Behaviour of sensors of autonomous vehicles in poor weather conditions (1-2 students)

With the development of advanced driver support systems and autonomous vehicles, the reliability of the sensors has to be increased. The sensors must be fully functional regardless of the weather conditions. As well, new types of sensors are emerging with the aim of coping with poor visibility conditions. To support the development and verification of these systems, there is a demand for testing of vehicle sensor systems in poor weather conditions. The weather conditions of interest are rain, fog, and water spray from a wet asphalt surface. The latter is the toughest condition for sensors to handle.

The goal of this project is to build competence at Chalmers and AstaZero [1] for modelling of water spray conditions at AstaZero's test track. Currently there is not much published in the literature on this subject and AstaZero is developing a repeatable spray system that is sufficiently similar to real conditions in order to support vehicle testing and sensor development. This system will give AstaZero a unique competence in Europe.

Images obtained at AstaZero's test track with a pilot spray rig. The rectangles are highlighting the contrast targets. Left: image taken without a wind; right: image taken with a side wind.

Content of the thesis work

Measure and describe generated spray in the existing pilot spray rig at AstaZero and analyze sprays obtained in reference field measurements.

Produce data that confirm that the spray in the existing rig is repeatable and sufficiently similar to a real spray.

Help in collecting data from measurements on real roads, both at AstaZero's test track and on a public road. This data will be used as a reference to confirm the similarities between the artificial spray and the real spray.

Develop a measurement methodology for spray characterization. Measurements and data collection will be a natural way to develop the methods for the spray analysis.

Simulate sprays in a lab environment at Chalmers laboratory [2] which will allow a cost-effective approach for sensor testing in lab conditions.

Method
In simple words, it is about having a vehicle equipped with a spray rig and followed by another vehicle equipped with sensors and measuring how the spray affects the sensor performance. Ordinary video and contrast targets are mainly used, but this will also be complemented with measurement by LIDAR, lasers, and high-speed cameras.
The asphalt on the test track is very smooth and uniform, while public roads can have much greater variations with an impact on collected data. Driving on public roads also has the side effect of seeing other phenomena that occur when there are several cars and trucks on the road around the test vehicle. That is why we want to collect data from public roads as well. A crucial factor here will be to be able to collect data when it is "right" weather, i.e. rain of appropriate intensity.
The challenges are to develop reliable methods for simulating the spray in windy conditions and characterizing the spray in daylight.
In the lab environment, the spray properties will be measured in detail and correlated with the scattering of the laser light caused by the spray. This correlation will then be applied in road conditions to characterize the spray. A similar measurement will be performed with an IR camera. For that, passive contrast targets will be replaced with heated targets.

Prerequisites for the thesis
Interest in autonomous vehicles, sensor technology, LIDAR, IR, advanced optical methods, fluid dynamics, and skilled in Matlab.

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References

[1] https://www.astazero.com/

[2] https://www.chalmers.se/en/departments/m2/simulator-labs/labs/chalmerswindtunnels/Pages/default.aspx