Development of a new pro-active vehicle actuated signal control strategy – Evaluation on an urban intersection in Athens

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Along with the appearance of traffic congestion during the second half of the 20th century, appeared the need for efficient signal control in urban networks. The insufficiency of traditional fixed-time control to address the problem of traffic congestion called for different approaches. Vehicle actuated (or traffic responsive) control is a quickly developing field of research. Several applications exist worldwide which result in better exploitation of the existing road capacity.

The aim of this thesis was to develop a new pro-active vehicle actuated signal control strategy which is able to operate effectively in busy urban environments, overcome some insufficiencies of previous approaches and enhance the performance of the selected control methods. Special consideration was given to the particularities of the city of Athens, Greece.

Within this thesis, existing methods and techniques from the literature were reviewed so as to realize the idea of the new strategy. The developed vehicle actuated strategy employs an implicit enumeration technique to solve the optimal signal control problem and introduces further enhancements to the method to improve the algorithmic speed. A hybrid traffic estimation module is also developed to feed the optimisation, which divides the prediction horizon in two periods - a short-term and a long-term, to allow for pro-active control without rendering the optimisation problem computational costly. Finally, the algorithm employs a rolling horizon approach to deliver optimal signal timings for a future time horizon but updating them every second to exploit the latest detector data.

The strategy was developed using the SITRAFFIC package of SIEMENS. This software package allows for the design and optimization of fixed time signal plans but also offers the possibility for the development of more sophisticated vehicle actuated algorithms, using the software called Traffic Language. The used software allows for the developed strategies to be communicated either to a real controller or to a simulation environment for their evaluation.

The developed strategy was tested in the VISSIM micro-simulation environment but remains applicable to a real environment. The network selected for the strategy evaluation was an urban intersection close to the city centre of Athens. The network was designed in VISSIM exploiting various sources of data for the geometrical design and a considerable number of loop detectors and manual counts for the traffic data. The evaluation was made for four different demand scenarios covering the most typical demand patterns during a weekday.

The developed strategy shows reductions (depending on the demand scenario) up to 31% for average vehicle delay, 28% for the number of stops, 30% for the stopped delay and increase up to 20% for the average vehicle speed. Moreover, a reduction up to 22% on fuel consumption is observed. The strategy is robust so as to be able to continue controlling the network under a number of unexpected incidents (i.e. detector failures, accidents); however, its response speed and its deterioration rate were found to vary depending on the type of incident.

Due to its decentralised nature and the properties of the traffic estimation module, the strategy can efficiently control any number of intersections along an arterial, a common problem concerning the wide applicability of other VA control strategies. Other advantages over existing VA control methods are its high degree of flexibility and its and pro-active nature (compared to reactive approaches).