Our paper on "Spatio-Temporal Meta-Graph Learning for Traffic Forecasting" has been accepted to the top international conference on artificial intelligence, AAAI2023.

— Realizing high-accuracy, high-efficiency, and high-interpretability traffic prediction by cutting-edge meta-graph learning —

InfoTech
Connected Advanced Development Div.
TOYOTA MOTOR CORPORATION
Jiawei Yong(Project Leader)
Yasumasa Kobayashi
Shintaro Fukushima(Group Manager)

Toyota Motor Corporation announces that a research paper on traffic prediction, as a joint research achievement with Assistant Professor Renhe Jiang, the University of Tokyo, has been accepted to the top international conference on artificial intelligence, AAAI2023.

✧ **Presentation Highlights:**

- In order to develop a traffic prediction method that achieves high accuracy, high efficiency, and high interpretability, we designed a Meta-graph Convolutional Recurrent Network (MegaCRN) by combining Meta-Graph Learner and Encoder-Decoder Graph Convolutional Recurrent Network.
- On benchmark datasets METR-LA, PEMS-BAY, and Toyota's original dataset EXPY-TKY, our proposed method achieved higher prediction accuracy than existing methods in most accuracy evaluation metrics for road speed prediction. Additionally, our proposed method has relatively fewer model parameters compared to existing methods, resulting in significant reduction of learning time.
- Various applications enhanced by this method, including implementation in real – world services, are expected in the future.

✧ **Presentation Contents**

- **Research Background**

Although considerable effort has been devoted to developing traffic prediction methods, it is still necessary to address the challenges associated with the unique characteristics of traffic data to achieve high accuracy, efficiency, and interpretability.

Characteristics (1)

Traffic conditions exhibit spatio-temporal heterogeneity, meaning that their nature

varies significantly depending on the road and time (resulting in temporal and spatial anisotropy in traffic patterns).

Challenge (1)

Therefore, in order to develop prediction methods with high accuracy and interpretability, it is necessary to effectively separate and integrate the different characteristics of traffic conditions.

Characteristics (2)

When accidents or congestion occur, traffic conditions become non-stationary, meaning that they deviate from the normal state of traffic patterns.

Challenge (2)

Therefore, it is necessary to develop prediction methods that are adaptive to changes in traffic conditions even after the occurrence of sudden events such as accidents and congestion.

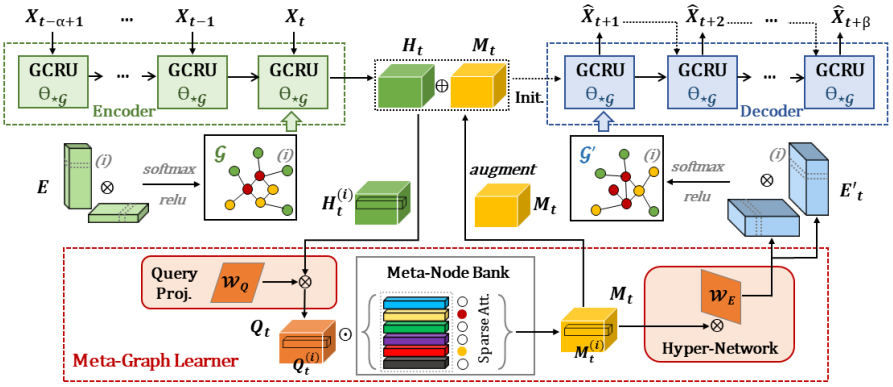
➢ Research Overview

This research aims to develop a prediction method with higher accuracy, efficiency, and interpretability compared to existing methods to address the challenges. The effectiveness of the proposed method was verified by the real-world data. We expect it to have broad applications, including its implementation in real services.

- **Methodology**

  To address challenge (1) in the traffic data, we designed a Meta-Graph Convolutional Recurrent Network (MegaCRN) that incorporates a Meta-Graph Learner and an Encoder-Decoder Graph Convolutional Recurrent Network. By leveraging the Meta-Graph Learner, MegaCRN is able to distinguish between patterns of roads and time with varying traffic conditions.

  Furthermore, to address challenge (2) in the traffic data, we achieved adaptive prediction capabilities by combining the Meta-Graph Learner and the Encoder-Decoder Graph Convolutional Recurrent Network, which can handle non-stationary traffic conditions such as accidents and congestion.



Framework of Meta-Graph Convolutional Recurrent Network (MegaCRN)

➢ **Evaluation Results**

・High Accuracy

Using benchmark datasets such as METR-LA, PEMS-BAY, and our own Toyota original dataset EXPY-TKY, we achieved higher prediction accuracy than existing methods in most evaluation metrics for road speed prediction. Our proposal's adaptive learning capabilities also make it possible to obtain high accuracy predictions even after the occurrence of sudden events such as accidents and congestion, where road speed decreases.

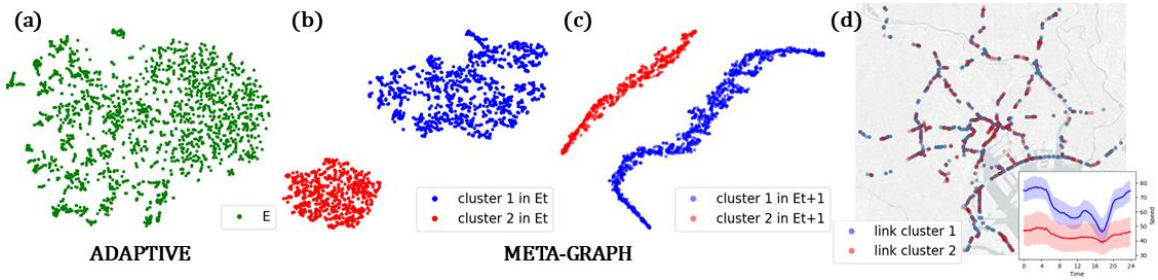
・High Efficiency

We were able to significantly reduce execution time compared to existing methods by limiting the number of parameters to a reasonable range.

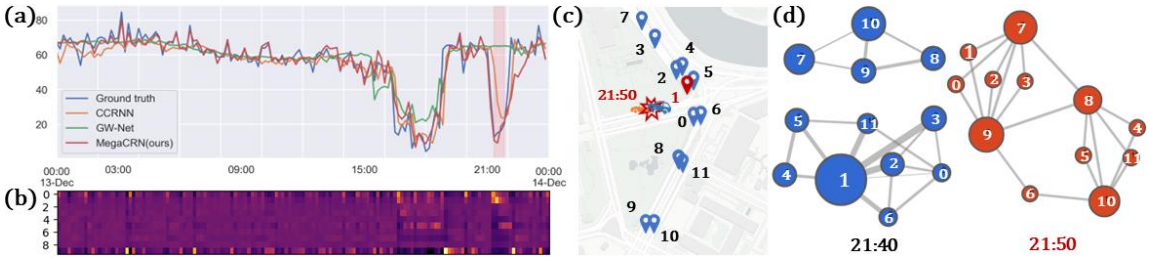
・High Interpretability

① Using Meta-Graph Learner, we explicitly aggregate and visualize road clusters based on their similarity in traffic conditions.

② By visualizing the local network structure of roads, we can display the extent and severity of the impact of sudden events. This provides valuable information for traffic management and control, allowing for effective response and mitigation of the impact on traffic flow.



① Spatio-Temporal Disentangling Effect of Meta-Graph Learning by Clustering Results



② (a)(b) Realization of adaptive speed prediction after traffic accidents (c)(d) Impact Visualization of the area and severity of accidents using Meta-Graphs

✧ **Presentation Info**

- Date： 9th Feb 2023
- Conference： AAAI2023 (The 37th AAAI Conference on Artificial Intelligence)
- Title： Spatio-Temporal Meta-Graph Learning for Traffic Forecasting
- Pre-print: https://arxiv.org/abs/2211.14701