2022 ACM Transactions on Intelligent Systems and Technology

GSeqAtt

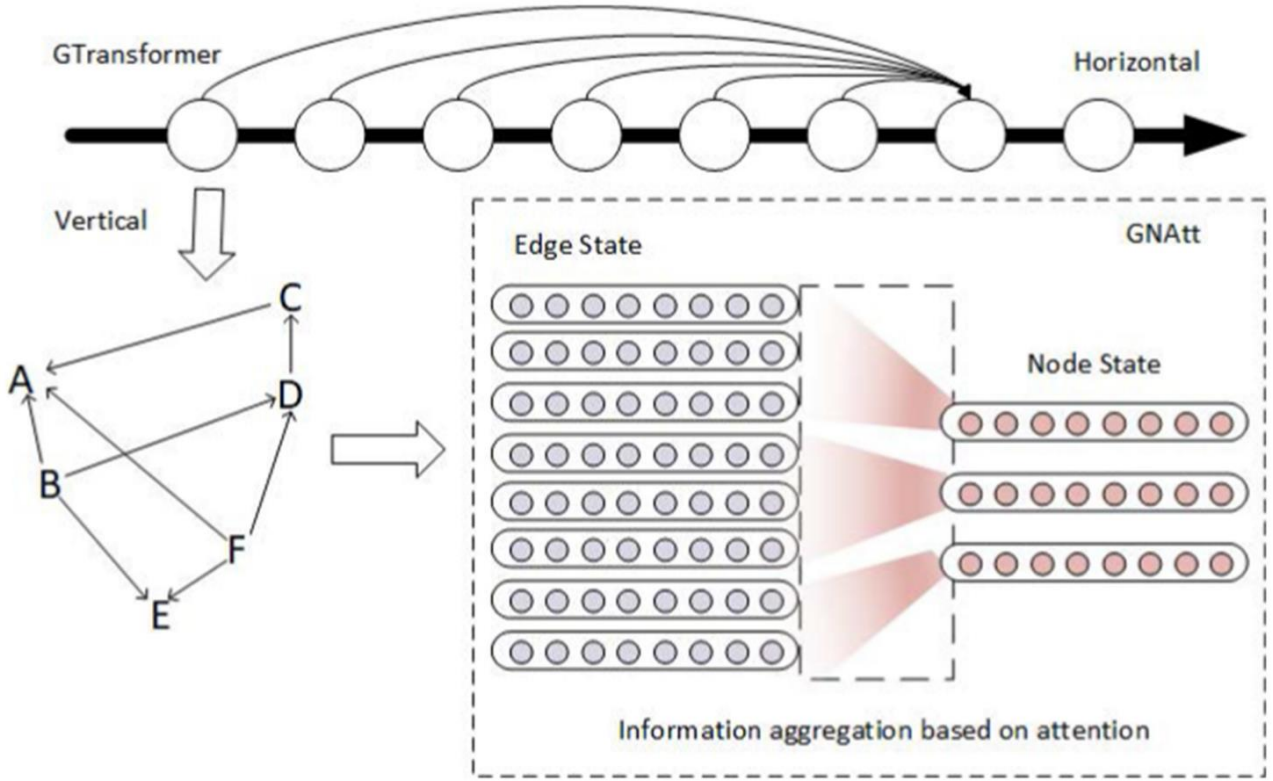
Graph **Seq**uence Neural Network with an **Att**ention Mechanism for Traffic Speed Prediction

23.3.15

Presented by Yyyq

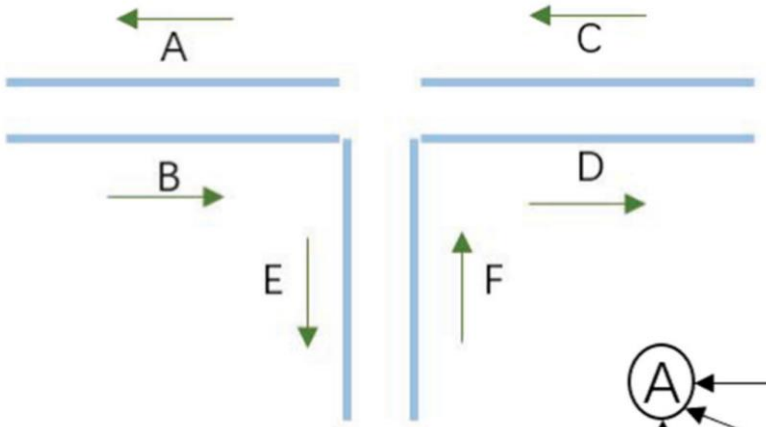
01 GSeqAtt 创新点

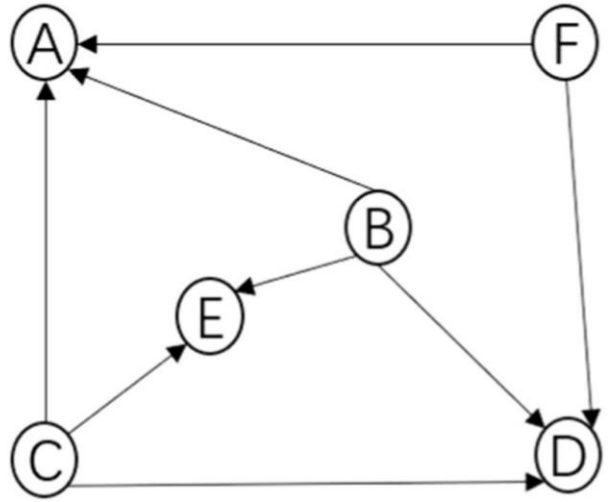
- **GNAtt：解决（有向）图中信息传播问题——a vertical mechanism**
- **GTransformer：实现时间自我注意机制处理图序列——a horizontal mechanism**



02 问题定义

- **Graph to Be Processed by a GNN** $G = (V, E, V^{attr}, E^{attr}, U^{attr})$
- **Road Network** $G = (V, E)$
- **Linkage Graph** $G^* = (V^*, E^*)$





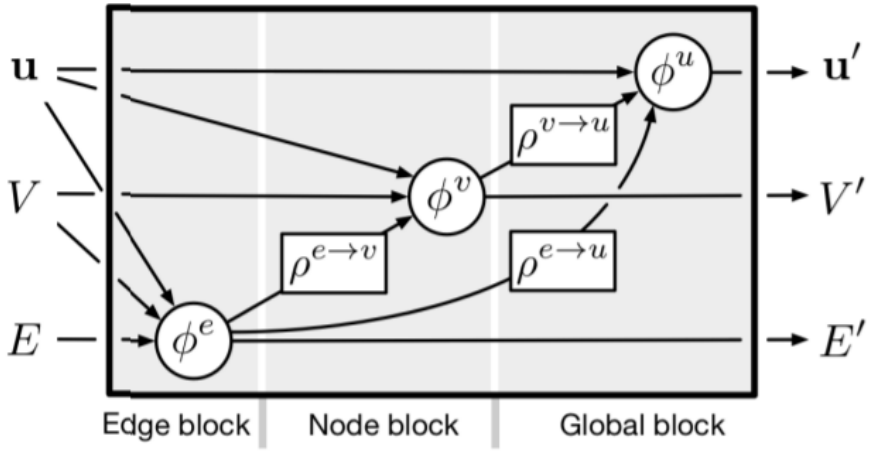
- $\left\{S_{t_r}^{v_i^*} \mid r = j, \ldots, j+l\right\} = \mathcal{F}\left\{S_{t_r}^{v_i^*} \mid r = j-k, \ldots, j-1\right\}.$

03 算法描述：GNAtt——GN Blocks + GATs

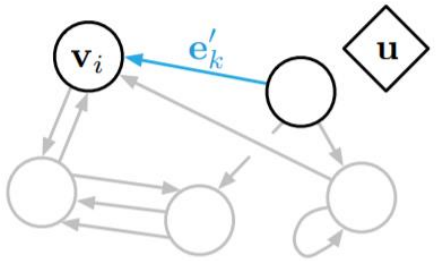
➢ **GN Block：Graph to Graph**

- **主要思想：**更新和聚合

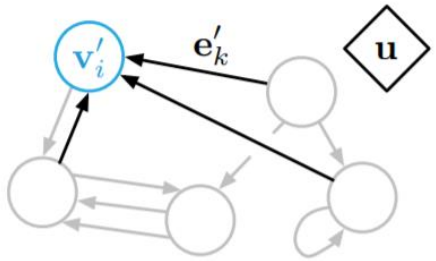
$$G = (u, V, E)$$



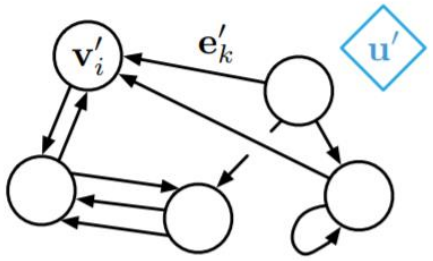
(a) Full GN block



(a) Edge update



(b) Node update



(c) Global update

*Relational inductive biases, deep learning, and graph networks

03 算法描述：GNAtt——GN Blocks + GATs

➢ **GAT：Graph Attention Networks**

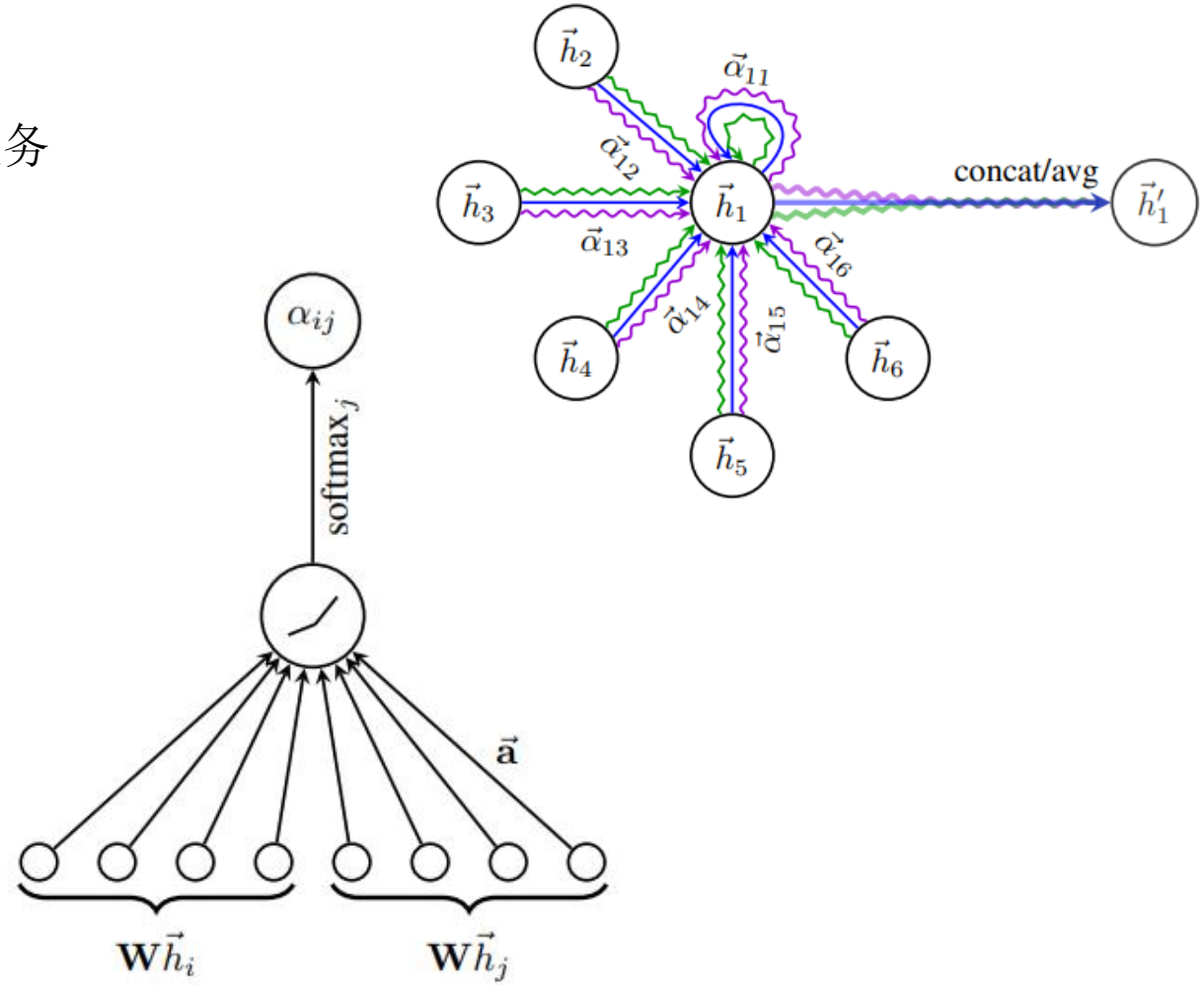
- **优势：**适用于有向图，适用于inductive任务

$$e_{ij} = a\left(\left[Wh_i \middle|\middle| Wh_j\right]\right), j \in \mathcal{N}_i$$

$$\alpha_{ij} = \frac{exp(LeakyReLU(e_{ij}))}{\sum_{k\in\mathcal{N}_i} exp(LeakyReLU(e_{ik}))}$$

$$h_i' = \sigma\left(\sum_{j\in\mathcal{N}_i} \alpha_{ij} W h_j\right)$$

$$h_i'(K) = \Big\|_{k=1}^{K} \sigma\left(\sum_{j\in\mathcal{N}_i} \alpha_{ij}^k W^k h_j\right)$$



* ICLR 2018： Graph Attention Networks

03 算法描述：GNAtt——GN Blocks + GATs

➢ **GNAtt:** GN Block with an Attention Mechanism

Input:
$G = (V, E, V^{attr}, E^{attr}, U^{attr})$
Output:
$G' = (V', E', V^{attr'}, E^{attr'}, U^{attr'})$

平均汇聚函数 → 差分加权汇聚

$$\rho_{ori}^{e2v} = \frac{1}{|inEdge(v)|} \sum_{e_{w,v} \in inEdge(v)} h_{e_{w,v}}^{l},$$

$$\rho_{att}^{e2v} = \sum_{e_{w,v} \in inEdge(v)} \alpha_{(v,e_{w,v})} * h_{e_{w,v}}^{l}.$$

$$h_{e_{w,v}}^{l} = \phi^{e}(e_{w,v}, w, v, U^{attr}).$$

$$\alpha_{(v,e_{w,v})} = \frac{\exp\left(LeakyReLU\left(DS1\left(h_{e_{w,v}}^{l}\right)\right)\right)}{\sum_{e_{w,k} \in inEdge(v)} \exp\left(LeakyReLU\left(DS1\left(h_{e_{k,v}}^{l}\right)\right)\right)}.$$

03 算法描述：GTransformer

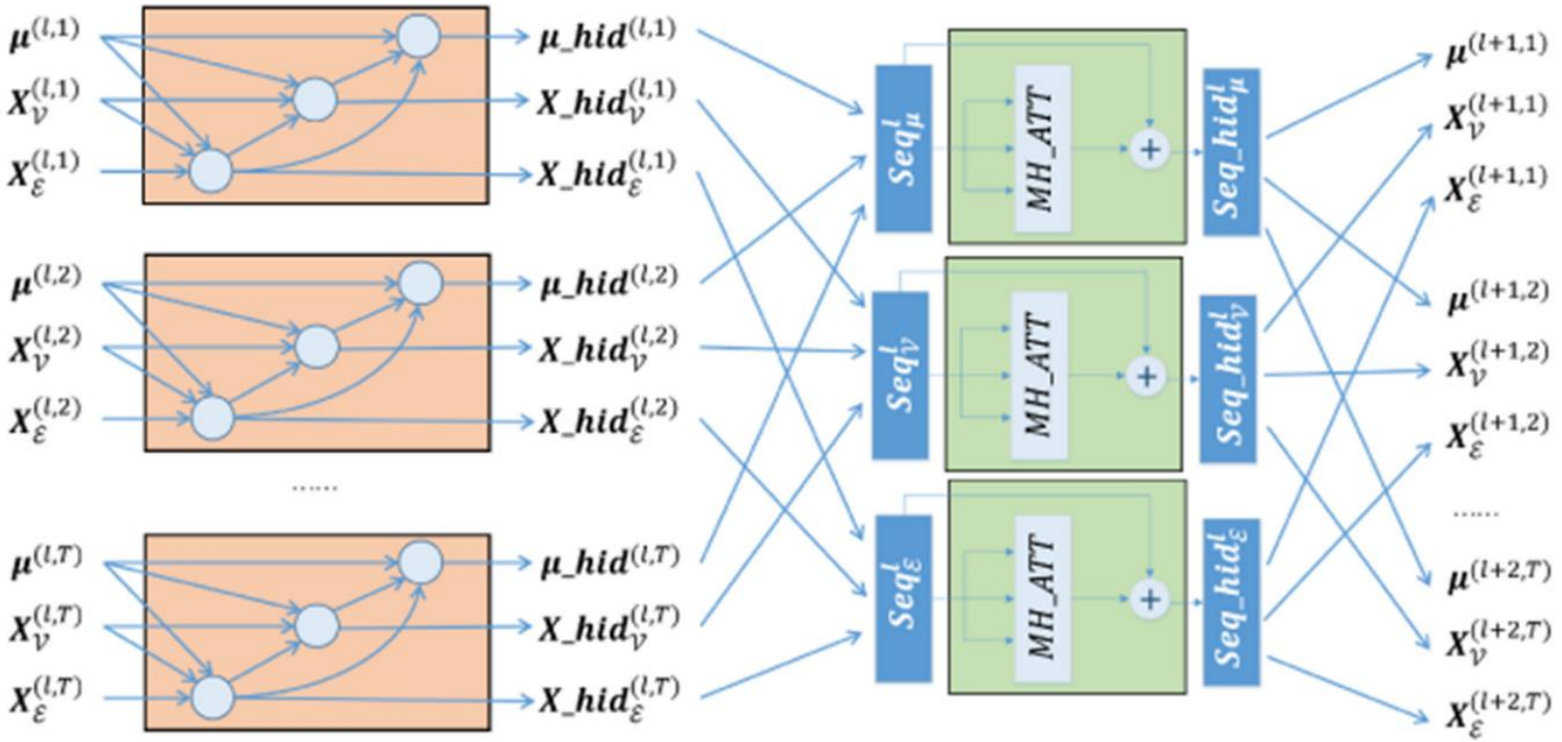
$$\mathcal{GSEQ\_IN} = [\mathcal{G}_{in}^1, \mathcal{G}_{in}^2, \ldots, \mathcal{G}_{in}^T], \quad \mathcal{G} = \{\mathcal{V}, \mathcal{E}\}$$

$$\mathcal{G}\_ele = \mathcal{V} \cup \mathcal{E} \cup G$$

$$[x_{ele}^1, x_{ele}^2, \ldots, x_{ele}^T] \xrightarrow{\text{Transformer}} [EMB\_hid_{ele}^1, EMB\_hid_{ele}^1, \ldots, EMB\_hid_{ele}^1]$$

$$\mathcal{GSEQ\_OUT} = [\mathcal{G}_{out}^1, \mathcal{G}_{out}^2, \ldots, \mathcal{G}_{out}^T].$$

03 算法描述：Mixed Attention



04 数据集

➢ Q-Traffic dataset

- query sub-dataset
- **traffic speed sub-dataset**
- **road network sub-dataset**

Table 1. Statistics of the Traffic Speed Sub-dataset

Item	Description
Road segments	15,073
Total length	738.91 km
Interval	15 minutes
Time	April 1, 2017–May 31, 2017
Total records	265,967,808
Long/lat bounding box	(116.10, 39.69, 116.71, 40.18)

Table 2. Examples of the Geographical Attributes of Each Road Segment

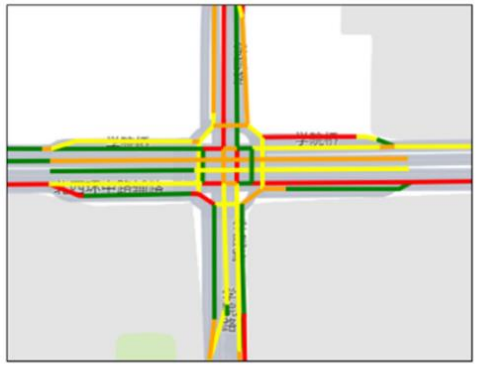
Field	Type	Description
link_id	Char(13)	road segment ID
width	Char(3)	width, 15: <=3.0 m; 30: (3.0 m, 5.0 m); 55: (5.5 m, 13 m); 130: >13 m
direction	Char(1)	direction, 0: unknown, default two-way; 1: two-way; 2: one-way, from start node to end node; 3: one-way, from end node to start node
snodeid	Char(13)	start node ID
enodeid	Char(13)	end node ID
length	Char(8)	length (km)
speedclass	Char(1)	speed limit (km/h), 1: >130; 2: (100, 130); 3: (90, 100); 4: (70, 90); 5: (50, 70); 6: (30, 50); 7: (11, 30); 8: <11
lanenum	Char(1)	number of lanes, 1: 1; 2: 2 or 3; 3: >=4

04 数据集

- **Q-Traffic dataset**

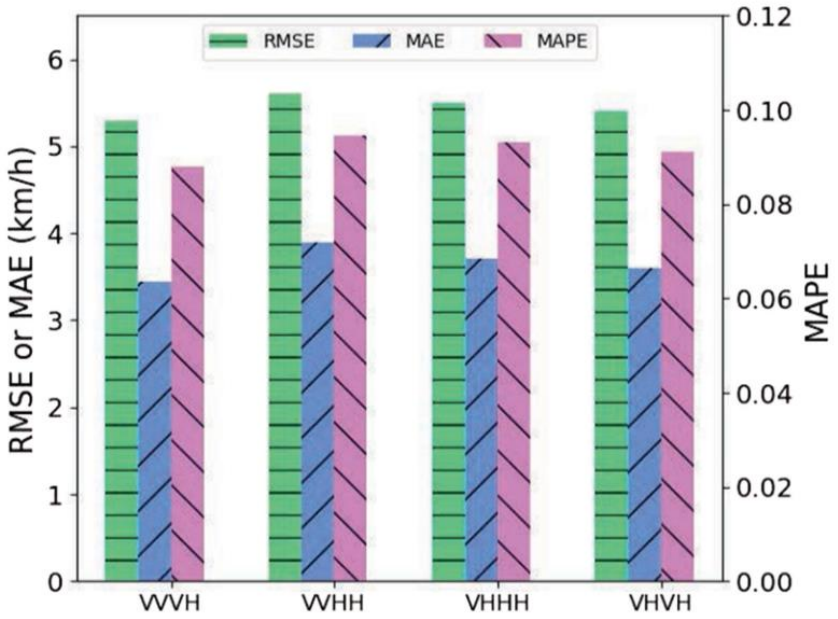
(a) Yue Quan Road

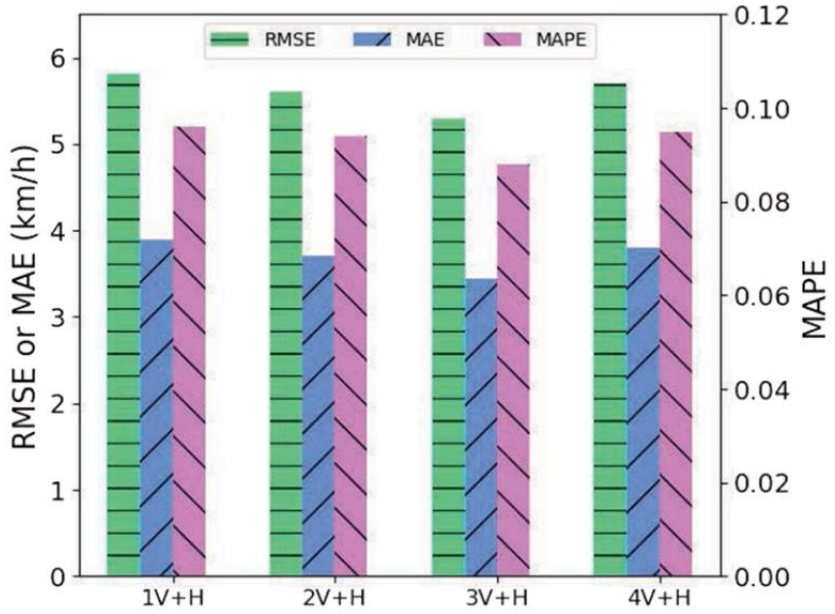
(b) Ping An Li



(c) Xue Yuan Road

05 实验结果1


RMSE
MAE
MAPE
RMSE or MAE (km/h)
MAPE
0
1
2
3
4
5
6
0.00
0.02
0.04
0.06
0.08
0.10
0.12
VVVH
VVHH
VHHH
VHVH


RMSE
MAE
MAPE
RMSE or MAE (km/h)
MAPE
0
1
2
3
4
5
6
0.00
0.02
0.04
0.06
0.08
0.10
0.12
1V+H
2V+H
3V+H
4V+H

05

实验结果2

Data	Model	1 Hour			3 Hour			6 Hour		
		MAE	MAPE	RMSE	MAE	MAPE	RMSE	MAE	MAPE	RMSE
Yue Quan Road	MLP	3.4639	0.0761	5.2033	3.8042	0.0852	5.3786	3.8714	0.0954	5.7589
	Seq2Seq	3.3441	0.0712	4.9605	3.7053	0.0844	5.3310	3.8398	0.0936	5.7815
	GRU	3.6023	0.0782	5.3816	3.8271	0.0873	5.4769	3.9036	0.0940	5.7829
	DCRNN	3.1801	0.0683	4.7700	3.6107	0.0836	5.2622	3.6679	0.0887	5.5405
	STGCN	3.7518	0.0928	5.8262	4.3161	0.1025	6.0208	4.5795	0.1077	6.9070
	Graph WaveNet	3.6133	0.0835	5.5938	3.8367	0.0939	5.6311	3.9329	0.0958	6.1191
	MTGNN	7.7003	0.1849	10.6605	10.6500	0.2539	14.2389	11.4670	0.2736	14.8771
	AGCRN	7.3494	0.1742	11.2873	8.7907	0.1862	11.7982	10.5558	0.2570	13.9753
	VertiAtt	3.3328	0.0704	4.7607	3.6382	0.0811	5.1676	3.6543	0.0884	5.4415
	HoriAtt	3.0470	0.0683	4.5744	3.5939	0.0799	5.1474	3.6325	0.0879	5.4032
	GSeqAtt	**2.8914**	**0.0671**	**4.5623**	**3.2231**	**0.0776**	**5.0533**	**3.5711**	**0.0873**	**5.3287**
Ping An Li	MLP	2.3964	0.0918	3.5636	2.6957	0.1062	4.0639	3.0638	0.1219	4.4889
	Seq2Seq	2.3019	0.0885	3.5112	2.6641	0.1056	4.0309	2.8125	0.1129	4.2554
	GRU	2.3545	0.0898	3.5392	2.6742	0.1061	4.0333	2.8480	0.1127	4.2570
	DCRNN	2.2722	0.0876	3.4725	2.6409	0.1035	3.9951	2.7202	0.1146	4.2474
	STGCN	2.6922	0.1010	4.0085	2.8591	0.1108	4.2573	3.1295	0.1161	4.5530
	Graph WaveNet	2.3997	0.0943	3.6222	2.7357	0.1069	4.2076	3.7439	0.1345	4.5576
	MTGNN	3.5532	0.1469	5.3652	4.9791	0.2017	6.7455	5.2471	0.2126	7.0226
	AGCRN	3.4418	0.1274	5.0347	4.8049	0.1748	6.5659	5.1134	0.1865	6.8276
	VertiAtt	2.2456	0.0860	3.4508	2.3968	0.0892	3.5908	2.4516	0.0911	3.6027
	HoriAtt	1.9147	0.0735	3.1218	2.3525	0.0851	3.4376	2.3827	0.0873	3.5733
	GSeqAtt	**1.8871**	**0.0700**	**2.9792**	**2.2011**	**0.0799**	**3.3431**	**2.2117**	**0.0843**	**3.4183**
Xue Yuan Road	MLP	4.9368	0.1579	7.2483	4.9726	0.1611	7.3456	5.8719	0.1777	7.8787
	Seq2Seq	3.0370	0.0899	4.3218	4.2041	0.1298	5.9677	4.8374	0.1542	6.9035
	GRU	3.1019	0.0907	4.4120	4.2916	0.1373	6.0957	5.0530	0.1641	7.1804
	DCRNN	2.7982	0.0861	4.1683	3.6573	0.1101	5.3324	3.7953	0.1151	5.6461
	STGCN	2.8467	0.0876	4.2055	4.0147	0.1208	5.9188	4.7712	0.1277	6.7191
	Graph WaveNet	3.3635	0.1014	4.5819	4.4054	0.1376	6.2891	4.9939	0.1626	7.3846
	MTGNN	7.5150	0.2211	9.7463	7.7815	0.2345	10.8573	8.8588	0.2679	11.6632
	AGCRN	7.2704	0.1995	8.9715	7.7378	0.2209	10.1259	8.4098	0.2399	11.3825
	VertiAtt	2.7698	0.0818	4.0068	3.4129	0.1074	5.1399	3.6051	0.1104	5.4934
	HoriAtt	2.6293	0.0762	3.8756	3.1697	0.0982	5.1001	3.4064	0.1053	5.2924
	GSeqAtt	**2.4062**	**0.0705**	**3.6453**	**2.9817**	**0.0879**	**4.3997**	**3.2312**	**0.0953**	**4.6851**

谢谢观看

MANY THANKS !

23.3.16