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Calpoly Autonomous Transportation Experience: Software for Driverless Vehicle Operating on Campus

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Abstract : Calpoly Autonomous Transportation Experience (CATE) is a driverless vehicle that we are developing to provide safe, accessible, and efficient transportation of passengers throughout the Cal Poly Pomona campus for events such as orientation tours. Unlike the other self-driving vehicles that are usually developed to operate with other vehicles and reside only on the road networks, CATE will operate exclusively on walk-paths of the campus (potentially narrow passages) with pedestrians traveling from multiple locations. Safety becomes paramount as CATE operates within the same environment as pedestrians. As driverless vehicles assume greater roles in today's transportation, this project will contribute to autonomous driving with pedestrian traffic in a highly dynamic environment. The CATE project requires significant interdisciplinary work. Researchers from mechanical engineering, electrical engineering and computer science are working together to attack the problem from different perspectives (hardware, software and system). In this abstract, we describe the software aspects of the project, with a focus on the requirements and the major components. CATE shall provide a GUI interface for the average user to interact with the car and access its available functionalities, such as selecting a destination from any origin on campus. We have developed an interface that provides an aerial view of the campus map, the current car location, routes, and the goal location. Users can interact with CATE through audio or manual inputs. CATE shall plan routes from the origin to the selected destination for the vehicle to travel. We will use an existing aerial map for the campus and convert it to a spatial graph configuration where the vertices represent the landmarks and edges represent paths that the car should follow with some designated behaviors (such as stay on the right side of the lane or follow an edge). Graph search algorithms such as A* will be implemented as the default path planning algorithm. D* Lite will be explored to efficiently recompute the path when there are any changes to the map. CATE shall avoid any static obstacles and walking pedestrians within some safe distance. Unlike traveling along traditional roadways, CATE's route directly coexists with pedestrians. To ensure the safety of the pedestrians, we will use sensor fusion techniques that combine data from both lidar and stereo vision for obstacle avoidance while also allowing CATE to operate along its intended route. We will also build prediction models for pedestrian traffic patterns. CATE shall improve its location and work under a GPS-denied situation. CATE relies on its GPS to give its current location, which has a precision of a few meters. We have implemented an Unscented Kalman Filter (UKF) that allows the fusion of data from multiple sensors (such as GPS, IMU, odometry) in order to increase the confidence of localization. We also noticed that GPS signals can easily get degraded or blocked on campus due to high-rise buildings or trees. UKF can also help here to generate a better state estimate. In summary, CATE will provide on-campus transportation experience that coexists with dynamic pedestrian traffic. In future work, we will extend it to multi-vehicle scenarios.

Keywords : driverless vehicle, path planning, sensor fusion, state estimate
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