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Model Predictive Control of Fuel-Efficient Vehicle-Following Model Considering Nonconvex and Discontinuous Characteristics of Engine and its Low-Computational-Cost Implementation

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This study implements low fuel consumption control in adaptive cruise control problems by considering the nonconvex and non-continuous characteristics of vehicle engines. The model predictive control (MPC) approach combines an optimization solver PANOC, which can handle nonconvex problems with fast computation, and the Douglas-Peucker algorithm, which implements a piecewise affine approximation, to computationally simplify the nonconvex, discontinuous fuel consumption model and achieve low computational consumption. As a result, the control objectives are achieved and the computational speed using this technique is significantly accelerated to meet the requirements of real-time performance.

The nonconvex and discontinuous characteristics of the engine are indicated by the fact that the fuel consumption function is a non-convex and discontinuous function. For the nonconvex, discontinuous fuel consumption function, we approximated it by the linear approximation Douglas-Puecker algorithm, which was used to simplify the computation of the proximal mapping of the PANOC algorithm, and the computation time was reduced by at least half after using this maneuver by comparison of the computational speed. We also used such a model for model predictive control of the low fuel consumption adaptive cruise control problem. By comparing the two cases of (i) the absence of fuel consumption term in the cost function and (ii) the presence of fuel consumption term in the cost function, the results of the simulation are shown in Figs. 1,2, respectively. The fuel consumption is lower in the case of carrying the fuel consumption term, while the vehicle is operated with staggered acceleration and deceleration in order to achieve lower fuel consumption.

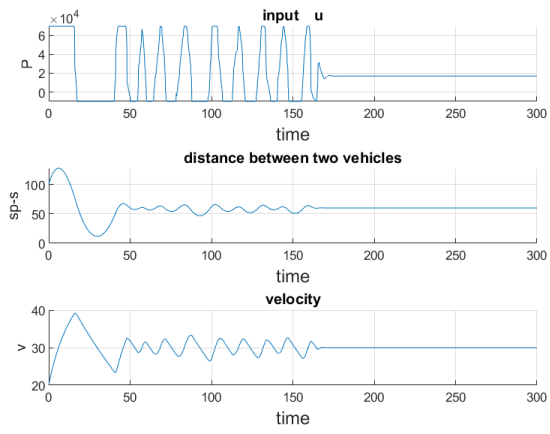

Fig. 1 Simulation results of (i)

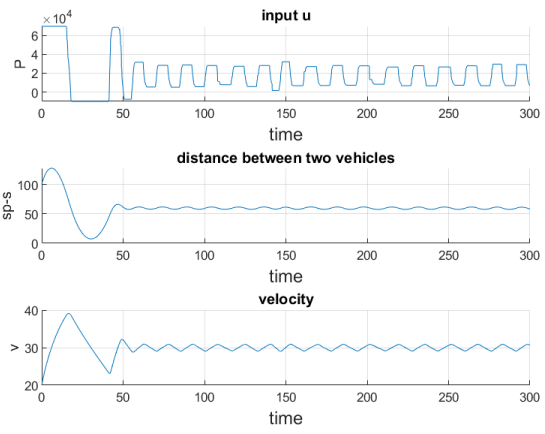

Fig. 2 Simulation results of (ii)