Short-Term Traffic Flow Prediction Based on Multi-Module Deep Learning with Rolling Variational Mode Decomposition

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Abstract:

Accurate traffic flow prediction is crucial for effective traffic management. Traditional methods often struggle to capture the nonlinear, periodic, and noisy characteristics of traffic data. Additionally, previous studies on traffic flow prediction using variational mode decomposition commonly suffer from "data leakage" issues, which affect model reliability. Notably, while variational mode decomposition has been widely applied, rolling variational mode decomposition techniques have not yet been explored in traffic flow prediction research. This study is the first to apply this technology in this field. We propose a deep learning architecture that integrates multi-dimensional temporal features with rolling variational mode decomposition, effectively avoiding the data leakage issue. The model inputs include not only traffic flow but also time-series related features, periodic historical traffic flow features, and multi-frequency modes obtained through rolling variational mode decomposition. Experimental results indicate that when using only traffic flow as input, the model achieves a mean absolute percentage error (MAPE) of 11.23%, a mean absolute error (MAE) of 221.54, and a root mean square error (RMSE) of 328.91. However, when integrating all features—time series, historical periodicity, and rolling variational mode decomposition—the prediction performance significantly improves. The MAPE is reduced to 7.4%, the MAE to 176.694, and the RMSE to 293.195. These results demonstrate the superiority of the method proposed in this study.

Keywords:

Traffic Flow Prediction, Variational Mode Decomposition, Deep Learning, Data Leakage.