Managing disruptions in urban road networks for real contexts

The growth of daily traffic flow happens in a large majority of downtown cities due to an increasing population concentration in urban areas. It is a great challenge to adapt urban road networks because the infrastructure cannot be infinitively improved due to limited resources for adding new lanes or even brand new road segments. The situation becomes more complex when disruptions occur, either predictable (ex. maintenance, public events, etc.) or not (ex. accidents, catastrophes, etc.). In such situations, a number of road segments become unavailable, which may reduce the traffic capacity and break travel paths between some locations (loss of strong connectivity) for a period of time. Thus, alternate paths (deviations) have to be addressed in a quick and clever way in order to minimize these impacts.

We investigate Road Network Problem with disruptions and connectivity requirements (RND) in (i) Unidirectional Road Networks (URND) [2], which address downtown cities where streets are often one-way, and in (ii) Multidirectional Road Networks (MRND) [3], which can model more general road networks with bi-directional streets and multiple lanes. In order to restore the accessibility in case of broken travel paths, reversing road directions is allowed. Consequently, drivers may be forced to change their driving habits. This may cause some confusion and conflict with on-board navigation systems. Thus the reversals should be limited. In these problems, we consider mainly two objectives: minimizing the total travel distance and minimizing the number of reversals. A bi-objective mathematical model is developed and two heuristics are proposed, a Biased Random Key Genetic Algorithm (BRKGA) [1] and an Iterated Local Search (ILS) [4]. Experiments show that the mathematical model is able to handle small instances only, while the heuristics can address in larger instances and were applied to Troyes city in France.

Besides, we are developing a decision support system named Optimal traffic Deviation System (ODS) which helps the tactical design of alternate paths on road networks. This system is able to compute deviations for each disruption with consideration of criteria of minimization: the deviation's distance, the number of segments used in the deviation, the number of traffic signals and the number of reversals. Vehicle types are also taken into account since a deviation suitable for small vehicles may break basic rules for tracks or buses (especially capacity or geometric constraints). Moreover, a large amount of infrastructure information (traffic lights, stops, traffic calming, etc.) were considered and integrated in our decision support system. ODS is connected to the planed disruptions database of Troyes, and to Geographical Information Systems (GIS). These data are fairly useful to provide qualitative evaluations for the deviations, such as the CO_2 emission and the quality of driving experience. The aforementioned algorithms have been adapted and integrated into ODS.

References:

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