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IMPLEMENTATION AND COMPARISON OF DIFFERENT ON-LINE SIGNAL CONTROL STRATEGIES

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INTRODUCTION

This research implements and assesses several online signal control strategies on a dynamic traffic network. The signal controls considered by this study include the P0 policy (Smith, 2012), the Equisaturation policy (Smith, 2012), and the Linear Decision Rule approach (Han, et al., 2015). Italso considers fixed signal timing plan as a benchmark. The online signal controls are informed by real-time flow data collected throughout the network, and are updated from cycle to cycle according to certain optimization criteria. In order to describe traffic dynamics, we employ the Lighthill-Whitham-Richards (LWR) (Lighthill & Whitham, 1955) model, which captures phenomena such as physical queues, shock waves, and spillback. The performance of each signal strategy is tested using a battery of simulations involving stochastic network inflows, and is compared based on total throughput, rate of network clearance, and robustness to stochasticity of the incoming flows. Conclusions about the generality of the results and the need for further experimenting on different road networks are drawn.

NETWORK AND FLOW SIMULATION

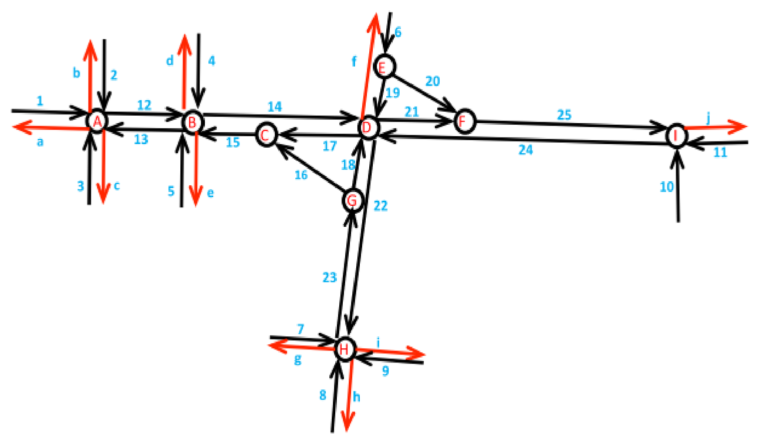

Figure 1a

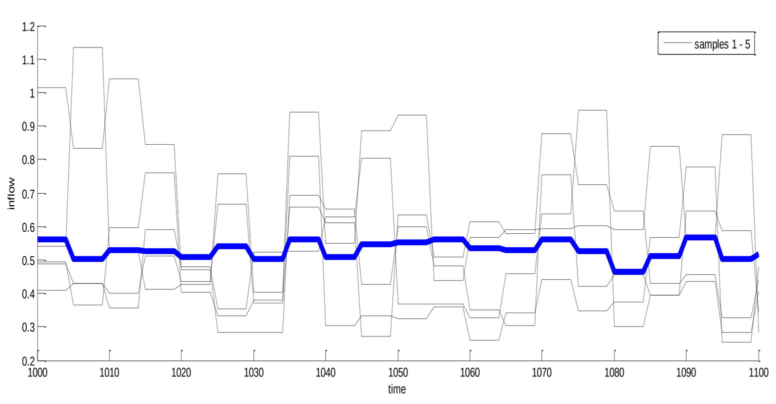

Figure 1b

All experiments were performed on the specific network illustrated in Figure 1a. Such network has 5 signalised junctions and represents a small portion of road network on the west end of Glasgow, Scotland. The network uses empirical data obtained from this location, however the data on the flows is provided as the historical average. Simulation of the flows for historical means does not provide enough useful information to be able to make conclusion as to the quality of an individual signal control strategy, therefore synthetic flows has to be simulated based on some probabilistic distribution. The Figure 1b illustrates the flow distribution of one of the simulated samples of network inflows

MOTIVATION

In order to justify the use of various signal timing strategies, it is important to see the performance of the network, given no thought was put in the optimisation of the signal timing. This was done by iteratively generating random fixed time signal controls and simulating the flows for these signal matrices. The table below represent key output values resulting from such simulation. Random signal timing was generated using a green-time split generated from a uniform distribution.

TABLE 1

Output parameter	Value
Maximum Total Throughput (vehicles)	3.40×10^3
Minimum Total Throughput (vehicles)	326
Difference in max and min total throughputs	3.075×10^3 (175% *of the mean*)
Maximum Objective	4.351637
Minimum Objective	1.264699
Difference in max and min total objectives	3.0869 (103% *of the mean*)
Average total throughput	1.75×10^3
Average objective	2.9944

RESULTS

As mentioned previously, the paper discussed and simulated the application of P0 policy, Equisaturation policy and Data Driven Linear Decision Rule (LDR) on a specific network. These control strategies were simulated for the range of stochastic inflows into the system and their performance was analysed on the basis of the total throughput of the system (Table 2), the rate of clearance (Figure 3), ability to adapt to variation in the incoming flows in the long term (day-to-day, Table 2; Figure 2b, Figure 2c, Figure 2d) and short term (cycle-to-cycle). Additionally, an off-line fixed timing signal control was introduced which is based on Particle Swarm Optimisation (PSO) (Banks, et al., 2007) principle and it acted as a benchmark value for the on-line simulations.

TABLE 2

Control strategy	Total throughput (vehicles)	Difference between mean and outer most quartile
Fixed (not optimised)	1.7657×10^3	–
Fixed (PSO)	3.0574×10^3	–
P0 Policy	3.2024×10^3	4.6 %
Equisaturation	3.8244×10^3	1.64 %
LDR	3.7822×10^3	1.65 %

FIGURE 2

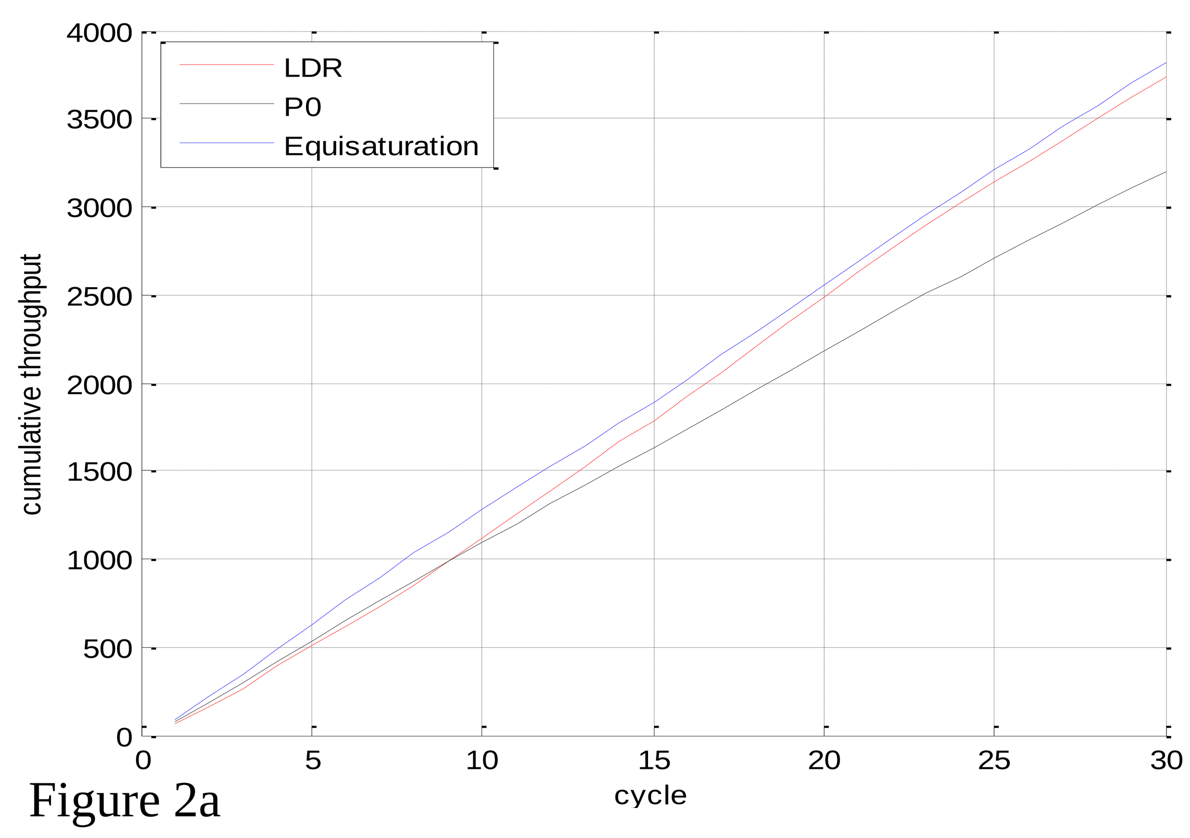

Figure 2a

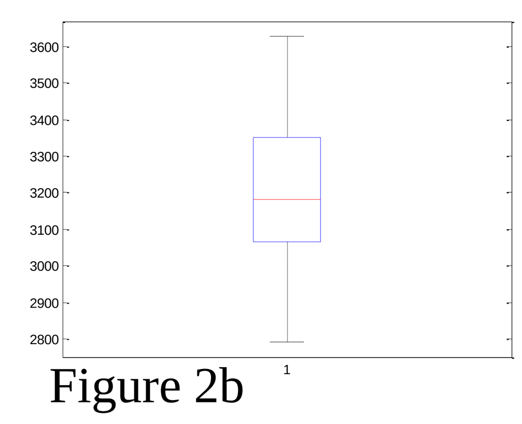

Figure 2b

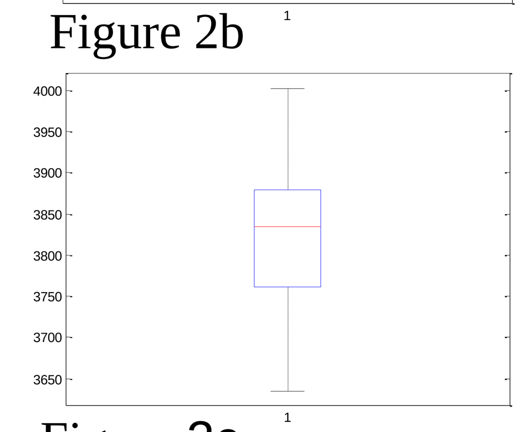

Figure 2c

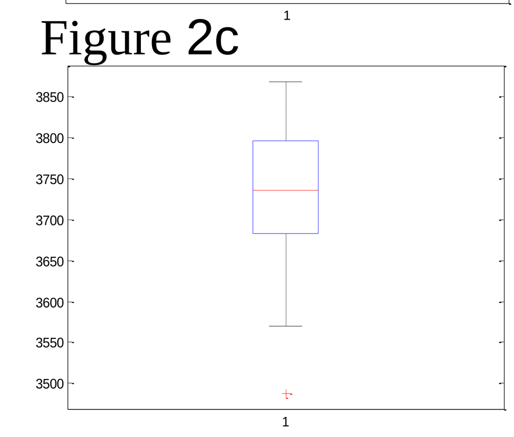

Figure 2d

Figure 2a – Cumulative throughput of the system for P0, Equisaturation and LDR
Figure 2b – Total throughput boxplot of P0 Policy
Figure 2c – Total throughput boxplot of EquisaturationPolicy
Figure 2d – Total throughput boxplot of LDR

CONCLUSION

This paper has demonstrated how different actuated and fixed signal control methods behave and compare to each other when incorporated in a complex system of roads. The P0 policy performs its function of converging the flow into a more stable form towards the end of the observation period, however in terms of throughput maximisation, this approach performed worse than Equisaturation and LDR approaches. It is reasonable to conclude that the Equisaturation policy and LDR-DRO method are very similar in performance on this particular network and are more efficient at optimizing throughput of the system than other methods of signal control introduced in this paper. With some slight differences, both methods succeeded at maximising the total throughput of the system and performed well at adapting to the stochasticity of the flow. LDR however performed better at stabilizing the flow within the observation period since a more uniform curve of throughputs was achieved, compared to the Equisaturation policy.

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