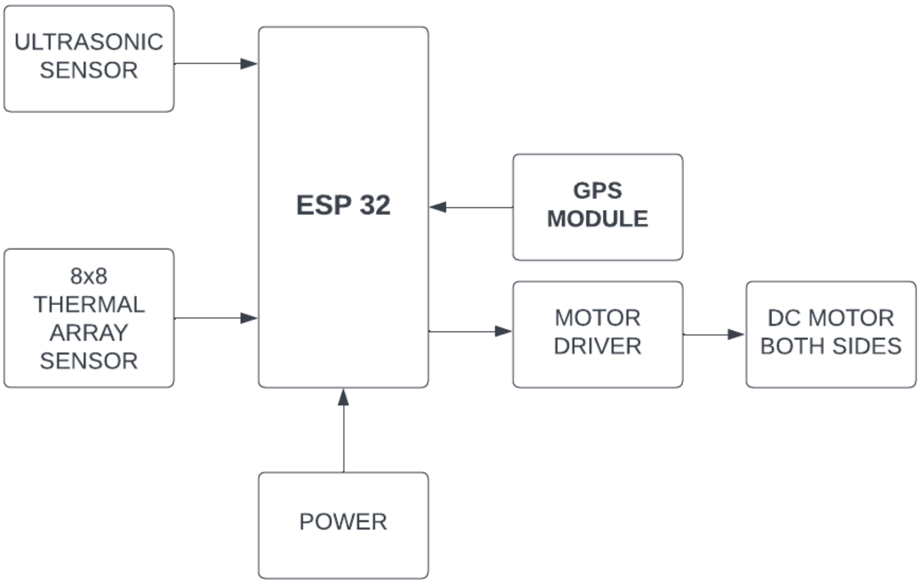


Figure 3.1: Block Diagram

1. ESP32 MODULE:

   - Purpose: To ensure that the robot do its functions properly without any fail.
   - Function: Takes in all the data from the sensors to process the information about the position, orientation, thermal readings and execute the algorithms properly.

2. THERMAL IR ARRAY:

   - Purpose: To detect the injured people during the disaster rescue operation
   - Function: Detects the thermal data of the peoples and differentiates it from the surroundings to know the positions of the injured during the disaster time.

3. ULTRASONIC SENSORS:

   - Purpose: To detect the obstacles near the robot
   - Function: Emits ultrasonic waves in 180°, detects the reflecting waves and calculate if there is an object near the robot for it avoid.

4. DC MOTOR:

- Purpose: To move the robot across the terrain.
- Function: Drives the caterpillar belt drivetrain to move the robot. It can also change the direction of the robot according to the need.

5. GPS MODULE:

- Purpose: To send the exact location of the robot.
- Function: Detect the GPS coordinates of the robot and send the information to the rescuer to know the position of surviving people.

3.1.1 THERMAL SENSING ARCHITECTURE

To identify the positions of human survivors, we chose to use a thermal infrared (IR) array sensor for its comparable performance to thermal IR cameras in detecting humans, while also being more compact and cost-effective. The array comprises $q \times q$ IR sensors, arranged according to Figure 3, with each sensor measuring the temperature of both humans and the surrounding environment.

The array is divided into three distinct areas: A, B, and C (as depicted in Figure 3). This segmentation enables easy recognition of the direction in which the robot should move while controlling its DC motors. By utilizing these predefined areas, the robot can approximate whether it should turn right, turn left, or maintain its current position. To improve precision, Equation (2) is employed to refine this method, allowing the robot to estimate the location of detected survivors more accurately.

In this scenario, we assume that area B corresponds to the robot's heading direction, positioned at the center of the sensor array. For example, if a human is detected in area A or C instead of area B, a motor control command is generated to align the robot's front towards area B. This ensures that the human's temperature position aligns with area B, minimizing the complexity of motor control commands and optimizing the robot's navigation strategy for efficient human survivor detection and localization.

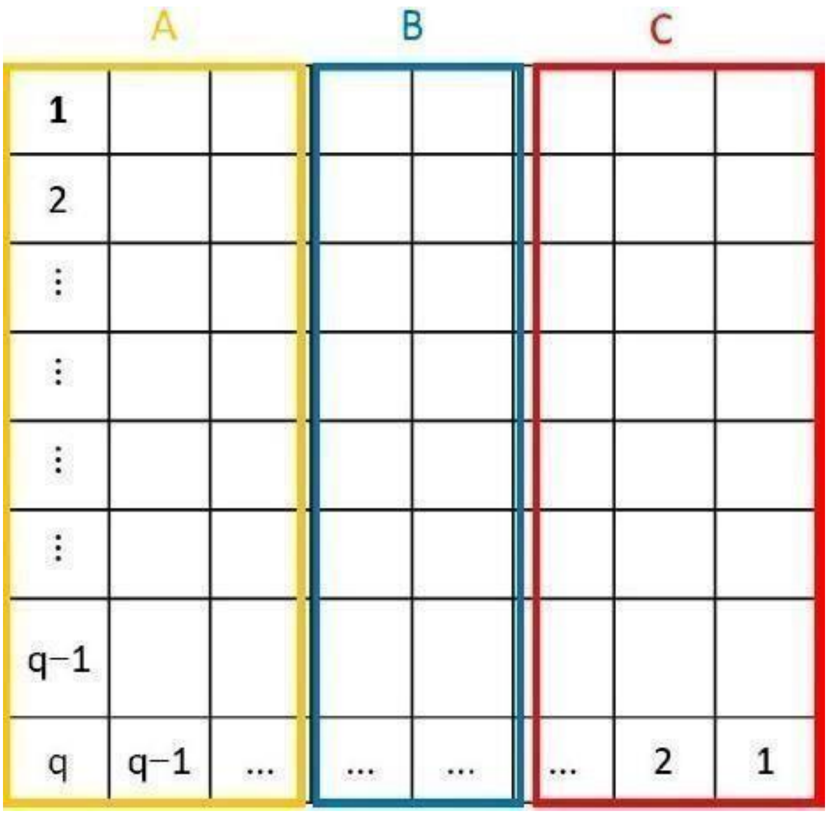


Figure 3.2:Differnt temperature regions(A,B,C)

Since the typical temperature range of a human body is 35.5~37.5 _C, we chose 34~38 _C as the threshold to detect the position of a human body, as shown in

$$T_A = \sum_{l=1}^{L} (34 \sim 38)$$

$$T_B = \sum_{m=1}^{M} (34 \sim 38)$$

$$T_C = \sum_{n=1}^{N} (34 \sim 38)$$

Utilizing the variables T_A, T_B, T_C, l, m, and n, which represent the cumulative human body temperature and the count of sensor cells detecting temperatures in the range of 34~38°C in areas A, B, and C, respectively, we can derive the horizontal position angle α of a human survivor. Referring to Equation (1) and defining T_{max} as $T_{max} = \max(T_A, T_B, T_C)$, the horizontal position angle α, illustrated in Figure 2, is determined as follows:

$$\alpha = \begin{cases} \dfrac{(-\gamma\times 2\times i_{h+3})+(-\gamma\times 3\times i_{h+4})+\cdots+\left[-\gamma\times\left(\frac{q}{2}-1\right)\times i_{q-1}\right]+\left[-\gamma\times\left(\frac{q}{2}\right)\times i_q\right]}{\sum\limits_{j=h+3}^{q} i_j}, & \text{if } T_{\max} = T_A \\ \dfrac{(\gamma\times i_{h+2})+(-\gamma\times i_{h+1})}{\sum\limits_{j=h+1}^{h+2} i_j}, & \text{if } T_{\max} = T_B \\ \dfrac{\left[\gamma\times\left(\frac{q}{2}-1\right)\times i_2\right]+\left[\gamma\times\left(\frac{q}{2}\right)\times i_1\right]+\cdots+(\gamma\times 2\times i_h)+(\gamma\times 3\times i_{h-1})}{\sum\limits_{k=1}^{h} i_k}, & \text{if } T_{\max} = T_C \end{cases}$$

Equation 1

where i1 to iq are the number of sensor cells detecting 34~38 _C in columns 1 to q, shown in *Figure 3*, respectively. *g* is the viewing angle resolution defined as *b*/q, where the viewing angle of the IR sensor array is _*b* degrees, and h is the number of the last column in area C.

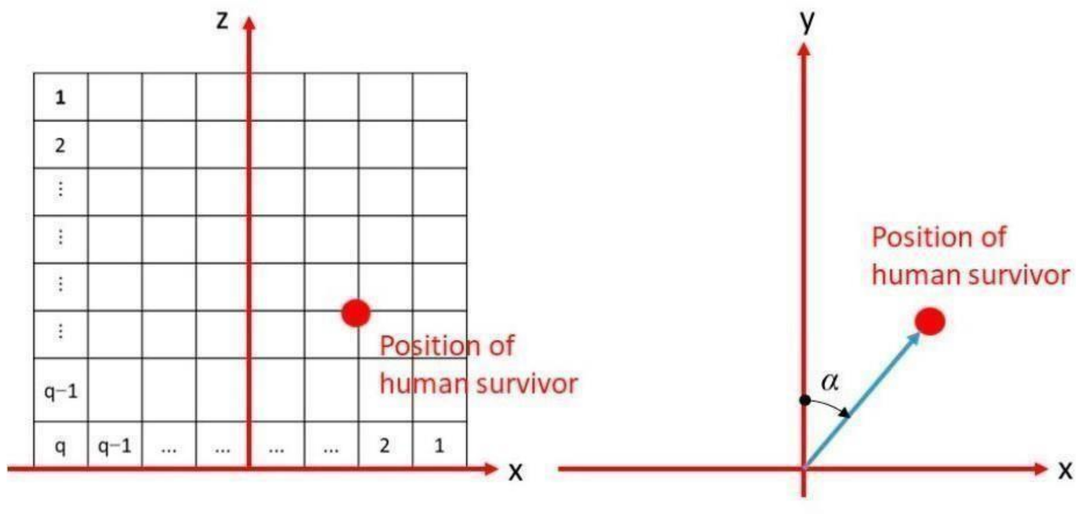


Figure 3.3: Front and top view of the position of survivor

3.1.2 OBSTACLE DETECTION

The obstacles are detected using two HC-SR04 ultrasonic sensors mounted on the sides of the robot. When the robot is moving through disaster places there would be many obstacles in place. Ultrasonic sensors emit the sound waves constantly and read the reflected wave the datais then passed onto the esp32 microcontroller for processing the distance between the objects and the robot. The wheels are then turned to change the direction of the robot away from potential obstacles.

Obstacle avoidance is based on an algorithm and data collected by the ultrasonic sensor. The sensor checks for any obstacle in front of it if there is no obstacle it moves forward, if an object is detected it stops and turns left and right at a time and takes some readings. According to these readings the robot will decide which is the appropriate path to be followed i.e. whether itshould turn right or left.

The flow chart for the process is given below.

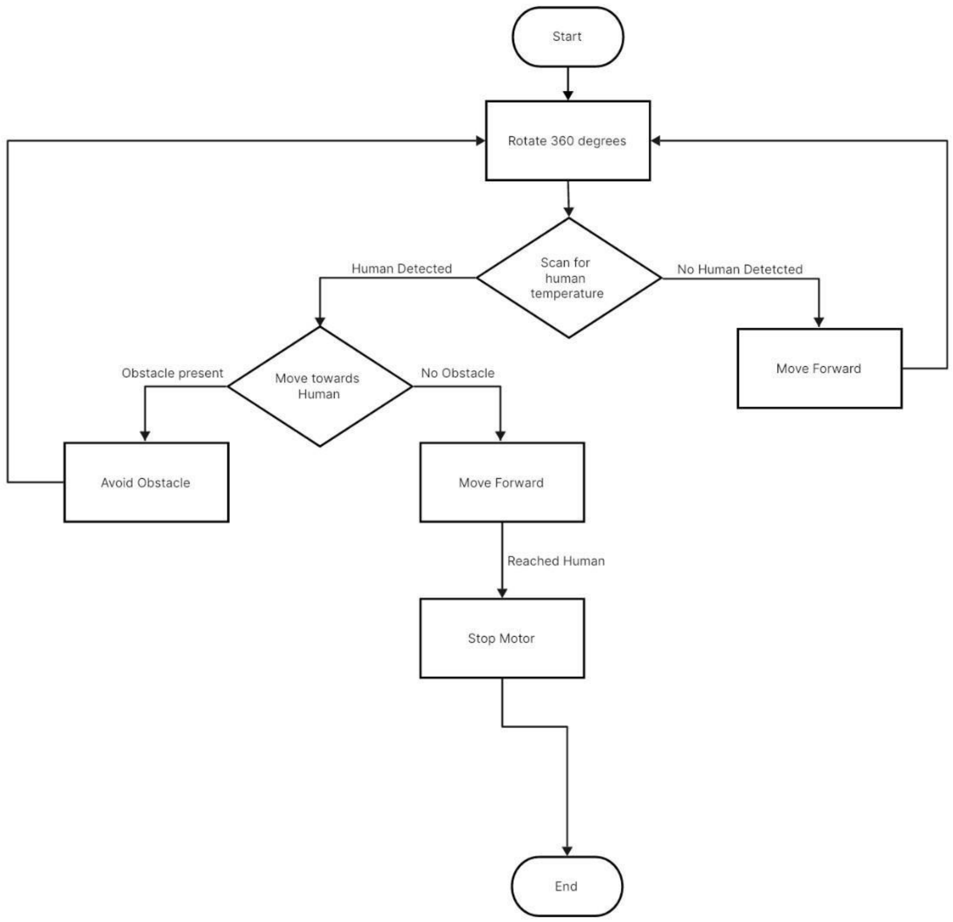


Figure 3.4: Flowchart for obstacle avoidance

1. Principle of Operation:

    - Ultrasonic sensors operate on the principle of echolocation, similar to how bats navigate. The sensor emits ultrasonic waves (inaudible sound waves) in pulses. These waves travel through the air until they encounter an obstacle.

2. Transmission of Ultrasonic Pulses:

    - The ultrasonic sensor contains a transducer that converts electrical energy into ultrasonic waves. These waves are emitted in short bursts or pulses.

3. Reflection from Obstacle:

    - When these ultrasonic pulses encounter an obstacle in their path, they get reflected back toward the sensor. The sensor's receiver detects the reflected waves.

4. Calculation of Distance:

    - By measuring the time, it takes for the ultrasonic pulses to travel to the obstacle and back, the sensor can calculate the distance to the object using the speed of sound in air (which is approximately 343 meters per second at room temperature).

5. Conversion to Distance Measurement:

    - The sensor typically provides a digital or analog output corresponding to the distance measured. Digital output might involve a binary signal indicating whether an obstacle is within a predefined range, while analog output can provide a continuous range of distance values.

6. Threshold Comparison:

    - In applications where a digital signal is used, a threshold distance is often set. If the measured distance falls below this threshold, the sensor triggers an obstacle detection event. This event can be used to initiate actions such as stopping a robot, activating an alarm, or altering the trajectory of a moving object.

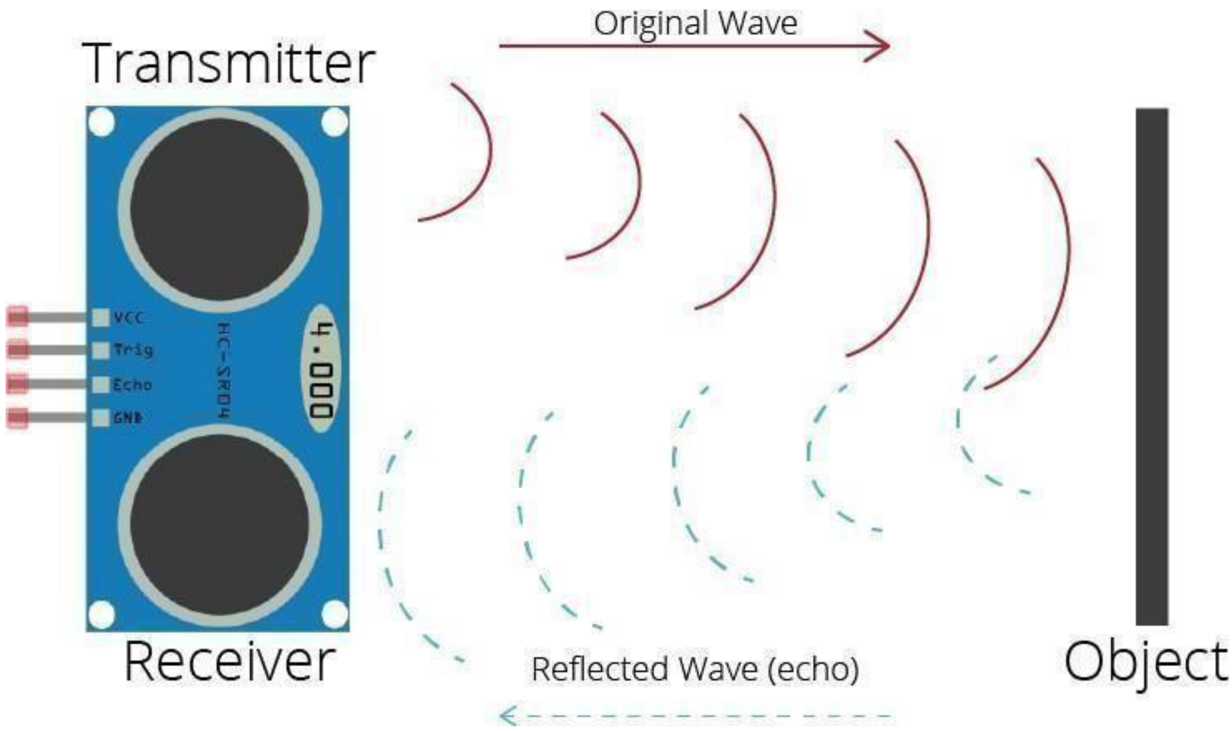


Figure 3.5: Ultrasonic sensor working.

3.2 CIRCUIT DIAGRAM

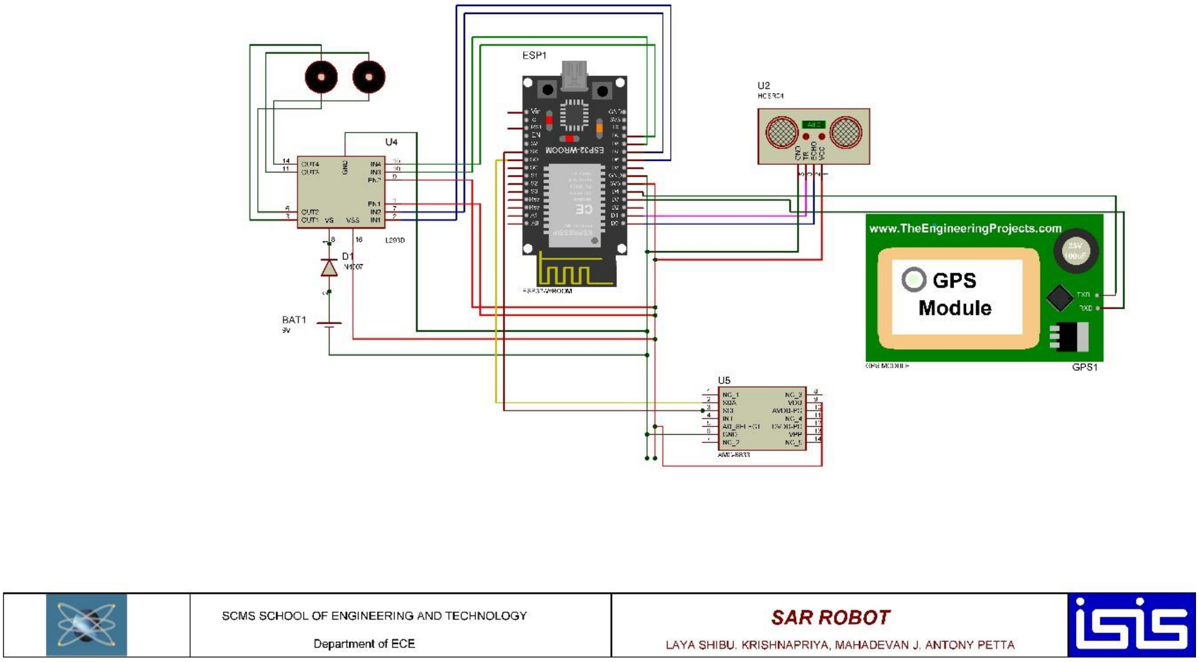


Figure3.6: Circuit diagram

In this circuit we have used ESP32 NodeMcu as the main microcontroller. The main input sensor is the AMG8833 IR array. It uses I2C communication protocol so we have connected the SDA and SCL pin of the ESP and AMG8833 for synchronization. Its through the SDA pin we get the data. SDA stands for serial data. SCL stands for serial clock for synchronization.

Pin configuration

Application	AMG8833(pin no)	ESP32(pin no)
VCC	9(3V)	8
GND	6	6
SDA	2	21
SCL	3	22

Table 3.1 Pinout

Next is the interfacing of ultrasonic sensor with the ESP32. Here we are using 2 sensors in our project.

Each module uses 4 pins of the ESP out of which 2 are for VCC and GND and the rest two for ECHO and TRIG. TRIG is used to produce ultrasonic waves and echo is used to detect the reflected waves back.

Application	**ESP32**	**HC-SR04**
VCC	8	1
GND	6	4
TRIG	15	2
ECHO	4	3

Table 3.2: Pinout 2

Interfacing of motor with ESP using motor driver. Using L2930 driver we can interface 2 motors at a time. There are several pins in L2930.

There are 2 separate VCC for motor and the driver itself. There is a enable pin. Separate power sourceis used to provide power for the motor this can be used to control the motor by PWM (Pulse Width Modulation).

Application	**L293D**
VCC1(for driver)	16
VCC2(for motor)	8
Input1(M1)	12
Input2(M1)	12
Input3(M2)	14
Input4(M2)	27
GND	6

Table 3.3: Pinout 3

CHAPTER 4

HARDWARE & SOFTWARE DESCRIPTION

4.1 HARDWARE DESCRIPTION

4.1.1 ESP32 NodeMcu

Figure 4.1 ESP32 Node MCU

The ESP32 NodeMCU is a development board that seamlessly integrates the ESP32 microcontroller, a versatile chip designed for Internet of Things (IoT) applications. With dual-core Tensilica LX6 CPUs running at speeds up to 240 MHz, the ESP32 boasts robustprocessing capabilities. The NodeMCU board simplifies the development process by providinga ready-to-use platform for prototyping and building IoT projects. Equipped with General Purpose Input/Output (GPIO) pins, it facilitates the connection of external devices such as sensors and actuators. The board features an Analog-to-Digital Converter (ADC) for reading analog sensor values, and it can be programmed using popular development environments likethe Arduino IDE. Additionally, the NodeMCU integrates a USB-to-Serial converter (typicallyCH340 or CP2102) for seamless communication with computers during programming and debugging. Operating at 3.3V, the NodeMCU can be powered through USB or an external supply, and it includes onboard flash memory for program and data storage. With built-in Wi- Fi (802.11b/g/n) and Bluetooth connectivity (Bluetooth 4.2/BLE), the NodeMCU enables wireless communication and connectivity to the internet. Supported by an active community, both the ESP32 microcontroller and the NodeMCU development board are open-source, fostering collaboration and innovation in the realm of embedded systems and IoT applications.

Microcontroller:

- NodeMCU is available in versions based on both ESP8266 and ESP32 microcontrollers, providing flexibility for different project requirements.

Wireless Connectivity:

- Integrated Wi-Fi capability (ESP8266: 802.11b/g/n, ESP32: dual-band 2.4 GHz and 5 GHz) enables wireless communication and internet connectivity for IoT applications.

Bluetooth Support (ESP32):

- In ESP32-based NodeMCU boards, Bluetooth support (Bluetooth 4.2/BLE) allows for additional wireless communication options.

GPIO Pins:

- General Purpose Input/Output (GPIO) pins enable the connection and control of external devices, such as sensors, LEDs, and actuators.

Analog-to-Digital Converter (ADC):

- The microcontroller includes an Analog-to-Digital Converter (ADC) for reading analog sensor values.

Programming:

- NodeMCU can be programmed using various development environments, including the Arduino IDE, PlatformIO, and Lua scripting language.

USB-to-Serial Converter:

- Integrated USB-to-Serial converters (like CH340 or CP2102) simplify the connection to a computer for programming and debugging.

Power Supply:

- Supports power input through USB or an external power supply. Operating voltage is typically 3.3V.

Flash Memory:

- Onboard flash memory is available for storing program code and data.

Form Factor:

- NodeMCU boards have a standardized form factor, making them easy to use and compatible with various accessories and expansion boards.

Community Support:

- Benefiting from an active and supportive community, NodeMCU users have access to a wealth of tutorials, documentation, and libraries.

Open-Source:

- Both the microcontroller and the NodeMCU development board are open-source, encouraging collaboration and customization for specific project needs.

4.1.2 THERMAL IR ARRAY

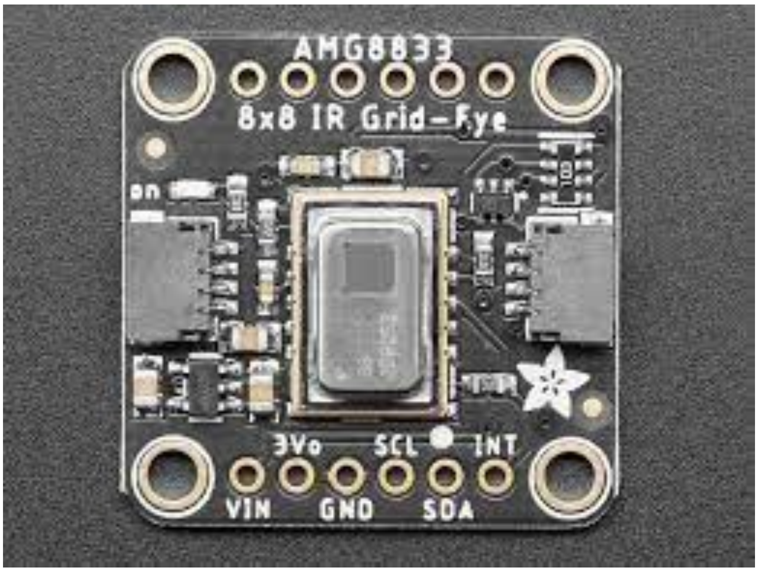


Figure 4.2 Thermal IR array sensor

Figure 4.2 IR sensor Camera Sensor is an infrared imaging device designed to detect and quantify temperature variations within its field of view. Its notable feature is an 8x8 array of thermal sensors, providing 64 pixels for thermal imaging applications. The sensor relies on the principle of infrared radiation emitted by objects, allowing it to create thermal maps or images based on temperature differences. With a digital output and I2C interface, it can efficiently communicate with microcontrollers, such as Arduino or Raspberry Pi, making it suitable for integration into various electronics projects.

One of the key aspects of the AMG8833 is its wide field of view, enabling it to capture a broader area for thermal analysis. The sensor operates at a specific frame rate, ensuring regular updates of thermal data. Adafruit, a reputable manufacturer of electronic components, offers support for the AMG8833 through dedicated libraries and example codes. This support streamlines the integration process and facilitates quick development for those using the sensor in their projects.

Applications for the AMG8833 are diverse, including but not limited to thermal imaging cameras and occupancy detection systems. The sensor is particularly useful in projects requiring non-contact temperature measurement. Its compact size makes it suitable for integration into small-scale electronic devices, and its low power consumption ensures efficiency, especially in battery-powered applications.

Resolution:

- The sensor features an 8x8 array of infrared thermal sensors, providing a total of 64 pixels for thermal imaging.

Thermal Sensing:

- It is designed to detect and measure temperature variations by sensing infrared radiation emitted by objects.

Temperature Range:

- The AMG8833 sensor typically has a temperature detection range suitable for human body temperature, making it suitable for applications like occupancy detection and thermal imaging.

I2C Interface:

- The sensor communicates with microcontrollers or other devices using the I2C (Inter-Integrated Circuit) communication protocol.

Digital Output:

- The sensor provides digital output, making it easy to interface with microcontrollers like Arduino, Raspberry Pi, or other embedded systems.

Field of View (FOV):

- The AMG8833 sensor has a wide field of view, allowing it to capture a broad area in its thermal imaging range.

Frame Rate:

- The sensor typically operates at a specific frame rate, allowing it to capture and update thermal data at regular intervals.

Accuracy:

- The accuracy of the sensor is important for reliable temperature measurements. The Adafruit AMG8833 is designed to provide reasonably accurate thermal data.

Adafruit Library Support:

- Adafruit, a well-known manufacturer of electronic components, provides libraries and example code for the AMG8833 sensor. This support simplifies the integration of the sensor into various projects.

Power Supply:

- The sensor operates on a specific voltage range and usually has low power consumption, making it suitable for battery-powered application.

4.1.3 ULTRASONIC SENSOR

Figure 4.3 Ultrasonic sensor

The Ultrasonic Sensor HC-SR04 is a popular and versatile distance measurement device widely used in electronics and robotics projects. Operating on the principle of ultrasonic sound waves, the sensor can accurately determine the distance between itself and an object. This HC-SR04 sensor consists of two main components: an ultrasonic transmitter and a receiver. The transmitter emits ultrasonic pulses, which then bounce off objects and return to the receiver. By measuring the time it takes for the pulses to travel to the object and back, the sensor calculates the distance using the speed of sound.

The HC-SR04 sensor typically operates in a range of 2 cm to 400 cm, providing a non-contact method for distance measurement. It is known for its ease of use and compatibility with various microcontrollers, such as Arduino and Raspberry Pi. The sensor communicates using a simple trigger and echo mechanism: a trigger signal initiates the ultrasonic pulses, and the echo signal indicates when the reflected pulses are received.

One notable feature of the HC-SR04 is its ability to measure distances with high precision, making it suitable for applications like obstacle avoidance in robotics, liquid level detection, and smart home projects. Its compact size, low cost, and straightforward interface contribute to its popularity among hobbyists and professionals alike.

To utilize the HC-SR04, users typically need to consider factors such as temperature, as the speed of sound can vary with temperature changes. Additionally, accurate distance readings may require incorporating appropriate error handling in the code due to potential interference or signal reflections.

The HC-SR04 Ultrasonic Sensor is a popular distance measuring device with several key features that make it suitable for a variety of applications:

Ultrasonic Distance Measurement:

- Utilizes ultrasonic sound waves to measure distance by calculating the time it takes for the waves to travel to an object and back.

Operating Range:

- Typically operates in a range of 2 cm to 400 cm, providing flexibility for both short and long-distance measurements.

Transmitter and Receiver:

- Consists of an ultrasonic transmitter that emits pulses and a receiver that detects the reflected signals.

Trigger and Echo Mechanism:

- Operates on a simple trigger and echo mechanism where a trigger signal initiates the ultrasonic pulses, and the echo signal indicates the time it takes for the pulses to return.

Precision:

- Capable of providing accurate distance measurements, making it suitable for applications that require precise object detection or avoidance.

Non-Contact Measurement:

- Enables non-contact distance measurement, making it ideal for applications where physical contact is not desired.

Operational Principle:

- Works based on the principle of time-of-flight measurement, where the time taken for the ultrasonic pulses to travel and return is used to calculate distance.

Adjustable Sensitivity:

- Some variations or implementations may allow users to adjust the sensitivity, providing customization options for specific project requirements.

4.1.4 MOTOR DRIVER(L293D)

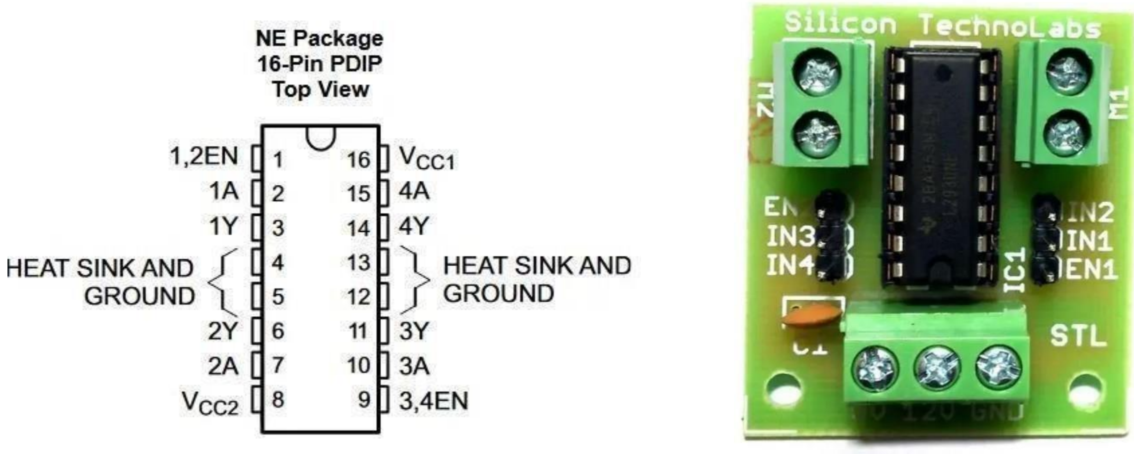


Figure4.4 Pin diagram of L293D and L293D module

The L293D serves as a specialized low-voltage motor driver with distinctive features that set it apart from other integrated circuits. Unlike some counterparts, its notable capability lies in delivering high voltage to the motor independently, ensuring bidirectional direct current without affecting the entire IC or other connected devices. This IC incorporates an internal H-bridge for bidirectional control of two motors, allowing movement in either direction. Despite its compact size, the L293D demonstrates a higher power output capacity, capable of controlling DC motor speed and direction within a voltage range of 4.5 to 36 volts. Diodes are integrated for protection against back electromotive force (EMF).

To efficiently handle a maximum current of 600mA, the L293D features an internal "Darlington transistor sink" for current control and a "pseudo-Darlington source" for amplifying input signals to seamlessly control high-voltage DC motors. Key features include simultaneous control of two motors, speed adjustment via the enable pin, easy direction changes, and compatibility with a wide voltage supply range. The IC supports a maximum continuous current of nearly 600mA, with a peak current range of 1.2A. An automatic shutdown system activates in thermal conditions, and its working temperature range spans from0 to 70 degrees Celsius, catering to diverse applications.

Crucial for motor control, input pins determine the motor's direction, allowing for precise control based on logic states and enable pin adjustments. The L293D's compact size, protective features, and versatility in motor control applications make it a valuable component in electronic circuits, offering bidirectional control, high voltage handling, and effective protective measures for diverse applications.

4.1.5 DC MOTOR

Figure 4.5 DC Motor

A DC motor, short for direct current motor, is an electrical machine that converts electrical energy into mechanical energy through the principles of electromagnetism. It consists of a stator, generating a magnetic field when current flows through it, and a rotor or armature, typically a coil of wire mounted on a shaft. When a DC is applied, the current in the armature interacts with the magnetic field, producing torque and causing rotor rotation. The commutator ensures continuous rotation by periodically reversing the current.

DC motors come in various types. Brushed DC motors use brushes and a commutator for current reversal, while brushless DC motors (BLDC) use electronic commutation, offering efficiency and reduced maintenance. Their applications range widely, from household appliances and industrial systems (like conveyor belts and robotics) to significant roles in electric vehicles and hybrid cars within the automotive industry.

4.1.6 GPS MODULE(NEO-6M)

Figure 4.6 GPS Module

The NEO-6M GPS module is a widely utilized Global Positioning System (GPS) receiver module recognized for its compact design and dependability. Here are key features and details about the NEO-6M GPS module:

1. GPS Receiver

- The NEO-6M is a GPS receiver module designed to communicate with satellites, determining its precise location through signals from the Global Navigation Satellite System (GNSS).

2. U-Blox Technology:

- Developed by u-blox, a prominent provider of GPS technology, the NEO-6M employs u-blox's advanced positioning technology for accurate and reliable location information.

3. Compact Size:

- The module's compact design makes it suitable for integration into various electronic projects and devices with limited space.

4. Serial Communication:

- Serial communication is a typical mode for the module, facilitating interaction with microcontrollers or other devices. It utilizes the NMEA (National Marine Electronics Association) protocol to transmit GPS data.

5. UART Interface:

- Utilizing a UART (Universal Asynchronous Receiver-Transmitter) interface for serial communication, the NEO-6M easily integrates with popular microcontrollers like Arduino.

6. Voltage Compatibility:

- Operating on a low voltage, the module is compatible with a range of electronic systems, typically requiring a voltage supply in the range of 3.3V to 5V.

7. Position Accuracy:

- The NEO-6M provides precise position information, generally with a few meters of accuracy. Factors such as satellite visibility, environmental conditions, and module configuration can influence accuracy.

8. Time to First Fix (TTFF):

- Representing the time taken for the GPS receiver to determine its initial position after powering on, the NEO-6M is known for a quick Time to First Fix, enabling rapid acquisition of satellite signals.

9. Update Rate:

- Supporting various update rates, users can configure how often the module provides new position data. Common update rates range from 1 Hz to 10 Hz.

10. Built-in Antenna:

- Some variants of the NEO-6M GPS module feature a built-in ceramic patch antenna, streamlining the hardware setup.

4.1.7 SINGLE 9V BATTERY

Figure 4.7 single 9V battery

The 9-volt battery is a compact and versatile power source formed by six cylindrical cells connected in series, providing a combined voltage of 9 volts. Recognizable by its rectangular shape and distinct positive and negative terminals, this battery is widely used in electronic devices requiring higher voltage outputs. It is commonly employed in safety equipment like smoke detectors, portable radios, electronic toys, and specific audio equipment such as microphones and guitar pedals. The battery's physical design includes a snap-style connector, ensuring easy integration into compatible devices. Available in alkaline and lithium variants, these batteries offer a balance of cost and performance or extended life and better performance in extreme temperatures, respectively. Despite their small size, 9-volt batteries are crucial in powering a diverse range of electronic gadgets, thanks to their higher voltage output, convenient form factor, and adaptability in various applications.

4.2 SOFTWARE DESCRIPTION

ARDUINO IDE

The Arduino Integrated Development Environment (IDE) serves as a crucial tool in the Arduino ecosystem, providing a comprehensive and accessible platform for users to develop and program their Arduino projects. With its open-source nature, the IDE not only encourages transparency and collaboration but also allows users to delve into the source code, fostering a culture of continuous improvement and customization. Its cross-platform compatibility ensures that Arduino enthusiasts using different operating systems can seamlessly engage with the IDE.

The IDE's user interface is carefully designed to cater to a broad spectrum of users, striking a balance between simplicity and functionality. The built-in code editor is equipped with features such as syntax highlighting and auto-indentation, facilitating a smoother coding experience.

Supporting the Arduino programming language, a simplified version of C/C++, the IDE makes coding approachable for beginners while still offering versatility for more experienced developers.

A notable feature of the Arduino IDE is the Library Manager, which simplifies the management of external libraries. These libraries contain pre-written code snippets and functions that users can easily incorporate into their projects, saving time and effort. The inclusion of a Serial Monitor is another valuable aspect, enabling real-time monitoring and debugging of the communication between the Arduino board and a connected computer.

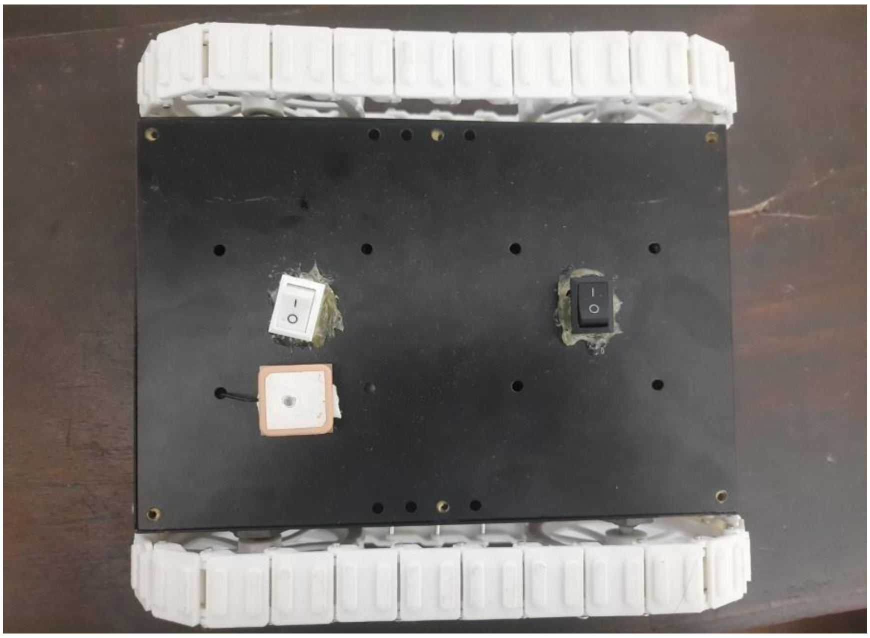
The integration of compilation and upload processes within the IDE is a significant convenience. Users can write their code, verify its correctness, and upload it directly to the connected Arduino board with just a few clicks.

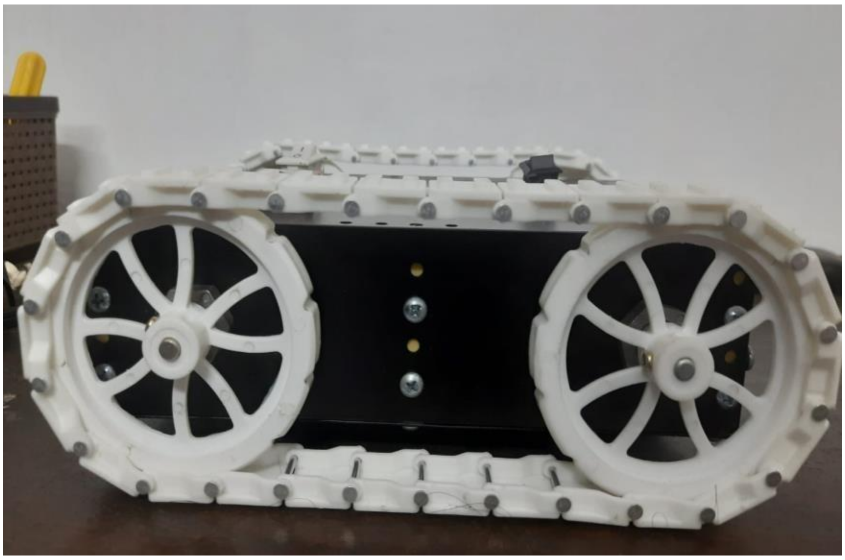
In conclusion, the Arduino IDE stands as a powerful and versatile tool that empowers individuals to bring their electronic creations to life. Its well-designed interface, integrated tools, and supportive community make it an ideal choice for both beginners exploring the world of electronics and seasoned developers pushing the boundaries of innovation within theArduino ecosystem.

CHAPTER 5
RESULT

The implementation of the Search Assistant Rescue Robot project revolutionizes search and rescue operations, offering swift, efficient, and safe responses to emergencies. Equipped with advanced thermal IR sensors, ultrasonic sensors, and GPS, the robot autonomously navigates through challenging environments, providing real-time data to responders. Its ability to cover expansive areas and assess hazardous conditions minimizes the risk to human responders while accelerating the detection and rescue of survivors. By fostering collaboration between technology experts, emergency responders, and policymakers, this innovative solution not only enhances the effectiveness of rescue missions but also instills public confidence in the capabilities of emergency response agencies.

We have successfully designed a robot that detects the human temperature around 32- 37 degrees and displays it on serial monitor. The algorithm that has been developed by us detects the obstacle and performs obstacle avoidance. According to our algorithm, the robot rotates in its place after obstacle detection and moves forward in the direction where human temperature is detected. After detecting humans, the location of the body is sent out via GPS. With the location coordinates, it will be easier to locate the humans and rescue them.





CHAPTER 6

CONCLUSION

In conclusion, the development and implementation of the Search Assistant Rescue Robot (SARR) represent a significant milestone in the ongoing efforts to enhance disaster response capabilities. Through the integration of thermal Infrared (IR) sensors, ultrasonic sensors, and GPS technology, the SARR has demonstrated its effectiveness in locating and rescuing survivors in hazardous and challenging environments.

The successful deployment of the SARR in simulated disaster scenarios has showcased its ability to navigate complex terrain, detect human bodies through thermal signatures, and provide accurate location data through GPS tracking. These capabilities have not only expedited rescue operations but have also contributed to the mitigation of casualties and the preservation of human life.

Furthermore, the modular design and adaptable architecture of the SARR facilitate future enhancements and refinements to its capabilities. As technology continues to evolve, there is significant potential for the integration of additional sensors and advanced algorithms to further improve the SARR's performance and effectiveness in real-world disaster scenarios.

Beyond its technical prowess, the SARR embodies a testament to collaboration and innovation in the field of search and rescue robotics. The interdisciplinary efforts of engineers, researchers, and emergency responders have culminated in a solution that transcends traditional limitations and empowers rescue teams with the tools and technologies necessary to save lives.

As we look to the future, it is imperative that we continue to invest in research and development initiatives aimed at advancing search and rescue robotics. By harnessing the power of technology and innovation, we can build upon the foundation laid by the SARR and further strengthen our collective ability to respond to disasters with speed, efficiency, and compassion.

In closing, the Search Assistant Rescue Robot stands as a beacon of hope in times of crisis—a testament to human ingenuity and resilience in the face of adversity. With continued dedication and collaboration, we can build a safer and more resilient world for generations to come.

CHAPTER 7

FUTURE SCOPE

A Search Assistant Rescue Robot equipped with thermal IR sensors, ultrasonic sensors, and GPS, has significant potential for various applications, especially in search and rescue operations. Here are some future scope considerations for such a project:

1. Enhanced Sensor Integration: Continuously improving the integration and capabilities of sensors can significantly enhance the robot's performance. For instance, integrating advanced machine learning algorithms with thermal IR sensors can enable the robot to detect and recognize human body heat signatures more accurately, even in challenging environmental conditions.

2. Multi-Robot Coordination: Exploring the feasibility of deploying multiple robots equipped with similar sensor suites and enabling them to collaborate efficiently can enhance the scalability and coverage of search and rescue missions. Coordination algorithms can facilitate communication and task allocation among multiple robots to optimize search efforts.

3. Integration of Communication Systems: Incorporating communication systems such as Wi-Fi, LTE, or satellite communication can enable the robot to transmit real-time data to remote operators or command center’s. This includes video feeds, sensor data, and robot status updates, enhancing situational awareness and enabling remote guidance.

4. Human-Robot Interaction: Improving the interface and interaction between the robot and human operators can enhance usability and effectiveness in real-world scenarios. This includes intuitive control interfaces, augmented reality overlays for displaying sensor data, and natural language processing for voice commands and communication.

5. Robustness and Reliability: Ensuring the robustness and reliability of the robot in harsh and unpredictable environments is crucial for successful search and rescue missions. This involves ruggedizing the hardware, implementing fault-tolerant software architectures, and conducting extensive testing in various environmental conditions.

6. Integration with Drones and Aerial Platforms: Exploring integration possibilities with drones

and other aerial platforms can provide complementary capabilities for reconnaissance and mapping in large-scale search and rescue operations. Collaboration between ground-based robots and aerial assets can enhance coverage and efficiency in locating and rescuing survivors.

7. Community Engagement and Deployment: Collaborating with emergency response organizations, disaster management agencies, and community stakeholders is essential for validating the effectiveness of the robot in real-world scenarios. Conducting field trials and simulations in collaboration with relevant stakeholders can provide valuable insights for further refinement and deployment.

8. Adaptability to Different Environments: Designing the robot to be adaptable to different types of environments, such as urban areas, wilderness, or disaster zones, requires versatile sensor suites and robust navigation algorithms. Customizable configurations and modular design approaches can facilitate adaptation to specific mission requirements.

9. Ethical and Legal Considerations: Addressing ethical and legal considerations related to privacy, data security, and the use of autonomous systems in emergency situations is essential. Ensuring transparency, accountability, and adherence to regulatory frameworks will be critical for gaining public trust and acceptance of search and rescue robots.

By considering these aspects, the Search Assistant Rescue Robot can evolve into a highly capable and reliable asset for enhancing search and rescue operations in various scenarios

APPENDIX

```
#include <WiFi.h>
#include <Wire.h>
#include <Adafruit_AMG88xx.h>
#include <NewPing.h>
#include <TinyGPS++.h>
#include <SoftwareSerial.h>

const char* ssid = "yourssid";
const char* password = "yourpasswd";

WiFiServer server(80);

// Define pins for motor control
#define MOTOR_PIN1 27
#define MOTOR_PIN2 14
#define MOTOR_PIN3 12
#define MOTOR_PIN4 13

// Define pins for sensors
#define I2C_SDA_PIN 21
#define I2C_SCL_PIN 22
#define TRIGGER_PIN 15 // Connect to the trigger pin of HC-SR04
#define ECHO_PIN 4     // Connect to the echo pin of HC-SR04
#define MIN_DISTANCE_TO_OBSTACLE 20

// Create instances of the NewPing (HC-SR04) and TinyGPS++ libraries
NewPing sonar(TRIGGER_PIN, ECHO_PIN);
TinyGPSPlus gps;

// Create a SoftwareSerial object to communicate with the GPS module
SoftwareSerial gpsSerial(16, 17); // RX, TX

// Create an instance of the AMG88xx library for temperature sensor
Adafruit_AMG88xx amg;

// Define array to store temperature values
float temperatureArray[8][8];

void setup() {
  Serial.begin(115200);
  gpsSerial.begin(9600); // Initialize the GPS serial communication
```

```
  // Setup motors
  pinMode(MOTOR_PIN1, OUTPUT);
  pinMode(MOTOR_PIN2, OUTPUT);
  pinMode(MOTOR_PIN3, OUTPUT);
  pinMode(MOTOR_PIN4, OUTPUT);

  // Initialize I2C
  Wire.begin(I2C_SDA_PIN, I2C_SCL_PIN);

  // Initialize WiFi
  WiFi.begin(ssid, password);
  Serial.print("Connecting to ");
  Serial.println(ssid);
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected.");
  Serial.println("IP address: ");
  Serial.println(WiFi.localIP());

  server.begin();

  // Initialize AMG88xx sensor
  if (!amg.begin()) {
    Serial.println("Could not find a valid AMG88xx sensor, check wiring!");
    while (1);
  }
  else {
    Serial.println("AMG88xx sensor initialized.");
  }
}

void loop() {
  // Rotate 360 degrees for scanning
  rotateRobot360();

  // Check for human temperature
  bool humanDetected = scanForHumanTemperature();
```

```
if (humanDetected) {
  stopRobot();
  delay(2000);
  moveForward();
} else {
  Serial.println("No human temperature detected. Continuing scanning.");
  delay(1000); // Delay for stability
  stopRobot();
  delay(2000);
  moveForward();
  delay(3000);
}

// Check for obstacle
avoidObstacle();

// Update the GPS data
while (gpsSerial.available() > 0) {
  if (gps.encode(gpsSerial.read())) {
    // If new GPS data is available, print it to Serial
    Serial.print("Latitude: ");
    Serial.println(gps.location.lat(), 6);
    Serial.print("Longitude: ");
    Serial.println(gps.location.lng(), 6);
  }
}

// Check for incoming clients
WiFiClient client = server.available();
if (client) {
  Serial.println("New Client.");
  String currentLine = "";
  while (client.connected()) {
  if (client.available()) {
      char c = client.read();
      Serial.write(c);
      if (c == '\n') {
        if (currentLine.length() == 0) {
          // Respond to HTTP request
          client.println("HTTP/1.1 200 OK");
          client.println("Content-type:text/html");
```

```
          client.println();
          client.print("GPS Location: ");
          client.print("Latitude: ");
          client.print(gps.location.lat(), 6);
          client.print(", Longitude: ");
          client.print(gps.location.lng(), 6);
          client.println();
          break;
        } else {
          currentLine = "";
        }
      } else if (c != '\r') {
        currentLine += c;
      }
    }
  }
  // Close the connection
  client.stop();
  Serial.println("Client Disconnected.");
 }
}

bool scanForHumanTemperature() {
 bool humanDetected = false;  // Variable to store whether human temperature is detected

 // Read temperature and store it in the array
 readAndStoreTemperature();

 // Check temperature range for human presence
 for (int row = 0; row < 8; row++) {
  for (int col = 0; col < 8; col++) {
   if (temperatureArray[row][col] >= 32 && temperatureArray[row][col] <= 36) {
    Serial.println("Human temperature detected!");
    humanDetected = true;
    return humanDetected; // If human temperature is detected, return immediately
   }
  }
 }
 return humanDetected;
}
```

```
void readAndStoreTemperature() {
  float pixels[AMG88xx_PIXEL_ARRAY_SIZE];
  amg.readPixels(pixels);

  // Copy temperature values to the temperatureArray
  for (int i = 0; i < AMG88xx_PIXEL_ARRAY_SIZE; i++) {
    int row = i / 8;
    int col = i % 8;
    temperatureArray[row][col] = pixels[i];
  }
}

void moveForward() {
  // Move forward
  digitalWrite(MOTOR_PIN1, LOW);
  digitalWrite(MOTOR_PIN2, HIGH);
  digitalWrite(MOTOR_PIN3, LOW);
  digitalWrite(MOTOR_PIN4, HIGH);
}

void stopRobot() {
  // Stop both motors
  digitalWrite(MOTOR_PIN1, LOW);
  digitalWrite(MOTOR_PIN2, LOW);
  digitalWrite(MOTOR_PIN3, LOW);
  digitalWrite(MOTOR_PIN4, LOW);
}

void avoidObstacle() {
  unsigned int distance = sonar.ping_cm(); // Send ping, get distance in cm and print result (0
= outside set distance range)

  // If an obstacle is detected within the minimum distance
  if (distance < MIN_DISTANCE_TO_OBSTACLE) {
  stopRobot();
    delay(2000); // Reverse for a certain amount of time
    rotateRobot360(); // Turn left
    delay(2000); // Wait for the turn to complete
  }
}
```

```
void rotateRobot360() {
  // Rotate the robot 360 degrees
  digitalWrite(MOTOR_PIN1, HIGH);
  digitalWrite(MOTOR_PIN2, LOW);
  digitalWrite(MOTOR_PIN3, LOW);
  digitalWrite(MOTOR_PIN4, HIGH);
}
```

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