ADAPT

LINKÖPING UNIVERSITY

INTRO

Currently, autonomous vehicles is a hot topic in academia and industry. At LiU, there is an ongoing CDIO project, *Autonomous Truck with a Trailer*, with the aim to create an education and research platform within the area. The system consists of a *LEGO* truck equipped with an *EV3* control unit and a *Raspberry Pi*. During this year's edition of the project, the task has been to improve the interaction with dynamic obstacles as well as developing a fast MPC-controller.

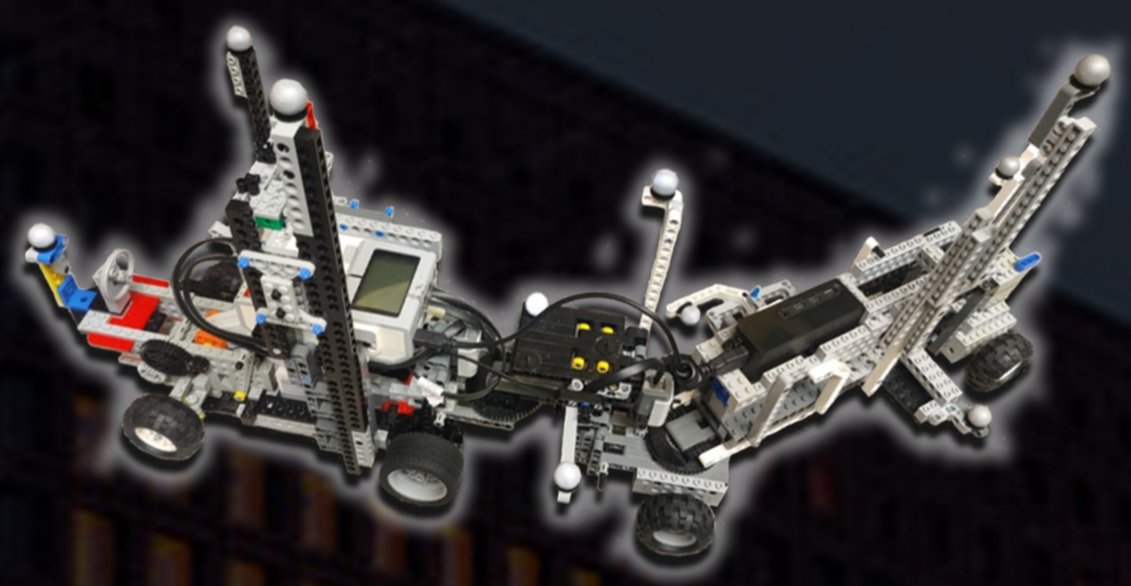

Figure 1: *The LEGO truck*

PROJECT GOALS

- Implement planning algorithms for handling dynamic obstacles
- Implement prediction models for estimation of movement
- Integration of modules into the system's architecture
- Visualizing the integrated system in simulations and *Visionen*

IMM-FILTER

The purpose of implementing an IMM-filter is to estimate obstacles movements and behaviours. This is fundamental to reduce collisions and important information when planning a route. The implemented IMM-filter predicts future states of pedestrians and ground vehicles such as a remote car. This is done by utilizing several motion models and determining the most probable using probability theory.

The IMM-filter should then supply the dynamic motion planner with a future trajectory of the dynamic obstacles based on the most probable motion model. This aims to lower the mean squared error. It is presumed that pedestrians and ground vehicles can enter the modes of *idle*, *moving forward with constant velocity* and *keeping constant velocity while doing a coordinated turn*. It is also presumed that ground vehicles can enter a mode of *constant acceleration*. The code for the IMM-filter is handwritten and integrated with *ROS*. A visualization of the IMM-filter is shown in **Figure 2**.

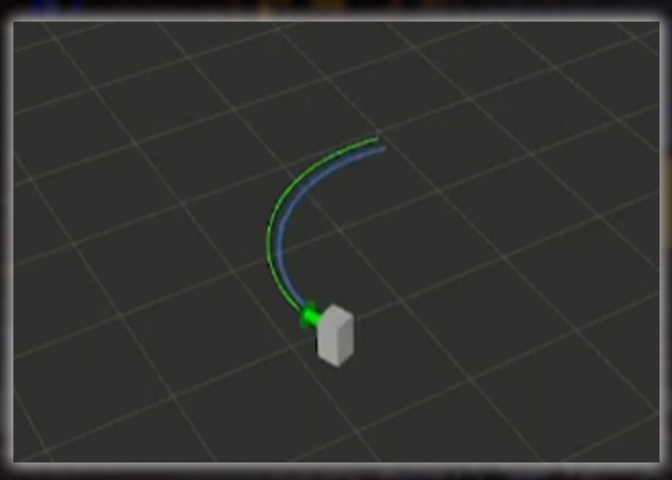

Figure 2: *The IMM-filter*

DYNAMIC MOTION PLANNER

A new dynamic motion planner has been developed in the project. The planner receives a pre-planned path from a previously developed static motion planner and observations of dynamic obstacles from the IMM-filter. While the truck is driving, it continuously calculates an acceleration profile and combines this with the path to create a trajectory. The trajectory is updated such that it is void of dynamic obstacles in the environment.

This functionality is realized by utilizing a *Partially Observable Markov Decision Process* (POMDP). In a POMDP, the consequences (observations) after taking specific actions are simulated and given a specific reward. After simulating a tree of actions and observations the branch with the highest accumulated reward is selected and thus an acceleration profile is generated. The POMDP is implemented with the online solver *DESPOT*, which is compatible with *ROS*. A plot of the motion planner is shown in **Figure 3**.

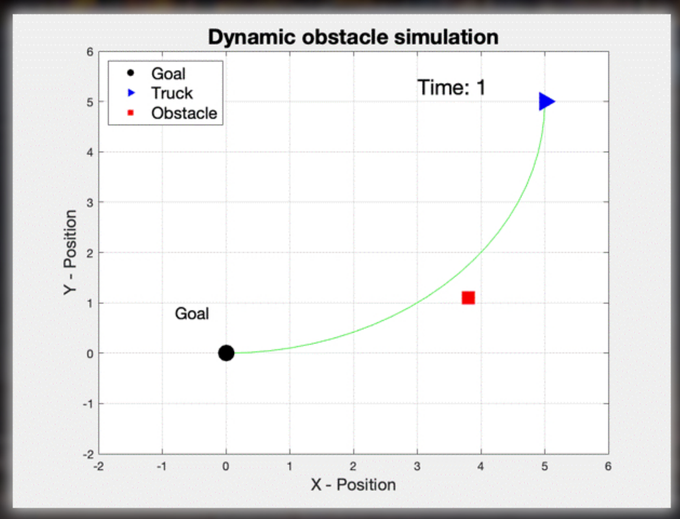

Figure 3: *The motion planner*

MPC-CONTROLLER

The truck's MPC-controller was originally based on a race car implementation. Since the dynamics differs, constrains are defined differently to solve this nonlinear problem with a linear cost matrix. As shown in **Figure 4**, the MPC-controller follows the track well. This solution is done in *ACADOS*, a *MATLAB* library, and then generated to *C* code. Since *ROS* operates with *C++*, the conversion is doable. This module includes a node program that handles the communication with *ROS* and an engine program that handles the logic in the background.

The MPC-controller takes seven states: *x*, *y*, *theta*, *beta2*, *beta3*, *v* and *kappa*. The integrated module is able to race the track forwards and backwards.

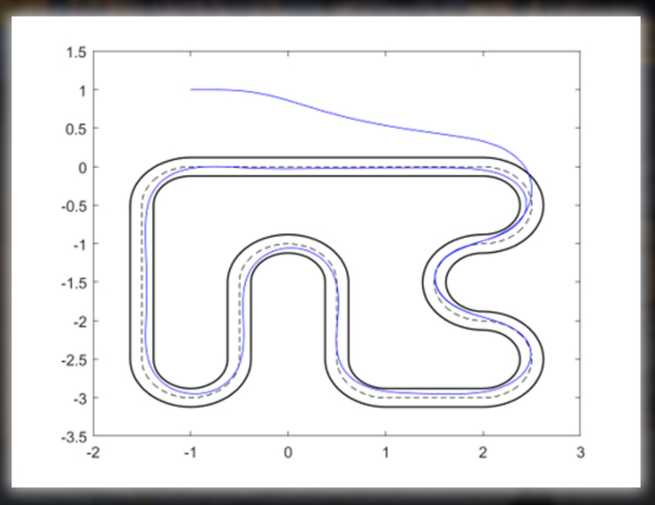

Figure 4: *The MPC-controller*

RESULTS

All the modules work separately. The IMM-filter has been successfully implemented in *ROS*. The motion planner could not be implemented due to dependencies from previous years, which are no longer functional. The MPC-controller is defined and works well in *MATLAB*, but is not fully functional in *ROS*.

Autonomous Dynamic obstacle detection And Path planning Truck

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