Robotics,
Autonomous systems

RubbleScout Project Report

School year 2023-2024

RubbleScout,

"Navigating Chaos, Saving Lives"

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1. Introduction

RubbleScout is a semi-autonomous robot designed to enhance search and rescue operations in disaster-stricken environments. The primary goal is to reduce risks for rescuers and speed up interventions by providing accurate data on affected environments.

Project Goals:

- **Reduce Risks:** Minimise the exposure of rescuers to dangerous and unstable conditions.
- **Accelerate Interventions:** Improve the efficiency and speed of search and rescue operations.
- **Provide Accurate Data:** Offer precise and reliable information about the disaster area to aid in decision-making.

Main Applications:

- **3D Mapping:** Create detailed maps of disaster-stricken areas to assist in navigation and planning.
- **Obstacle and Survivor Detection:** Identify obstacles and detect survivors in the debris to facilitate rescue efforts.

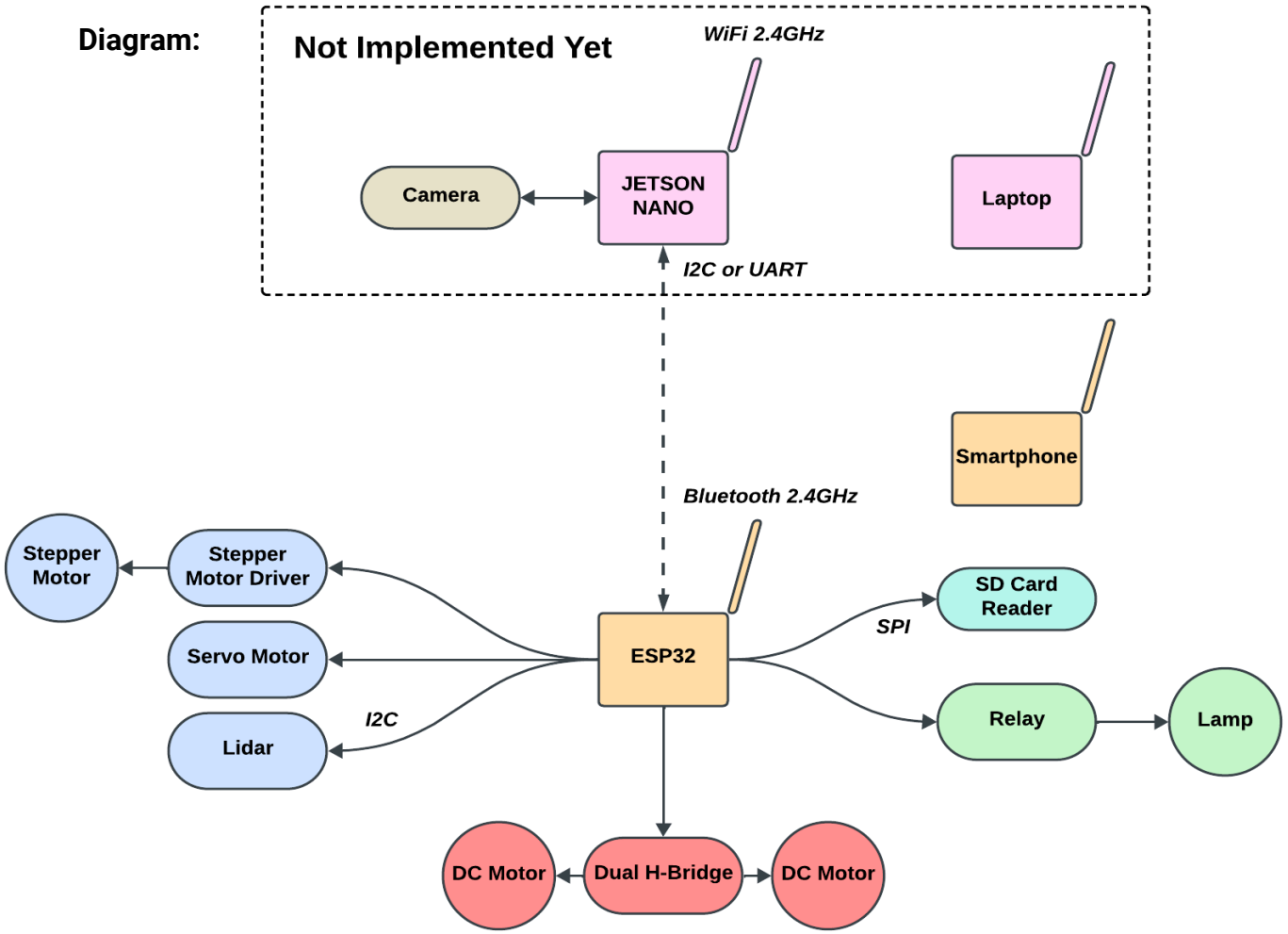
2. Architecture

The following schematic illustrates the overall architecture and key components of the RubbleScout project. The system is centered around the ESP32 microcontroller, which interfaces with various sensors and actuators to perform the necessary functions. For detailed wiring connections, please refer to the appendix.

Main Components:

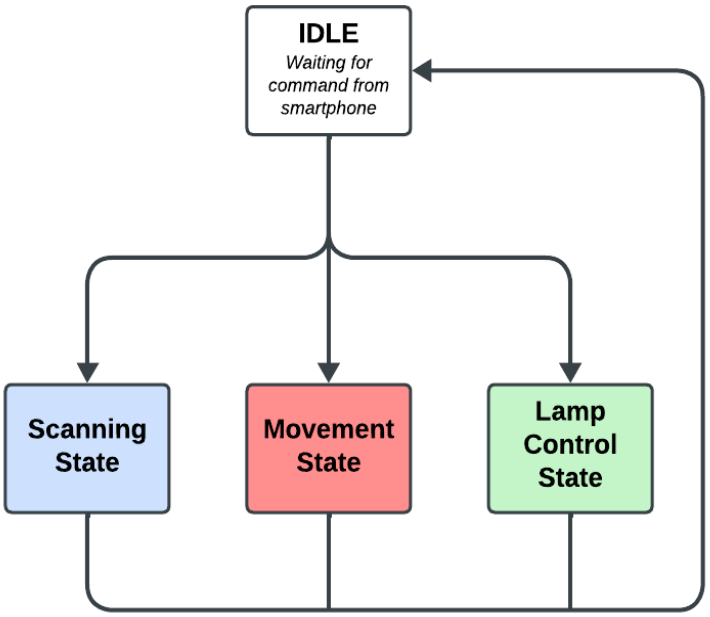
ESP32: The central microcontroller responsible for processing data and controlling the system.
Lidar + Servo and Stepper Motor: Used for distance measurement and 3D mapping.
Jetson Nano + Camera: Planned for future implementation, responsible for advanced processing tasks like video streaming and object recognition.
SD Card Reader: Data logging.

Diagram:



Note: The complete wiring schematic is included in the appendix for further reference.

3. Algorithm



The functionality is divided into different tasks managed by the ESP32 microcontroller.

The state machine for RubbleScout defines the different operational states of the robot and the transitions between these states.

This simplified diagram provides an overview of the key states and transitions:

Note: The complete state machine diagram is included in the appendix.

4. Project Cost

Component	Cost (€)
3D Scan Module	430
Chassis + Motors	180
Jetson + Camera	290
ESP32 + SD	40
Battery + Buck	70
Lamp + Relay	30
Building Materials	120
Miscellaneous	90
Total	1 250

In total I worked around **200 hours** on the project (including 72 hours in the project session), and at an hourly rate of 23.75€, that works out at **4 750€** for the labour involved.

The total estimated cost is therefore **6 000€.**

5. Issues and Solutions

Problem:

Power Supply Overload

Solution:

Replaced the LDO with a Buck Converter, which is more efficient and capable of handling higher power loads without overheating.

Problem:

The Arduino Uno microcontroller was unable to handle the computational demands of the project, particularly for the 3D scanning task which required more processing power and memory.

Solution:

Upgraded to an ESP32 microcontroller, which offers dual-core processing, integrated Bluetooth and Wi-Fi, and greater speed and memory capacity.

Problem:

The initial code implementation was too slow, causing delays in data processing and system responsiveness.

Solution:

Implemented multithreading using the ESP-IDF (Espressif IoT Development Framework) to run tasks in parallel, significantly improving the speed and efficiency of the system.

6. Conclusion and Future Work

RubbleScout has successfully achieved several key milestones:

3D Scanning: The system can perform 3D scans of its environment using Lidar, servo motors, and stepper motors. The data collected is stored on an SD card for further analysis.
Basic Movement: The robot can be controlled via a smartphone using Bluetooth, allowing for precise movement control.
Lamp Control: The system includes a relay-controlled lamp, which can be turned on and off remotely to provide illumination in dark environments.

However, some aspects of the project are still in development:

Jetson Nano Integration: The advanced computational capabilities of the Jetson Nano, such as video streaming, object recognition, and autonomous navigation, have not been fully implemented.

Future Work

To fully realize the potential of RubbleScout, the following developments are planned:

Integration of Jetson Nano:

-Implement video streaming and real-time processing for object and person recognition.
-Develop and integrate advanced navigation algorithms to enable autonomous operation.

Addition of New Sensors:

Integrate additional sensors such as temperature, gas, and humidity sensors to provide more comprehensive environmental data.

Long-Range Communication:

Implement long-range communication protocols (e.g., ELRS, CROSSFIRE) to extend the operational range of the robot in disaster-stricken areas.

Robustness and Durability:

Enhance the physical design of the robot to withstand harsh conditions in disaster environments, including shock absorption and waterproofing.

Conclusion:

RubbleScout represents a significant step forward in improving search and rescue operations. With further development and enhancements, it has the potential to become a vital tool for rescuers, providing them with the necessary data and capabilities to save lives more effectively and safely.

7. Appendix

Fig 1 : Front View of RubbleScout

Fig 2 : Back View of RubbleScout

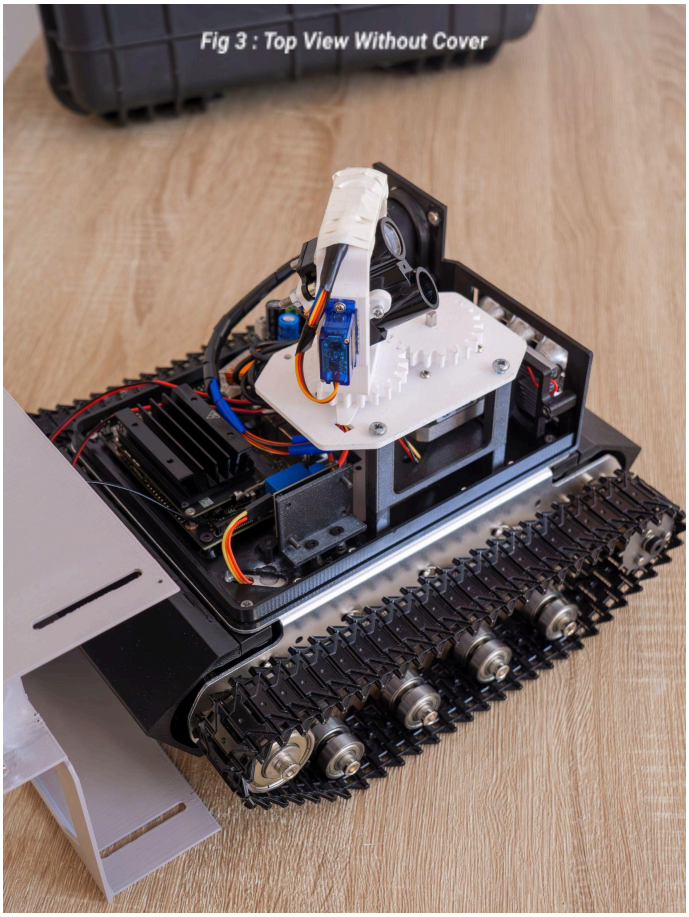


Fig 3 : Top View Without Cover

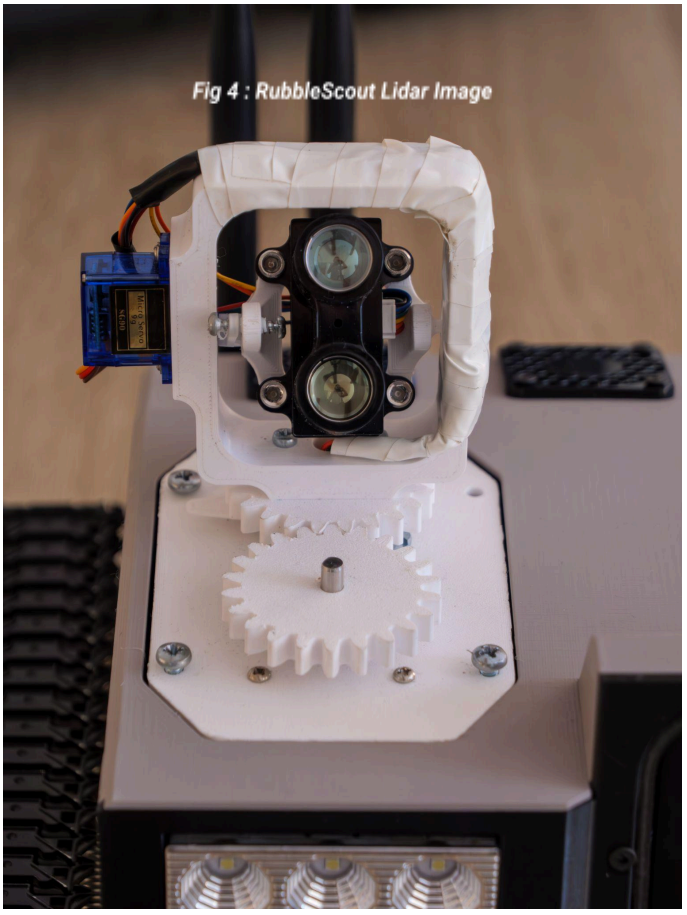
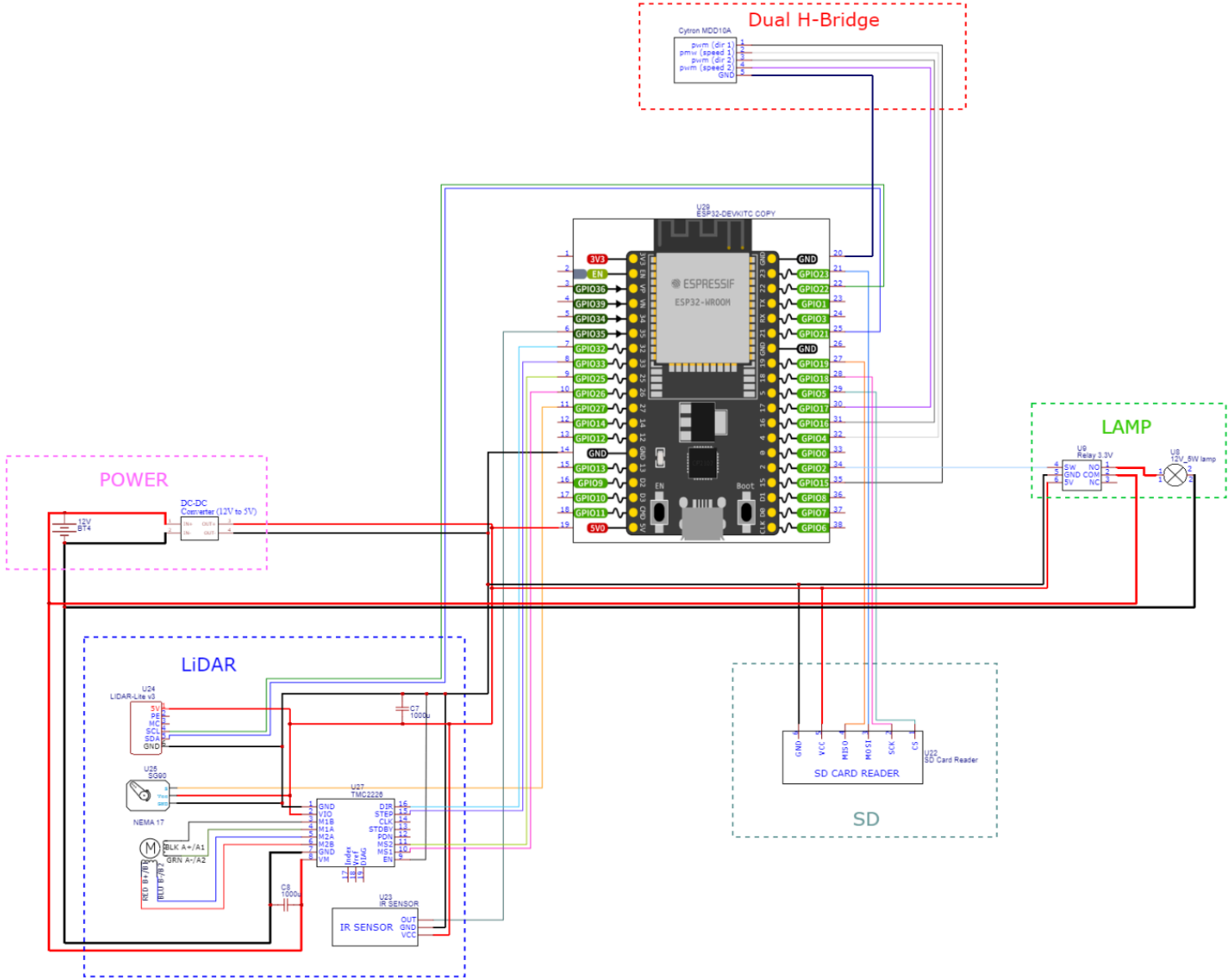


Fig 4 : RubbleScout Lidar Image



TITLE: RubbleScout ESP32 Wiring		REV: 1.0
EasyEDA	Company: RubbleScout	Sheet: 1/1
	Date: 2024-02-16 Drawn By: Lorenz	

Fig 5 : State Machine Diagram