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Passivity-Based Model Predictive Control for Mobile Vehicle Motion Planning

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To Enver, Djula and Adaleta

AD

To Giuliana, Carlo and Silvia

MG

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Contents

Abstract

An autonomous mobile vehicle able to traverse a wide range of poor natural terrains is an indubitable useful concept that can be utilized in different kinds of fields. A variety of needs of planetary explorations, rescue missions in hazard areas, humanitarian demining as well as agriculture applications have recently triggered a lot of research works aiming at developing sufficiently reliable motion and navigation planning approaches in such environments. This work presents such a concept to guide the vehicle to reach a goal position regardless the terrain shapes.

The presented navigation planning approach is based on the model predictive control paradigm (MPC). The MPC-like approaches allow for taking into account a variety of different constraints, such as guaranteeing stability, avoiding obstacles, and preventing the vehicle from sideslip and rollover. An additional feature of an MPC approach is that it continuously repeats the optimization during the task execution allowing for new local sensor measurements to be taken into account. Such a policy is used for continuous finding collision-free paths and to guarantee the safe task execution. Additionally, it inherently provides a certain level of robustness to an MPC generated path comparing to the approaches where the complete path is being found prior the task execution.

In order to adopt an MPC-like approach for the purpose of mobile vehicle navigation, we use energy shaping technique to include the terrain map and the goal position into the system model. The passivity-based control theory is then used to obtain a stable MPC framework (PB/MPC) guaranteeing task completion, which means the vehicle is being capable to reach the goal position.

The straightforward procedure for finding feasible control actions, regardless the complexity of the vehicle model, makes this approach a good tool to be used in outdoor environments. Namely, using a precise complex model that reflects the vehicle behavior on rough terrains, during the planning stage, provides a safer planner which generates trajectories that can be easily tracked by the vehicle during the execution stage. The problem of using a simplified model to generate trajectories during the planning stage is certainly an issue of the navigation planning for complex vehicles and environments.