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APPLICATION OF FUZZY LOGIC TO TRAFFIC SIGNAL CONTROL UNDER MIXED TRAFFIC CONDITIONS

Traffic signal control is commonly used at road intersections to minimise vehicular delay. Fixed time control shows good results in conditions where there is a little fluctuation in traffic demand, however in time-varying traffic fixed time control becomes inflexible and inefficient. This may produce traffic congestion and lead to increased delays and air pollution. Demand responsive traffic signal control must be introduced to overcome these problems.

However, all the available demand responsive traffic signal control methods such as Vehicle Actuated Controller (VAC), Traffic Optimisation Logic (TOL), Microprocessor Optimised Vehicle Actuation (MOVA) and Fuzzy Logic Traffic Signal Controllers (FLTSC) have been developed for non-mixed traffic conditions, considering only motor vehicles move in clearly defined lanes, neglecting motorcycles. These demand responsive traffic signal controls are not appropriate for the mixed traffic conditions of developing countries such as Indonesia, where the traffic streams consist of different types of vehicle with a wide variation in their static, dynamic and operating characteristics, and with a particularly high proportion (30% - 70%) of motorcycles. Also there is lack of lane discipline.

This thesis describes the design and evaluation of an adaptive traffic signal controller based on fuzzy logic for an isolated four-way intersection with specific reference to mixed traffic in developing countries, including a high proportion of motorcycles. Four proposed controllers have been developed for different schemes. The controllers were designed to be responsive to real time traffic demands. The study identifies two traffic parameters as appropriate as input data for an adaptive traffic signal controller under mixed traffic conditions such as the proposed FLTSC: the average occupancy rate (%) and maximum queue length (metres). The literature study suggest that this data should be collected using advances video image processing. The proposed FLTSC uses maximum queue lengths and average occupancy rates collected during the previous cycle to estimate the number of seconds of green time required by each set of signal groups during the next cycle.

The effectiveness of the proposed FLTSC was analysed using the microscopic traffic simulation model VISSIM. Prior to doing so, the VISSIM model was calibrated and validated. From the validation process it was apparent that the VISSIM model could be adapted to simulate mixed traffic conditions by use of the Packet approach. In this approach, motorcycles are modelled as a group of motorcycles.

The performance of the proposed FLTSC was contrasted with a Fixed Time Controller (FTC) for different case studies on a simulated four-way intersection. The FTC is represented by the calculation as suggested in the Indonesian Highway Capacity Manual. Separate analysis using TRANSYT show that this is a valid assumption to make. The simulation results show that the proposed FLTSC is generally better than the FTC in terms of the average delay of vehicles at an intersection, especially under time-varying traffic.

Further analysis was carried out to compare the performance of the proposed FLTSC against a Vehicle Actuated Controller (VAC) for different traffic conditions on a simulated four-way intersection, East-West and North-South without turning movements. In order to analyse the performance of VAC, a refined VISSIM model was developed. This used the latest version of the VISSIM software and allowed individual vehicles (and particularly motorcycles) to be modelled in mixed traffic.

The phase extension time is one of the most critical parameters to affect the overall performance of VAC (Bullen, 1989). To provide a fair comparison of the performance between the proposed FLTSC and the VAC, an investigation was carried out to find the most appropriate extension time for the VAC that was suitable for mixed traffic. The effect of motorcycles to the performance of the VAC was also investigated. Two schemes were carried out to observe it, namely: Scheme 1 where detector detects all vehicle types (DfT, 2006) and Scheme 2 where detector detects all vehicle types, apart from motorcycles.

The simulation results show that the VAC System D (DfT, 2006) using an extension time of 1.2 seconds and the VAC Extension Principle (Kell and Fullerton, 1991) with a detector position of 30 metres and extension time of 3.0 seconds produced better performance than the other extension times tested for both schemes in terms of the average delay of vehicles. This is slightly shorter than current practice in developed countries.

The simulation results indicate that the performance of the VACs with scheme 1 is generally worse than with scheme 2. The performance of the VACs with scheme 1 against scheme 2 tended to reduce significantly as the percentage of motorcycles in traffic increased.

The study compares the effectiveness of FTC, VAC Extension Principle (VAC-EP), VAC System D (VAC-SD) and proposed FLTSC in various traffic conditions. The simulation results indicate that the average delay of the proposed FLTSC is close to the average delay of the FTC when used in cases with constant traffic flows but sometimes worse. However, in cases of time-varying traffic the proposed FLTSC is superior to the FTC. When comparing the simulation results of the proposed FLTSC, VAC-SD and VAC-EP, again the proposed FLTSC does not improve average delay, when traffic flows constant but produces better results in cases of time-varying traffic.