Rutgers ECE
Capstone Program Fall 2024 - Spring 2025
Project Scope of Work Info

Please provide the following information to be shared with on capstone information exchange platform:

1. **Project Number:** S25-02

2. **Project title (as will appear on the poster):**

3. **Team members: Rajeev Atla, Parshva Mehta, Aman Patel, Abhiram Vemuri**

4. **Adviser(s) name(s): Kristin Dana**

5. **Up to 5 keywords that will help to classify the project scope:**

6. **Project scope of work (up to 1000 words):**
   [General guidelines: The abstract should include a discussion about the problem addressed in the project; background review of the state of the art in the relevant field; objective of the proposed projects; and the adopted approach.]

   Parking has become an issue for all citizens who use automobile transport, especially in populated centers and learning institutions throughout the United States. Rutgers University, as a major center of student, scholarly, social, and career life, is emblematic of this external problem. Daily, thousands of students, faculty, and staff spend their valuable time driving to campus and still grapple with the issue of where to park their cars. This routine conflict may entail driving around car parks for a considerable time, consuming fuel, and time, and causing uninvited pressure. The results and ramifications extend to productivity, mental health, and environmental conservation.

   The parking management challenge stems from issues like unsuhjbl-time parking space information. Present strategies to address the parking problem like static signage depicting the lot status, smartphone applications with information entered manually, or even physical lot greeters are inadequate or lack the real-time, accurate information commuters require. These inefficiencies are magnified at Rutgers University due to the size of the campus and the largely commuter student population.

   In this respect, the goal of our work is to develop and realize a new robotic system that can move without intervention in on-campus car parks, detect empty car parking spaces in real-time, and inform the users thereof via a mobile application. Therefore, the idea is to revolutionize the parking experience meant for Rutgers commuters with the help of improvements in robotics, computer vision, and IoT applications. The primary goal of this project is to mitigate time wastage, and stress and seek to add value to the parking system which in effect reduces unnecessary effects on the environment.

To position this project within the current state of the art, we first discuss existing technologies and solutions to parking management. Automatic parking systems available in smart cities include the use of static sensors placed on the parking slot or on lampposts to identify the state of the parking. These systems can be effective in some contexts but involve major investments in infrastructure and cannot be easily integrated into parking lots already in use. Mobile applications, in contrast, base their information on user-provided data or, in the case of the static parking lot capacity, on updates that do not represent real-time situations in most cases. However, neither solution effectively handles the constantly changing and extensive parking needs of a facility such as Rutgers University.

Mobile and flexible robotic systems are being considered in numerous disciplines because of their autonomous capabilities and real-time data sampling. Self-driven robots supplemented by sensors & intelligent algorithms are now to be found across both agricultural and warehousing industries. However, their application concerning parking management can still attract little attention. In this work, we present a new solution that uses the benefit of robotic systems together with state-of-art computer vision wireless communication to solve the problem of parking on a large university compound.

The proposed solution stems from developing a mobile robot that can self-navigate within parking lots and provide the occupancy status of specific parking spaces. The robot will also incorporate camera systems with high-definition resolution, ultrasound systems, and LIDAR systems to give correct estimations of empty and occupied locations regardless of lighting or environmental conditions. The data gathered by these sensors will be analyzed through machine learning algorithms to guarantee the objective detection of both vehicles and open spaces. Real-time path planning means that the robot will traverse through parking lots along pre-designated paths but with room for changes in response to new conditions in the parking lots; for example, some of the paths may be blocked while others have more cars than usual.

It is anticipated that once parking data is recorded, it will be relayed wirelessly to a network server as part of a mobile application that can be used by commuters from Rutgers. It shall display real-time parking updates on the map for users to scroll through with a user-friendly interface that allows users to filter the parking lots by nearby locations or preferred lots, and offer updates when more data is collected. This system will benefit not only the times taken individually in specific parking searches but also the overall function of parking resources within the campus.

The implication of this particular project therefore goes beyond the surface-level penetration as discussed in this paper. From an individual perspective, a commuter would experience improved travel time, less stress, and more certainty when it comes to parking. On a macrostructural level, the scheme might help optimize Rutgers' parking system operations, thus possibly avoiding or postponing future expansions. The environmental benefits are equally compelling: Cutting the time that drivers use their cars for cruising around in search of parking spaces also means that vehicles will emit fewer amounts of gasses into the atmosphere which coincides with the university's sustainability objectives.