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Deep Learning Framework for Predicting Bus Travel Times with Multiple Bus Routes: A Single-Step Multi-Station Forecasting Approach

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Abstract : Bus transit is a crucial component of transportation networks, especially in urban areas. Any intelligent transportation system must have accurate real-time information on bus travel times since it minimizes waiting times for passengers at different stations along a route, improves service reliability, and significantly optimizes travel patterns. Bus agencies must enhance the quality of their information service to serve their passengers better and draw in more travelers since people waiting at bus stops are frequently anxious about when the bus will arrive at their starting point and when it will reach their destination. For solving this issue, different models have been developed for predicting bus travel times recently, but most of them are focused on smaller road networks due to their relatively subpar performance in high-density urban areas on a vast network. This paper develops a deep learning-based architecture using a single-step multi-station forecasting approach to predict average bus travel times for numerous routes, stops, and trips on a large-scale network using heterogeneous bus transit data collected from the GTFS database. Over one week, data was gathered from multiple bus routes in Saint Louis, Missouri. In this study, Gated Recurrent Unit (GRU) neural network was followed to predict the mean vehicle travel times for different hours of the day for multiple stations along multiple routes. Historical time steps and prediction horizon were set up to 5 and 1, respectively, which means that five hours of historical average travel time data were used to predict average travel time for the following hour. The spatial and temporal information and the historical average travel times were captured from the dataset for model input parameters. As adjacency matrices for the spatial input parameters, the station distances and sequence numbers were used, and the time of day (hour) was considered for the temporal inputs. Other inputs, including volatility information such as standard deviation and variance of journey durations, were also included in the model to make it more robust. The model's performance was evaluated based on a metric called mean absolute percentage error (MAPE). The observed prediction errors for various routes, trips, and stations remained consistent throughout the day. The results showed that the developed model could predict travel times more accurately during peak traffic hours, having a MAPE of around 14%, and performed less accurately during the latter part of the day. In the context of a complicated transportation network in high-density urban areas, the model showed its applicability for real-time travel time prediction of public transportation and ensured the high quality of the predictions generated by the model.

Keywords : gated recurrent unit, mean absolute percentage error, single-step forecasting, travel time prediction.
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