Structural Recurrent Neural Network for Traffic Speed Prediction

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Introduction

▪**Traffic Prediction**: forecasting of future traffic state based on historical traffic data

▪**Traffic Data**: usually measured by magnetic induction loop detectors

- **Traffic speed**
- Traffic flow

▪**Spatio-Temporal Characteristic** of Traffic Data

- Sequence of traffic data on a road segment:
  a **time series**
- Each time series on each road segment has a **spatial relationship** with each other

▪Deep Neural Networks for Traffic Prediction

- Convolutional neural networks (CNNs)
  - Effective in understanding spatial features
- Recurrent neural networks (RNNs)
  - Traffic prediction as a time series forecasting
- Traffic data as spatio-temporal images
  - CNN or capsule network (CapsNet)[1] to capture spatio-temporal relationship

Purpose

- To develop a traffic prediction method that represents well **both the spatial and temporal** dynamics of the traffic and is **computationally efficient**.

Contribution

- A structural RNN (SRNN) approach for traffic prediction that incorporates the topological information of the road network.
  - The SRNN proposed in [2] has been usually applied to driver maneuver anticipation, human motion forecasting, human activity anticipation, and human trajectory prediction.
- The prediction performance and computational efficiency are validated with real data from the SETA EU project.

Methods

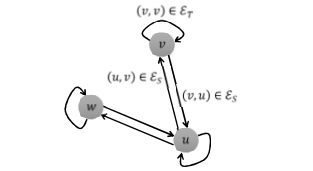
- Problem Definition

- Given a sequence of traffic speed data $\{x_v^t\}$ at time steps $t = T - l + 1, \dots, T$, we predict the future traffic speed x_v^{T+1} on each road segment $v = 1, \dots, N$.

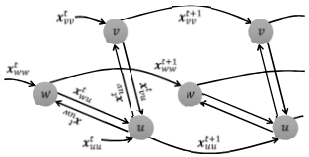
T: current time step

l: the length of data sequence

- Spatio-Temporal Graph Representation



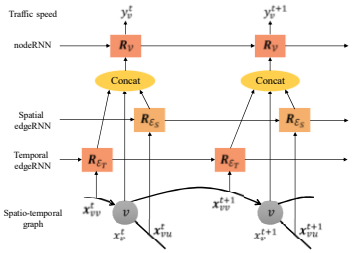
(a) Nodes represent road segments and the nodes are inked by spatial edges $\mathcal{E}_S$ and temporal edges $\mathcal{E}_T$



(b) The spatio-temporal graph is unrolled over time using the temporal edges $\mathcal{E}_T$. The edges are labelled with corresponding feature vectors.

Methods

- Model Architecture



Architecture of the SRNN in perspective of node v drawn with the unrolled spatio-temporal graph.

- Uses 3 sets of RNNs: node RNN, spatial edge RNN, temporal edge RNN.

- Feature vector of spatial edge RNN: current traffic speed values of adjacent road segments.

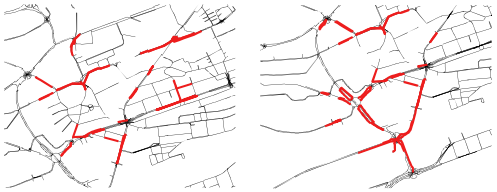
- Feature vector of temporal edge RNN: current and previous traffic speed values of each road segment.

- Feature vector of node RNN: current traffic speed value concatenated with the results of the above edge RNNs.

Validation with Real Data

- Traffic speed and road network dataset from SETA EU project, measured every 15 minutes in the central Santander city of Spain for the year of 2016.
- Compare the performance of the proposed **SRNN** with the **CapsNet**-based approach[1] and other approaches
  - Task 1: prediction based on 10-time-step data
  - Task 2: prediction based on 15-time-step data

Validation with Real Data



Two different sets of road segments used in the experiment. Each set contains 50 road segments marked in red.

Speed prediction performance (unit: km/h).

	CapsNet		SRNN	
	MAE	*RMSE*	*MAE*	*RMSE*
Task 1	5.720	9.133	5.632	8.906
Task 2	5.741	9.172	5.588	8.975

❖MAE: mean absolute error / RMSE: root mean squared error

Number of trainable parameters.

	CapsNet	SRNN
Task 1	5.1×10^7	1.1×10^6
Task 2	7.6×10^7	

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References

1) Y. Kim, P. Wang, Y. Zhu, and L. Mihaylova, "A Capsule Network for Traffic Speed Prediction in Complex Road Networks", *Proc. from the IEEE SDF Workshop*, 2018.

2) A. Jain, A. R. Zamir, S. Savarese, and A. Saxena, "Structural-RNN: Deep Learning on Spatio-temporal Graphs", *Proc. from the ICVPR*, 2016.