Journal of Harbin Engineering University
ISSN: 1006-7043

Vol 44 No. 7
July 2023

Network Traffic Prediction and Analysis in VANET Using Deep Learning Techniques: A Survey

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Abstract

Recent advancements in information technology, intelligent public transit, and computer systems have thrown up a plethora of intelligent options for roadway security, convenience, and profitability. Among the main concerns of Intelligent Transportation Systems are the minimization of communication latency between vehicles and remote sensing units, as well as the smooth operation of traffic flow. For such issues, the Vehicular Ad hoc Network (VANET) has received interest from many research groups. Furthermore, network traffic patterns, particularly in Vehicular networks, exhibit extremely complicated behaviour due to a variety of variables such as device portability and network variability. Deep learning (DL) is being successfully used to analytics and information discovery. This study gives an in-depth examination of applications for DL in Network Traffic Prediction and Analysis (NTPA). We begin by providing basic context for our assessment. Then, we discuss the intersection of deep learning and NTPA, as well as deep learning methodologies suggested for NTPA applications. In conclusion, we explore important hurdles, unresolved concerns, and future research objectives for NTPA applications that use deep learning.

Keywords: VANET, Deep learning, NTPA, Network Traffic, Intelligent Transportation Systems.

1 Introduction

Vehicular Ad hoc Networks (VANETs) are built on intelligent cars and may support vehicle-to-vehicle (V2V) and vehicle-to-roadside unit (V2R) communications. Recent advancements in interactions, intelligent transportation networks, and number of intelligent options have been made available by computer technology to improve safety, simplicity, and efficiency in traffic [1]. Therefore, a better routing protocol contributes to a higher level of VANET performance by allowing services to be available more frequently. The biggest concern in today's fast-paced and changing world is traffic congestion [2]. The conventional method to traffic management is inefficient due to the increased usage of private automobiles and limited road network capacity [3]. Traffic has a significant impact on pollution and individual efficiency. VANET is regarded as the most prominent and potential transport technologies today [5]. Though, VANET is vulnerable to a number of flaws that may lead to an incursion. Before VANET technology may be used, this incursion must be resolved [6].

Figure 1: VANET System

Road transportation is the most dangerous, with substantial deaths and injuries. It is also confronted with a number of ongoing issues, including the regular loss of life and property caused by accidents [7]. This problem can be resolved by taking appropriate steps, such as developing an autonomous incident detection system using artificial intelligence and machine learning [8]. In an intelligent transportation system, traffic flow forecasting plays an important role. It represents an accurate forecast of traffic flow in a given area at a specific time in the future [9]. Communication between cars and RSUs should be as delayed as possible, traffic flow should be smooth, and road safety should be prioritized. Traditionally, network management techniques are used to monitor and analyze data in such networks, but they are hampered by multiple obstacles and concerns [10].

VANET is a new study subject in intelligent transportation systems that provide critical data to the network's cars. Road surface faults are critical issues for ensuring the movement of traffic should be safe and smooth VANET is one of the emerging modes of transportation which has a significant influence on urban traffic control and road safety by effectively employing data exchange among cars [11]. Prediction of traffic congestion is crucial for reducing car crashes while controlling in order to ensure the safety of all road users, traffic must be controlled.

The network traffic predictions challenge entails predicting prospective network traffic features based on historical traffic measurements. Many academics have been drawn to the area of smart transport, which has been explored using both ML and IoT methodologies [12]. This data is utilised for a variety of objectives, including routing, increasing driver awareness, forecasting mobility to avoid dangerous circumstances, and enhancing client convenience, security, and the standard of road interaction.

2 Related Work

Transportation is among the most important considerations that goes into the planning and building of smart cities. Mobile technology research and development includes a number of critical components, including transportation assessment and prediction [13]. Overload caused by excessive vehicle traffic is one of the most significant problems facing big centres today. These technologies and procedures have also been developed to use this traffic-related information.

In this study [14], we suggested an ideal for forecasting network traffic by taking into account the factors that might contribute to the occurrence of road traffic. The suggested model incorporates an algorithm known as Random Forest- Gated Recurrent Unit- Network Traffic Prediction (RF-GRU-NTP) in order to make predictions about the flow of network activity based on the traffic that is occurring concurrently on roads and networks.

This research [15] consequently offers a novel ML to enhance the concert of intrusion detection systems (IDSs) in order to increase the detection rate and the detection efficiency; we use RF and posterior identification based on different types of data. In this work [16], we give an extensive assessment of AI methods that are presently being investigated by a variety of study activities in the ground of VANETs. As a result, a method of machine learning that relies on ensembles is used in order to anticipate VANET mobility. The effectiveness of the routing, which depends on a hybrid metaheuristic algorithm, produces dramatically enhanced outcomes when paired with ensemble learning.

The primary objective of utilising AI is to reduce the amount of manual interface. Several different methods have been developed in order to combat this issue. The traffic monitoring system is comprised of a variety of tools and techniques that are used to collect data from a wide variety of sources [17]. This model [18] might be an efficient method for forecasting and making use of accurate information in order to provide successful outcomes in smart cars.

This article [19] provides a description of artificial intelligence (AI) and machine learning (ML) as they relate to the development of autonomous event detector systems, with the goal of reducing the number of automobile accidents. Analysing traffic forecasts may help reduce congestion, improve safety and efficiency, and improve travel quality in general [20].

The methodology known as "machine learning" refers to a process in which a system dynamically grows and enhances itself depending on data that it has previously analysed [21]. Deep learning models are being used by researchers in the area of networking for Network Traffic Monitoring and Analysis (NTMA) apps, such as traffic categorization and prediction. These accomplishments have motivated these researchers to employ these models [22]. The purpose of this study is to offer an extensive evaluation of the uses of deep learning in NTMA.

Deep Neural Networks (DNN) with Bat Algorithms (BA) provides a dynamic type of traffic management in VANET, which is discussed in this study [23]. It is very important to have accurate forecasts of traffic congestion for the purpose of reducing accident rates that occur on the roads and to provide improved traffic flow for the general public.

The development of artificial intelligence provides a wide variety of insightful solutions that may be of assistance to IoV networks in addressing all of these challenges and concerns [24]. Machine learning is one of the greatest effective AI technologies available, and it has been widely used to the resolution of all of the significant concerns stated.

The dynamic behaviour of the autos in the system has a negative impact on the effectiveness of DL algorithms for the prediction of traffic congestion. In this research [25], we offered a complete overview on several machine learning approaches that may be used to both the interaction and network aspects of a vehicular network.

The ability to make accurate and up-to-date projections of the flow of traffic is essential to the effective management of traffic. In this research [26], a data-driven strategy to creating an AI model for predicting the behaviour of vehicle traffic was presented. The information contained in the data must be leveraged in innovative ways in order to deliver better outcomes while also being able to scale and deal with rising volumes of data and developing cities as a consequence of the quick growth in the quantity, quality, and level of detail of traffic data [27].

Researchers have long relied on a single strategy for predicting traffic flow, despite the fact that this approach is successful under only a limited range of circumstances [28]. In recent years, there has been some research done on merging these approaches to create a variety of other hybrid methods.

The purpose of this article [29] is to showcase the ML strategy; several criteria are used to identify traffic congestion, including hard delay limits, speeds accessible through GSP vehicle trajectory, etc. In this paper [30], for the prediction of traffic flow in autonomous vehicles, we investigate various deep learning models and assess their suitability for use in current intelligent transportation systems. In order to make a relative comparison of the many different deep learning models, a variety of parameters are used. In addition, the paper delves into the difficulties that must be overcome as well as possible future study avenues.

3 Deep Learning Models In VANET

Because of the increasing expansion of devices that are derived from a set and the amount of traffic data, more sophisticated NTPA solutions are required to assure the reliability and accessibility of communication networks. NTMA consists of five phases, which are described in the following sections. Most extant research studies adhere to all or a portion of the structure shown in Fig 2.

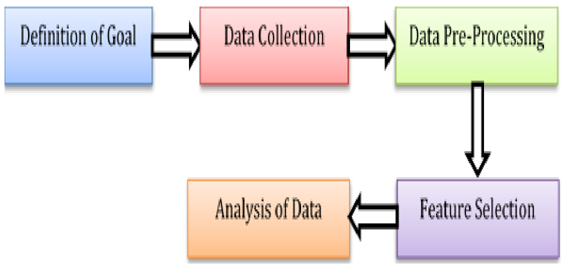

Figure 2: General framework for NTPA procedure

Figure 3 depicts the taxonomy of data in VANET that may be utilised for various reasons. Furthermore, different traffic circumstances may provide insight into a variety of data kinds.

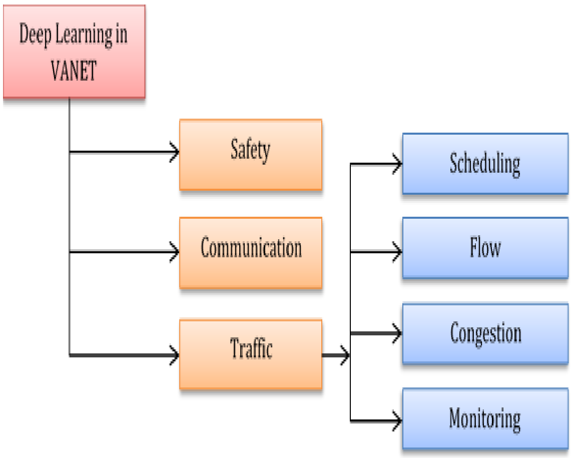

Figure 3: Deep Learning Development in VANETs: A Classification of Solutions

4 Traffic

The objective of controlling traffic in the VANET systems is to gather different sorts of data, such as traffic volume, route forecasting, and traffic in the roads, by treating as mobile nodes. The core premise of the Intelligent Transport System (ITS) must be two primary fields: i) evaluation of facts acquired by nodes that are mobile and RSUs, and ii) advance notification of traffic facts and preferred pathways to the driver. Traffic management includes not just traffic elements, but also the highest-priority requests from importance nodes, accident forecasts, and lane management. Accident prediction and traffic control have become more important in the VANET system.

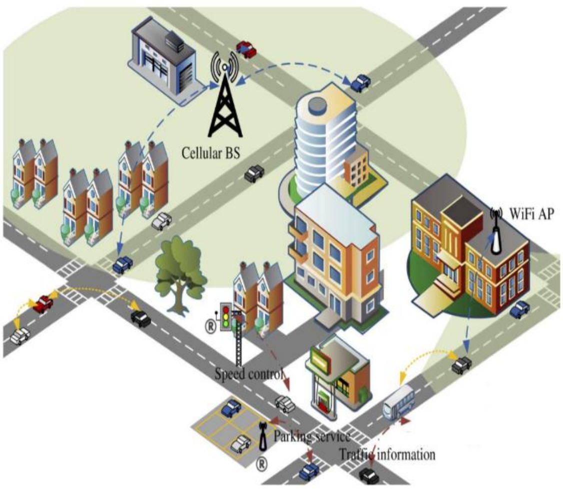

Figure 4: VANET Traffic Control

4.1 Flow of Traffic

Conditions of weather, unbalanced traffic patterns of distribution, accidents, and other factors all have an impact on traffic flow. As a result of this factor, traffic is affected by an increase in uncertainty and a decrease in data collection.

4.2 Congestion in the Traffic

Incompetence and disruptions in traffic flow causes congested roads. Images from Surveillance video, pedestrians speed, speed of cars, motorcycle speed, road utilisation rate, and other information may all be used to help address this issue. Furthermore, because to the anomalous and intense traffic flow, derived from a set-to-infrastructure interaction is hampered.

4.3 Scheduling in Traffic

Traffic scheduling include traffic planning and groupings, traffic sign planning, traffic speed planning, as well as route prediction. The length of traffic signals may be made adaptable under various traffic scenarios, such as an on-going movement or a complicated and unbalanced flow. Several efforts have been completed to address scheduling concerns and give the most ideal solution.

4.4 Traffic Monitoring

As part of the traffic monitoring process, it is necessary to continuously assess and plan the individual components of traffic flow to minimise the potential for disruption in the future. These items may be classified as road and infrastructure elements. The data obtained encompassed a broad variety of data that demonstrated many distinct scenarios on road conditions at various times of the day. This system can rapidly assess traffic arrangements and volume, resulting in an appropriate review of the allocation of resources approach.

There are many measures for evaluating the outputs of deep learning models, including:

$$MSE = \frac{1}{m}\sum_{s=1}^{m} e_t^2 \qquad (1)$$

$$RMSE = \sqrt{\frac{1}{m}\sum_{s=1}^{m} e_t^2} \qquad (2)$$

$$MAE = \frac{1}{m}\sum_{s=1}^{m} |e^t| \qquad (3)$$

A Classification Analysis is used in order to evaluate the accuracy of the classification algorithm forecasting. Precision defines how derived from a set/accurate the model is in terms of determining which of the anticipated positives are really positive.

$$Precision = \frac{True\ Positive}{True\ positive + False\ Positive} \qquad (4)$$

Recall determines the amount of real positives derived from a set.

$$Recall = True\,\frac{True\ Positive}{True\ positive + False\ Negative} \qquad (5)$$

F1 Score strives for a balance of Precise and Recall.

$$F1 - Score = \frac{2 * Precision * Recall}{Precision + Recall} \qquad (6)$$

Table 1: Deep learning methods: primary characteristics and VANET application areas

Techniques of DL	**Important Benefits**	**The possibilities of the VANET wherein deep learning may be used**
Deep Reinforcement Learning (DRL)	There is no requirement for constrained previous information, and it is successful under hostile settings.	Provide effective traffic control on the roads. Allocation of both inside and outside resources. Can improve VANET users' access to the actual communication route. Improves relay assignment for multiple-point networking by learning from past routes under various road restrictions.

5 Conclusion

A network traffic patterns, particularly in Vehicular networks, exhibit extremely complicated behaviour due to a variety of variables such as device portability and network variability. This paper provided a complete literature overview of DL utilisation in order to manage and analyze network traffic. In this study, we discuss the way of deep Learning methods may be used to expand the performance of VANETs. The study is examined from several viewpoints of systems for traffic management. We evaluated and analysed the benefits and drawbacks of deep learning methods utilised in NTPA applications. Network traffic categorization and prediction are among the applications.

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