Autonomous Food Delivery Based on Google Maps Data

Lauren Kidman, Mehmet Eren Aldemir, Zhoucai Ni

Objective and Motivation

—

We are aiming to create a robot that will autonomously conduct food delivery from a restaurant to a target point, both specified on Google Maps. The motivation for this project is the limited availability of food delivery options in the Hanover area due to the limited number of delivery people.

Related Work

—

See page 2.

Formal Problem Statement

—

Inputs:

- Coordinates of source restaurant *s*
- Coordinates of target point *t*

Outputs:

- Robot obtains the environment from Google Maps, generates a grid, calculates the appropriate path and follows it

Assumptions:

- The environment is static, i.e., no pedestrians or cars. (Future work can incorporate a dynamic environment.)

Methodology

—

There are a number of subtasks that need to be addressed:

1. Obtaining the environment data: We will be using Google Maps to programmatically build the environment the robot will operate in. Our aim is to utilize image processing to convert the map to a grid.
2. Movement: We will be using PID control to implement the basic movement of the robot. This will also include moving as close as possible to the side of the road to make sure that the robot is not moving on the roads but on the pavements.
3. Pathfinding: We will be utilizing A* search to efficiently generate a path.

We will use Stage to test our implementation. We will be using the Hanover area map for testing, but our aim is to create a generalizable functionality that will work in other environments as well.

Timeline

—

- *May 16:* Image Processing Module for Grid Generation
- *May 18:* PID Controller for Movement
- *May 19:* Progress Report
- *May 22:* A* Implementation
- *May 24*: Integration of Modules and Testing on Stage
- *May 26*: Final Presentation
- *June 3*: Final Report and Code

Allocation of Effort

—

- Lauren Kidman : PID Controller and A* Search
- Mehmet Eren Aldemir : Grid Generation and Integration
- Zhoucai Ni : A* Search and Integration
- Joint Effort: Presentation, Report Writing, Experiments

Related Work

—

While the world was already on a steady shift towards AI-powered vehicular transportation and delivery, the unprecedented outbreak of COVID-19 led to an exponential growth in subjects like online retailing and, important to our problem at hand, accelerated the need for contactless delivery. As mentioned, the goal of our project is to develop a robot capable of delivering food from various restaurants to a target destination; in terms of related work, there have been multiple attempts to develop fully autonomous robot delivery vehicles.

One of the earliest examples of a physical prototype came to being around late 2019 with Refraction AI's REV. A somewhat large, conical three wheeled robot, the REV strives to provide "safe, sustainable, and cost-effective last-mile delivery". The REV can operate in all weather conditions; can navigate both car and bike lanes; and, due to its short stopping distance, can quickly and easily stop for obstacles to avoid accidents. The final product is a robot that utilizes 90% less carbon, 80% less energy, and 25% of the cost of traditional delivery services.[1] Another real world example is Starship's autonomous delivery robots. Making use of ultrasonic sensors, radar, neural networks, 12 cameras, and similar, the robots operate at Level 4 autonomy, meaning they require zero human interaction and are extremely intelligent for detecting obstacles in its path. For localization, the robot uses a combination of Computer vision and GPS to pinpoint its exact location to the nearest inch, and "proprietary mapping techniques" to ensure accuracy. Like the REV, it is also more environmentally friendly, as it is battery powered (unlike most traditional cars).[2]

Looking deeper into the algorithms behind autonomous delivery vehicles, Guruji et al[3]. described a modified, time-efficient A* search algorithm that evaluates the heuristic function in real-time rather than computing heuristics values in full at the beginning. Depending on the time availability, we might implement this algorithm rather than conventional A*. On the other hand, we can take another approach using random sampling strategy called the Probabilistic Roadmaps Method (PRM). In the paper *Probabilistic Roadmaps for Path Planning in High-Dimensional Configuration Spaces*,[4] Kavraki et al. describes that the PRM can find effective paths in high dimensional space that algorithms such as A* and Dijkstra tend to struggle with. The PRM can be separated into two phases: construction and query. During the construction phase, a graph where nodes represent feasible (i.e., collision-free) configurations and edges represent feasible paths between configurations is created. This graph will function as our roadmap during the query phase and is constructed by randomly sampling configurations and connecting nearby feasible configurations. In the query phase, a path finding algorithm such as Dijkstra is employed to find a path between the starting and goal node. The advantage of this approach is that the computationally expensive process of roadmap constructing is done in advance and can be reused for multiple path planning queries. This method could help us navigate the robot in a complex environment more efficiently and resolve the challenge of higher dimensional path finding.

Thus, based on pre-existing solutions to autonomous food delivery services, it is clear that our solution should attempt to prioritize path generation. Positive industry prospects associated with robot-based food delivery services emphasizes the importance of our project as a whole. By addressing this issue, we look at future development in more sustainable food delivery systems that are more cost efficient (especially for our target audience, college students), time efficient, and also widen the breadth/availability of food options to choose from.

References

—

[1] “Refraction AI.” *Refraction AI*, https://refraction.ai. Accessed 13 May 2023.

[2] “Starship Technologies: Autonomous Robot Delivery.” *Starship Technologies: Autonomous Robot Delivery*, https://www.starship.xyz/. Accessed 13 May 2023.

[3] A. K. Guruji, H. Agarwal, and D. Parsediya, “Time-efficient A* Algorithm for Robot Path Planning.” *Procedia Technology*, vol. 23, pp. 144-149, 2016

[4] L. E. Kavraki, P. Svestka, J. . -C. Latombe and M. H. Overmars, "Probabilistic roadmaps for path planning in high-dimensional configuration spaces," in *IEEE Transactions on Robotics and Automation*, vol. 12, no. 4, pp. 566-580, Aug. 1996, doi: 10.1109/70.508439.