IACOS 2024 Project

Ricardo Severino
Luis Miguel Pinho

Problem Description

For this course's project we are considering a roadwork scenario. Such scenarios are particularly challenging for autonomous vehicles, particularly because these obstructions are unpredictable and are not part of any map vehicles rely on for path planning decision. As mentioned in WIRED, *"If you're a human driver, road construction probably annoys you: one more thing clogging traffic on your way home. If you're a self-driving car, though, it can be devastating. Work zones flummox the future rulers of our roads because they override or obliterate the sturdy markers by which the vehicles are taught to navigate. With no warning, they enter a world where cones trump double yellow lines, bollards replace curbs, and construction worker hand signals outweigh traffic lights."*

Interestingly, the complexity of such scenarios is such, that the strategy most autonomous vehicle makers have been following is to sidestep the problem all together. Indeed, in such situations, self-driving pioneers like Waymo address this by handing the control over to a human.

The fact is that the looks of a construction zone changes based on where it is and what's being done, and while engineers can expect human drivers to understand any improvised arrangement of placards, blinking arrows, and sign-spinning workers, that's way harder for a computer. Nissan became the first big player to declare it had no hope of making a car that could handle the whole world on its own. So it plans to rely on humans via remote call centers to guide troubled AVs around confusing situations, like construction zones. Fortunately, giving cars the ability to communicate with each other and with infrastructure can help to address this problem differently. If you fit a highway with a vehicular communication infrastructure one can warn a connected, autonomous car that a construction zone is up ahead, and maybe even how to get through it safely.

Overall, this is the problem we are proposing you to address in this project.

Such roadwork scenarios are particularly complex because they usually demand for a higher degree of cooperation between drivers and other eventual actors *in situ*, being the other drivers, the workers or a policeman. Often, a policeman plays this role of Authorized Traffic Controller (ATC) and is positioned in such scenarios to help with the traffic flow. His gestures supersede any other traffic rules, but can a vehicle interpret those signs?

You are to implement a ROS2 node that will carry out this task. Grab a stream from your webcam or any other camera and using tools such as OpenCV eventually coupled with AI techniques,

understand a set of signs. These can be hand gestures or traffic signs the ATC may hold. Your implementation should at the very least be capable of detecting signs to **stop**, **advance** or carry out **left** and **right turns**, to inform the vehicle from which side it must overtake the obstacle.
As an output of your node, you are to publish the result in a message of your own crafting, over a topic */atc/orders*.
These orders are then to be used in controlling the vehicle in a simple vehicle simulation scenario. You can rely on any simulator of your choice e.g., Gazebo. Regarding the vehicle stack, you can rely on Autoware or a simpler ROS navigation stack of your choice.

Objectives

- You are to overview most recent literature on the subject and proposed solutions to address such problems.
- Implement a node in ROS2 capable of processing a camera video input.
- Deploy the intelligence to detect and classify a few basic signs a human ATC could use in such situations.
- Publish the output of the classification process to a ROS2 topic.
- Subscribe to the topic in some behaviour planner or control module to create a new vehicle trajectory.

Deliverables
The project will have two deliverables:

Deliverable A (document) – Deadline 31/10/2024
Report on the relevant state of the art, technologies and system architecture.

Deliverable B (document, source code and video) – Deadline 02/12/2024
You are to deliver a short report and the source code of your system. A short video presenting the functionality should also complement the materials. The project report must complement the previous deliverable with the report on the implementation and critique of obtained results. Take enough time to carefully analyse the limitations and challenges of your approach.

The reports should be formatted as a small technical article maximum of 4 pages in LNCS format (https://www.springer.com/gp/computer-science/lncs/conference-proceedings-guidelines).
More pages can be allowed only if strictly necessary to describe particularly complex methodologies or algorithms.
The source code should be complemented with a readme file including some examples of usage. The analysis should appropriately reference the sources used.

The submission file format is PDF written in Portuguese or English.
Delivery should be made via Moodle, by submitting a compressed file with the required materials.
Presentations will be mandatory and will take place in the same week on the 5th of December.

Additional Rules
Deadlines are to be respected. Deliveries up to 2 days past the deadline can be accepted. However, penalties will be applied to late deliveries: 15% per 24 hours delay.
Project is to be carried out in groups of 3 students. If justified, a group can accommodate 4 students maximum.