

Multi-Objective Optimisation and Dynamic Routing Algorithms in Transportation Networks

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A multi-objective optimisation approach to dynamic routing in transportation is described. Transportation (particularly public transportation) is a more dynamic process than many traditional Geographic Information Science (GIS) subjects. Public transport network structures change in very important ways over time. Changes are spatial, temporal and topological. These dynamic, almost instantaneous, events cannot be easily dealt with in static time slices. A UCGIS (University Consortium for Geographic Information Science) research priority in the area of extensions to geographic representation is that routing algorithms need to be improved in order to perform dynamically to take advantage of real-time traffic information. Standard algorithms, such as Dijkstra's algorithm, respond to dynamic changes in network topology but they are not guaranteed to produce physically optimal route specification. Optimisation of transportation and route costs is a problem dealing with many kinds of characteristics of constraints; for example, route length, travel mode, and travel time. Solving this routing problem involves compromises within conflicting sets of goals and constraints. In dynamic environments human generated solutions are non-optimal due to the multi-variable nature of the problem.

A multi-objective optimisation approach is described dealing with three variables (objectives), that is, travel length, travel time and the number of modal changes required to complete a journey on a public transport network. All variables must be minimised to construct optimal solutions with no rigorous rules governing how each of these objectives functionally depends on each other. Three-dimensional vectors are used to represent each path's attributes with each vector entry representing one objective in the problem. A large population of paths (journey specifications) is

extracted from the graph/network model. Isolation of solutions or paths that are non-dominated is initiated towards finding the Pareto-optimal (Goldberg 1989) set of solutions. This set contains paths whose solutions cannot be bettered by any other solution on all n-criteria. Solutions within this set are ranked and prioritised allowing easy extraction of journey specifications for traveller information systems. The injection of real-time traffic information only requires a sub-region of paths to be recomputed. Newly generated solutions are ranked and prioritised as before thereby producing optimal solutions during dynamic network change. This approach may be extended to n-dimensional optimisation. This research is also investigating evolutionary computational approaches to the development of optimal public transport travel route structures. Current network structures are taken and evolved towards optimal network configurations. This allows for efficiency evaluation studies to be carried out on existing transportation infrastructures in major urban centres. Successful applications of this approach range from the design of aerodynamic compressor blades to several kinds of multivariable scheduling problems (Coello 1999).

References

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