Traffic Flow Prediction Based on a Deep Spatiotemporal Convolutional Hybrid Network

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Abstract

Traffic flow prediction is a core component of intelligent transportation systems (ITS) that aims to alleviate urban congestion, reduce energy consumption, and improve travel efficiency. However, the highly nonlinear, dynamic, and spatiotemporally correlated nature of traffic data, along with external factors such as weather and incidents, poses significant challenges to conventional models like historical average, ARIMA, and support vector regression. To address these limitations, this study proposes a hybrid deep learning framework that jointly captures temporal dependencies and spatial correlations for short-term traffic flow prediction. The method leverages long short-term memory (LSTM) networks to model sequential time dependencies and graph convolutional networks (GCN) to directly operate on the non-Euclidean road network topology, where sensors are nodes and roads are edges. To further integrate spatiotemporal features, a spatiotemporal graph convolutional network (STGCN) is constructed by alternately stacking graph convolution and gated temporal convolution layers. Additionally, a self-attention mechanism is incorporated to capture long-range dependencies across different time steps and spatial locations, and a dynamic graph learning module adaptively adjusts adjacency weights based on real-time traffic states. The model is evaluated on three public benchmark datasets: PeMSD4 (29 road segments), PeMSD8 (8 segments), and METR-LA (207 loop detectors), all aggregated at 5-minute intervals. Prediction horizons of 15, 30, and 60 minutes are tested using mean absolute error (MAE) and mean absolute percentage error (MAPE). Experimental results show that the proposed model achieves a MAPE of 13.8% on PeMSD4 for the next-step prediction, outperforming the best baseline LSTM (21.6% MAPE). On METR-LA, the MAE for 60-minute prediction is 275, which is 12.5% lower than that of Diffusion Convolutional Recurrent Neural Network (DCRNN). In conclusion, the proposed deep learning approach, integrating dynamic graph learning and attention mechanisms, outperforms traditional and baseline deep models, offering a robust and accurate solution for traffic flow prediction in real-world ITS applications

Keywords

Traffic Flow Prediction, Deep Learning, Spatiotemporal Graph Convolutional Networks, Attention Mechanism, Dynamic Graph Learning