Deep Learning on Traffic Prediction

DLTP - DTSA 5506

MSDS Student
Multidisciplinary College
University of Colorado-Boulder
Boulder-Colorado-United States
email@colorado.edu

ABSTRACT

This project presents a comparative analysis of Gated Recurrent Units (GRU) [1] and Convolutional Neural Networks (CNN) [2] for predicting traffic congestion in a time series problem. The study aims to show the effectiveness of these deep learning approaches in forecasting traffic jam occurrences based on historical data that being shared on Kaggle[3].

CCS CONCEPTS

• **Theory of Computation** → Design and Analysis of Algorithms
• **Mathematics of Computing** → Continuous Mathematics
• **Computing Methodologies** → Machine Learning

KEYWORDS

Deep Learning, Traffic Prediction, Big Data, IoT, Governmental Project

ACM Reference format:

MSDS Student. 2024. Deep Learning on Traffic Prediction: DLTP – DTSA 5506 – Proposal. In *Proceedings of ACM Woodstock conference (WOODSTOCK'18). ACM, New York, NY, USA, 2 pages.* https://doi.org/10.1145/1234567890

1 Introduction

In this project I am going to apply the pipeline and some methods of Data Mining that been covered in this specialization into the Prediction of Traffic[4]. Such that, after this proposal is being submitted, I am planning to cover to in detail a prior related work, which I found a proper dataset in Kaggle. Obviously, we are talking about a sequential problem, such that we want to study the predicted number of vehicles per unit of time. This implies that, and in terms of Tools required for implementing such a project,
we need a complete IoT system distributed in vitals highways and roads of the city in order to get benefit of implementing such Big Data project, that's why I mentioned earlier that this type of projects is considered to be governmental where it is hard to have experiments by individual scientists. Also, I am going to discuss the Algorithm used by the selected previous related work[5], and compare it with different approach against my selected approach, noting that the purpose of this project is not implement a Machine Learning project, presenting a proper Data Mining Method for the problem is the main goal here. Once, the exact nature, a previous related work being presented and discussed, and a proper method being implemented against the referenced previous work, then we can move to the evaluation part, and since we are dealing with sequential dataset with a regression task, then we are going to compare with the RMSE[6] (Root Mean Square Error), such that the previous project used GRU as a Deep Learning Approach, while I am going to present CNN as another Deep Learning Approach and then we can discover which and why would be one of them is the best approach.

2 Problem Statement

Traffic congestion is a significant issue in urban areas, leading to increased travel times, fuel consumption, and environmental pollution. Accurately predicting traffic jams can help transportation authorities implement proactive measures to mitigate congestion and improve traffic flow. The problem addressed in this project is to develop and compare deep learning models for predicting traffic congestion in a time series context. Specifically, we aim to assess the effectiveness of Gated Recurrent Units (GRU) and Convolutional Neural Networks (CNN) in forecasting traffic patterns based on historical traffic data.

3 Relevant Previous Work

The notebook presented by Karnika Kapoor[5] applied GRU approach to predict traffic patterns across the four junctions. By preprocessing the data, including feature engineering and normalization, the study transformed the raw traffic data into a format suitable for training GRU models. The GRU-based models were trained using TensorFlow, with an architecture consisting of multiple GRU layers followed by dense layers for prediction. The performance of the models was evaluated using metrics such as root mean squared error (RMSE), providing insights into the accuracy of traffic predictions.

WOODSTOCK'18, June, 2018, El Paso, Texas USA

https://doi.org/10.1145/1234567890

4 Proposed Work

I am focusing on implementing CNN against GRU. Following same preprocessing that being performed bey Karnika Karpoor I have built a CNN model[7] and applied it to predict the traffic volume at the specified junction. Then I have used RMSE as an evaluation metric that I am discussing in the evaluation section

5 Evaluation

The RMSE values for each junction are shown in Tables below where GRU results are from Karpoor's project and CNN are results I obtained upon fitting my model.

Using GRU	
Junction	RMSE
J1	0.2459
J2	0.5586
J3	0.6061
J4	1.0242

Using CNN	
Junction	RMSE
J1	0.2895
J2	0.5696
J3	0.6524
J4	1.1979

We observe that CNN approach has higher RMSE values than GRU, which means that referring to RMSE metric the proposed work performed relatively worse than the previous work. However, fitting the GRU model took around 4 times to implement a one junction prediction. This indicates that even GRU is performing better is it is significantly more complicated than CNN, and that is what exactly this study is aiming to reveal. So, in case if we are talking about thousands of junctions, implementing the GRU model would cost around 4 times resources more than the CNN approach which is very important to select what is a proper algorithm when dealing with big traffic data.

6 Conclusions

This study aims to compare between GRU and CNN Algorithms in the Traffic Jam Prediction which is considered as a Time Series Problem. The relative previous work shows the implementation of GRU while the proposed work shows the CNN approach. RMSE is selected to be the evaluation metric of this task where the proposed work (CNN) showed a worse result comparing with the previous relative work (GRU). Taking time complexity in considerations, we conclude that CNN Algorithm is faster 4 times than GRU one. This would advise the stakeholders of such project to be cautious in their model selection such that choosing GRU would give more accurate results than CNN but would cost approximately four times resources more than the CNN Algorithm.

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[4] Traffic Prediction: How Machine Learning Helps Forecast Congestions and Plan Optimal Routes https://www.altexsoft.com/blog/traffic-prediction/

[5] Traffic Prediction GRU by Karnika Karpoor https://www.kaggle.com/code/karnikakapoor/traffic-prediction-gru

[6] Root mean square deviation on Wikipedia https://en.wikipedia.org/wiki/Root-mean-square_deviation

[7] The notebook of CNN on my GitHub https://github.com/laithrasheed/DTSA-5506--Data-Mining-Project/blob/main/Deep%20Learning%20on%20Traffic%20PRediction%20-%20CNN%20.ipynb