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A Self-Driving Transport Vehicle Based on Fusion Camera and Radar

Jinane Mounsef[1], Muhieddin Amer[1]
[1]Rochester Institute of Technology Dubai
Dubai Silicon Oasis, Dubai, UAE
jmbcad@rit.edu; mxaeee@rit.edu

Extended Abstract

Autonomous vehicles play a crucial role in optimizing the traditional transportation process in terms of time, cost, safety, and preservation of the environment. Naturally, the need arises to extend the benefits of autonomous vehicles to more specific applications, such as logistics and goods handling. Our work proposes the use of a ground-based self-driving vehicle for use in the field of logistics by considering a low-cost fusion camera and radar. We select the Frequency Modulated Continuous Wave (FMCW) radar, a hybrid radar technology that blends Doppler Radar and Pulsed Radar to maximize functionality and performance while minimizing limitations [1]. Consequently, the camera and radar sensors complement each other in providing the most comprehensive view of the environment through the data they provide to the autonomous vehicle. In [2] and [3], it is stated that sensor fusion is the best approach when it comes to automated vehicles as it allows for a deeper understanding of the surrounding by accounting for different variables. Cameras are indispensable to autonomous vehicles through the visualization of the surrounding, thus facilitating many of the processes essential to self-driving. However, camera-only based solutions can be computationally taxing as most high-definition cameras produce millions of pixels per framework and require advanced software and hardware capabilities to process them. In [3], the authors discuss how radars can complement cameras by addressing the requirement for localization. However, they generate less angular accuracy and capture less data than the expensive Lidar. This leads us to adopt a low-cost yet efficient solution based on the fusion of camera and radar.

The proposed navigation approach is driven by a GPS module. The module is programmed to process positional information and in turn used as a general compass and direction guidance for the autonomous vehicle. The process is coupled with obstacle detection, tracking and avoidance to produce an optimal navigation setup. A probabilistic regression model that predicts bounding boxes around objects based on YOLO (You Only Look Once) algorithm is used to detect the objects in every individual frame [4], followed by object tracking, which identifies and tags every single object through a series of frames. Tracking is represented as a line that follows an object to show the path the object has taken and is implemented using Kalman filtering. To associate the Kalman's filter track to its corresponding bounding box, we use the Deep SORT, which uses a matching algorithm called the "Hungarian algorithm" [4-5].

Obstacle avoidance complements the path planning and navigation by avoiding obstacles that might be stationary or mobile. For stationary obstacles, there are many algorithms in the literature, such as the Bug algorithm, the Vector Field Histogram algorithm (VFH algorithm), the Hybrid Navigation Algorithm (HNA), and the New Hybrid Navigation Algorithm (NHNA) [6]. In this work, we select the VFH algorithm, as it is less likely to go into local minima and allows the robot to navigate at faster speeds without colliding with obstacles. On the other hand, for mobile obstacles, the improved Dynamic Window Approach (DWA) is used to solve the obstacle avoidance problem as proposed in [7]. The radar provides the robot with the surrounding objects distance, speed, and angle. If the obstacle is intervening with the robot's way at a relatively high speed, the robot slows down or even stops until its path is clear. On the other hand, if an object is moving in a trajectory that is parallel to the robot's path, then the robot does not stop and continues moving.

References

[1] J. Cole. (2020, August 30). The Science of Stationary-Object Detection with FMCW [Online]. Available: https://blog.preco.com/the-science-of-stationary-object-detection-with-fmcw
[2] J. Kocić, N. Jovičić and V. Drndarević, "Sensors and Sensor Fusion in Autonomous Vehicles," *in Proceedings of the Telecommunications Forum*, Belgrade, Serbia, 2018.

[3] R. Kumar and S. Jayashankar, “Radar and Camera Sensor Fusion with ROS for Autonomous Driving,” in *Proceedings of the International Conference on Image Information Processing*, India, 2019.
[4] S. Maiya, (2020, August 30). DeepSORT: Deep Learning to track custom objects in a video [Online]. Available: https://nanonets.com/blog/object-tracking-deepsort/
[5] A. Bewley, Z. Ge, L. Ott, F. Ramos and B. Upcroft, "Simple Online and Realtime Tracking", in *Proceedings of the International Conference on Image Information Processing*, Phoenix, USA, 2017.
[6] M. B. Alatise and G. P. Hancke, “A Review on Challenges of Autonomous Mobile Robot and Sensor Fusion Methods,” *IEEE Access*, vol. 8, pp. 39830–39846, 2020.
[7] X. Li, F. Liu, J. Liu and S. Liang, “Obstacle avoidance for mobile robot based on improved dynamic window approach,” *Turkish Journal of Electrical Engineering & Computer Sciences*, vol. *25*, no. 2, pp.666-676, 2017.