Strengthening Drone-Assisted Micro-level Driving Decision Making by Edge Computing

In their visions for the next generation of smart vehicles, many automotive companies (e.g., Ford, Mazda, Land Rover, Mercedes-Benz) foresee car-mounted drones (CMD) as an important extension to autonomous vehicles. Ground vehicles will be capable of launching and landing drones, which follow the moving cars and provide bird's-eye view video streaming. Such video streaming can be processed at the edge of the network (either on cars or on drones) to extract real-time environmental information, which may not be captured by car-mounted cameras. Such information can be used by micro-level driving decision-making algorithms to improve the driving safety and fuel efficiency of autonomous vehicles (AV).

However, due to the limited battery capacity of the drone, CMD needs to choose between a longer flight time and the accuracy and timeliness of the information it provides. If the drone transmits high-resolution video to be processed by car-mounted computers, the latency for streaming video over WiFi channel is very high and will significantly affect driving decision making. If the video is compressed to low resolution before transmission, some details may be missing causing extracted information to be inaccurate.

This project proposes to solve this problem by dividing video frames into time-sensitive regions and time-insensitive regions based on their impact on the driving decision making algorithm, processing the time-sensitive tasks on the drone locally, and offloading the time-insensitive tasks to car-mounted computers. Our solution makes it possible for AV to strengthen driving decision making by leveraging drone-provided information, without draining the drone's battery.

Students will work on the following aspects to fully implement our vision:

1) Develop object segmentation algorithm for bird's-eye view video streams.
2) Model how the division between computing tasks locally and transmitting video to cars impacts the power consumption of the drone and the information delay on the car. The model should take as input (a) the computing resources on the drone and car, (b)the computation complexity of information extraction algorithms, (c)the battery and network status of the drone, and output (a) an optimal workload division, and (b) the estimated latency for time-sensitive tasks.
3) Integrate the above model with micro-level decision-making algorithms. Based on the optimal workload division, we plan to develop a new decision-making algorithm, which can utilize the time-insensitive objects in a previous time slot and the car-mounted sensor data to guide the selection and processing of time-sensitive objects in the next time slot, so that the overall utility of the decision-making algorithm based on the time-sensitive information obtained from the drone can be optimized.
4) Build testbeds to evaluate our system's performance. We plan to first build an emulation environment to assess the performance of the proposed edge computing system and the driving decision algorithms' impact on fuel efficiency and driving safety.