Implementing Deep Learning-Based Traffic Prediction on Las Vegas Highways

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Introduction:

- Traffic congestion is one of the main issues facing the transportation industry.
- A recent growth in highway detectors makes data-driven traffic prediction techniques feasible.
- The Las Vegas cyber-physical traffic prediction system uses deep-learning models to perform predictions on one stretch of highway, but is very limited.

Purpose/Aim:

- Determine, through experimentation, the optimal conditions for deep learning-based traffic prediction on a given stretch of a highway in Las Vegas
- Expand the capabilities of the traffic prediction system (Figure 1) currently implemented in the Las Vegas urban area.

Methods:

- Create ARIMA (Autoregressive Integrated Moving Average) model to perform comparisons of prediction models.
- Train/test models using various time sampling periods (1, 5, 15 minutes) in order to determine which would result in best performance.
- Perform ablation studies with several methods of combining detector data (just main portion, main and feed-in, main and feed-out, and main and ramps) to determine which spatial combination would result in best performance.
- Expand model to accommodate other highways/examine which highways perform best.
- Obtain data from MySQL database, clean/prepare using interpolation and imputation algorithms, and test on eRCNN (Error Recurrent Convolutional Neural Network) and encoder decoder deep learning models.

Results:

- The 15-minute and 1-minute sampling periods were found to be the most accurate (Lowest MAE/MSE) (Figure 2 left).
- Just training/testing the models on the main portion of the highway leads to best/most consistent performance (Figure 2 right).
- The US-95 highway yielded exceptional results, the I-15 and CC-215 highways yielded reasonable results, and the I-515 and I-215 highways yielded the poorest results.
- The results were used to expand the prediction model from 26 to 99 active highway sensors (Figure 3).

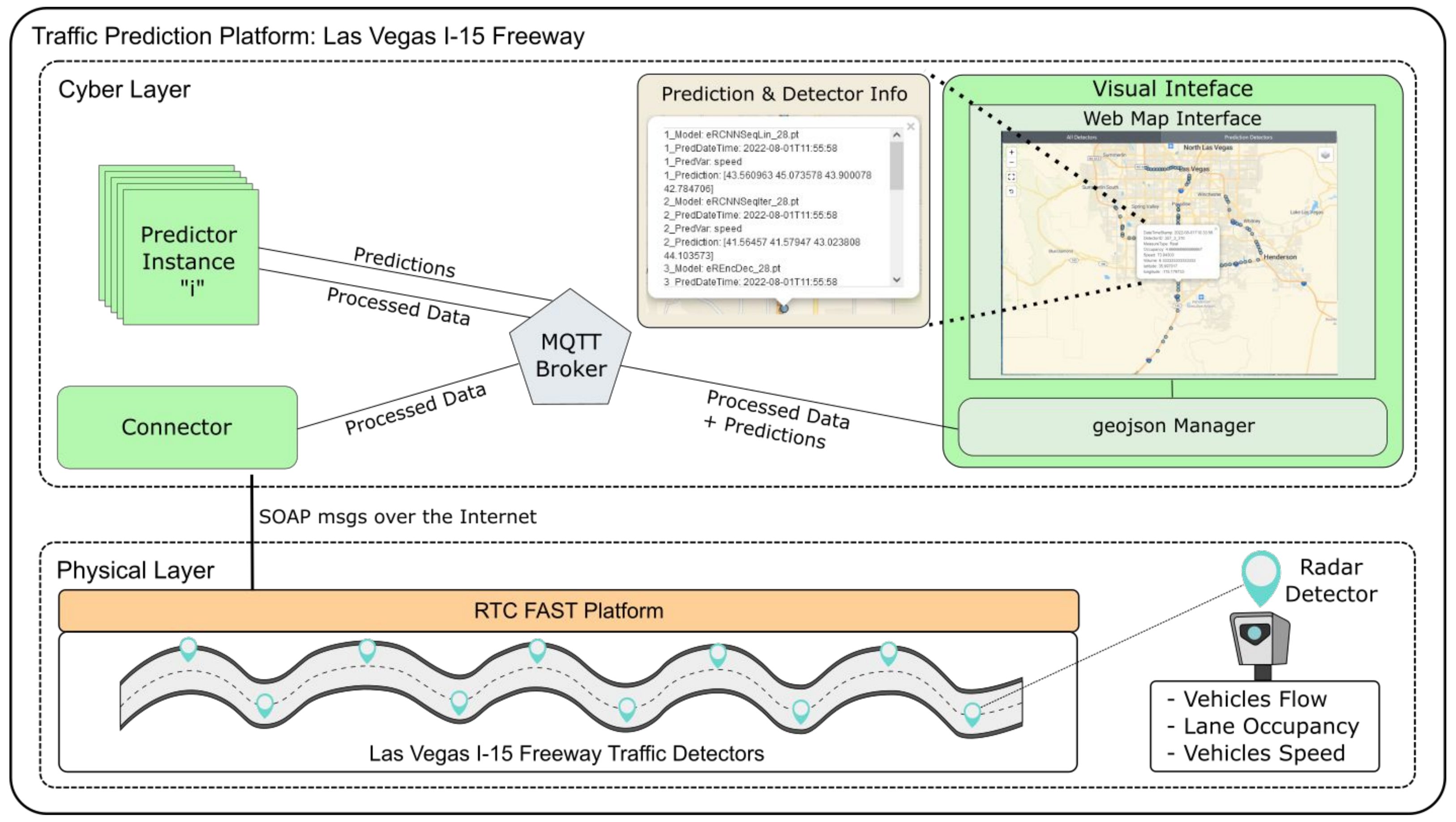

Figure 1. Cyber-Physical Traffic Prediction System Representation

Prediction Horizon (Minutes)	I-15 1-Min (MSE, MAE)	I-15 5-Min (MSE, MAE)	I-15 15-Min (MSE, MAE)	US-95 1-Min (MSE, MAE)	US-95 5-Min (MSE, MAE)	US-95 15-Min (MSE, MAE)
15	76.09, 5.53	77.89, 5.71	72.85, 5.85	25.83, 3.26	26.82, 3.36	24.76, 3.40
30	85.21, 5.95	89.07, 6.27	78.85, 6.00	27.74, 3.39	29.02, 3.51	25.72, 3.39
45	91.06, 6.20	92.41, 6.40	84.41, 6.23	29.14, 3.48	30.36, 3.58	27.51, 3.55
60	95.54, 6.34	97.65, 6.63	87.30, 6.31	30.17, 3.54	31.62, 3.64	28.29, 3.54
Average	**86.98, 6.00**	**89.26, 6.17**	**80.85, 6.10**	**28.22, 3.42**	**29.46, 3.52**	**26.57, 3.47**
Standard Deviation	**7.27, 0.31**	**7.24, 0.34**	**5.53, 0.18**	**1.63, 0.11**	**1.78, 0.10**	**1.40, 0.08**

***MSE: Mean Square Error
***MAE: Mean Absolute Error

Detectors Included	eRED I-15 (MSE, MAE)	eRCNN SeqIter I-15 (MSE, MAE)	eRCNN SeqLin I-15 (MSE, MAE)	eRED US-95 (MSE, MAE) eRCNN	eRCNN SeqIter US-95 (MSE, MAE)	eRCNN SeqLin US-95 (MSE, MAE)
Main Only	96.42, 6.86 95.14, 6.7 103.38, 7.35 100.77, 6.94 **98.93, 6.96** **3.31, 0.24**	72.97, 5.88 77.47, 5.98 81.37, 6.11 85.82, 6.25 **79.4, 6.06** **4.75, 0.14**	66.74, 5.29 74.41, 5.62 80.78, 5.94 84.61, 6.11 **76.64, 5.74** **6.78, 0.31**	99.37, 7.17 71.14, 6.22 97.87, 7.53 44.46, 4.63 **78.21, 6.39** **22.49, 1.12**	32.55, 3.92 33.85, 3.97 34.77, 4.04 33.87, 3.9 **33.76, 3.96** **0.79, 0.05**	24.06, 3.11 25.79, 3.24 27.25, 3.33 28.37, 3.42 **26.37, 3.28** **1.62, 0.11**
Main and Feed-In	541.2, 16.4 193.81, 10.1 164.86, 9.16 163.33, 8.98 **265.8, 11.18** **159.47, 3.07**	140.84, 8.21 141.52, 8.19 143.37, 8.25 142.43, 8.18 **142.04, 8.21** **0.95, 0.03**	136.7, 8.41 137.44, 8.1 139.3, 8.15 140.52, 8.19 **138.48, 8.15** **1.51, 0.03**	68.7, 6.2 44.97, 4.8 51.72, 5.26 41.51, 4.46 **51.73, 5.18** **10.47, 0.65**	33.32, 4.03 33.78, 4.05 34.4, 4.08 34.67, 4.04 **34.04, 4.05** **0.53, 0.02**	24.64, 3.18 26.73, 3.33 28.29, 3.46 29.62, 3.57 **27.32, 3.39** **1.85, 0.15**
Main and Feed-Out	130.6, 8.01 133.05, 8.04 167.37, 9.43 129.95, 7.91 **140.24, 8.35** **15.7, 0.63**	127.28, 7.91 128.92, 7.94 129.6, 7.95 130.2, 7.95 **129.0, 7.94** **1.09, 0.02**	122.83, 7.74 124.73, 7.77 126.61, 7.82 128.77, 7.87 **125.74, 7.8** **2.2, 0.05**	77.8, 6.75 69.56, 6.25 38.69, 4.37 238.34, 11.2 **106.1, 7.15** **77.73, 2.51**	29.1, 3.66 31.07, 3.77 31.61, 3.77 32.04, 3.76 **30.95, 3.74** **1.12, 0.05**	24.05, 3.12 25.79, 3.26 27.18, 3.35 28.51, 3.44 **26.38, 3.29** **1.65, 0.12**
Main and Ramps	160.34, 9.06 137.34, 8.15 347.18, 13.1 189.08, 9.91 **208.49, 10.1** **82.15, 1.88**	137.52, 8.12 138.81, 8.13 141.1, 8.17 140.29, 8.11 **139.43, 8.13** **1.37, 0.02**	133.67, 8.03 135.56, 8.04 138.11, 8.09 138.69, 8.1 **136.51, 8.07** **2.02, 0.03**	241.24, 12.0 241.26, 11.9 295.34, 13.7 238.2, 11.93 **254.0, 12.39** **23.9, 0.78**	232.2, 12.07 233.78, 12.1 233.8, 12.04 233.6, 12.03 **233.34, 12.1** **0.67, 0.03**	228.09, 11.5 227.8, 11.48 228.7, 11.53 229.44, 11.6 **228.52, 11.5** **0.62, 0.03**

Figure 2. Experimentation Results (Left:Time Sampling Periods, Right: Spatial Combinations)

Discussion:

- 15-minute sampling period is the best because it allows the least room for missing/inaccurate data.
- Including ramps lead to worst performance, but most consistent results across the different time horizons.
- The different highways yield different performance results because certain segments may have detectors with more inconsistent data/spatial gaps between detectors may lead to inconsistencies in traffic readings.

Conclusions & Future Research:

- Informed expansion of model was shown to be feasible, and was accomplished.
- Future research includes finding out why different highways have poorer/improved performance, finding out why the inclusion of ramp detectors leads to more consistent results.

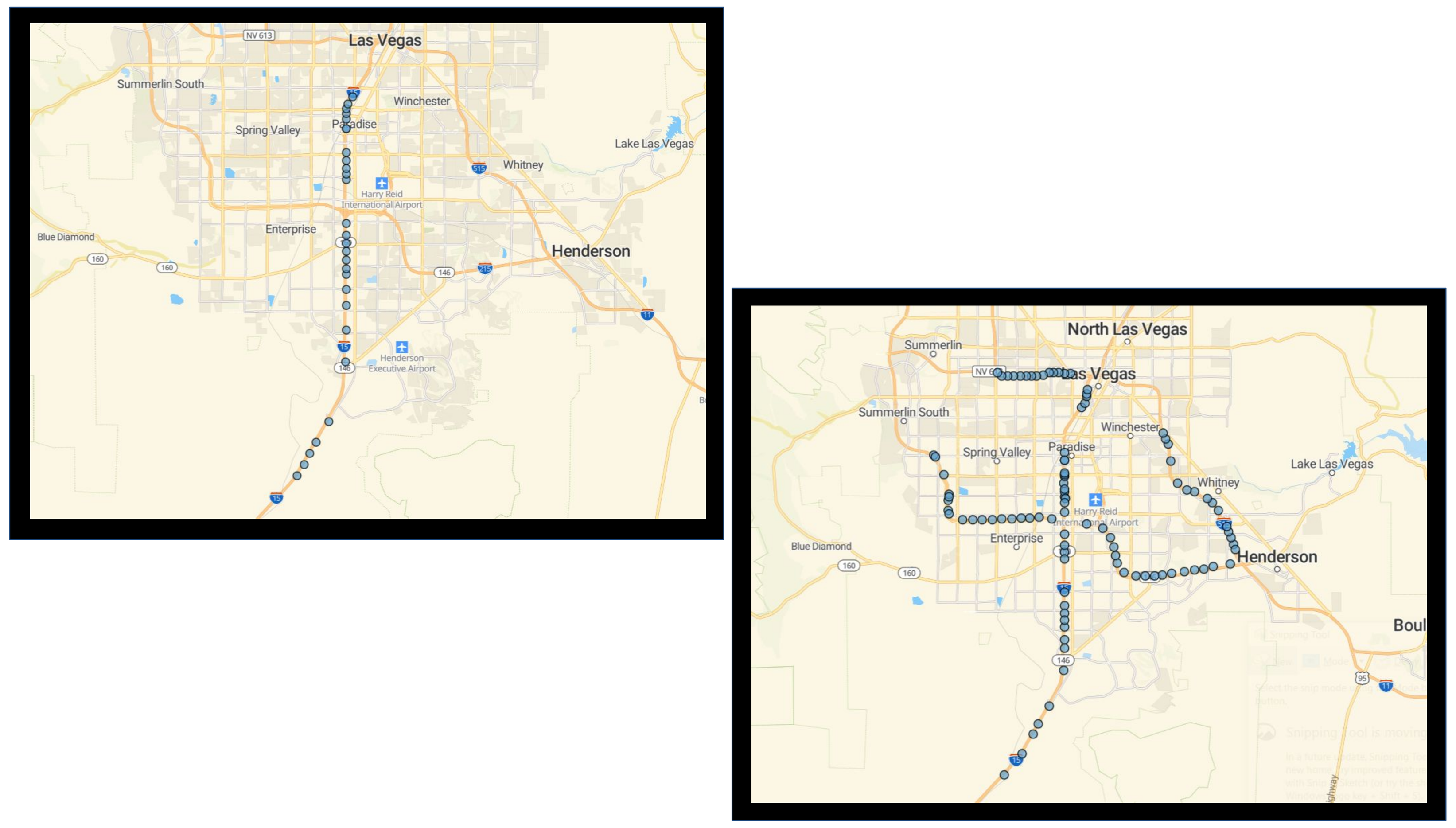

Figure 3. Before (Left) and After (Right) of Traffic Prediction Interface

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