# Revolve NTNU: Egomotion estimation and map building for Autonomous Race Car

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## Objective

The project addressed in this Masters topic is to develop a solid and precise method for estimating both the ego-motion of the race car as well as the structure of the environment through which this race car moves. With this goal, the project builds on the results and experiences of the previous project / Masters thesis work. The aim is to further increase both the stability as well as the precision of the previous method and experiment with new components and approaches to be used in the context of egomotion estimation and map building.

Currently, the egomotion and map building component (here also called 'dynamic state estimation') uses mainly LiDaR measurements to build a map of the environment, which is essentially a plane racing ground and a track which is marked by cones put on the track boundaries. It uses a so-called graph-based SLAM approach, building on available libraries for graph-based optimiization, in particular the iSAM2 library by Kaess, Dellaert et al.

In the new approach, the individual components of the existing system will be re-inspected in depth, in particular in the area of data association. This term denotes the process of associating each detected landmark (here: the LiDaR-detected cones) at time instant N with the correctly corresponding landmark at time instant N+1. As the cones all look the same, and as the cone detector will sometimes produce errors (cones missed, or wrong cones hallucinated), this problem is difficult, and it is of utmost importance to make this association right, as even few undetected 'outliers' in the measurements / detection result can lead to catastrophic consequences in the egomotion estimation and map building.

The approaches to be investigated in the new version of the SLAM algorithm focus on this data association process. They will explicitly use a dynamic model of the car motion and extensive statistical modeling of the landmark detector reliability as well as statistical modeling of all other sources of error in the data processing process, as far as the tolerable computational effort allows for this.

It is also desired that the data association process is implemented using criteria for self-supervision. The possibiliy of multi-hypothesis operation, and using backtracking and 'warm restart' in case of (rare) failures of the overall dynamic state estimation process should be investigated. Optionally, it can be investigated if and where usage of modern machine learning methods may contribute to a safe and solid solution to the dynamic state estimation process.

The project requires experience in statistical data analysis, or the willingness to acquire corresponding background knowledge in the preparatory phase, interest or experience in real time programming, and of course some enthusiasm towards the idea of building an 'intelligent car'.

## Responsibility

The student is responsible for designing and implementing an autonomous software module for detection and localization, intended to run on the car in 2021 or beyond, and that can contribute to a better performing car through efficient and robust processing.

## Environment

Revolve is a hands on, practical experience providing a great environment for testing and validation of your effort. You will work closely with an ambitious and goal-oriented team, and gives a unique opportunity to meet like-minded and talented students who can help you write a great Master's thesis while performing research for an autonomous race car.

For more information, see: *www.revolve.no/masteroppgave-for-revolve-ntnu*