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# Rescue Robot using Backtracking Algorithm and SLAM Algorithm

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***Abstract*: In times of disasters, it is important to locate survivors and provide them with necessary help as soon as possible. However, this can be challenging due to the hazardous environment created by disasters. In order to overcome these challenges, rescue robots equipped with backtracking algorithm and LoRa communication can be utilized to locate people and send GPS signals to a device outside the disaster area [1], [2]. This paper focuses on the algorithms used by robots to move, LoRa communication, and the algorithms used to form the whole map of the disaster area.**

***Keywords*: Backtracking, SLAM (Simultaneous Localization and Mapping), LIDAR (Light Detection and Ranging).**

## 1. Introduction

Disasters have the power to wreak havoc on both human life and property. The search and rescue operation is essential to rescue as many lives as possible following a tragedy. Rescue workers may struggle to find survivors in a catastrophe region due to the dangerous environment. In this sense, the employment of rescue robots in disaster zones has the potential to change the game. These robots can navigate dangerous terrain and find those who require assistance. This research focuses on how backtracking algorithm for finding routes and how LoRa connectivity will help rescue robots to create a map of the disaster region using SLAM algorithm.

## 2. Backtracking Algorithm

Backtracking algorithm is a search algorithm that is used for finding all possible solutions to a problem by exploring all possible paths in a given search space. This algorithm is widely used in computer science for solving problems such as combinatorial optimization, constraint satisfaction, and decision-making problems. In the context of a rescue robot in a disaster area, backtracking can be used to efficiently search for and locate missing people.

When a rescue robot is sent into a disaster area to search for missing people, it faces numerous obstacles such as debris, rubble, and blocked pathways. Back-tracking algorithm can be used to plan and execute the movement of the robot in such a way that it covers the entire area while efficiently searching for people in the process. The robot's movement can be broken down into a series of steps that it takes to navigate through the area [3]. At each step, the robot can use backtracking algorithm to determine the best direction to move in based on the available information.

The backtracking algorithm works by exploring all possible paths that the robot can take at each step. It starts by selecting a direction to move in and then moves the robot in that direction. If the robot encounters an obstacle or a dead-end, it backtracks to the previous step and tries a different direction. This process continues until the robot has covered the entire search space and located all missing people.

To implement the backtracking algorithm in a rescue robot, the robot must be equipped with sensors that can detect obstacles and map out the search space. The robot must also have a way to keep track of its current location and the paths it has already explored. This can be achieved using GPS, lidar, or other positioning technologies.

Overall, the backtracking algorithm is a powerful tool for finding solutions to complex problems, and its use in the movement of rescue robots in disaster areas can help save lives by efficiently locating missing people.

## 3. LoRA Communication

LoRa (Long Range) is a low-power wireless communication technology that enables long-range communication between devices, while consuming very little power. LoRa technology operates in the unlicensed radio spectrum, which means that it is available for use by anyone without the need for a license. This makes it an ideal communication network for use in disaster areas, where traditional communication networks may be disrupted or unavailable. In the context of rescue robots in a disaster area, LoRa technology can be used to enable communication between the robots and outside personnel. Each robot can be equipped with a LoRa transceiver, which allows it to communicate with other robots and an outside control center. The LoRa transceiver can be configured to send and receive data at a specific frequency and data rate, enabling reliable communication over long distances.

One of the main advantages of LoRa technology is its low power consumption. This is critical in a disaster area where power may be limited or unavailable. LoRa transceivers can operate on batteries or other low-power sources, enabling them

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to operate for extended periods without needing to be recharged or replaced.

To use LoRa technology for communication between rescue robots, each robot can periodically broadcast its location data and status to other robots and the outside control center. This data can be sent using a standard message format that includes the robot's unique identifier, its current location, and its status. Other robots and the control center can receive this data and use it to build a real-time map of the disaster area.

The LoRa network can be configured to support multiple communication channels, allowing robots and the control center to communicate simultaneously without interference. In addition, the LoRa network can be encrypted to ensure secure communication and prevent unauthorized access.

Overall, LoRa technology is an ideal communication network for use in disaster areas, where traditional communication networks may be unavailable or disrupted. Its low power consumption, long-range communication, and reliable data transmission make it an ideal choice for communication between rescue robots and the outside control center, enabling the robots to work together to locate and rescue people in need.

## 4. LIDAR Sensor

A sort of remote sensing technology known as a Lidar (Light Detection and Ranging) sensor uses laser pulses to produce a 3D map of the area around it. A laser beam is sent by the Lidar sensor, which bounces off nearby objects before returning to the sensor. The distance between the sensor and the item is determined by measuring the amount of time it takes for the laser pulse to return. Many times per second, this procedure is repeated, resulting in a 3D point cloud of the area surrounding the sensor.

Rescue robots map their surroundings and instantly identify threats and impediments thanks to lidar sensors. The robot can navigate through complex areas with increased safety and efficiency because to the sensors' constant scanning of the environment for comprehensive information.

## 5. Processors

### *A. Raspberry Pi*

The rescue robot's master controller, the Raspberry Pi, is in charge of acquiring and processing information from the GPS module and Lidar sensors. The Raspberry Pi creates a 360-degree map of the surroundings using information from the Lidar sensors and identifies any threats or barriers in the environment. Using this data and a backtracking method, the Raspberry Pi calculates a secure path through the environment. Additionally, the Raspberry Pi makes use of the GPS module to continuously track the location of the robot and transmit that data via LoRa to an external controller. The Rasp-berry Pi can offer real-time information about the robot's surroundings and location thanks to the combination of these data [4].

### *B. STM 32*

As the rescue robot's slave controller, the STM32 Nucleo-64 Board is in charge of managing the servo motors that drive its legs. The device uses the control signals it receives from the Raspberry Pi to modify the servo motors' speed and direction. By altering the motor control signals in response to feedback from the Lidar sensors, the board is programmed to maintain a steady gait while exploring the environment. The STM32 Nucleo-64 Board enables the robot to travel through an area, avoid obstacles, and determine the quickest path to the destination by cooperating with the Raspberry Pi. These two controllers work together to give rescuers a complete solution for navigating challenging situations and better disaster response.

## 6. SLAM Algorithm

SLAM (Simultaneous Localization and Mapping) algorithm is a computational technique used in robotics and computer vision to simultaneously build a map of an unknown environment and locate the robot within it. The SLAM algorithm can be used in a disaster area to build a map of the environment using GPS location data from various rescue robots.

In a disaster area, rescue robots can be deployed to search for missing people and survey the damage. Each robot can be equipped with GPS sensors that provide its location coordinates. However, these coordinates alone are not enough to build an accurate map of the environment, as GPS signals may be disrupted or inaccurate in the disaster area. Additionally, the robots may not be able to see or sense all obstacles and features of the environment. The SLAM algorithm solves this problem by using sensor data from the robots to build a map of the environment while also localizing the robots within the map. The SLAM algorithm uses a combination of probabilistic models and algorithms to estimate the location of the robot and the features of the environment.

The SLAM algorithm works by integrating sensor data from the robots to update the map and the robot's position estimate in real-time. As the robot moves through the environment, it continuously collects sensor data and updates its position and the map. This process continues until the robot has covered the entire search space and built an accurate map of the environment.

The map created by the SLAM algorithm can be used to guide rescue robots to specific locations, identify obstacles and hazards, and plan search and rescue operations. The map can also be used to track the progress of the rescue operation and identify areas that need further attention.

Overall, the SLAM algorithm is a powerful tool for building accurate maps of unknown environments and localizing robots within them. In the context of a disaster area, the SLAM algorithm can be used to build a map of the environment using GPS location data from rescue robots, providing critical information to guide rescue operations and locate missing people.

## 7. Implementation

### *A. Locomotion*

A quadrupedal [5] rescue robot typically uses 8 servo motors, with 2 for each leg, to control the movement of its legs. These servo motors provide precise position control, making them ideal for use in robotics applications. Each leg of the robot is controlled by a servo motor at the hip joint and another at the knee joint. By controlling the movement of these joints, the robot can walk, run, and climb over obstacles, allowing it to traverse challenging terrain and reach areas that may be inaccessible to humans. The servo motors can be controlled using a variety of signals, such as PWM or serial communication, depending on the specific application. Overall, the use of servo motors in a quadrupedal rescue robot is essential to enable precise and coordinated movement of the legs, which is critical for maintaining balance and mobility in challenging environments.

### *B. Design*

In The mechanical construction of the robot must be carefully considered while designing a quadrupedal rescue robot with four legs that houses a Raspberry Pi, STM32 microprocessor, servo motors, and batteries. The robot needs to be built to be sturdy and capable of navigating challenging terrain, such as debris or rubble in a disaster region. The robot's legs should be built with sufficient range of motion for climbing, running, and walking. The legs have to be made to sustain the weight of the robot and any cargo it could be carrying while still being light and strong.

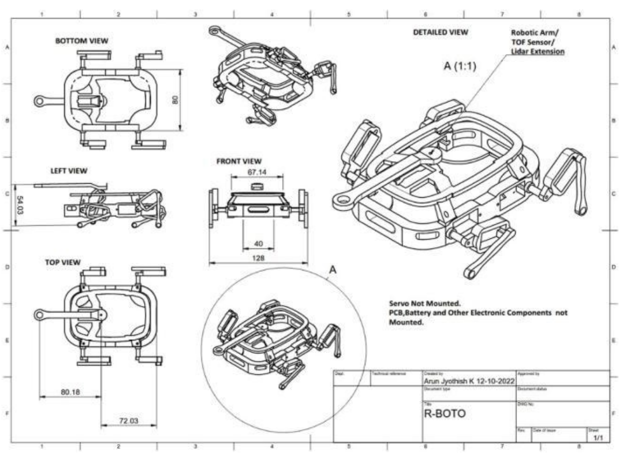

Fig. 1. 3D design of the robot

### *C. Block Diagram*

The block diagram consists of sensors, GPS Module, a processor and transceiver module.

### *D. Flow Chart*

This method enables the rescue robot to move safely across a space while gathering information to map the region for rescue operations. The Raspberry Pi analyses the data from the Lidar sensors, which give the robot real-time information about its surroundings, to decide how to move. When the GPS module gathers location information to map the region, the STM32 microcontroller manages the robot's legs in accordance with decisions made by the Raspberry Pi. Overall, this algorithm enables the rescue robot to move independently and successfully complete its task.

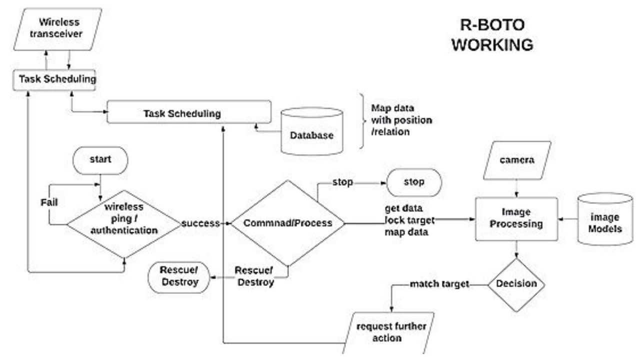

Fig. 2. Robot hardware block diagram

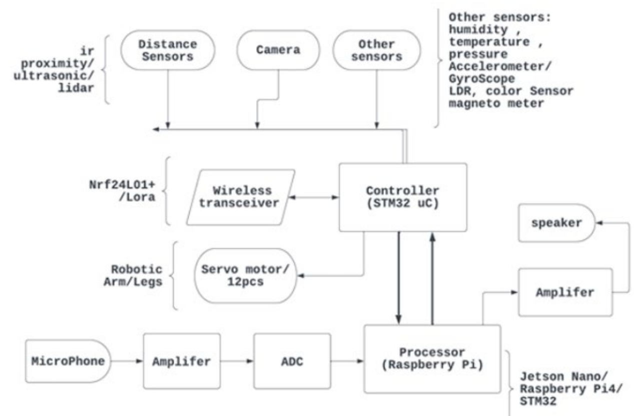

Fig. 3. R-Boto hardware

Using the SLAM technique, this algorithm enables the key device to gather GPS location information from numerous robots utilising LoRa connection and use it to create a map of the disaster region. Using the map that is produced, rescuers can efficiently plan and coordinate their efforts. Rescuers can track the status of each robot involved in the operation thanks to the algorithm, which refreshes the map on a constant basis with new position information and flags dormant robots. In order to ensure the safety of both the robots and the victims, the algorithm also sends alerts or cautions if any new impediments or threats are found.

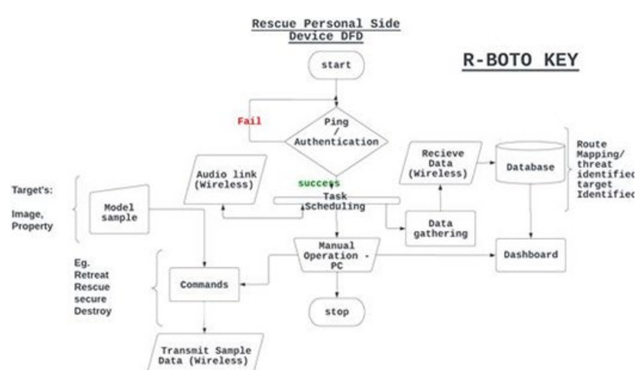

Fig. 4. Flow chart of key device

## 8. Results

Implemented and tested backtracking algorithm using a pathfinder program which implements backtracking algorithm to find all the routes in a given maze without repeating a route.


Fig. 5. Sample output to demonstrate backtracking algorithm used

Rescue robot model assembled with Raspberry Pi and servo motors.

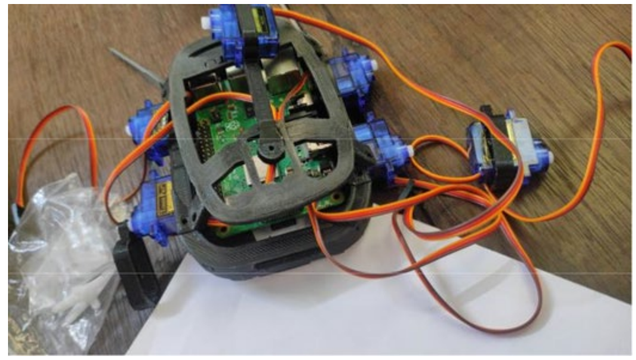

Fig. 6. Fully assembled rescue robot model

## 9. Conclusion

This paper presented the implementation of rescue robot using backtracking algorithm and SLAM algorithm.

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