Real-time prediction of the lane-based delay for group-based adaptive traffic operations using LSTM

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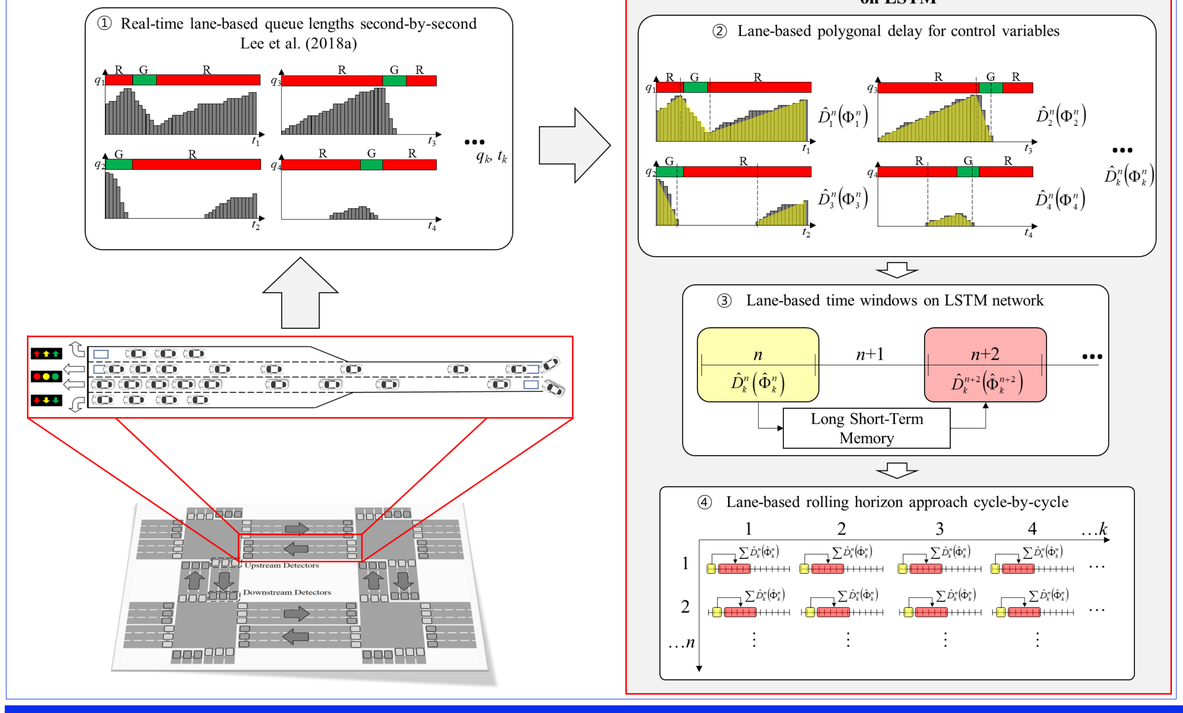
INTRODUCTION

According to the review of the use of the control delay formula and the deep learning method in traffic operations, we found that there is plenty of room for improvements in simultaneously considering; 1) **minimisation of the inherent predictive errors**, 2) a lower computational burden for a **real-time non-linear optimisation process** in the ATCS, and 3) a detailed **lane-based control delay formula** for maximising flexibility in traffic controls.

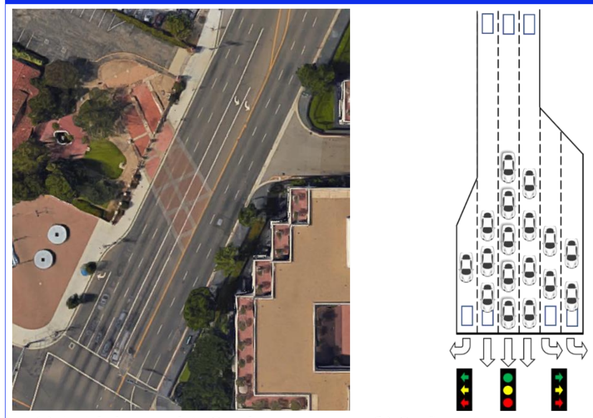
AIM

The purposes of this study is to develop **an architecture of the deterministic real-time lane-based control delay formula for traffic operations based on the LSTM network**. The main contributions of this paper are below: 1) The LSTM is constructed to predict a **cycle-based control delay in an individual lane** while minimising the inherent errors in the algorithm, 2) The LSTM captures short-term arrival patterns and long-term control delay trends to **improve the accuracy of the estimates of queueing profiles** for the future signal cycles, and 3) The proposed method is analysed and validated using both **synthetic and real-world high-resolution detector datasets**.

METHODS

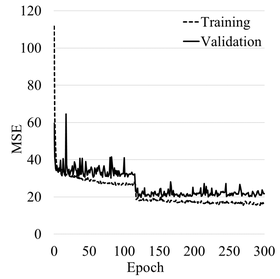


RESULTS

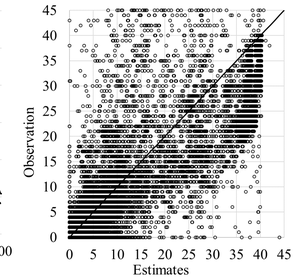


(a) Aerial photograph in Google

(b) Configuration

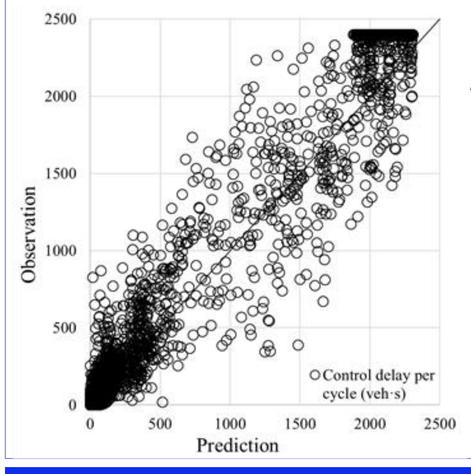


(a) History of MSE



(b) Scatter plot of Ω_k^{n+1} and Ψ_k^{n+1}

1. Lankershim Boulevard in Los Angeles, U.S.
2. Full set of required data
3. Time-series digital images recorded by five video cameras
4. **Extracting the vehicle trajectory data** collected on June 16, 2005 from 8:28 a.m. to 9:00 a.m.
5. Lankershim Boulevard/ Campo De Cahuenga Way/ Universal Hollywood Drive (No. 2 intersection).



$$\sum_{k=1}^{K} D_k^{n+1}\left(\mathbf{\Gamma}_k^{n+1},\mathbf{\Omega}_k^{n+1},\mathbf{\Phi}_k^{n+1}\right) \approx \sum_{k=1}^{K} \hat{D}_k^{n+1}\left(\hat{\mathbf{\Gamma}}^{n+1},\hat{\mathbf{\Omega}}_k^{n+1},\hat{\mathbf{\Phi}}_k^{n+1}\right)$$

The LSTM network provides more accurate predictions of the control delay than the Kalman based approach the proposed model. Their predictions are densely distributed on the periphery of its 45-degree line, although the proposed model provides **under-predicted values**, and there are many outliers at the high level of vehicular delay in other models. In other words, **the proposed model outperforms the other models in predicting the lane-based control delay cycle-by-cycle.**

CONCLUSIONS

1) **Data-driven and model-based approaches** are integrated to improve the reliability and the accuracy of the control delay predictive formula; 2) the novel LSTM is constructed to predict a cycle-based control delay in an individual lane while minimising the inherent errors in the algorithm; 3) short-term arrival patterns and long-term con-trol delay trends are captured by the LSTM to improve the accuracy of estimates of the queueing profiles for the future signal cycles; 4) predicted queue lengths at inflec-ion points and adjustment factors are used to construct the delay polygons in the future cycle, and 5) the proposed method paves the way for applying the deep learning to predict the control delay in real-time for lane-based ATCS.

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