How to drive a train blindfolded

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Abstract

In August 2023, searching "Things that can be done blindfolded" in popular search engines shows results that can be mainly classified in two categories: solving rubik cubes and sex. We found not a single search result on how to drive a train blindfolded. Driving a train can be described briefly as applying traction and brake at the right times while showing every 20 to 60 seconds that the person in command is still alive. The earlier task becomes more complex in reality since driving conditions like the weather affect how a train should be driven but are uncertain *a priori*. For instance, wheels slip more when it is raining due to the lower friction between wheel and rail, so traction and brake must be applied more gently than in dry conditions. In this extended abstract we aim to cover the gap previously mentioned by developing a mathematical theory on driving a train blindfolded under uncertain driving conditions. In our previous research we analyzed data from train trajectories realized under different driving conditions and used parameter estimation to quantify their impact on the train dynamics. Here we formulate a robust train trajectory optimization problem that aims to find an open-loop robust-optimal control policy for driving a train to its destination timely while consuming the least amount of energy that is feasible for all the sets of parameter estimates considered. The obtained control policy describes the exact amount of traction and brake to be applied at all times to drive a train to its destination. It can be used as a reference, for instance, by blindfolded drivers, in Driver Advisory Systems, in Automatic Train Operation and in the timetabling process. It is open-loop since it shows how to drive a train without receiving feedback at any time on the actual performance of the driving with respect to the calculated effect of the robust-optimal control policy. The drivability of the calculated control policy is guaranteed under uncertain driving conditions by requiring it to be feasible for several sets of parameter estimates. This means that if any of the driving operating conditions represented by the sets of estimates considered takes place again, following the robust-optimal control policy will allow to drive the train to its destination timely and without overspeeding. This feasibility requirement is very demanding, as it shrinks the solution space. To keep its size large enough so that a solution of the robust train trajectory optimization problem may exist, we have to relax the arrival conditions of the problem by allowing a slight delay, early arrivals and arriving to a station with nonzero speed. We will show some of the robust-optimal trajectories we have calculated and discuss potential applications.

Keywords Robust Train Trajectory Optimization, Train Trajectory Optimization, Minimax Optimal Control, Robust Maximum Principle, Parametric Uncertainty