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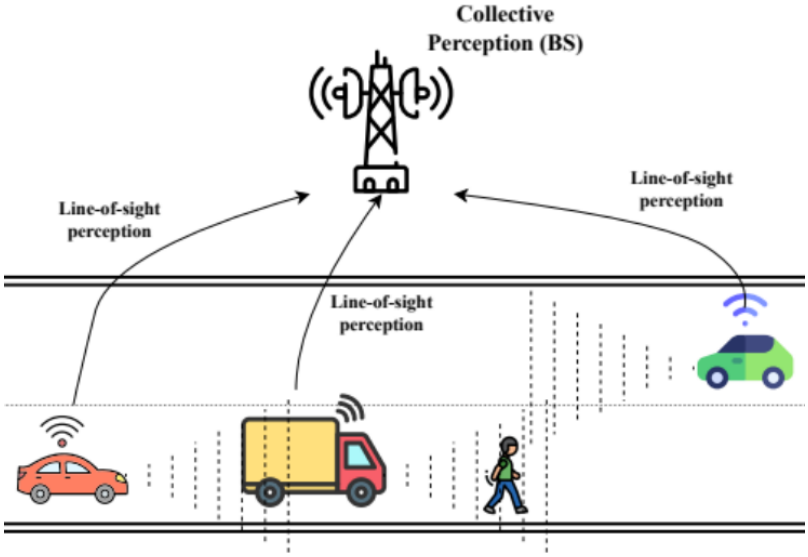
Masters Thesis

Distributed Object Detection for Cooperative Perception

Abstract

To ensure the secure and safe execution of automated actions in traffic, it is important that vehicles and other traffic participants possess sufficient awareness of their surroundings. Due to their reliance on line-of-sight detection, various state-of-the-art sensor systems fail to satisfy the functional requirements of automated driving applications. One way to address this limitation is to develop a collective perception of the environment, where individual entities share their perception of the local environment through a shared infrastructure.



For instance in Figure 1, each vehicle communicates its line-of-sight perception of the environment to a shared infrastructure, e.g., base station (BS), which stores the collective perception. Using the collective perception, the red car is able to identify the presence of a person in front of the truck. To maintain this collective perception, each vehicle can use pre-trained ML models for object detection (such as YOLO v8) to detect objects in their line-of-sight and report this information to a central location, e.g., the BS.

Goals of the Thesis

To develop a real-life testbed and various mobility scenarios to facilitate the realization of collective perception. This involves establishing a benchmark for collective perception using a real-life environment simulator such as Virtual Cycling Environment (VCE) and running it on NebulaStream. We will also develop an algorithm to perform operator placement for object detection in those scenarios.

The objectives of the thesis can be summarized as follows:

- Comprehensive literature review on collective perception \& object detection in mobility scenarios.
- Utilizing the Virtual Cycling Environment (VCE), construct a benchmark that emulates various collective perception scenarios in mobility. Include crucial metrics that are applicable to the given scenarios (e.g., throughput for object detection, communication latency, amount of data transferred, and so forth).
- Thorough performance evaluation of the object detection model utilizing the MLInfer operator in NebulaStream.
- Determine the optimal placement for object detection on the vehicles or the basestation based on the result from of benchmarking.
- Design an algorithm for the purpose of automating placement of object detection.

Keywords and Resources

NebulaStream (https://nebula.stream), Object Detection, YOLO v8 (https://github.com/ultralytics/ultralytics), PyTorch, Virtual Cycling Environment (https://github.com/tkn-tub/virtual-cycling-environment, https://vce.readthedocs.io/en/latest/getting_started/)

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