ABSTRACT
PERFORMANCE ANALYSIS OF A CONSTANT SPEED LOCAL OBSTACLE
AVOIDANCE CONTROLLER USING AN MPC ALGORITHM
ON GRANULAR TERRAIN

Nicholas Haraus, B.S.M.E.

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A Model Predictive Control (MPC) LIDAR-based constant speed local obstacle avoidance algorithm has been implemented on rigid terrain and granular terrain in Chrono to examine the robustness of this control method. Provided LIDAR data as well as a target location, a vehicle can route itself around obstacles as it encounters them and arrive at an end goal via an optimal route. Using Chrono, a multibody physics API, this controller has been tested on a complex multibody physics HMMWV model representing the plant in this study. A penalty-based DEM approach is used to model contacts on both rigid ground and granular terrain. We draw conclusions regarding the MPC algorithm performance based on its ability to navigate the Chrono HMMWV on rigid and granular terrain. A novel simulation framework has been developed to efficiently simulate granular terrain for this application.

Two experiments were conducted to analyze the performance of the MPC LIDAR-based constant speed local obstacle avoidance controller. In the first, two separate controllers were developed, one using a 2-DOF yaw plane analytical model to predict the HMMWV behavior, and the second using a higher fidelity 14-DOF vehicle model. In this first experiment, the two controllers were compared as they controlled the HMMWV on two obstacle fields on both rigid ground and granular terrain to understand the influence of model fidelity and terrain influence on controller performance. Based on these results, an improved lateral force model was developed for use in the 2-DOF vehicle model to better model the tire ground interaction using terramechanics relations. A series of open loop experiments were conducted to confirm this new force model results in better vehicle trajectory predictions. Finally, a second experiment was performed to compare two developed controllers. One used the 2-DOF vehicle model using the Pacejka Magic Formula to estimate tire forces while the second controller used a 2-DOF vehicle model with the newly developed force model to estimate lateral tire forces. The results of these two experiments are summarized in this thesis.