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Long-term Traffic Forecasting in Smart Traffic Management: A Taiwan Case Study Based on the Informer Architecture for Highway Traffic Analysis

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1 Introduction

Rapid urbanization and rising traffic demand in Taiwan have heightened the challenges of highway management. This study uses the Informer model [1], an advanced adaptation of the Transformer architecture, to accurately predict traffic speed and flow on Taiwan's highways, enhancing road safety and traffic efficiency. The architecture of the Informer model, shown in Fig. 1, illustrates its structure and key components that enable accurate long-sequence forecasting.

Building on the Transformer architecture, initially developed for natural language processing (NLP) tasks, the Informer model exhibits exceptional capability in long-sequence forecasting. Its self-attention mechanism effectively captures dependencies across sequences without relying on fixed window sizes, overcoming a key limitation in traditional methods. In contrast to recurrent neural networks (RNNs) and long short-term memory networks (LSTMs), which often encounter gradient-related challenges, the Informer model alleviates these issues, making it particularly well-suited for traffic data characterized by strong temporal dependencies.

This study applies the Informer model to forecast traffic during peak and critical periods on Taiwan's highways, integrating real-time data to support timely traffic adjustments. Pre-processing ensures data accuracy, and the model's reliability is evaluated across diverse traffic conditions.

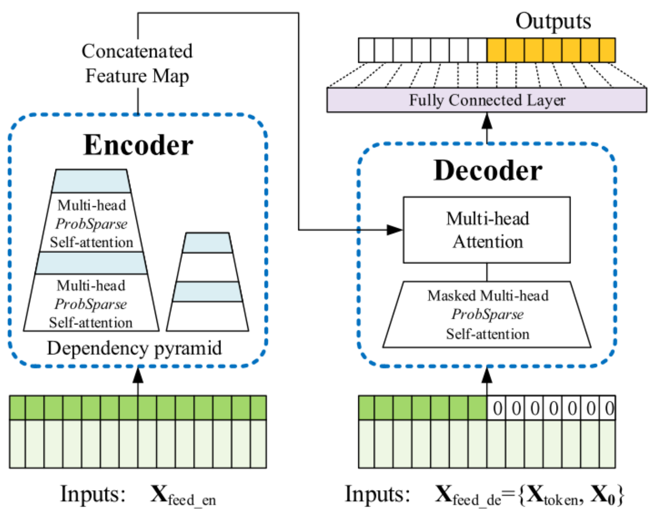

Fig. 1. The architecture of Informer.

2 Methodology

This study uses median travel speed data provided by Traffic Data Collection System (TDCS) [2]. Using Python's requests library, daily traffic data was automatically downloaded and processed into hourly averages for model training and testing, focusing specifically on passenger car data. The overall training procedure is illustrated in Fig. 2, providing a structured overview of the steps involved from data collection to model deployment.

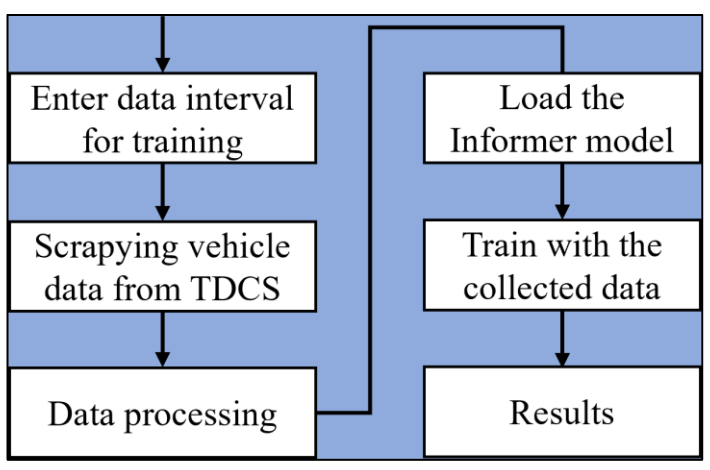

Fig. 2. Training Procedure Overview

2.1 Model Training and Optimization

Based on the experimental methods outlined in the original paper and the source code available on GitHub, we established the Informer model used in this study. We built our training framework according to Doheon's contribution on GitHub [3], making appropriate modifications to the inputs and outputs from the original paper. The model was trained using traffic flow and speed data from January to October 2023, with the goal of generating predictions for the last week of October. The forecasted results were compared with actual data through charts, and the Mean Absolute Percentage Error (MAPE) (1) was calculated to assess the model's prediction accuracy.

$$MAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i^{\text{true}} - y_i^{\text{pred}}}{y_i^{\text{true}}}\right| \times 100 \qquad (1)$$

2.2 Model Application and Insights

The trained model was applied to scenarios like weekday peak hours and holiday surges, successfully capturing traffic flow patterns with minimal deviation. The results validate the Informer model's effectiveness, demonstrating its potential for optimizing traffic management strategies and providing actionable insights for future planning.

3 Results and Analysis

In this study, we utilized the Informer model to forecast highway traffic flow for the last week of October 2023 and compared the predicted results with the real data.

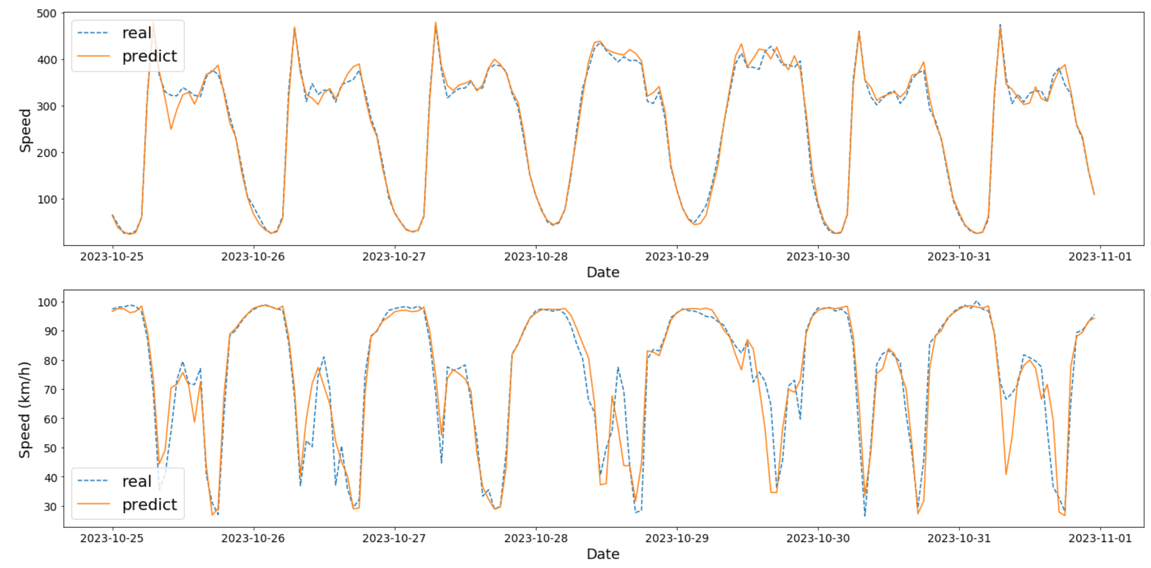

Fig. 3(a). Comparison of traffic flow predictions for Wugu with real data. Fig. 3(b) Comparison of speed predictions for Wugu with real data.

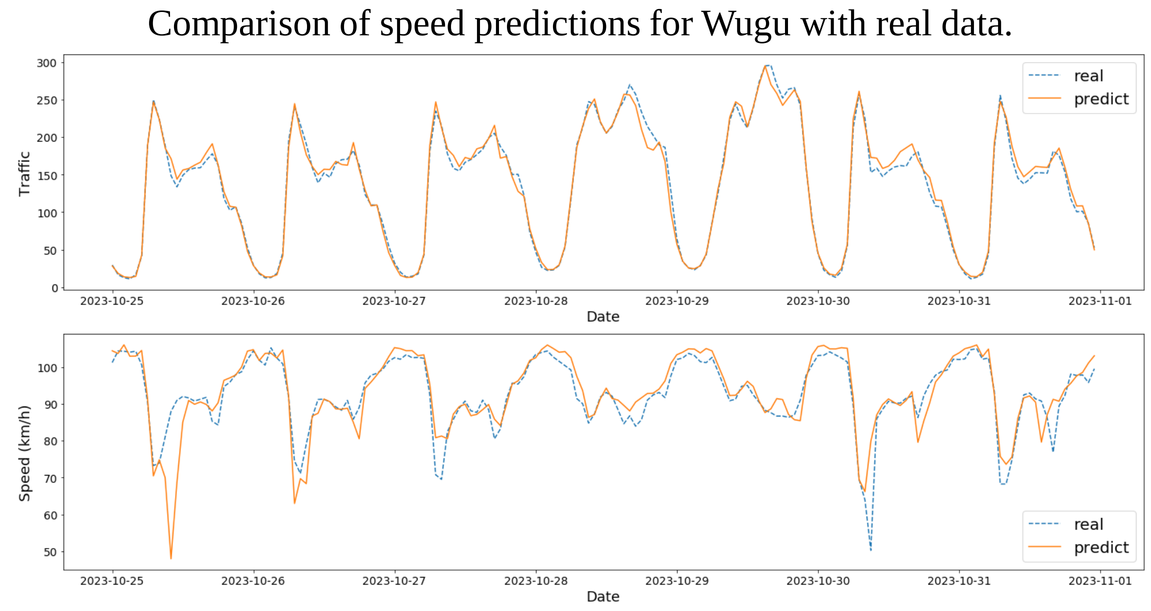

Fig. 4(a). Comparison of traffic flow predictions for Dingjin with real data. Fig. 4(b). Comparison of speed predictions for Dingjin with real data.

3.2 Accuracy Assessment

To evaluate prediction accuracy, we calculated the Mean Absolute Percentage Error (MAPE) for both high-flow sections, as listed in Table 1.

Table 1 Experiment results(MAPE)

Traffic of Wugu	Speed of Wugu	Traffic of Dingjin	Speed of Dingjin
4.55915	7.38320	6.06787	3.40963

3.3 Results Analysis

In Fig. 3(a), peaks indicate high traffic density, or congestion, while troughs represent smoother flow. The model closely aligns with actual data during these busy periods, demonstrating its predictive accuracy. Fig. 4(a) also shows accurate predictions for the Dingjin Interchange, with alignment in trends despite fewer extreme peaks and troughs, showcasing the model's adaptability to various high-traffic environments.

Figs. 3(b) and 4(b) reveal that the model captures overall speed trends well in both sections. Peaks correspond to smooth flow, while troughs indicate reduced speeds. The model accurately reflects these shifts, especially during rapid changes, and remains effective across different high-traffic scenarios. However, slight discrepancies, especially in troughs, suggest the model may need improvement in handling sudden disruptions, such as accidents or unexpected congestion.

4 Conclusion

This study introduces a highway traffic forecasting approach using the Informer model, achieving high accuracy with an average error of 4.559% and proving valuable for congestion management and operational efficiency. Future work will enhance the model with additional data (e.g., weather, accidents) and validate its adaptability across various regions, aiming to support smarter, safer traffic systems.

References

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