An Exploration of Artificial Intelligence and Deep Learning

Emerging & Innovative Technologies

State of Vermont

Presented by

John Quinn, Secretary of Digital Services and State CIO

Award Nominee – Josiah Raiche

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Executive Summary

The State of Vermont's Agency of Digital Services (ADS) has been working with its partner Agency, the Agency of Transportation (AOT), to apply Deep Learning (DL) through Artificial Neural Networks (ANNs) to their data to gain insight into the state of the AOT's highway assets. The individual leading this effort is Systems Developer Josiah Raiche. It is through Josiah's efforts to understanding what Artificial Intelligence (AI) is and how to apply ANNs to data that both AOT and ADS have gained a better understanding of their data and has allowed both agencies to begin to make strategic decisions. Josiah has also been instrumental in educating his leadership in AI, so that we can make strategic decisions about where and how to best apply AI to the benefit of the taxpayers of Vermont.

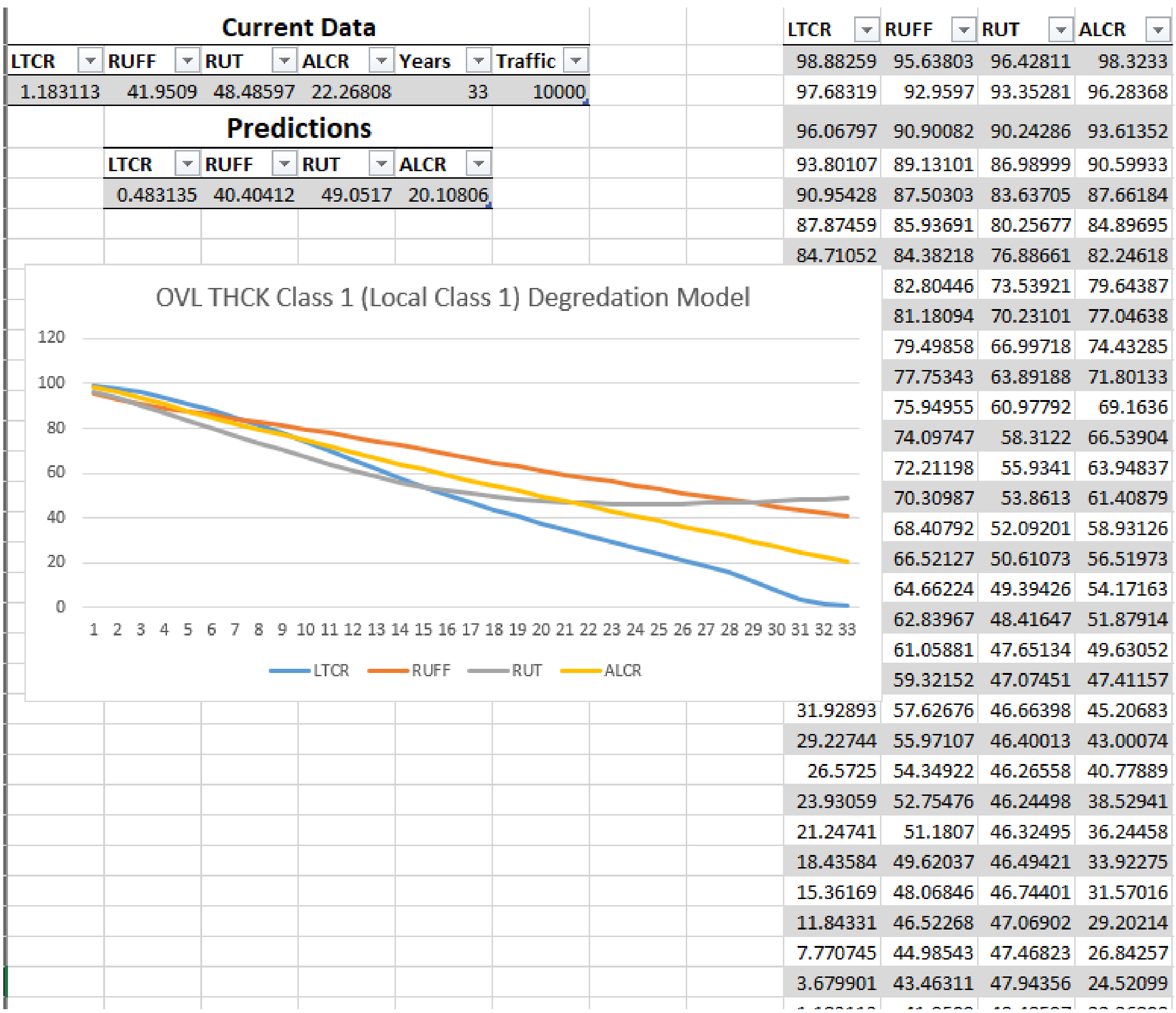
Concept

The Vermont Agency of Transportation (AOT) has a number of rich datasets for their transportation-related assets. AOT has accumulated years of pavement, bridge, and travel data. However, the process to analyze these datasets required that subject matter experts pore over these datasets, sometimes for months, to extract useful statistical information, such as degradation over time.

With the recent rise of AI and Machine Learning entering into the IT vernacular, AOT had an opportunity to improve its abilities to analyze its data. Coupled with research being done at the Vermont Agency of Digital Services (ADS), it seemed the time was right for Vermont state government to engage in this valuable data science practice.

Significance

Systems Developer Josiah Raiche was researching Artificial Intelligence (AI), Artificial Neural Networks (ANNs), and Deep Learning (DL). Based on his research, he developed a proof-of-



Current Data

LTCR	RUFF	RUT	ALCR	Years	Traffic
1.183113	41.9509	48.48597	22.26808	33	10000

Predictions

LTCR	RUFF	RUT	ALCR
0.483135	40.40412	49.0517	20.10806

LTCR	RUFF	RUT	ALCR
98.88259	95.63803	96.42811	98.3233
97.68319	92.9597	93.35281	96.28368
96.06797	90.90082	90.24286	93.61352
93.80107	89.13101	86.98999	90.59933
90.95428	87.50303	83.63705	87.66184
87.87459	85.93691	80.25677	84.89695
84.71052	84.38218	76.88661	82.24618
	82.80446	73.53921	79.64387
	81.18094	70.23101	77.04638
	79.49858	66.99718	74.43285
	77.75343	63.89188	71.80133
	75.94955	60.97792	69.1636
	74.09747	58.3122	66.53904
	72.21198	55.9341	63.94837
	70.30987	53.8613	61.40879
	68.40792	52.09201	58.93126
	66.52127	50.61073	56.51973
	64.66224	49.39426	54.17163
	62.83967	48.41647	51.87914
	61.05881	47.65134	49.63052
	59.32152	47.07451	47.41157
31.92893	57.62676	46.66398	45.20683
29.22744	55.97107	46.40013	43.00074
26.5725	54.34922	46.26558	40.77889
23.93059	52.75476	46.24498	38.52941
21.24741	51.1807	46.32495	36.24458
18.43584	49.62037	46.49421	33.92275
15.36169	48.06846	46.74401	31.57016
11.84331	46.52268	47.06902	29.20214
7.770745	44.98543	47.46823	26.84257
3.679901	43.46311	47.94356	24.52099

Figure 1: Early ANN Outputs to Excel

concept for using an ANN to analyze pavement condition. His early work predicted degradation faster than the preferred mathematical models, but the work was promising. Josiah added the ability generate the models to Excel (see fig. 1), allowing the users to analyze the results that Josiah was getting, and test new scenarios.

All of Josiah's work to this point had been hard coded. He was developing the ANNs specific to the data that they were processing. If the ANNs were going to be versatile, he needed to write a generic interface for loading data and assign criticality (bias) to key data point. So he designed a flexible interface that would allow users to load data from a .CSV file, set their biases, and run the ANNs through a series of training. Once a sufficient number of training had been completed, the user was able to output the result model to Excel for further analytics and use. With this version of generic ANNs, Josiah was able to successfully and accurately create a predictive model for AOT's bridge degradation.

At about this time, several AI researchers were pointing out to the industry the opacity of the current work being done by AI. Results were being generated that were correct, however, there was no fundamental way of understanding how ANNs were achieving their results. Josiah designed a method for automatically mapping his ANNs and visualizing the impacts of the data points in a given dataset. Figure 2 shows both numerically positive (blue) and negative (red) impacts, as well as the relative weight of the impacts, based on line thickness.

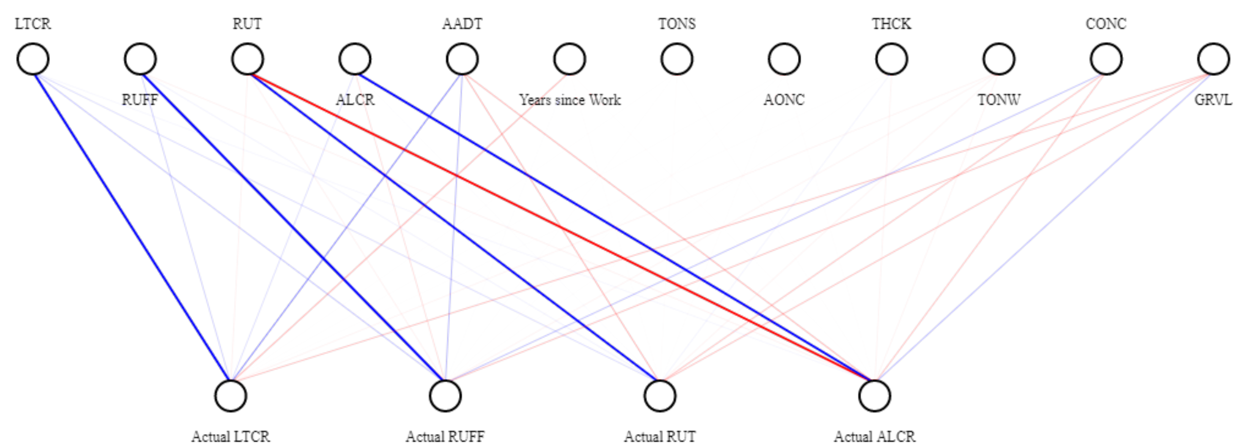


Figure 2: ANN data point visualization

At this point, Josiah began exploring the use "slices" of the data points vs. network output to determine the veracity of the ANNs' output. His thought was to take multiple slices and compare them for similarity. The more similar the slices, the more likely that the ANN was performing correctly.

His next neural network analysis was of rail bridges. This predictive analysis attempted to determine what factors were significant to the load rating of a rail bridge. The result of this analysis showed that to improve load rating for rail bridges, it would probably be best to focus maintenance activities on abutments, the superstructures, and then decks. Substructures were not as significant to load rating as one might think.

At this time, Josiah was considering the impact of his work as well as the work AI industry. He wrote a whitepaper on the societal impact of AI, which he shared with leadership. His points were insightful and cautionary. AI has a potential to bring business to rural settings, just as it has potential to take over the jobs of our lowest paid and most vulnerable. We need to consider the impacts as we move to this technology.

The next dataset that Josiah analyzed was tire grip against pavement impacted by winter weather. While he was not satisfied with the results, which he felt were not conclusive enough for use, he was able to show the additional level of complexity he applied to analysis (see fig. 3).

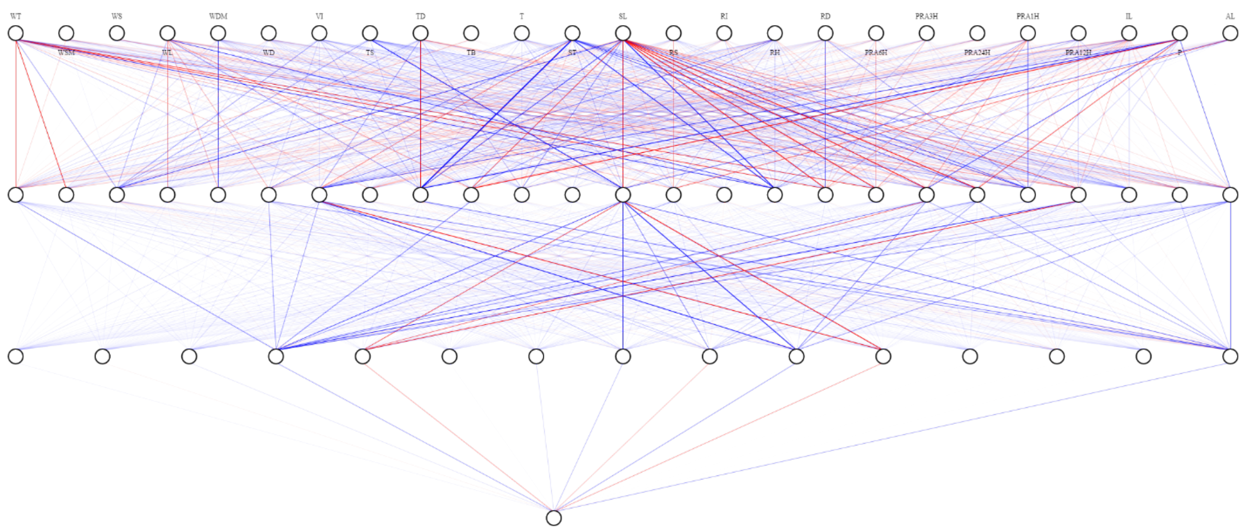


Figure 3: Four-Layer "Perceptron" for Grip Analysis

In December of 2017, AOT undertook a special project in collaboration with the University of Vermont to use machine learning to identify and classify roadside signage. Josiah was asked to participate in the role of special advisor. Josiah's valuable contributions to the project have been his familiarity with AOT data, GIS, artificial intelligence and machine learning, and an understanding of the complexity of the challenge, based on prior research. Josiah also performed an analysis to help set the parameters of the project:
https://app.powerbi.com/view?r=eyJrIjoiZDMyZjI2ZDktNGZlMy00YzdjLTg4NmUtYTQ0ODJiYmZkY2RiIiwidCI6IjIwYjQ5MzNiLWJhYWQtNDMzYy05YzAyLTcwZWRjYzc1NTljNiIsImMiOjN9&pageName=ReportSection74b797231badf95b49aa

Impact

As a result of Josiah's passion and effort, AOT now has:

A robust pavement model prototype that can handle variations in traffic volumes and more accurately models rare treatments. At the height of its analyses, the model was over 85% accurate in its next-year predictions;

An initial proof of concept that predicted 1, 5, and 10-year condition ratings for the decks of all the bridges in the state, using over 100 dimensions of data. The AI can generate customized models for each bridge. Initial results are looking promising;

A research project underway to couple computer vision with AI trying to identify sign locations with high accuracy from a single-camera stream of images. This project holds the potential to also quickly identify damage or destruction of signs, guardrail, and eventually many other potential hazards in near real time. If successful, this would also be the first publicly-available sign classifier for American road signs.

This type of self-driven exploration of technology and his dedication to improving the delivery of service to Vermonters through new and emerging technologies makes Josiah Raiche an exceptional candidate for this award. Without the creativity and passion of our dedicated IT professionals like Josiah, we would not be advancing at the rapid pace that we are today. I hope that you consider Josiah Raiche for the award.