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A Stacked Long Short-Term Memory Neural Networks for Parking Occupancy Rate Prediction

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***Abstract*— In recent times, it is noticed that the number of vehicles is considerably increasing on the road. To locate the parking lot in cities is becoming a tedious job for drivers. To accurately predict the parking occupancy, we constructed a Stacked LSTM (Long short-term memory) model. This model can analyze sequential data precisely as it has a memory capacity. Stacking the LSTM hidden layers intensifies the model and increases the prediction accuracy. We validated the proposed predictive model in terms of key error indicators (RMSE and MAE). We also evaluated the proposed model with baseline time series methods like ARIMA and SARIMA. The Stacked LSTM model outperforms the traditional models and enhanced prediction accuracy.**

Keywords—Time series Prediction; LSTM; Parking occupancy; Deep learning

I. INTRODUCTION

Traffic congestion is a common problem in cities due to a large number of vehicles in the city. In urban traffic, the accurate and real-time prediction of parking space [9] plays an important role. Parking availability is depending on multiple factors like day of the week, time of parking, climate conditions, Holydays etc. A huge amount of city traffic is caused by drivers looking for a free parking spot. This extra traffic also leads to health issues [8] to the urban people due to the extra carbon dioxide being added to the air. During peak hours, parking space occupancy prediction can help the drivers to locate the parking space effectively. The parking problem can be expanded in different dimensions. The major objective of this work is to(i) predict the occupancy rate, which is the ratio of occupied parking spot over the total number of spots (ii) try to find out the impact of timing and weekdays in occupancy rate prediction(iii) Reduce the error in estimation pattern in the occupancy prediction.

For attaining the above objectives different machine learning models can predict the occupancy rate. In this paper, we are discussing a stacked LSTM model. The most challenging prediction problem can be solved efficiently by adding depth to the neural networks. In stacked LSTM [1], the hidden LSTM layers make it deeper. These layers understood the learned representation from the previous layer and combined it to get a new representation with a higher level of abstraction. It is mainly used in challenging sequence prediction. This stable technique contains multiple LSTM layers as hidden layers. In stacked LSTM, the above LSTM layer provides a sequence of values as its output to the below LSTM layer for processing. The major beneficial and critical part of the precise and accurate parking prediction is it reduces time and effort to search a free parking space [11]. It facilitates the parking lot utilization efficiently. Based on the prediction results the parking space reservation [10] can also be controlled. It assists traffic agencies to understand the traffic conditions in advance. It helps them for better resource allocation [7] like traffic police. We have observed that the parking pattern is repeating periodically and predictably. The arrival and departure of cars in a parking lot follows a pattern. That occupancy rate of the vehicle in the parking lot is affected by factors like Day of the week and time in which is parked.

II. RELATED WORK

Huang et al. [2] used a recurrent neural network (RNN) for predicting car occupancy prediction. The system used a genetic algorithm for RNN architecture optimization. Felix Caicedo et al. [5] proposed a real-time parking system. It consists of three components. The first part is for allocating simulated parking request; the second one is used for estimating future departure and the third one for predicting the parking availability. It uses a calibrated discrete model for the prediction. Stolfi et al. [6] performed a study in parking data published by Birmingham city council. They applied different prediction strategies like polynomial fitting, k-means clustering, and Fourier series and time series prediction. This study helped to remove a lot of noisy data from the dataset. Sun et al. [12] has conducted a survey on Houston's freeway to predict the traffic speed using linear regression model. It has performed a better accuracy than the kernel smoothing methods. Deshpande and Baijaja [13] applied a Support vector machine model for predicting the traffic flow in Chennai. Chen and Wang [14] has proposed an ensemble model based on genetic algorithm and support Vector machine to predict the traffic demand in China. The model provides a high-quality prediction results. Dou et al.

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