

# Abstract

**Ahmed A Ezzat**

## **Multi-Objective Optimization of Sustainable Traffic Control Systems**

Modelling of traffic systems has long been regarded in literature as a sub-branch of queuing theory. Classical studies often propose queuing theoretic frameworks for the modelling and evaluation of control strategies within traffic systems. While primarily focusing on enhancing the system's mobility, most of these studies have overlooked an equally important, yet less highlighted factor, which is the environmental aspect of the problem. The road transportation sector is a major contributor of air quality deterioration in urban cities. Therefore, a deeper understanding about the nature of on-road emission generation is indispensable to mitigate its serious environmental implications. State-of-the-art research has concluded that emission rates heavily depend on instantaneous vehicular speed and acceleration profiles, rather than the average flow characteristics, favoring the use of microscopic over macroscopic simulation models. The former are highly affected by the changes in signalization settings. This study develops a multi-objective formulation that is of two-folds: mobility and sustainability of traffic systems. Unlike most of the existing literature which often solely focuses on mobility by cutting off congestion in both space and time, this study accomplishes a sensible trade-off by considering the sustainability aspect of the problem, concurrently with the traffic mobility. A multi-stage modelling framework is proposed to analyze incoming data from the traffic stochastic environment, model traffic emissions and optimize the control settings for better sustainability and mobility. The proposed framework employs advanced data mining models such as artificial neural networks (ANN's) to model vehicular emissions as a function of instantaneous vehicular speed and acceleration. In addition, a simulator that numerically mimics the behavior of the traffic environment is developed. Both the emission model and the simulator are fed into a Non-dominated Sorting Genetic Algorithm (NSGA), to solve the formulated mathematical model and achieve the optimal balance between the desired objectives. Benefits of this study lie at achieving a deeper understanding about the emission generation process and its relationship to driving modes and to traffic mobility. Moreover, the introduction of ANN's to the problem of emission modelling appears to achieve promising results over the widely used regression analyses. Last but not least, NSGA's are shown to successfully achieve the desired optimality without significant computational burden.