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Real time eco-driving of high speed trains by simulation-based dynamic multi-objective optimization

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Abstract— Eco-driving is a traffic operation measure that may lead to important energy savings in high speed railway systems. Eco-driving optimization has been applied offline in the design of commercial services. However, the benefits of the efficient driving can also be applied on-line in the regulation stage to recover train delays or in general, to adapt the driving to the changing conditions in the line. In this paper the train regulation problem is stated as a dynamic multi-objective optimization model to take advantage in real time of accurate results provided by detailed train simulation. If the simulation model is realistic, the railway operator will be confident on the fulfillment of punctuality requirements. The aim of the optimization model is to find the Pareto front of the possible speed profiles and update it during the train travel. It continuously calculates a set of optimal speed profiles and, when necessary, one of them is used to substitute the nominal driving. The new speed profile is energy efficient under the changing conditions of the problem. The dynamic multi-objective optimization algorithms DNSGA-II and DMOPSO combined with a detailed simulation model are applied to solve this problem. The performance of the dynamic algorithms has been analyzed in a case study using real data from a Spanish high speed line. The results show that dynamic algorithms are faster tracking the Pareto front changes than their static versions. In addition, the chosen algorithms have been compared with the typical delay recovery strategy of drivers showing that DMOPSO provides 7.8% of energy savings.

Index Terms— Simulation; Delay recovery; Dynamic multi-objective optimization; Eco-driving; High speed railway; Real-time traffic operation

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