Robotics and Autonomous Systems Thesis Defense

Simulation Framework for Driving Data Collection and Object Detection Algorithms to Aid Autonomous Vehicle Emulation of Human Driving Styles

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Abstract

Autonomous Vehicles (AVs), or self-driving cars, are poised to have an enormous impact on the automotive industry and road transportation. While advances have been made towards the development of safe, competent AVs, there has been inadequate attention to the control of AVs in unanticipated situations, such as imminent crashes. Even if AVs follow all safety measures, accidents are inevitable, and humans must trust AVs to respond appropriately in such scenarios. It is not plausible to program AVs with a set of rules to tackle every possible crash scenario. Instead, a logical approach is to align AV decision-making capabilities with the moral priorities, values, and social motivations of trustworthy human drivers. Toward this end, this thesis contributes a simulation framework for collecting, analyzing, and replicating human driving behaviors in a variety of scenarios, including imminent crashes. Four driving scenarios in an urban traffic environment were designed in the CARLA driving simulator platform, in which simulated cars can either drive autonomously or be driven by a user via a steering wheel and pedals. These included three unavoidable crash scenarios, representing classic trolley-problem ethical dilemmas, and a scenario in which a car must be driven through a school zone, in order to examine driver prioritization of reaching a destination versus ensuring safety. Sample human driving data in CARLA was logged from the simulated car's sensors, including the IMU, LiDAR, and camera. In order to reproduce human driving behaviors in a simulated AV, it is necessary for the AV to be able to identify objects in the environment and evaluate the volume of their bounding boxes for prediction and planning. An object detection method was developed that processes LiDAR point cloud data using the PointNet neural network architecture, analyzes RGB images via transfer learning using the Xception convolutional neural network architecture, and fuses the outputs of these two networks. This method was trained and tested on both the KITTI Vision Benchmark Suite dataset and a virtual dataset generated from CARLA. When applied to the KITTI dataset, the object detection method achieved an average classification accuracy of 96.17% and an average Intersection over Union (IoU) of 0.71, where the IoU metric compares predicted bounding boxes to those used for training.

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Zoom Link: https://asu.zoom.us/j/3363114482