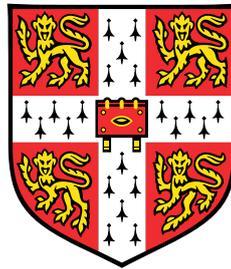


City-scale eco-routing and pavement eco-maintenance scheduling for CO₂ mitigation



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Declaration

I hereby declare that except where specific reference is made to the work of others, the contents of this dissertation are original and have not been submitted in whole or in part for consideration for any other degree or qualification in this, or any other university. This dissertation is my own work and contains nothing which is the outcome of work done in collaboration with others, except as specified in the text and Acknowledgements. This dissertation contains fewer than 65,000 words including appendices, bibliography, footnotes, tables and equations and has fewer than 150 figures.

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Responsible for more than one-sixth of the world's CO₂ emissions and growing, the road transportation is an unavoidable component in tackling the global carbon reduction challenge. Within the subdivisions of infrastructure management and traffic management, different carbon mitigation approaches have been discussed to contribute to a greener transportation system. However, given the complex interactions that exist between the road users and the infrastructures, certain carbon mitigation proposals are best evaluated within a comprehensive environment to ensure the correct consideration of the interactions, as well as the comparability of the results.

It is the aim of this thesis to develop such a unified framework to reflect interactions and outcomes of different CO₂ mitigation approaches from both the road infrastructure and the traffic mobility sides. This allows combining and comparing the effectiveness of a single or multiple carbon mitigation approaches across different perspectives. Specifically, on the traffic operation side, a mesoscopic traffic model is adopted for simulating drivers' route choices with varying percentages of travellers to choose the eco-friendly routes. From the infrastructure asset management perspective, a city-scale pavement degradation model is built and utilised in testing pavement maintenance scenarios. San Francisco is chosen as the case study area due to the availability of various traffic mobility and infrastructure condition data.

In Chapter 3 of the thesis, the traffic simulation module is developed that implements the efficient macroscopic road link-level speed-flow relationship while retaining detailed origin, destination and departure hour information for each individual trip. The traffic simulation model uses a highly detailed network representation for the study area and has the hourly traffic demand informed by Traffic Network Companies (TNC) data. The model is capable of capturing the spatio-temporal variations in traffic distributions. In addition, in Chapter 4, assumptions are also tested as for the extent that the availability of real-time traffic information affects the travellers' behaviours and model results.

As ageing pavements induce additional carbon emissions, in Chapter 5, a city-scale pavement degradation model is proposed based on 20 years of survey data. After comparing three model forms (non-spatial categorical, non-spatial individual road based and spatial hierarchical models) and two independent predictors (pavement age, cumulative traffic load), the spatial model with age as the predictor is found to give the best overall performance in

terms of model fitting and complexity. As a result, it is used later in this thesis for degradation forecasting and maintenance planning.

The traffic simulation and the pavement degradation models are joined together in Chapter 6 to test the carbon mitigation scenarios, including the eco-friendly route selection (eco-routing) and eco-friendly pavement maintenance scheduling (eco-maintenance). Interactions between the road users and the pavement management occur when: (1) pavement maintenance site selection is based on both pavement roughness and traffic volume (the eco-maintenance case). (2) The renewed pavement condition, with a smoother surface and reduced emission factor, becomes part of the route selection criteria of the drivers (the eco-routing case). It is found that the outcomes of eco-maintenance are sensitive to a variety of factors, including the budget level, the pavement degradation rate as well as the maintenance quality. The eco-routing approach tends to shift travellers to the local network but is effective in reducing the overall emissions. However, the reinforcing interactions between these two strategies are the most noticeable only when both eco-routing and eco-maintenance strategies are enforced to an extreme.

Through the simulation of city-scale traffic and infrastructure dynamics, it is able to quantitatively compare carbon mitigation scenarios and understand how an action from one specific perspective ripples through the transportation system. Also, sensitivity tests suggest limiting conditions for each approach to make a difference. This research highlights the need to include combined simulations in certain cases and such results are expected to give confidence to decision makers as for the potential induced demand or other secondary effects whose influences extend beyond a single sub-system.