

PROJECT SUMMARY

Overview:

Collaborative Research: CPS: Medium: RUI: Cooperative AI Inference in Vehicular Edge Networks for Advanced Driver-Assistance Systems.

Increasing driving safety for commercial vehicles is one of the fundamental challenges in intelligent transportation systems. Recent Artificial Intelligence (AI) methodologies, especially Deep Neural Networks (DNNs), have led to superior performance in driving-assistant applications. However, the high computation expense of DNN-based solutions often limits their deployment in the Advanced Driver-Assistance Systems (ADAS) of the majority of vehicles due to insufficient onboard processing capability. To address this challenge, the overall objective of this project is to explore cooperative AI inference on ADAS with the emerging vehicular edge computing paradigm. Cooperative AI inference decomposes a DNN-based solution into a set of tasks, i.e., layers/components, and distributes them between the vehicle and server. Cooperative DNN computing brings three significant advantages over naive edge computation offloading that offloads raw sensory data to the edge server for fully remote AI inference. First, the inference offloading traffic can be significantly reduced with onboard vehicle processing due to the intrinsic characteristics of DNN operations, e.g., convolution, pooling, etc. Second, it enables vehicle and edge server parallel processing for the topological prior encoded DNN components. Third, the inference task assignment can be dynamically adjusted based on the actual communication bandwidth for the best performance. Leveraging the team's rich research experience and encouraging preliminary results, the project aims to investigate the above issues comprehensively on the theory, application, and testbed aspects. Theory-wise, the PIs plan to explore distributed DNN processing scheduling, task assignment, and DNN model parallelism optimization with the consideration of the complex architecture of DNNs and the network environment. Application-wise, the PIs will design novel DNN solutions for ADAS tasks with the coordination of cooperative AI inference paradigm. Testbed-wise, a vehicle edge computing platform with V2X communication and edge computing capability will be developed at Kettering University GM Mobility Research Center. The cooperative AI inference system will be implemented and the research findings will be validated on realistic vehicular edge computing environments thoroughly.

Intellectual Merit:

The proposed research opens new perspectives on existing ADAS systems for future connected vehicles, i.e., shifting from the standalone ADAS design to the distributed and connected ADAS design. The PIs explore integrative research to enable deep learning technologies in resource-constrained ADAS for high-accuracy and real-time inference by exploring the cooperation between vehicles and edge systems. A multi-disciplinary team is assembled to pursue the project goal with a coordinated study that balances theory, application, and testbed development and validation. This project will hone the following research gaps: (1) investigation of the impact of the fine-grained cooperative AI inference; (2) coordination between DNN inference algorithm design in ADAS and cooperative edge computing paradigm; and (3) vehicular edge computing testbed development and real-world empirical validation.

Broader Impacts:

Currently, the high cost of high-end onboard computation units is one of the main reasons that commercial vehicles only achieve Level 1 to Level 2 automation. Cooperative AI inference eliminates the high-cost of installing high-end onboard computation units. The project will inspire greater collaborations between experts in wireless communication, edge computing, computer vision, autonomous driving testbed development, and automotive manufacturing. The research finding can support AI applications deployment in a variety of Internet of Things systems. The PIs will work together to develop a new educational testbed integrated course with hands-on experiments developed from this project to train the next-generation intelligent transportation systems workforce. Both undergraduate and graduate students will be involved in the project via undergraduate research programs, e.g., REU, SAE International AutoDrive Challenge, etc. Minorities and underrepresented groups will be reached out via ACM-W, Women in Science and Engineering (WISE), K-12 students via robotics summer camp, Rowan Academy of Mobile Programming, etc. This project benefits master and Ph.D. programs from multiple institutes and our industrial collaborators, such as Toyota Research Institute North America.

Keywords: Safety, Transformation including air and ground, Networking, Internet of Things