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Traffic Flow Prediction With Big Data: A Deep Learning Approach

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***Abstract*—Accurate and timely traffic flow information is important for the successful deployment of intelligent transportation systems. Over the last few years, traffic data have been exploding, and we have truly entered the era of big data for transportation. Existing traffic flow prediction methods mainly use shallow traffic prediction models and are still unsatisfying for many real-world applications. This situation inspires us to rethink the traffic flow prediction problem based on deep architecture models with big traffic data. In this paper, a novel deep-learning-based traffic flow prediction method is proposed, which considers the spatial and temporal correlations inherently. A stacked autoencoder model is used to learn generic traffic flow features, and it is trained in a greedy layerwise fashion. To the best of our knowledge, this is the first time that a deep architecture model is applied using autoencoders as building blocks to represent traffic flow features for prediction. Moreover, experiments demonstrate that the proposed method for traffic flow prediction has superior performance.**

***Index Terms*—Deep learning, stacked autoencoders (SAEs), traffic flow prediction.**

I. Introduction

ACCURATE and timely traffic flow information is currently strongly needed for individual travelers, business sectors, and government agencies [1]. It has the potential to help road users make better travel decisions, alleviate traffic congestion, reduce carbon emissions, and improve traffic operation efficiency. The objective of traffic flow prediction is to provide such traffic flow information. Traffic flow prediction has gained more and more attention with the rapid development and deployment of intelligent transportation systems (ITSs). It is regarded as a critical element for the successful deployment of ITS subsystems, particularly advanced traveler information systems, advanced traffic management systems, advanced public transportation systems, and commercial vehicle operations.

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Traffic flow prediction heavily depends on historical and real-time traffic data collected from various sensor sources, including inductive loops, radars, cameras, mobile Global Positioning System, crowd sourcing, social media, etc. With the widespread traditional traffic sensors and new emerging traffic sensor technologies, traffic data are exploding, and we have entered the era of big data transportation. Transportation management and control is now becoming more data driven [2], [3]. Although there have been already many traffic flow prediction systems and models, most of them use shallow traffic models and are still somewhat unsatisfying. This inspires us to rethink the traffic flow prediction problem based on deep architecture models with such rich amount of traffic data.

Recently, deep learning, which is a type of machine learning method, has drawn a lot of academic and industrial interest [4]. It has been applied with success in classification tasks, natural language processing, dimensionality reduction, object detection, motion modeling, and so on [5]–[9]. Deep learning algorithms use multiple-layer architectures or deep architectures to extract inherent features in data from the lowest level to the highest level, and they can discover huge amounts of structure in the data. As a traffic flow process is complicated in nature, deep learning algorithms can represent traffic features without prior knowledge, which has good performance for traffic flow prediction.

In this paper, we propose a deep-learning-based traffic flow prediction method. Herein, a stacked autoencoder (SAE) model is used to learn generic traffic flow features, and it is trained in a layerwise greedy fashion. To the best of the authors' knowledge, it is the first time that the SAE approach is used to represent traffic flow features for prediction. The spatial and temporal correlations are inherently considered in the modeling. In addition, it demonstrates that the proposed method for traffic flow prediction has superior performance.

The rest of this paper is organized as follows. Section II reviews the studies on short-term traffic flow prediction. Section III presents the deep learning approach with autoencoders as building blocks for traffic flow prediction. Section IV discusses the experimental results. Concluding remarks are described in Section V.

II. Literature Review

Traffic flow prediction has been long regarded as a key functional component in ITSs. Over the past few decades, a number of traffic flow prediction models have been developed to assist in traffic management and control for improving transportation efficiency ranging from route guidance and vehicle