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Coasting advice based on the analytical solutions of the train motion model

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A large variety of supervision, data analysis and communication algorithms monitor trains, exploiting most of their available computational power. On-board eco-driving algorithms such as Driver Advisory Systems are no exception, as the computational power available can limit their complexity and features. This was the case of Roltijd, the in-house developed Driver Advisory System based on coasting advice of Nederlandse Spoorwegen (NS), the main Dutch passenger railway undertaking. This platform calculated the coasting curves at every second by integrating the equations of motion numerically, assuming that the track is flat. However, the plans of NS regarding generating more complex driving advice require replacing this coasting curve calculation by a more computationally-efficient algorithm. In this article we propose a new coasting advice algorithm based on the analytical solutions of the train motion model's differential equations that assumes the gradients and speed limits as piecewise constant functions of the train location. We analyze the qualitative properties of these solutions using the theory of dynamical systems, showing that bifurcations arise depending on the value of the gradient and the applied tractive effort. We validate the proposed algorithm by comparing its performance and accuracy against the previous method and a train trajectory optimizer based on a pseudospectral method, finding that our algorithm is accurate and can be 15 times faster than the previous method. This allows NS to implement the proposed method on the trains running in the Dutch railway network, contributing daily to the sustainable mobility of 1.3 million passengers.

Keywords
Driver Advisory Systems, Eco-driving, Coasting, Differential Equations, Railways