ENHANCED VEHICLE ARRIVAL TIME PREDICTION WITH GRAPH NEURAL NETWORKS (GNN) USING GPS DATA

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Accurate prediction of vehicle arrival times is crucial for efficient transportation systems and improved user experience. This study explores the application of Graph Neural Networks (GNNs) to enhance the precision of vehicle arrival time predictions by leveraging GPS data. GNNs are a powerful class of machine learning models capable of modeling complex relationships in graph-structured data, making them well-suited for the spatiotemporal nature of transportation networks. This research presents a novel approach that harnesses GNNs to model the dynamic interactions between vehicles and road networks, resulting in more reliable predictions. The findings demonstrate that GNN-based models outperform traditional methods, offering significant advancements in arrival time prediction accuracy.

Keywords: Graph Neural Networks, Transportation, Arrival time, Forecasting

INTRODUCTION

Transportation systems are the lifeblood of modern societies, enabling the seamless movement of people and goods. In this dynamic landscape, the accurate prediction of vehicle arrival times is a cornerstone for ensuring the efficiency of these systems and enhancing the overall user experience [1]–[3]. Whether its commuters planning their daily routes, businesses optimizing their logistics operations, or passengers waiting for public transportation, precise arrival time predictions have far-reaching implications for diverse stakeholders.

Traditionally, predicting vehicle arrival times has relied on conventional statistical and mathematical models. However, the intricate spatiotemporal nature of transportation networks, influenced by factors such as traffic congestion, road conditions, and varying driver behaviors, often renders these methods insufficient in capturing the complex interactions that govern real-world scenarios. Recognizing these limitations, this study takes a significant leap forward by exploring the application of Graph Neural Networks (GNNs) to enhance the precision of vehicle arrival time predictions, leveraging the wealth of data provided by GPS technology.

METHODOLOGY

Graph Neural Networks (GNNs) have garnered significant attention in recent years as a potent class of machine learning models tailored to the analysis of data structured as graphs [4]–[10] . They excel in capturing intricate relationships within interconnected data, making them well-suited for the dynamic and interconnected nature of transportation networks. Graph embedding and Convolutional Neural Networks (CNNs) are two major influences on GNNs. They have a role in the foresight of nodes, edges, and other graph-based operations.

Images are classified with the help of CNNs. Similarly, GNNs use graph structure (a grid of pixels) to make a classification prediction. On the other hand, text categorization with recurrent neural networks is possible. As each word in a phrase represents a node in a graph, GNNs may be used to such structures.

GNNs were introduced when Convolutional Neural Networks are unsuccessful to achieve optimal results due to the arbitrary size of the graph and complex structure.

A chain of neural networks processes the input graph. By transforming the input graph structure into a graph embedding, we may preserve data about the graph's nodes, edges, and overall context.

The layer of the neural network is represented in Figure 1 processing the feature vector of nodes A and C. It compiles these characteristics and sends them on to the subsequent stage.

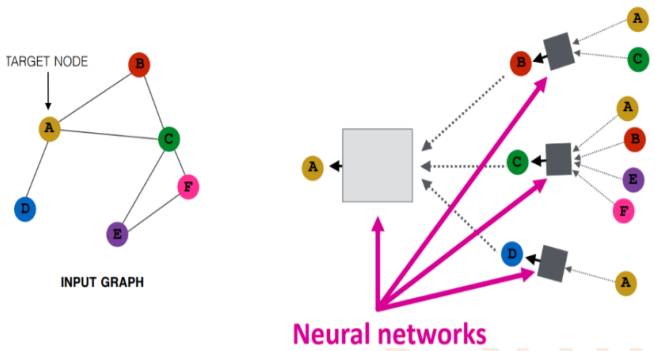

Figure 1. Graph Neural Network Structure

In the context of vehicle arrival time prediction, GNNs offer a promising avenue for modeling the complex interactions

between vehicles and the road network, incorporating not only temporal but also spatial dependencies.

A Novel Approach: Leveraging GNNs for Arrival Time Prediction

This research presents a novel approach that harnesses the capabilities of GNNs to model the dynamic interactions between vehicles and road networks. By integrating GPS data into the GNN framework, the study aims to provide more reliable and accurate predictions of vehicle arrival times. The spatiotemporal information contained within GPS data serves as a rich source of context, enabling GNNs to capture the nuances of travel patterns, road conditions, and congestion dynamics. The primary goal is to demonstrate that GNN-based models can outperform traditional methods in predicting vehicle arrival times. Through an in-depth exploration of the methodology and comprehensive experimentation, the research seeks to establish the superiority of GNNs in offering more precise predictions, ultimately enhancing the efficiency of transportation systems and elevating the user experience.

CONCLUSION

By showcasing the advantages of GNNs over conventional approaches, the research contributes to the evolving landscape of intelligent transportation systems. The findings of this study hold immense significance for both researchers and practitioners in the field of transportation. The enhanced prediction accuracy achieved through GNN-based models can lead to a multitude of practical applications, including improved traffic management, better route planning for commuters, reduced waiting times for passengers, and optimized logistics for businesses. The idea embarks on a journey to revolutionize vehicle arrival time prediction by embracing the power of Graph Neural Networks (GNNs) and harnessing GPS data. Through rigorous experimentation and a meticulous exploration of the methodology, the study sets out to advance the field and cover the way for more efficient and user-centric transportation systems.

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