Autonomous Delivery Robot (ADR)

Project Proposal

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1. **Introduction**

1.1. Document Purpose

The objective of the document is to deliver a proposal on developing system architecture, and system requirements for an Autonomous Mobile Robot mainly focused on delivering items. The document template was modified from references [1] & [2].

1.2. Team Members

Our project team consists of Manu Madhu Pillai, Mukundhan Rajendiran, Sidney Leigh Molnar, and Xinyi Yang.

1.3. References

The following references were used for the development of this proposal:

1. 621 HW3 Project Proposal Template, by Dr. Tony Barber, 2022.
2. 621 HW 3 Project Proposal Example-FSS UAV, by Dr. Tony Barber, 2022.
3. Autonomous Delivery Vehicles, by Derick Omondi, 2021. [CrossRef]

2. Project Scope

Our team proposes to develop the context-level architecture, stakeholder requirements, system requirements, and system architecture for an Autonomous Mobile Robot, typically used for delivering products.

3. Stakeholders and Statement of Need

The primary stakeholders for our system would be companies like **Uber Eats, DoorDash, FedEx,** and **UPS**. The secondary stakeholders for our system would be private and state-owned Universities.

Life at a university is fast-paced. Students and staff spend considerable time and effort picking up various things such as food, packages from online retailers, documents, etc. In order to do so, they use various modes of transportation such as cars,e-scooter, and bikes causing traffic that further delays their day-to-day activities. The proposed system would help alleviate this issue by delivering the required items to their doorstep.

4. System Functionality/Capabilities

The most important capabilities of the system in order of priority are listed in Table 1 below:

Table 1: Prioritized Capability List

Capability I.D.	Capability	Priority
C1.1	Detect sidewalks, roads, pedestrian crossings, and road signs.	1
C1.2	Detect Motor vehicles, pedestrians, cyclists, animals, and similar dynamic obstacles.	2
C1.3	Detect plants, trees, buildings, railings, and similar static obstacles.	3
C1.4	Detect and identify other ADRs.	4

C2	Avoid Collisions with dynamic and static obstacles in the surroundings.	5
C3	Navigate on the given path following road safety laws.	6
C4	Carry payloads from source to destination as assigned.	7
C5	Monitor the remaining battery and return to the charging station at the failsafe level.	8
C6.1	Provide tracking status and maintain communication with the central server.	9
C6.2	Report theft, vandalism, or tampering with the ADR and its payload.	10
C7	Open respective payload bay among the segmented payload bays when authorized.	11

5. Measures of Effectiveness

The measures of effectiveness for the system, their respective thresholds, and the desired objective values are listed in Table 2 below, and the values were calculated based on [3]:

Table 2: ADR System Measures of Effectiveness

I.D.	MOE	Threshold	Objective
MOE1	Maximum Operational Time on a single charge	> 4 hours	> 8 hours
MOE2	Maximum operational range (radius) on a single charge	> 1 mile	> 2 miles
MOE3	Maximum payload capacity	> 50 lbs	> 100 lbs
MOE4	Empty to full charging time	< 4 hours	< 2 hours
MOE5	Maximum communication (telemetry) range from central server	> 1 mile	> 2 miles
MOE6	Perception Range for Collision avoidance	> 66 ft	> 165 ft
MOE7	Maximum Operational speed	> 5 mph	> 15 mph

6. System Concept

This system is designed to deliver food or small packages from local restaurants or stores to people on a university campus within two hours with a number of Autonomous Delivery Robots (ADRs).

The elements that make up the system of interest are:

1. Sensor System
2. Control System
3. Locomotion System
4. Power Supply System
5. Telemetry system
6. Mobile Application
7. Lock System
8. Management system

The sensor system sends sensor data to the control system to check if the payloads are inside ADR and if there are any static and/or dynamic obstacles in the surroundings. The control system controls the ADR to avoid obstacles, navigate to destinations, and make sure that the payloads are put into the ADR at the source (restaurants/stores) and taken out at the destination (users) by using the data received from the sensor system. The motion system receives directions from control and derives power from the power supply to move (left/right/forward/backward/stop). The wireless communication system sends the real-time location of the ADR from the sensor data to the user by a mobile application.

When the ADR reaches its source or destination, it requires a user verification QR code to open the package storage compartment of the ADR. The wireless communication sends the QR code to the user through the application and the communication sends it back to the control after the user scans the code. The control system verifies the code before opening the storage compartment by sending a signal to the lock system. The management system provides maintenance and logistical support for the ADRs including charging, cleaning, and regular maintenance.

The intended users of the system of interest are faculty, staff, and students on large university campuses. Users can order a delivery that can then be transported from one end of campus to the other. This puts the ADR in a dynamic environment where it will need to avoid several moving obstacles such as pedestrians, cars, bikes, and scooters. Conversely, pedestrians and people operating vehicles must know to navigate around the ADR. As such, the ADR will have a signaling structure that exists at eye level for greater visibility to cars and pedestrians.

Aside from the dynamic aspects of a university campus, the ADR will need to be able to navigate along sidewalks and roads, avoiding stairs, construction, and otherwise dangerous terrains. Additionally, for campuses that face seasonal changes, the ADR will need to travel through various types of inclement weather such as rain, high winds, or snow. Once the ADR makes it safely to the intended location, users will be able to access their order in the secured compartment before the ADR moves on to the next order, navigating through the dynamic environment again.