Hacettepe University

Computer Engineering Department

BBM479 Project Proposal Report

Project Details

Title	Algorithm implementation on a Real Mobile Robot	
Short Description (max. 200 words)	The goal is to implement algorithms on an actual mobile robot. The algorithms include SLAM (simultaneous localization and mapping), navigation, planning, object detection, object tracking, calibration… The robot has a 3D Lidar, depth camera and it moves with a differential drive locomotion system. One of the objectives is to use and learn ROS (Robot Operating System). We will also collect data from the campus at different semester times and try to teach the robot to navigate itself from one specific point to another.	
Supervisor	Özgür Erkent	
Technical and Scientific Difficulty	( ) Easy (X) Mediocre ( ) Challenging	
External Support	( ) Yes (X) No	
If yes,	**Type**	**Details**
	( ) Company Funding / Support	Company name: Amount:
	( ) TÜBİTAK Project Fund	Type: Amount:
	( ) Other Fund	Source : Amount:

Group Members

	Full Name	Student ID
1	Tuana Cetinkaya	21985164
2	Kaan Tunçer	21946644
3	Yunus Emre Yazıcı	21827981

Project Summary (/ 20 Points)

Explain the project in summary, including your motivation to do the project, your solution plan in short and your expected outcome and impact. You have to summarize your project in between 200-500 words.

The project's main goal is to design algorithms for a mobile robot inside the Gazebo simulation. These algorithms provide the robot the ability to map the environment using the camera and radar systems on the robot and to move from point A to point B without getting stuck on any possible non-moving obstacles on the road. To achieve moving between points, the GPS should be implemented as well. On the robot, there are RS-16 Lidar, Zed 2, and camera systems to scan the environment.

Our first goal is to simulate a similar robot to ours within a simulator. As an initial step, we will experiment with the simulation and implement different path algorithms to see the behavior. We expect this step to be complete when the simulated robot manages to pass through the gates without a problem.

Then we will use ROS to implement a SLAM (Simultaneous localization and mapping) algorithm for the navigation. Also include the existent sensors (or similar sensors that exists within the system) of our robot inside the simulation.

Finally, we are planning to try the algorithms on the actual robot to calculate errors and fix our approach, and if necessary, change and adapt the algorithm. After completing the trial successfully, we will generate the scanned version of the necessary portion of the campus using the laser sensors and provide a way to validate the location using its camera.

By the end of this semester, our expected outcome is to have the successful implementation of the navigation, mapping and movement algorithms with testing them on the actual robot and scanning some certain areas on the campus.

In the next semester's BBM480 project, we expect the robot to use the algorithms we generate this semester and be able to map our department's basement floor and move from our department's door to the rectorate building.

Problem Definition and Literature Review (/ 20 Points)

Define your problem as clearly as possible. Explain your inputs, your context, your outputs and your limitations. Try to use a scientific language as much as possible. Where necessary use citations to existing literature to create context and clarify the problem. Equations, flow charts, etc. are welcome.

The main problem of this project is to write algorithms for a mobile robot. These algorithms should enable the robot to traverse from point A to point B without colliding with any object and traverse through difficult paths.

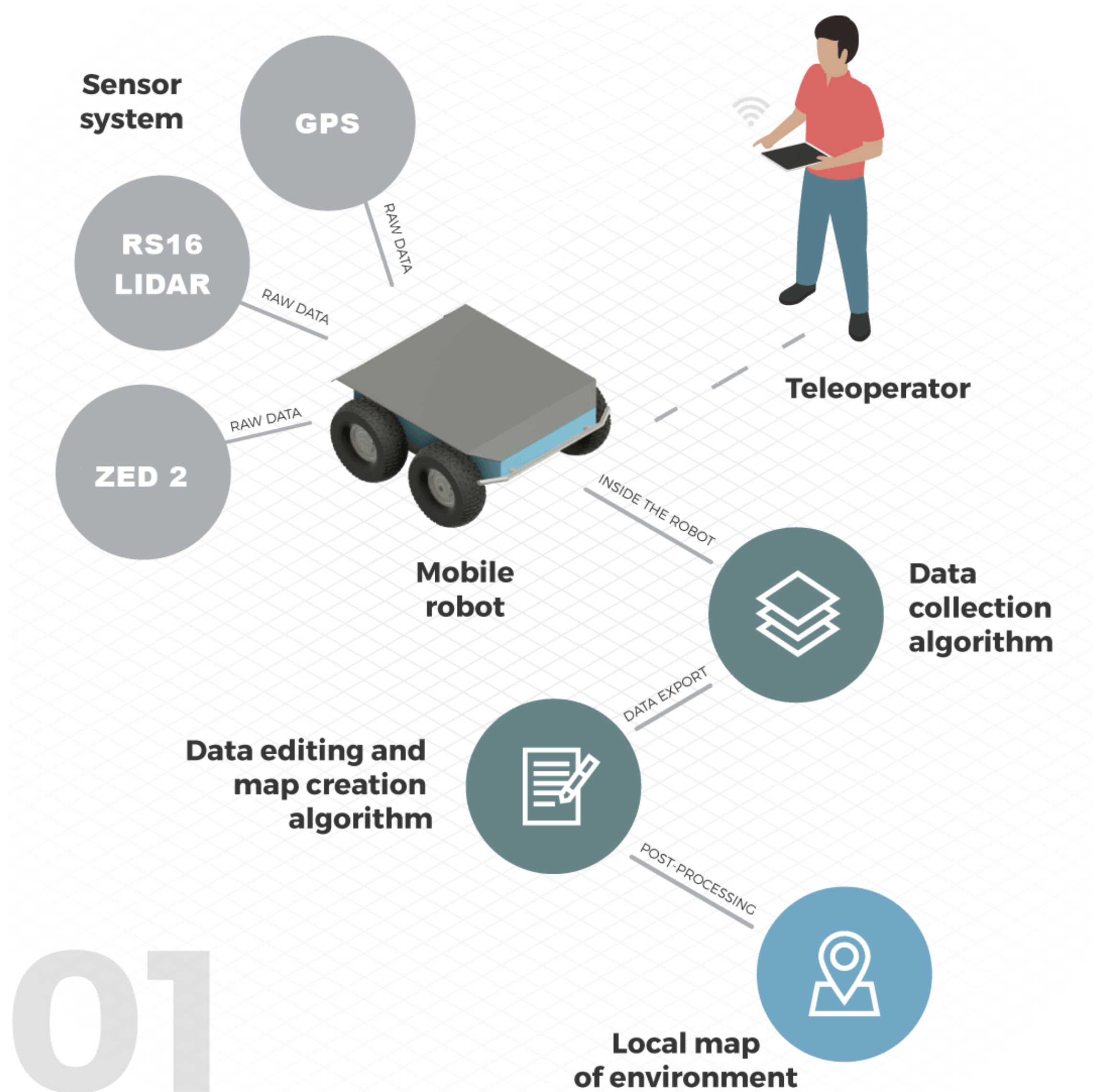
“The purpose of a robot is to make human’s work easier and safer. A robot is basically a utilitarian machine. “A discipline overlapping artificial intelligence and mechanical engineering. It is concerned with building robots: programmable devices consisting of mechanical actuators and sensory organs that are linked to a computer. The mechanical structure might involve manipulators, as in industrial robotics, or might concern the movement of the robot as a vehicle, as in mobile robotics. Robotics research is used in artificial intelligence as a framework for exploring key problems and techniques through a well-defined application” (Butterfield & Ngondi, 2016, p. 497).

In mobile robotics applications, the most common tasks comprise mapping, localization, navigation and obstacle avoidance. In order to perform these approaches efficiently, the robot needs to sense the environment, calculate the distances to the possible obstacles and to build the map for its navigation.

The robot has RS16 Lidar, Zed2 and a GPS sensor to get inputs from its surroundings. It will use the lidar and the zed2 sensor’s inputs to map out it’s surroundings and avoid obstacles. It will use the gps sensor’s input to track where it’s location is and where it should try to go next.

At the end of this term we will have simulation of a robot that can move from point A to point B without colliding with an object and can pass through small gaps such as doors. We will aim to write efficient algorithms and keep the accuracy of the algorithms as high as possible when we use them on the robot.

As for the limitations of the project, we are limited by the robot’s camera systems and it’s general capabilities.


Sensor system
GPS
RS16 LIDAR
ZED 2
RAW DATA
RAW DATA
RAW DATA
Teleoperator
Mobile robot
INSIDE THE ROBOT
Data collection algorithm
DATA EXPORT
Data editing and map creation algorithm
POST-PROCESSING
Local map of environment
01

Solution Plan (/ 20 Points)

Explain the potential paths to solution. You should propose at least one solid plan to attack the problem. Dissect your plan into steps and clearly identify the inputs and outputs of each step. You are not expected to provide the technical details of each step. Provide a weekly timeline/Gantt chart displaying the relevant weeks for each step.

Researching and Learning about the new technologies - 2 week

- We researched the technologies used for robotic developments such as Robotic Operating Systems (ROS), and Gazebo simulators. In this step, we are aiming to learn these technologies and their algorithms.

Simulation for the default robot - 1 week

- After learning more about the new technologies, we will create a simulation with its default robot. The main purpose of this step is to get proficient with the simulation and test the robot's abilities. Algorithms for making the robot go from point A to point B and passing fixed obstacles such as doorways will be also tested in this step.

Create the model of our actual robot in the simulation - 2 weeks

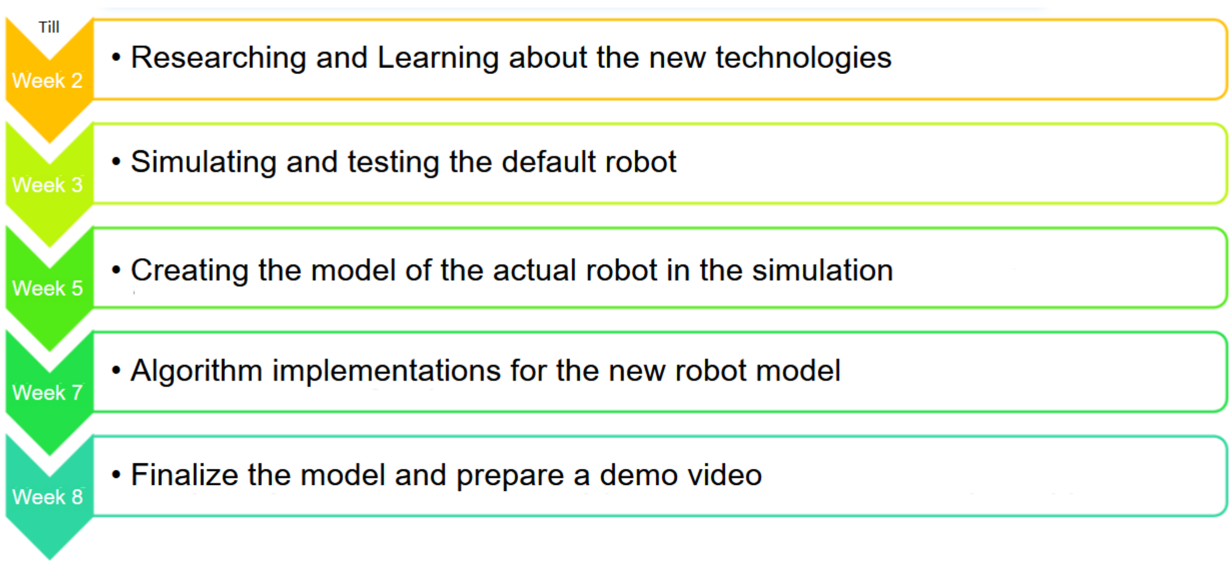
- In this step, a model for the actual robot will be created in the simulation. To achieve it, the measurements from the robot such as the weight, and height of its parts will be taken. The implementations of the robot sensors (GPS, Zed2, and LIDAR) will also be added. These parts will be divided into parts in the group. After creating a model, a way to combine the camera and sensors will be researched so the model can have a more accurate mapping ability. At the end of this step, testing on the model using the actual robot and bug fixing will be also made if necessary.

Algorithm implementations for the new robot model - 2 weeks

- This step aims to get familiar with using our sensors in simulation and move our robot the same way as we did with the default model of the simulator in step two and includes implementations of SLAM algorithms on the actual model. There will be two different configurations with changes in the height of the robot which will also affect the camera's and sensors' places. In this step, the model will be tested in passing through the doors and exiting its current environment.

Finalize the model and prepare a demo video - 1 week

- To finalize the ongoing steps, the algorithms will be tested on the actual robot and bugs will be fixed if necessary. Then we will prepare a video to present and explain the processes along the way.


Till
Week 2
• Researching and Learning about the new technologies
Week 3
• Simulating and testing the default robot
Week 5
• Creating the model of the actual robot in the simulation
Week 7
• Algorithm implementations for the new robot model
Week 8
• Finalize the model and prepare a demo video

Methodology (/ 20 Points)

Explain the methodology you will use in each of the steps you have described under your solution plan. Here, you are expected to give more technical details about each solution step. Also explain how each member of the project will contribute by assigning members to steps. If you are assigning more than one member to a step, explain their specific role and how the work will be divided among them.

1- Researching and Learning the new technologies - 2 weeks

- Each member will dive into ROS and experiment with the libraries to learn more about path-finding algorithms that exist within.
    - ROS is an acronym for Robot Operating System. It's an open-source robotics middleware suite. ROS is used to manage Python scripts that take inputs from the sensors of the robot and feed necessary information and commands to the other parts of the robot.
- Each member will learn to create a model in Gazebo.
    - Gazebo is an open-source 3D robotics simulator. It communicates with ROS scripts to simulate a real robot. It provides realistic rendering of environments including high-quality lighting, shadows, and textures. It can model sensors that "see" the simulated environment, such as laser range finders, cameras (including wide-angle), Kinect-style sensors, etc.
- Then we'll meet at the end of the learning period to review each other's work and teach us what we've learned. That way we'll be on the same page and proceed to apply our knowledge to create a mostly accurate model of the robot for the next week.
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2- Simulating and testing the default robot - 1 week

- Each member will use the default robot in Gazebo and test ROS algorithms to learn about how Gazebo interacts with ROS
- We will test the algorithms we found together on the default robot to see how to use them, and which algorithm works best for our case

3- Creating the model of the actual robot in the simulation - 2 weeks

- Group will measure the required data for components from the real robot.
- Kaan will simulate a template for the real robot using existing motors
- Emre will find the corresponding Laser sensor’s replacement inside Gazebo and learn the proper methods for the sensor to be used within ROS
- The robot has 2 different sensors, Zed2 and 3D LIDAR.
    - RS16 LiDAR (Light Detection and Ranging) sensor is an equipment that measures the distance between the equipment and the object from the round-trip traveling time of the pulse laser that is projected to the object. It can also measure the depth up to 200m.
    - ZED 2 is a stereo RGB camera that uses neural networks to reproduce human vision. Its working range is up to 20m. It is useful for closer environments compared to the LiDAR sensor.
- Tuana will find the corresponding Camera sensor’s replacement inside Gazebo and learn the proper methods for the sensor to be used within ROS
- The group will meet to merge the sensors with the robot template
- Group will search for ways to combine camera and laser sensors together to generate a more accurate mapping procedure.
- Group will finalize the simulated model and test on the actual model if the code is working as expected according to what we’ve seen in the simulations.
- For this procedure, we will check the sensor inputs and compare the generated data from real life to review and improve our code
- If the code is working as expected in real life, we proceed to the next step.

4- Algorithm implementations for the new robot model - 2 weeks

- We will try the SLAM algorithms with two configurations being:
    1. The default configuration: a taller version of the robot. Sensors are placed with a larger interval than the second configuration and the laser is at a higher point.
    2. Compact configuration: laser and camera sensors are aligned closer and the height of the robot is now decreased
- Group will test the applied SLAM algorithms with defined configurations and compare the results to arrive at a conclusion
- We will move the simulated model and try to guide it to pass through the door by locating the exit of the provided environment.

5- Finalize the model and prepare a demo video - 1 week

- Group will test the written code on the actual robot and see if it applies.
- We will then prepare a video using the simulated robot and show the moving patterns and explain the path solutions along the way.
- Next semester we will use this model to draw a map of our campus and try to navigate the real robot from one given point to another.

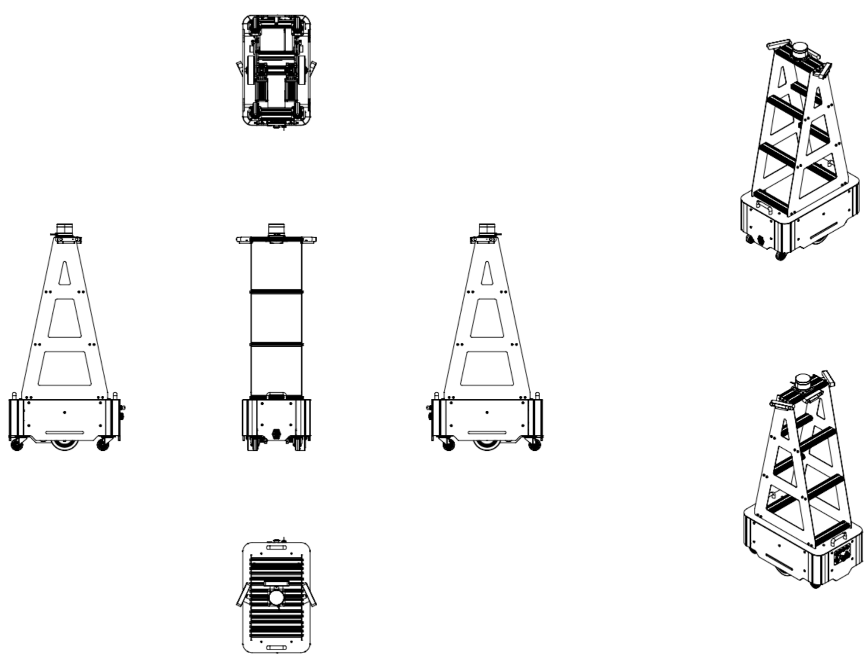
Outcome and Impact (/ 20 Points)

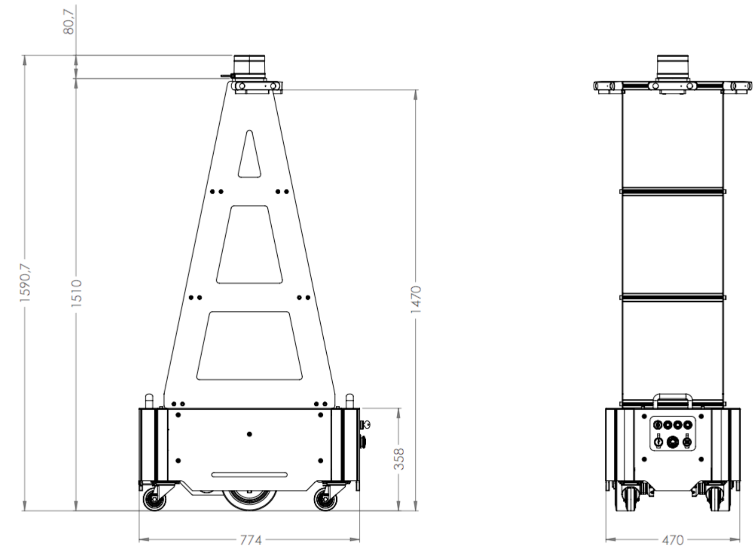
Explain the expected outcome of your project. If it is a software product, try to include example screen designs, if it is a hardware product, try to provide detailed technical specifications, if it is research output try to explain the outcome's contribution to the field. Also, explain the potential impacts of your results. These may be how the result will be used in real life, how it will change an existing process, or where it will be published, etc.

The robot is made out of aluminum and it features a differential wheel system with two wheels. It also has four additional support wheels. The robot also features a rocker-bogie system for suspension.

For sensors, the robot features a 3D Lidar, a Zed2 camera, and a GPS module. The lidar sensor will be used to map objects that are further away while the Zed2 camera will be used to map objects that are closer to the robot. We will try to combine these sensors to be able to map the surroundings more accurately. Finally, the GPS sensor will be used to get the location data of the robot. This data will then be used as input to compare the accuracy of the generated map to the real world.

The robot has two configurations. The first configuration is a taller version of the robot and it's the main configuration that we are going to use.





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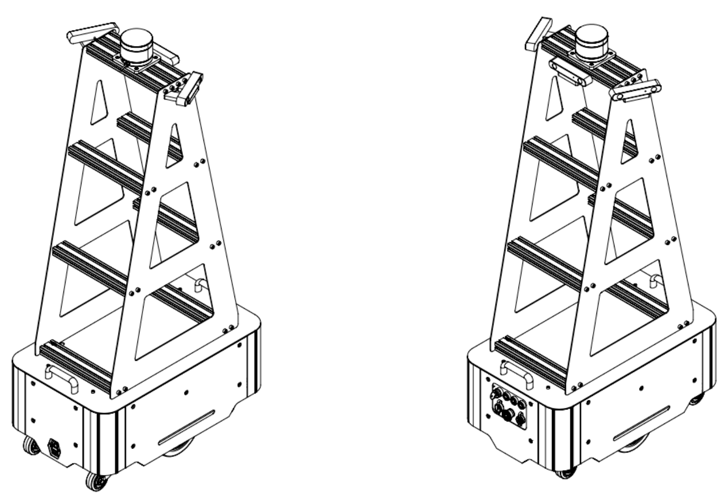
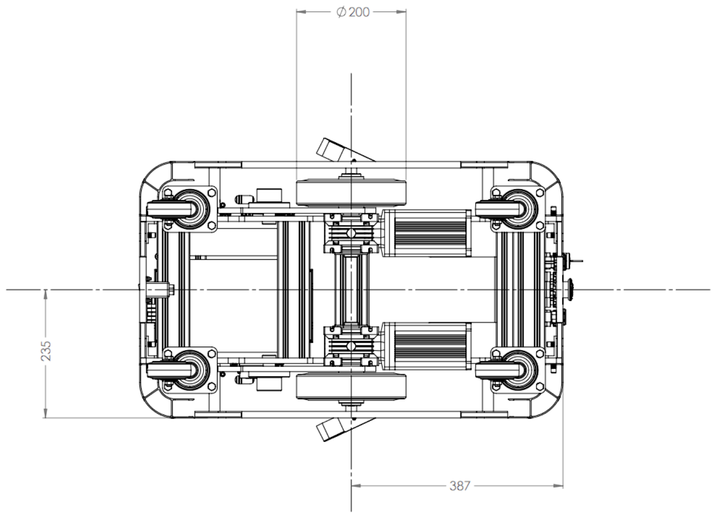
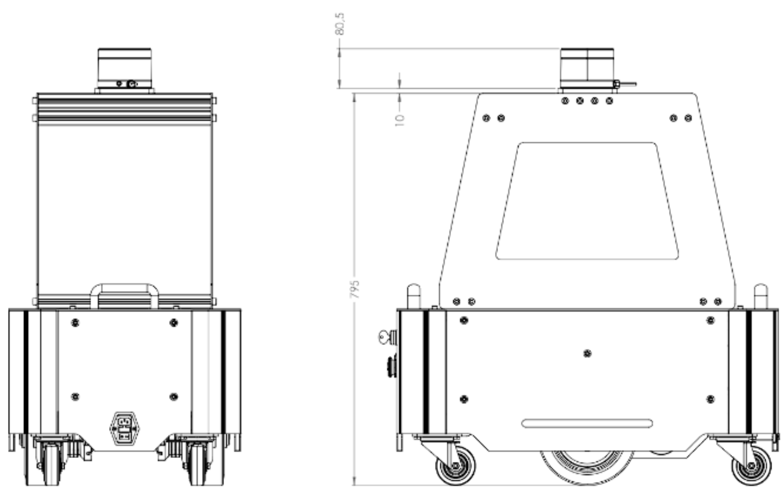




The second configuration is much shorter and compact.



At the end of this term we will have simulation of a robot that can move from point A to point B without colliding with an object and can pass through small gaps such as doors. By completing this simulation we will have the basis for working with the actual robot.

In the end, we’ll demonstrate that these types of robots are possible and could be used for many applications. Possible applications include delivery, guidance, and collector robots. Furthermore, by expanding on our project, a robot that can follow moving objects could be developed.