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Short term traffic prediction on the UK motorway network using neural networks

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Abstract

To be able to predict reliably traffic conditions over the short term (15 minutes into the future) may reduce congestion on a transport system. With the emergence of large datasets comes the opportunity to test the effectiveness of pattern recognition techniques to solve complex, non-linear problems such as the one in question.

This paper presents the results of applying artificial intelligence, specifically artificial neural networks (ANNs), to estimate traffic conditions a 15 minutes into the future given current / historic traffic information. For this study, data from Highways England's Motorway Incident Detection and Automatic Signalling (MIDAS) system for approximately 20km of the M60, M62 and M602 motorway near Manchester, UK was used to build a short term prediction model. To reduce the complexity of the problem, the number of input dimensions to the model was successfully reduced using an autoencoder. The final model exhibits very good predictive power with 90% of all predictions within 2.6 veh/km/lane of observed values.

The approach adopted in this research is one that can be transferred to other parts of the UK motorway network where MIDAS is installed, and once trained, the application of an ANN is straightforward. An algorithm such as the one derived has multiple applications including: refining predictions within intelligent transport systems (ITS) and / or enabling traffic controllers to take proactive decisions to mitigate the impacts of expected congestion. It could also be the engine behind a "traffic-cast" system which could provide the public with a forecast of expected traffic conditions. This could result in reduced congestion on the transport system as accessibility to more accurate information could encourage beneficial behavioural changes in users.

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Keywords: artificial intelligence; short term prediciton; neural networks

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1. Introduction

The ability to predict traffic conditions over the short-term has the potential to improve traffic management by allowing decisions to be proactive to changing traffic conditions rather than reactive. This paper explores the application of a machine learning technique, specifically neural networks, to predict traffic conditions on a section of the UK motorway network 15 minutes ahead of time. It first discusses the potential applications of the research, provides an overview of the machine learning technique used and a literature review of previous relevant research (section 2). It then outlines the technical approach undertaken (section 3), the data collected and processed (section 4) and reports on and discusses the results (section 5). Finally, the findings are concluded (section 6) and a number of future research opportunities which have arisen from this study are identified (section 7).

2. Background

2.1. Potential application

Short term traffic prediction has a number of real world applications and could be used to better manage congestion on the transport system. For example, some intelligent transport systems (ITS) systems react to current traffic conditions and introduce measures to try and mitigate the impact of congestion. Amongst others, these include variable speed limits on busy motorways and urban traffic control systems which help control traffic within complex urban environments. ITS systems used to manage traffic would benefit from being able to anticipate the onset of congestion through use of better short term predictions (i.e. if the system knows congestion is expected in the near future it could take proactive measures to help mitigate the impact of the expected congested future state). The need for such systems is not waning either with the ITS global market expected to grow to be worth over $33bn by 2020 (Intelligent Transportation System Market by Component, 2015). In the UK, local authorities such as Transport for London recognises the value of accurate short term predictions and their integration with ITS as its to procure a predictive signalling system that adjusts traffic signal timings in response to short-term forecasts of traffic conditions (Short-term traffic forecasts to help TfL combat capital's jams, 2015). Also in the UK, £15.2bn was outlined in the Roads Investment Strategy and featured, amongst other schemes, the continued rollout of smart motorways which uses ITS to help manage traffic flows on the UK motorway network (DfT, 2014).

As well as the potential to refine automatic traffic management through ITS, better short term predictions could be used by traffic controllers to make proactive decisions on managing the network. This could be through warnings of expected congestion which would then allow more time for controllers to evaluate different mitigation strategies rather than making a reactive decision once the congestion materialises. A further extension could be that the predictions are made visible to the public in the form of a “traffic-cast”. This could benefit the transport system as it could allow users to optimise their travel arrangements by either re-routing or re-timing their trip (depending on how far into the future the “traffic-cast” predicts).

2.2. Neural networks

The prediction model developed as part of this research takes the form of an artificial neural network. Artificial neural networks are a type of learning model inspired by biological neural networks. They can be used to estimate or approximate functions that can depend on a large number of inputs and are generally unknown. Artificial neural networks are generally presented as systems of interconnected "neurons" which exchange messages between each other. The connections have numeric weights that can be tuned based on experience, making neural nets adaptive to inputs and capable of learning. Further information on neural networks is readily available in a host of publications. One such publication includes Stergiou and Siganos (Stergiou and Siganos, n.d.).

2.3. Previous research

Attempting to predict traffic conditions over the short term is not new. Numerous studies have used statistical techniques using empirical data to conduct such prediction. Zheng et al (2006) reports that previous research using