Engineering Applications of Artificial Intelligence. Volume: Number: Pages: -. December 2014

Multi objective particle swarm optimization algorithm for the design of efficient ATO speed profiles in metro lines

M. Domínguez, A. Fernández-Cardador, A.P. Cucala, T. Gonsalves, A. Fernández Rodríguez

Abstract— One of the strategies for the reduction of energy consumption in railways systems is to execute efficient drivings (eco-driving). This eco-driving is the speed profile that requires the minimum energy consumption without degrading commercial running times or passenger comfort. When the trains are equipped with Automatic Train Operation systems (ATO) additional difficulties are involved. Their particular features make it necessary to develop accurate models that optimize the combination of the ATO commands of each speed profile to be used by the traffic regulation system. These commands are transmitted to the train via encoded balises on the track with little channel capacity (bandwidth). Thus, only a few and discrete values of the commands can be sent and the solution space of every interstation is made up of a relatively small set of speed profiles. However, the new state-of-the-art of signalling technologies permit a better bandwidth resulting in an exponential solution space. This calls for new methods for the optimal design of the ATO speed profiles without an exhaustive simulation of all the combinations. A MOPSO algorithm (Multi Objective Particle Swarm Optimization) to obtain the consumption/time Pareto front based on the simulation of a train with a real ATO system is proposed. The algorithm is able even to take into account only the comfortable speed profiles of the solution space. The fitness of the Pareto front is verified by comparing it with a NSGA-II algorithm (non-dominated sorting genetic algorithm II) and with the real Pareto front. Further, it has been used to obtain the optimal speed profiles in a real line of the Madrid Underground.

Index Terms— Energy efficiency, train simulation, ATO, metro, eco-driving, MOPSO algorithm, evolutionary algorithm

Citation:
Domínguez, M.; Fernández-Cardador, A.; Cucala, A.P.; Gonsalves, T.; Fernández Rodríguez, A.; "Multi objective particle swarm optimization algorithm for the design of efficient ATO speed profiles in metro lines", Engineering Applications of Artificial Intelligence, vol., no., pp.-. December, 2014.