ANEBIT
AUTONOMOUS UNMANNED GROUND VEHICLE (UGV)

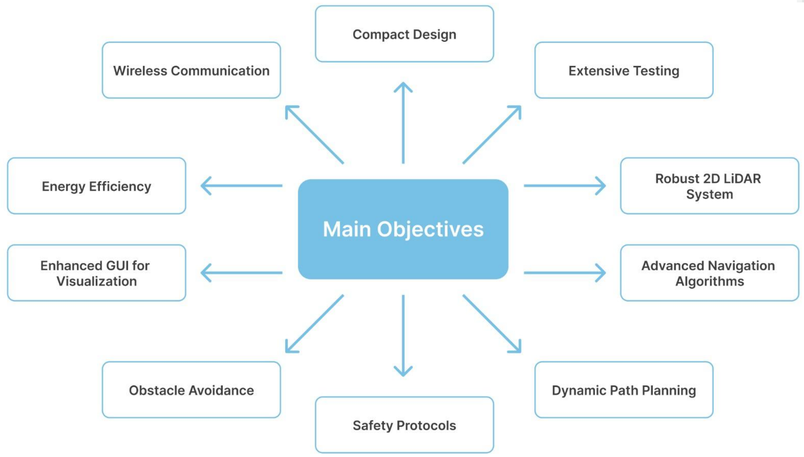
Ata Oğuz Tanrıkulu, Doruk Yazıcı, Ebrar Çakmak, Erkin Atay Toka, Yunus Emre Tüysüz

Middle East Technical University
Department of Electrical and Electronics Engineering

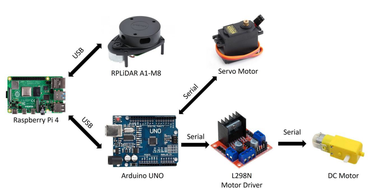
Project Description

The project aims to design an Autonomous Unmanned Ground Vehicle (UGV) for indoor navigation using a single 2D LiDAR sensor for precise 3D mapping. The UGV will generate maps without manual corrections, featuring advanced perception, planning, and control technologies. It will include a graphical user interface for real-time wireless communication, map visualization, and vehicle control. The UGV will autonomously detect and avoid obstacles, planning the most effective paths. Additionally, its mechanical design will ensure stable motion, accommodate sensors and processors, and prevent mobility failures through rigorous testing.

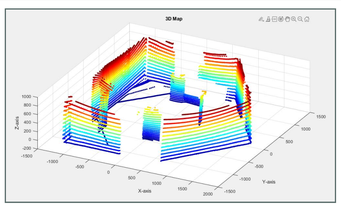
Objectives



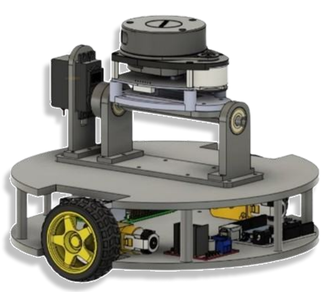
Deliverables



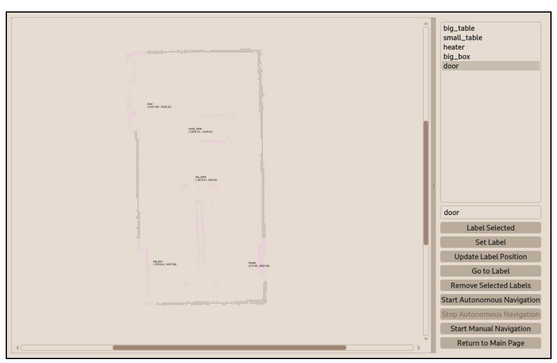
Connectivity Kit



3D Mapping Software



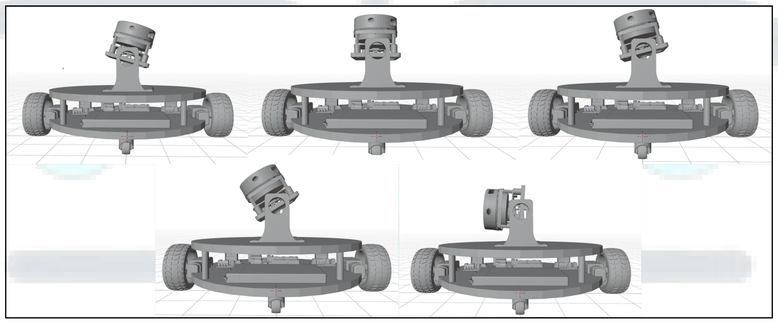
UGV Prototype

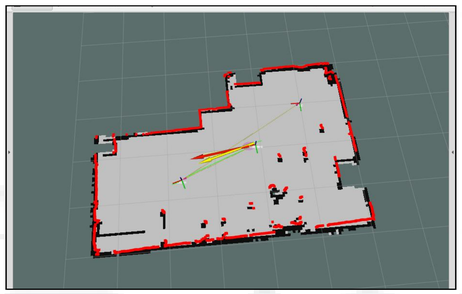


Graphical User Interface Desktop Application

System Design

Mapping Subsystem creates 3D and 2D maps for environment investigation and UGV navigation using an RPLiDAR A1-M8 for 360° scans, processed by custom software with Hector-SLAM. A Raspberry Pi 4 converts LiDAR readings into actionable maps. The **2D LiDAR rotates to collect 3D data**, enhancing scanning for comprehensive mapping.



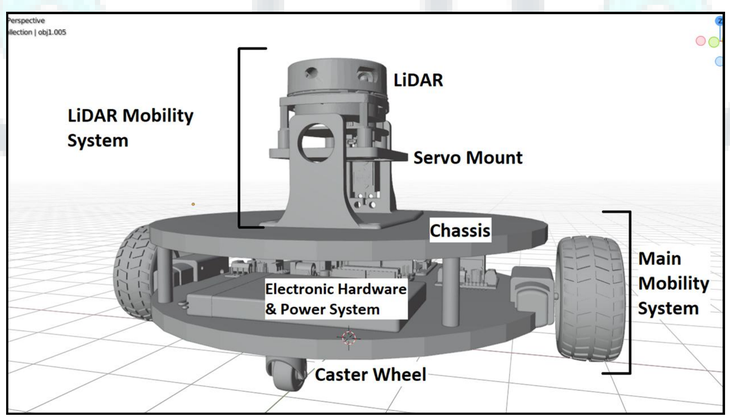


Navigation Subsystem enables user-directed & **autonomous navigation** with obstacle avoidance. It also comprises a motor control unit and a path planning unit:

- The motor control unit adjusts DC motor speeds
- The path planning unit uses global and local planners and the **AMCL algorithm** for precise localization and real-time path adjustments.

Mechanical Subsystem ensures structural integrity, stability, and efficient mobility

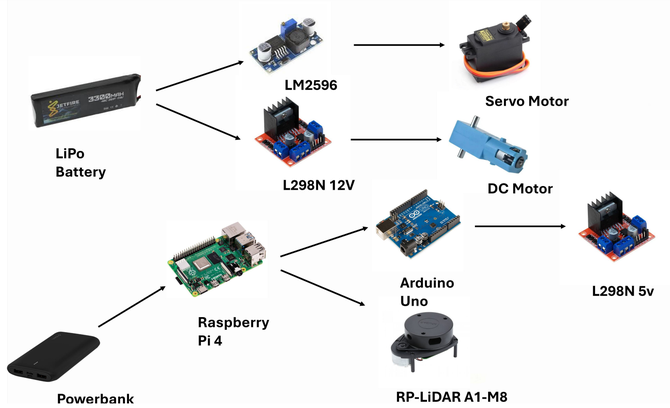
- Two circular floors, LiDAR mobility system on the upper floor to avoid interference
- Two main wheels driven by brushed DC motors, two caster wheels for stability
- A servo motor in the LiDAR mobility unit allows precise rotational control of the LiDAR.



System Integration Subsystem ensures that all components of the UGV work together. It also:

- Provides a user-friendly interface for operation
- Manages power distribution to ensure stable and efficient operation
- Facilitates **wireless communication** for remote control and data transfer
- Includes a **graphical user interface** for easy command input, **map visualization**, and **real-time monitoring**.

Power Management



Cost Analysis

Component	Price (₺)	Price ($)
RPLidar A1-M8	2872,00	88,71
Raspberry Pi 4	1862,00	57,51
Power System	1802.8	55.69
Arduino Uno	163,00	5,03
LiDAR Mobility Unit	260,00	8.03
L298N Motor Driver	64,00	1,98
Motors&Wheels	278.4	8.59
Chassis	400,00	12,35
Screws, Standoffs	55,00	1,69
Cables	341,5	10.51

$/₺ = 32,3745

Total:
8098,70 ₺ / **250,16 $**

Test Results

- **3D Mapping Test** resulted in an error rate below 17 cm meeting performance requirements.
- **Localization and Navigation Test** demonstrated self-localization with an error below 10 cm and target navigation with an error below 15 cm.
- **Power Consumption Test** confirmed that this design allows for approximately 90 minutes of navigation or 116 minutes of mapping, meeting the operational duration requirement.

Overall, UGV subsystems performed well and their performance met our objectives & requirements.

Acknowledgements

Special thanks to:
- **Prof. Dr. Ali Özgür Yılmaz** for his expert guidance throughout our journey,
- **Firuze Şenyurt** for her endless creativity in our poster and design elements,
- **Rüstem Şevik, Zeynep Neslişah Yılmaz, Umut Deniz Kapıcı**, for manufacturing our 3D printed components,
- **Uğur Uyanık** for pioneering the early stages of our mechanical design,
- **Kerim Batur, Alperen Eser, Oğuzhan Kepenek** for bringing our ideas to life with an animated video,
- **Yazıcı and Bilge Families** for their warm hospitality that made us feel at home,
- **All of our families** for unwavering love, support, and belief in our vision.

Instagram

Trailer