CAREER: Self-Orchestrating Cooperative Autonomy

Project Summary

Overview

The confluence of advances in edge computing and machine learning (ML) have transformed our cyber-physical world, as we see modern autonomous systems, such as autonomous cars, delivery drones, and humanoid robots, coming into our daily lives. Relying on advanced sensors onboard, the data-driven ML engines are able to, in most cases, make sense of and interact with the physical world. Yet it is challenging to scale these individual agents to the long-tail events where they either struggle to perform reliably or are fundamentally limited by the sensing and compute capabilities.

Humans communicate to gain knowledge, and collaborate to improve task reliability. Compared to humans, autonomous agents have a much lower communication barrier and less overhead. Networked autonomous agents, if orchestrated correctly, can cooperate in real time to not only tackle long tail corner cases, but also unlock novel capabilities previously not demonstrated. Building on top of prior work on cooperative perception, the proposed work infuses collaborative intelligence into networked heterogenous autonomous systems, empowering them to achieve capabilities and reliabilities beyond individuals.

Intellectual Merit

Current autonomous systems are task or domain specific with multi-modality sensors and complex actuation pipelines; it is non-trivial to construct a common language and open up an interface on each agent to communicate and collaborate. In dynamic environments, such collaboration can be opportunistic and hard to orchestrate in an ad-hoc fashion. Moreover, the tension between the richness of the sensor data and the network bottleneck poses huge challenges to scaling.

The proposal seeks to investigate the abstractions, algorithms and framework to address the above challenges in enabling self-orchestrating cooperative autonomous systems. The proposed research will develop: 1) generalizable methods to encode the common physical world into compact representations of the spatial-temporal context interpretable across various autonomy stacks, 2) a scalable situation-aware orchestration framework for dynamic representation sharing and fusion. 3) an ecosystem around cooperative autonomy including monitoring, continuous learning, and redeployment, 4) active cooperation mechanisms to drive agents in search of knowledge needed to complete tasks. The project will implement and be evaluated on multiple autonomy pipelines (*e.g.* cooperative driving, drone delivery) primarily using real-world prototypes (self-driving cars, drones, smart intersections, and radios).

Broader Impact

In collaboration with local self-driving company Ohmio, the proposed work will facilitate connected autonomous shuttle deployment in Riverside with enhanced reliability from infrastructure sensor support, serving communities with societal impact. The cooperative autonomy is expected to bring a paradigm shift from individual to cooperative agents in both industry and academia. The PI will integrate the research into both Electrical and Computer Engineering and Computer Science curriculum, designing new courses exposing the frontier technologies in self-driving, edge computing, and machine learning systems. The PI will continue actively recruiting and mentoring high-school students, undergraduates, and under-represented students in the Riverside area. The collaboration with Waymo and General Motors will ease the path towards technology transfer, exposing PhD students to the self-driving industry.