Conflict Resolution At Connected Railway Junctions

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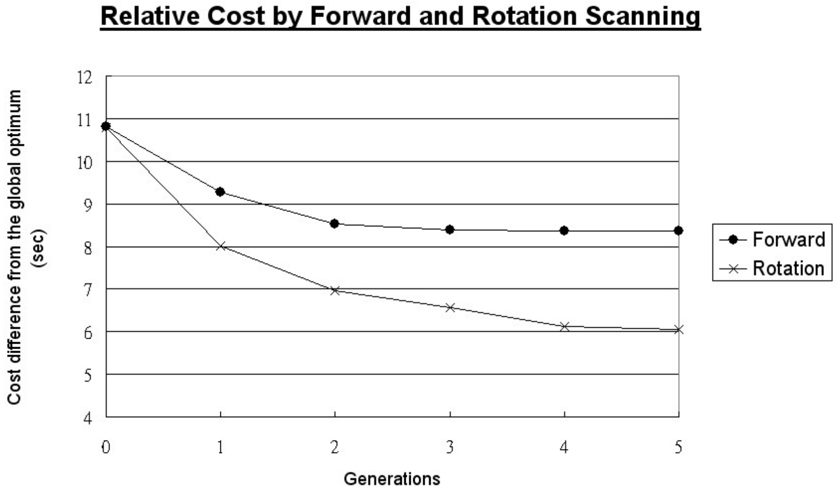
Purpose of study: Traffic conflicts occur when trains on different routes approach a converging junction in a railway network at the same time. To prevent collisions, a right-of-way assignment is needed to control the order in which the trains should pass the junction. Such control action inevitably requires the braking and/or stopping of trains, which lengthens their travelling times and leads to delays. Train delays cause a loss of punctuality and hence directly affect the quality of service. It is therefore important to minimise the delays by devising a suitable right-of-way assignment.

One of the major difficulties in attaining the optimal right-of-way assignment is that the number of feasible assignments increases dramatically with the number of trains. Connected-junctions further complicate the problem. Exhaustive search for the optimal solution is time-consuming and infeasible for area control (multi-junction). Even with the more intelligent deterministic optimisation method revealed in [1], the computation demand is still considerable, which hinders real-time control. In practice, as suggested in [2], the optimality may be traded off by shorter computation time, and heuristic searches provide alternatives for this optimisation problem.

Methodologies: This paper focuses on applying a heuristic optimisation method [3], *Genetic Algorithm (GA)*, to search for the optimal (or near-optimal) right-of-way assignment for trains approaching an area with two junctions. However, the traditional genetic operators, *crossover* and *mutation*, pose difficulties in this application as they often produce right-of-way assignments that are outside the solution space because of the definitions of the chromosomes. Two chromosome scanning methods, forward and rotation, have been developed to locate the invalidity of the chromosomes and modify them before they are admitted to the next generation for evolution.

Results: A performance comparison between the two scanning methods has been carried out by computer simulation. It involves two trains on each incoming routes of two connected junctions. The size of the solution space is 90 and the initial population size is 16. The cost function is the total weighted delays of the trains. The mean costs (over 100 trials) of the best chromosomes evolved using the two scanning methods are shown below.



Both methods enable convergence toward the optimal solution, but rotation scanning is found to be more effective since it provides more radical modifications on the chromosome so that it can offer more exit routes from the local optima.

Studies are also performed on the use of *first-come-first-serve* (FCFS) assignment as a seed to improve the *GA* search. Results have shown that the priorities of trains also have a significant effect on the optimality of the assignment and this will be discussed in more details in the full paper.

Conclusions: Optimal traffic control at connected railway junctions requires large computational demands and *GA* provides a means to generate a fast and near-optimal solution. Two scanning methods have been developed so that the advantages of the two traditional operators can be preserved. It has been shown that seeding with FCFS helps improve the performance of the *GA* search.

References

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