PREDICTING TRAFFIC SPEED FOR NEW JERSEY FREEWAY WORK ZONES – A DEEP LEARNING APPROACH

ABDULLAH SHABAREK, PH.D., PE

NJDOT RESEARCH SHOWCASE
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Background & Problem Statement

- Frequent Road Maintenance
- Accounts for 24% of non-recurrent congestion
- Accounts for10% of the overall congestion
- Delay at Upstream segments including connected freeways

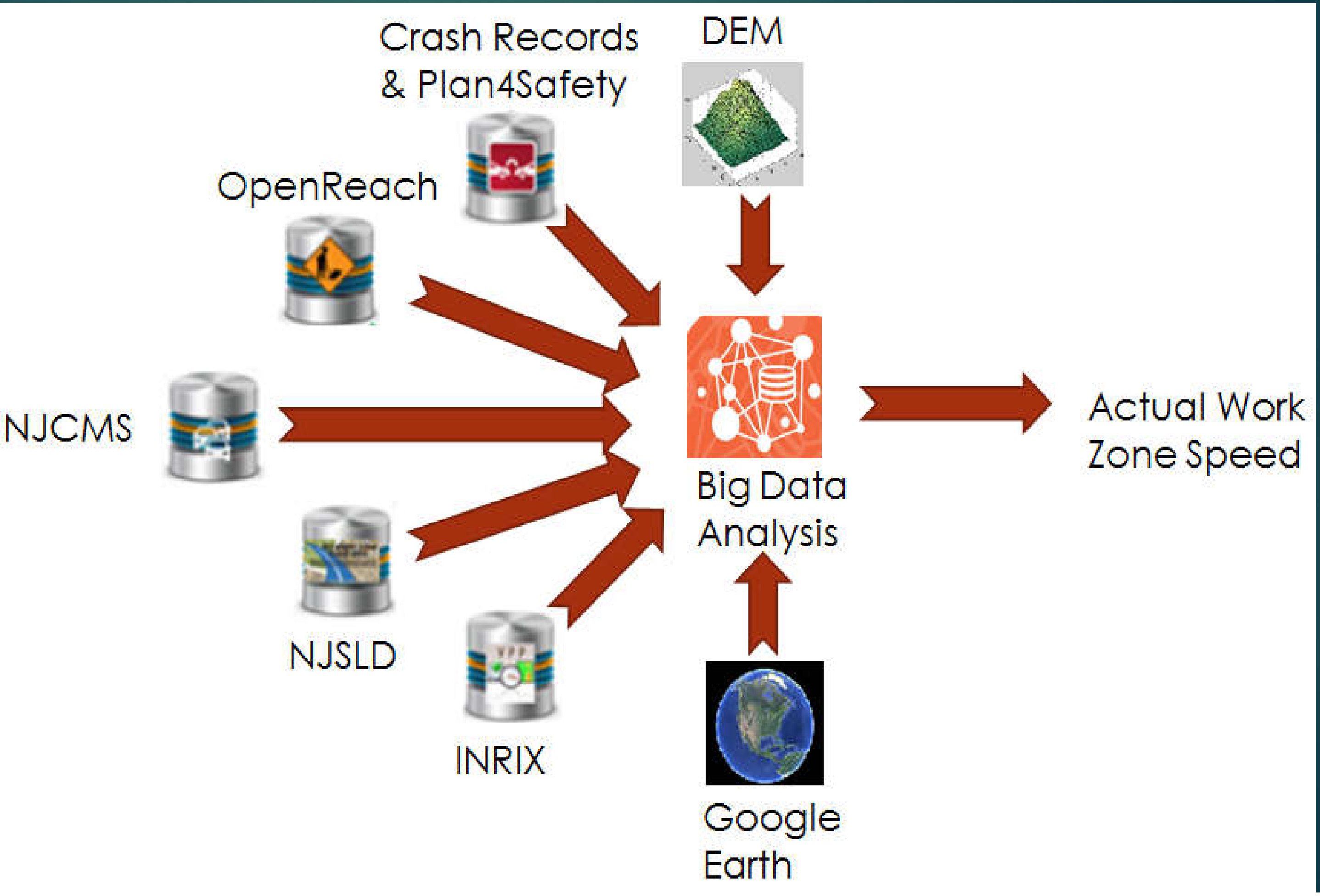
Objective

- Developing a sound model to Predict Traffic Speed under work zone conditions on both connected and mainline freeways

Work Scope

- New Jersey Freeways
- Work zone conditions
- 10-miles upstream work zone
- Data between 2014 and 2019
- CNN and Deep ANN

Data Collection



Background & Problem Statement

- No well-designed model to predict traffic speed on the connected freeways. (Overfitting issues)
- CNN and Deep ANN models

Pros & Cons of Modeling Approaches

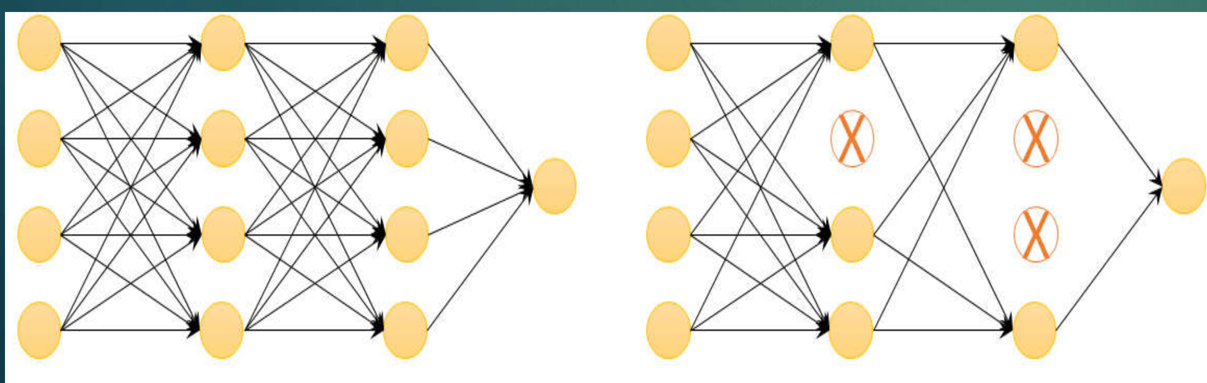
Model Type	Advantages	Disadvantages
Parametric Models	• Transferability • Scalability • Inexpensive	• Data distribution • Spatial-temporal data
Simulation Models	• High fidelity	• Specific work zone • High computation Power and Time • High calibration time
Non-Parametric Models	• Scalability • Extensibility • Less computational time • No data distribution	• Data dependency • Structure configuration

Tools for Work Zone Congestion Prediction

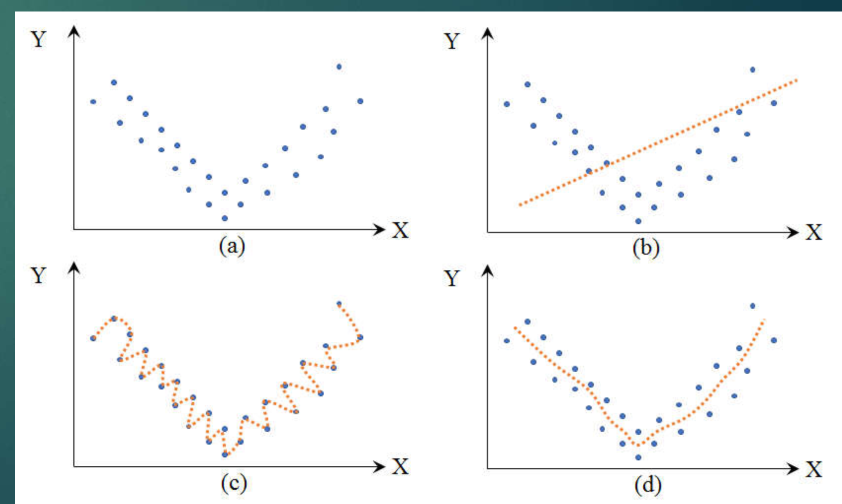
Tool	Inputs	Outputs	Modeling Approach
FlagSim	Time and location of work zone	• Traffic volume • Queue length • Delay	Parametric
Web-based Work Zone Traffic		• Delay cost • Queue length	Parametric
LCDSS		• Queue length	Parametric
WIMAP-P	Time, location of work zone, and values of time.	• Delay cost • Queue length • Predicted traffic speed	Non-parametric
RILCA	Time and location of work zone only for the GSP and NJTP.	• Queue length • Delay	Parametric

Deep Learning

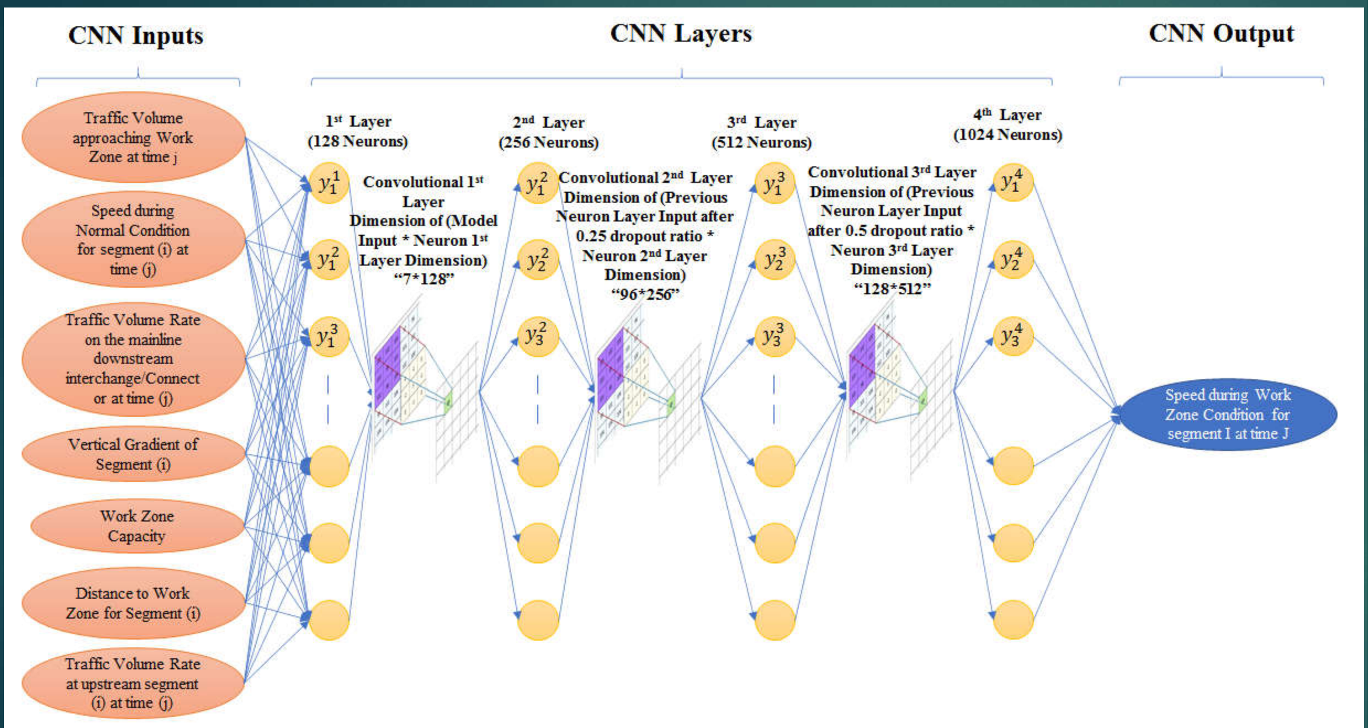
- Two or more hidden layers
- Number of neurons
- Overfitting
- Dropout is a regularization technique that is applied in hidden layers for the purpose of reducing the overfitting problem

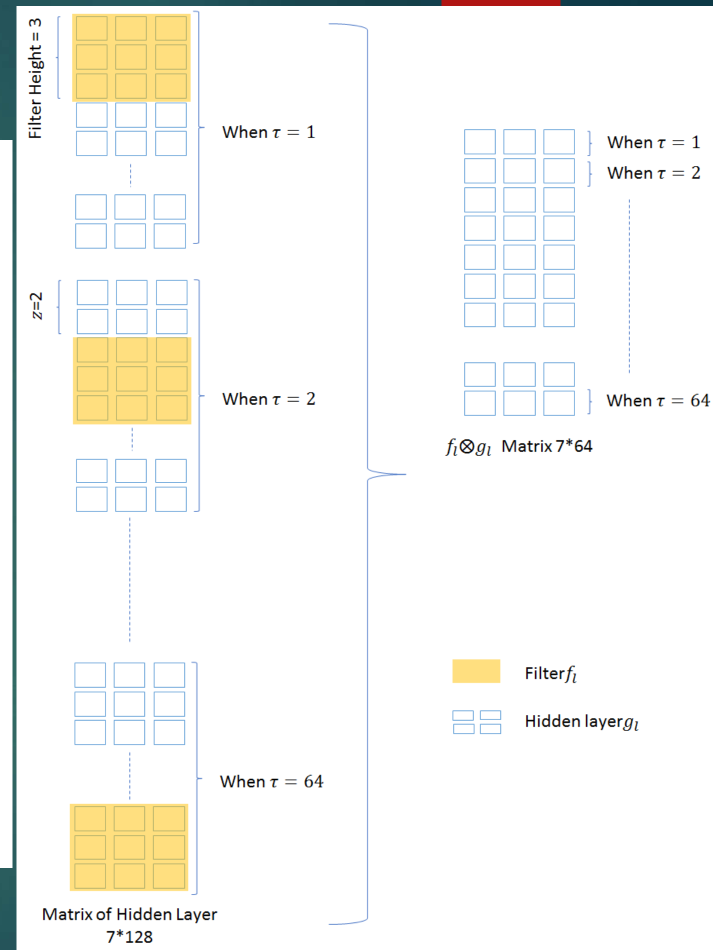


(a) Neural Network without Dropout (b) Neural Network with Dropout

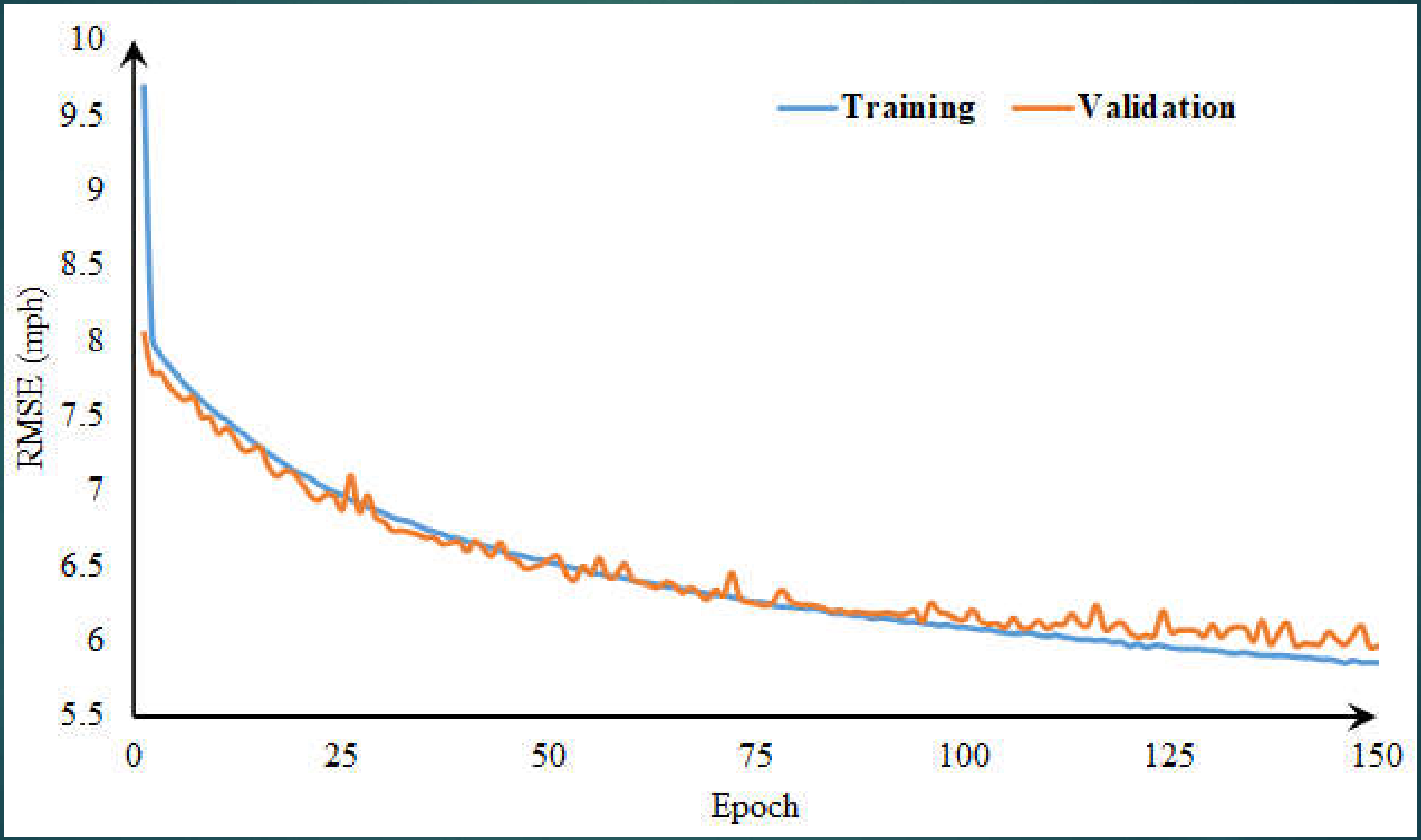


Developed CNN





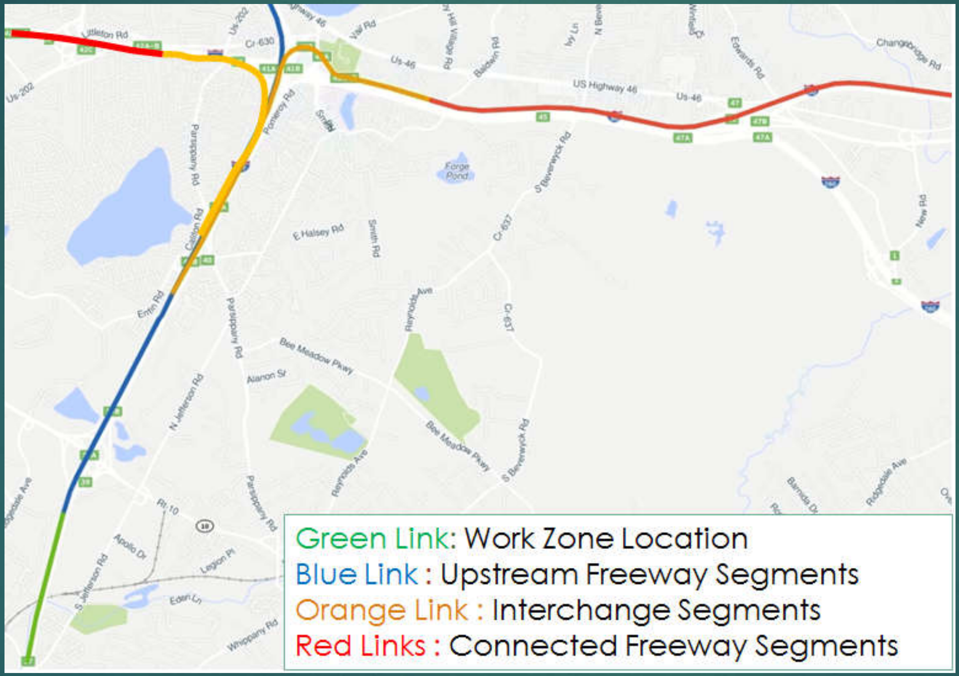
Developed CNN Results



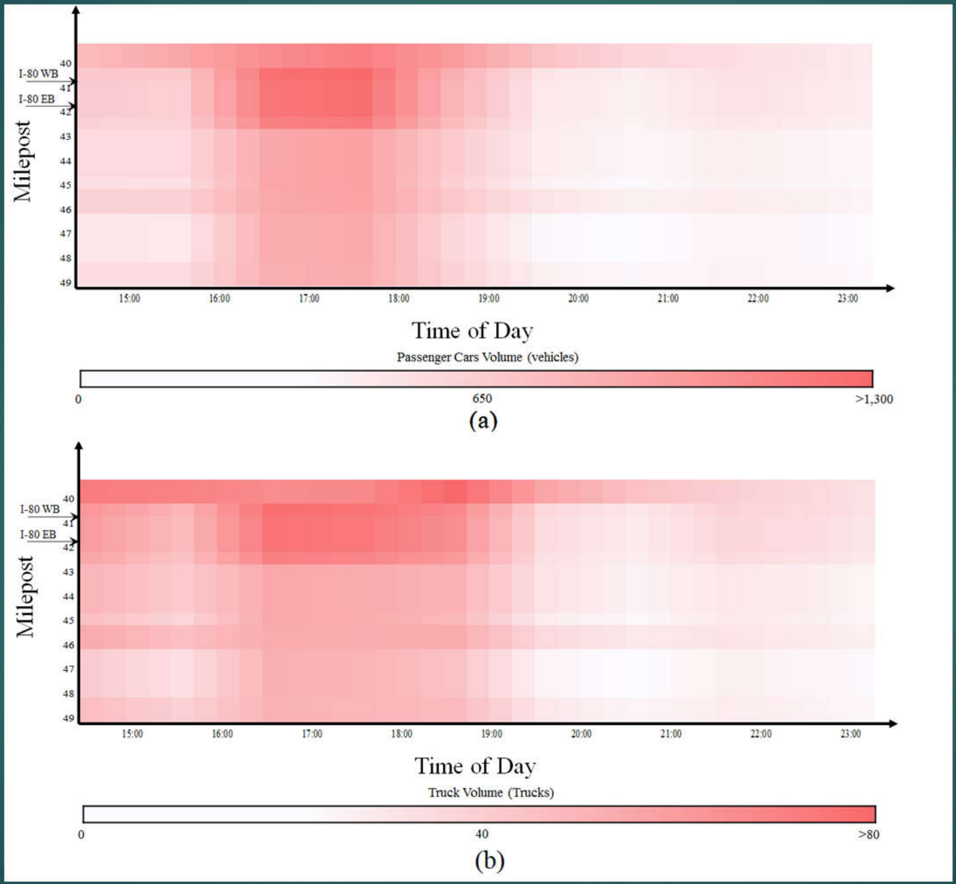
Case Study

- 1-mile work zone on I-287 SB
- One Lane closure over 4 lanes
- Milepost 39 and Milepost 38
- From 3:00 PM till 09:00 PM on 07/08/2015
- I-80 as a connected route

Case Study (Location)

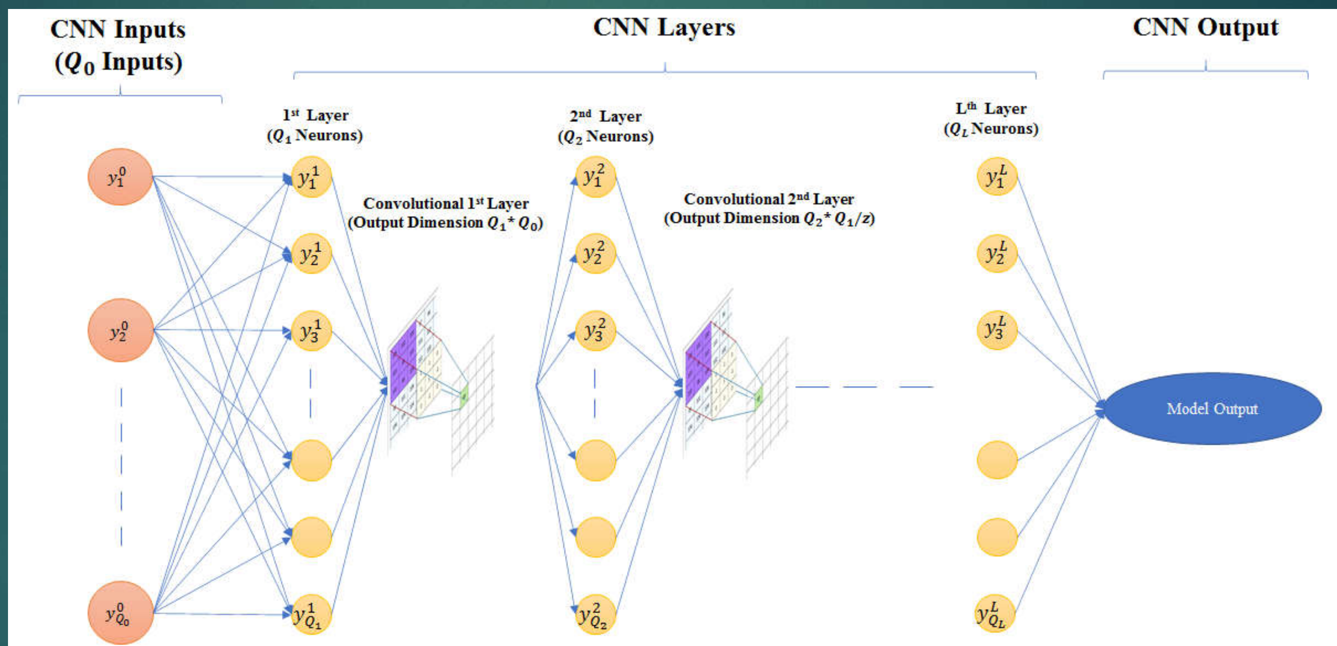


Case Study

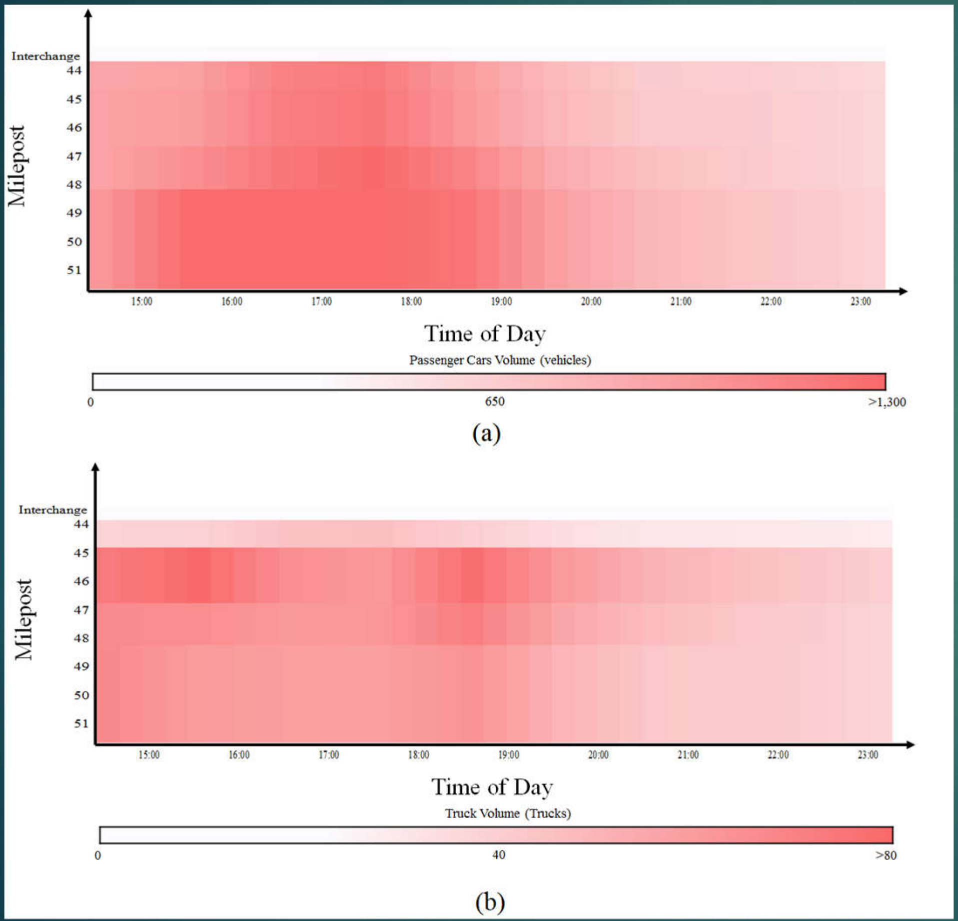


Heat map of (a) passenger cars and (b) trucks distribution for I-287 SB
Source: New Jersey Congestion Management Systems

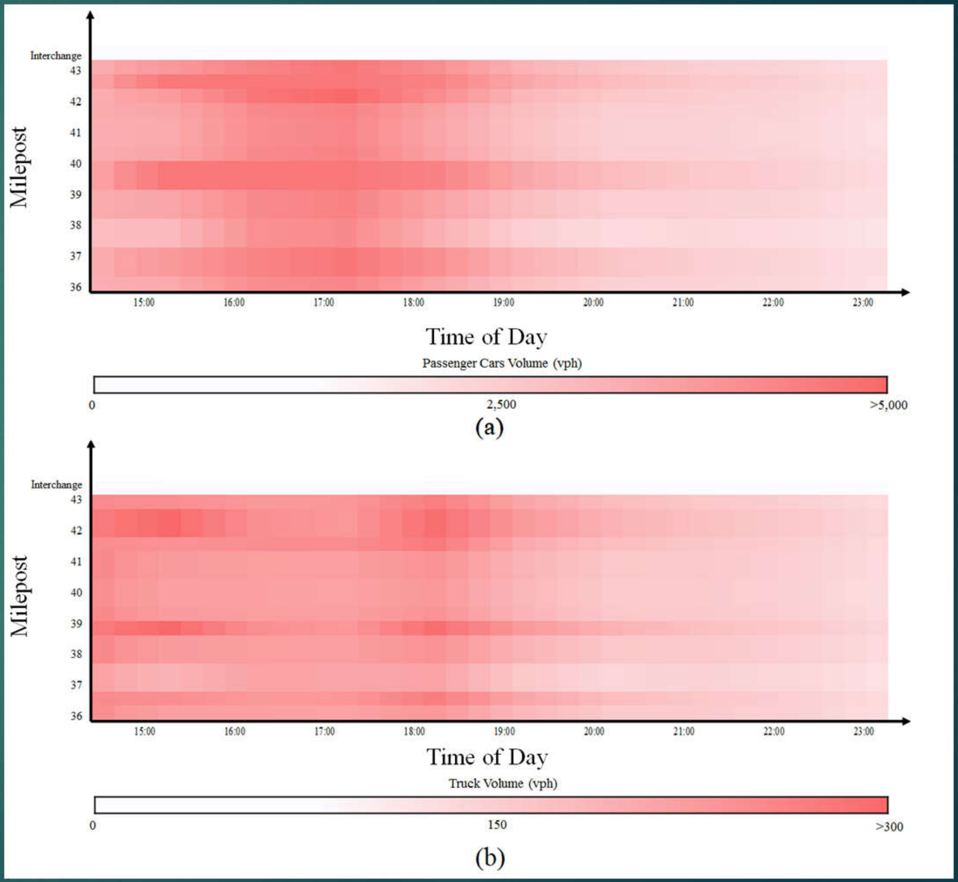
Methodology (CNN)



Case Study

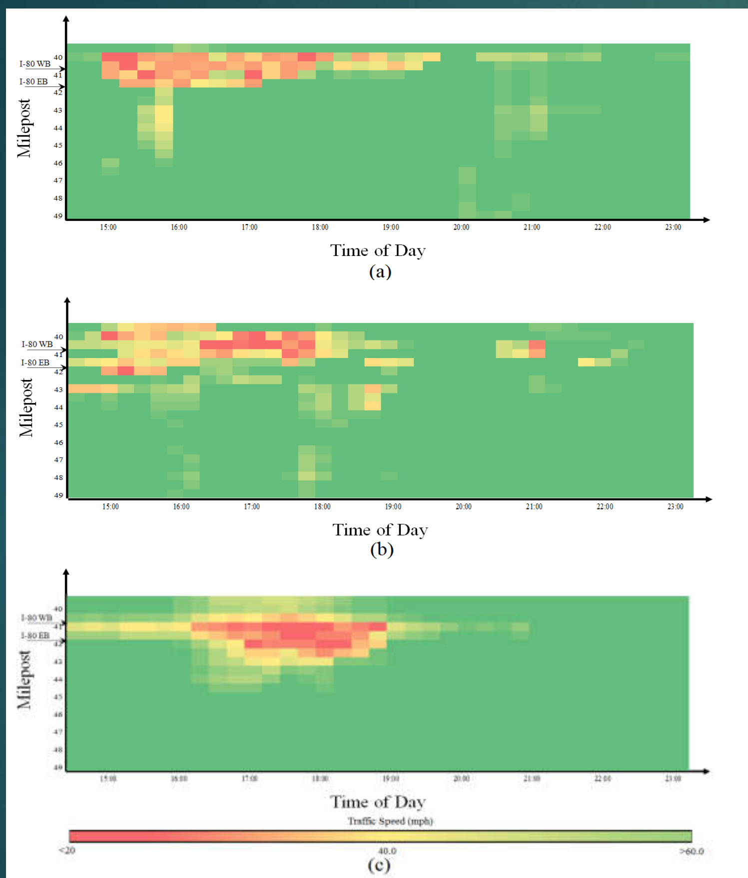


Heat map of (a) passenger cars and (b) truck volumes of I-80 Westbound
Source: New Jersey Congestion Management Systems.

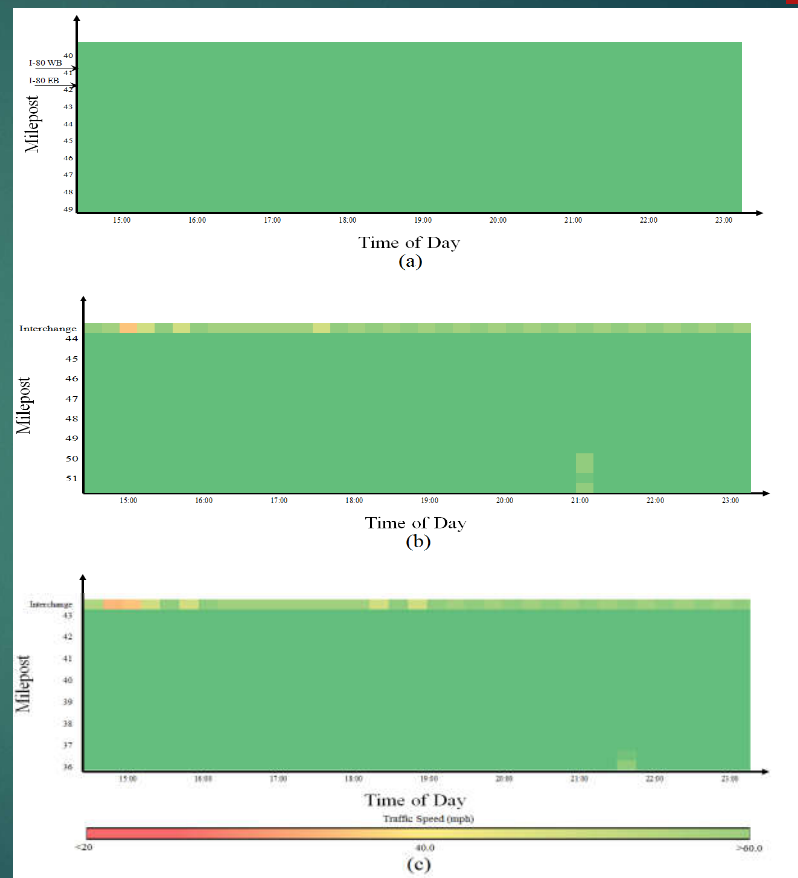


Heat map of (a) passenger cars and (b) truck volumes of I-80 Eastbound
Source: New Jersey Congestion Management Systems.

Case Study

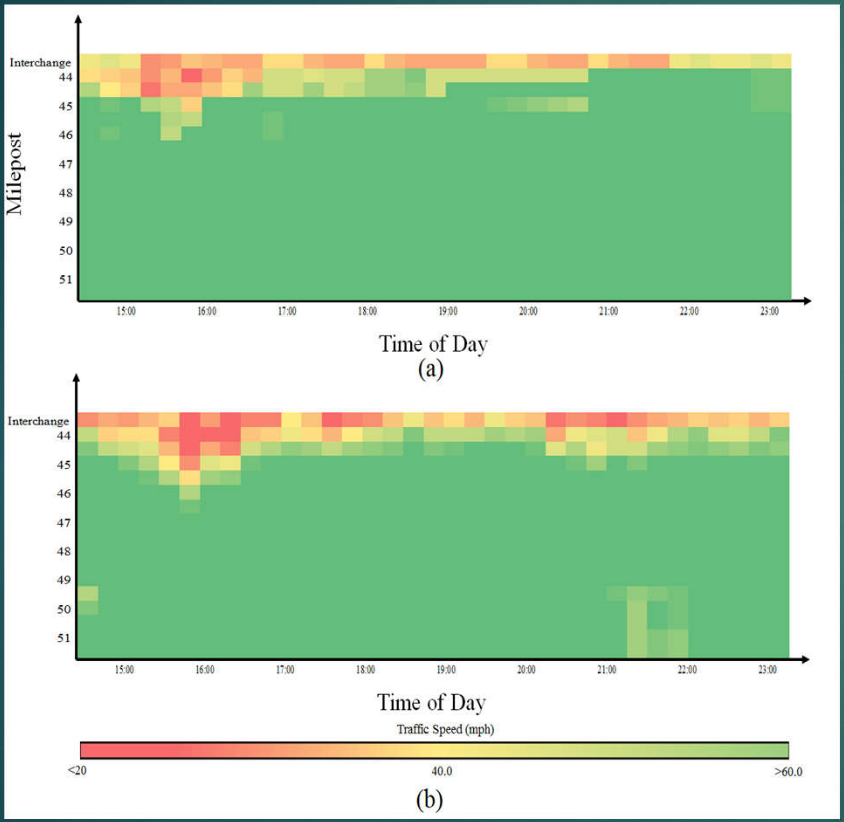


Heat map of I-287 SB of (a) Actual speed reported from INRIX (b) predicted speed from the CNN Model (c) predicted speed from the model of WIMAP-P

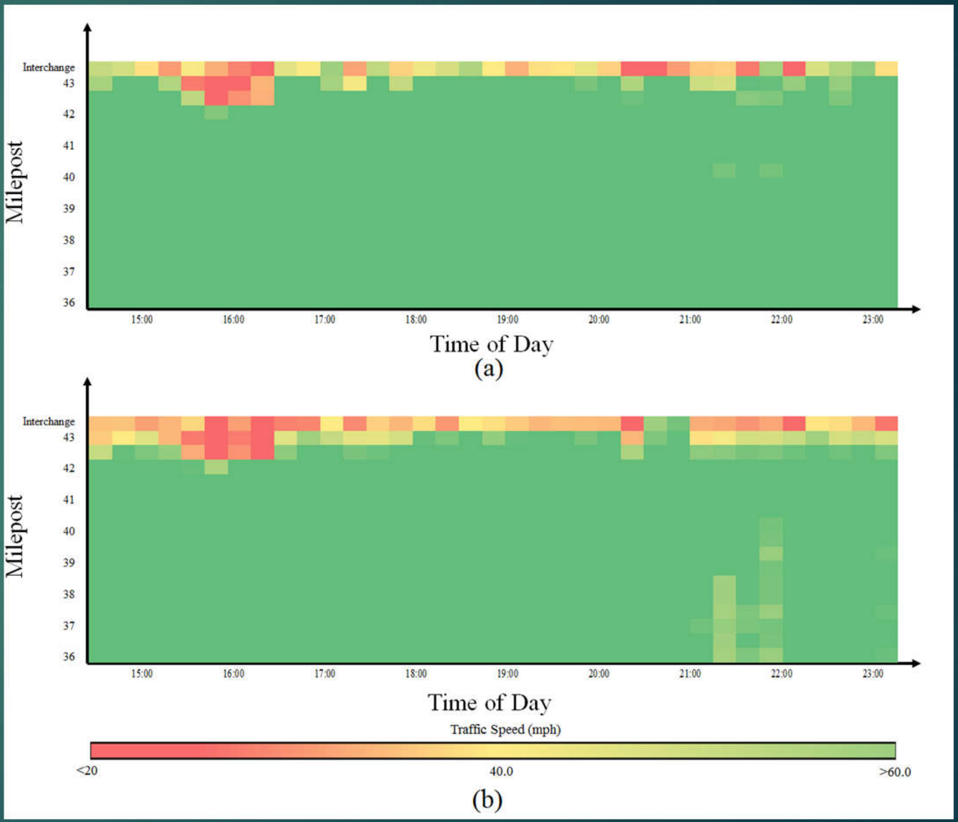


Heat map of traffic speed without work zone conditions for (a) I-287 SB (b) I-80 WB and (c) I-80 EB

Case Study

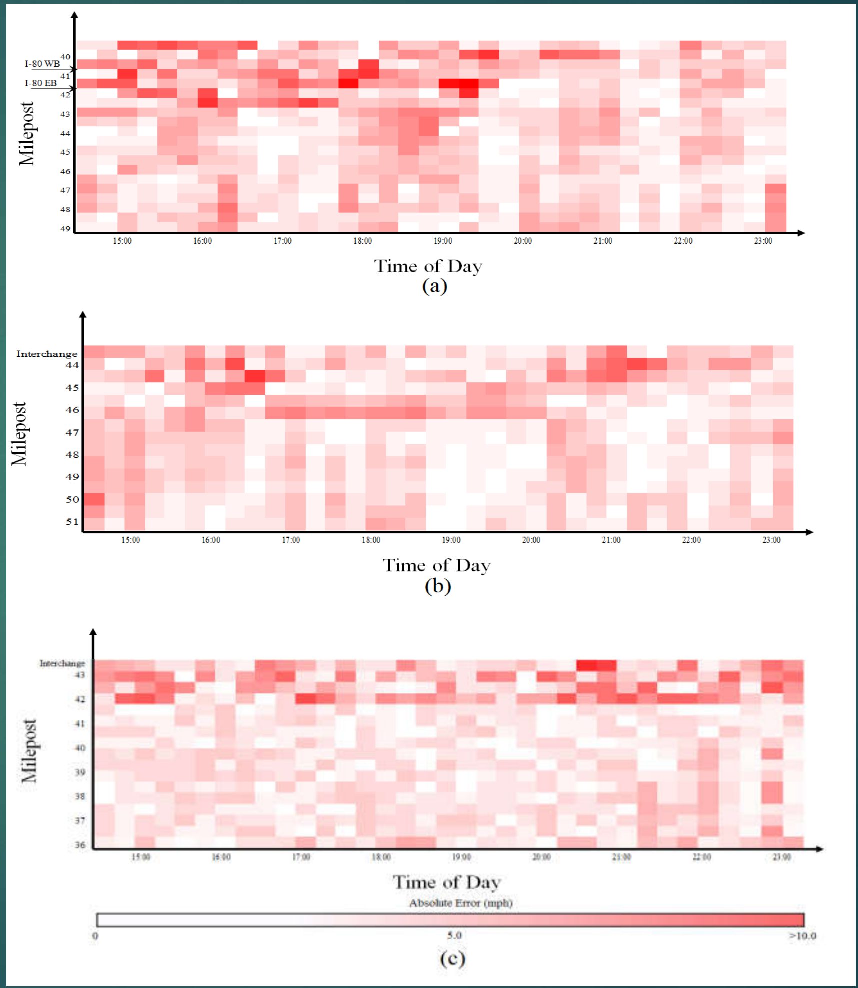


Heat map of traffic speed on I-80 WB from (a) the CNN prediction model (b) the actual traffic speed reported from INRIX.



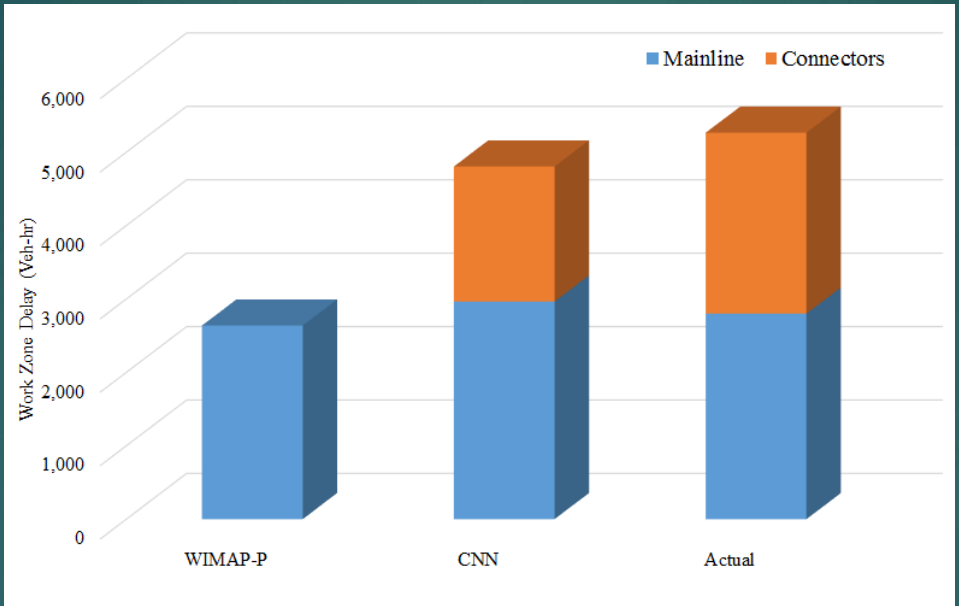
Heat map of traffic speed on I-80 EB from (a) the CNN prediction model (b) the actual traffic speed reported from INRIX

Case Study



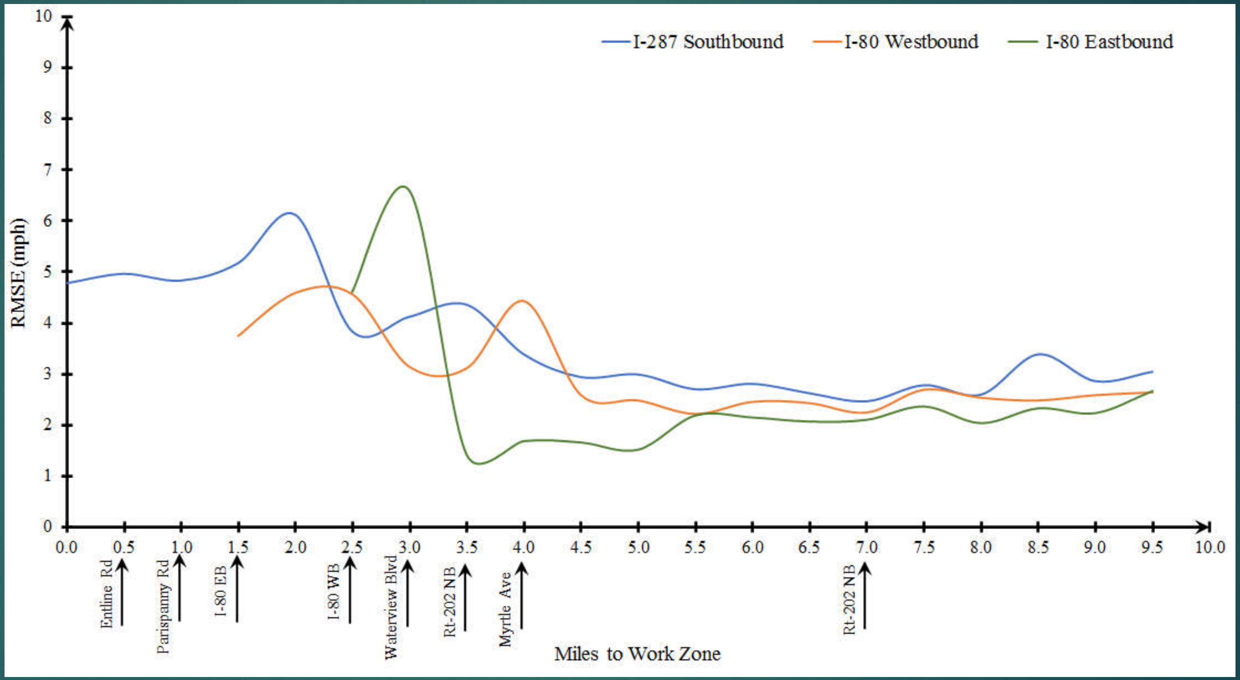
Heat map of absolute error of the CNN results again the actual speed for (a) I-287 SB (b) I-80 WB and (c) I-80 EB

Case Study



Comparison of total delay cost for both the mainline (i.e., I-287 SB) and the connectors segments (i.e., I-80 EB and I-80 WB) to the actual work zone delay.

Case Study



The RMSE values in variation of distance to work zone

Case Study

Two main categories of TMC segments are distinguished: Type 1, which is the TMC segments on the mainline immediate upstream to the on-ramp and Type 2, which is all the other TMC segments.

Type of TMC segment	Model	Number of Lanes	RMSE (mph) (% of testing data)		
			Shoulder Closure	One Lane Closure	Two Lane Closure
Type 1	Deep ANN	2	11.2 (5%)	9.5 (13 %)	NA (0 %)
		3	12.3 (8%)	9.1 (12 %)	10.5 (6 %)
		4	14.9 (4%)	11.0 (10 %)	11.3 (3 %)
	CNN	2	10.0 (5%)	9.2 (13%)	NA (0%)
		3	11.6 (8%)	8.2 (12%)	9.9 (6 %)
		4	14.1 (4%)	10.3 (10%)	10.6 (3 %)
Type 2	Deep ANN	2	6.4 (95%)	5.5 (87%)	NA (0%)
		3	5.9 (92%)	5.4 (88%)	7.3 (94 %)
		4	7.0 (96%)	5.7 (90%)	7.7 (97 %)
	CNN	2	6.0 (95%)	5.3 (87%)	NA (0%)
		3	5.4 (92%)	4.8 (88%)	7.2 (94 %)
		4	6.4 (96%)	5.8 (90%)	7.5 (97 %)

Applications

- Quantify the congestion costs (i.e., spatio-temporal)
- User delay costs
- User delay Vs. agencies costs
- Queue warning systems

Conclusions

- Connected roadways
- CNN outperforms Deep ANN and WIMAP-P
- Congestion mitigation plans
- Proximity to the mainline links immediate upstream segments
- Database

Future Research

- Optimal work zone scheduling with rerouting plans
- Work zone staging optimization
- Combination of work zone and accidents prediction modulus.


thank
you


Ask
Questions