Design of robust and energy efficient ATO speed profiles of metropolitan lines considering train load variations and delays

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Abstract— Metropolitan railway operators' strategic plans include nowadays actions to reduce energy consumption. The application of ecodriving initiatives in lines equipped with ATO (Automatic Train Operation) systems can provide important savings with low investments.
Previous studies carried out under ATO framework have not considered the main uncertainties in the traffic operation: the train load and delays in the line. This paper proposes a method to design robust and efficient speed profiles to be programmed in the ATO equipment of a metro line. First, an optimal Pareto front for ATO speed profiles that are robust to changes in train load is constructed. There are two objectives: running time and energy consumption. A robust optimization technique and an alternative method based on the conservation of the shape of the speed profiles (pattern robustness) are compared. Both procedures make use of MOPSO (Multi Objective Particle Swarm Optimization) algorithm.
Then, the set of speed profiles to be programmed in the ATO equipment is selected from the robust Pareto front by means of an optimization model. This model is a Particle Swarm Optimization algorithm (PSO) to minimise the total energy consumption considering the statistical information about delays in the line. This procedure has been applied to a case study. The results showed that the pattern-robustness is more restrictive and meaningful than the robust optimization technique as it provides information about shapes that are more comfortable for passengers. And the use of statistical information about delays provides additional energy savings between 3% and 14%.

Index Terms— Communication Based Train Control (CBTC), energy saving, multi objective particle swarm optimization (MOPSO), subway systems, train load variations, train operation, uncertainty

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