Vehicle Traffic Estimation Using Deep Learning

Meetkumar Patel and **Daniel L. Silver**
Jodrey School of Computer Science, Acadia University, Wolfville, NS Canada B4P 2R6

People have access to the weather forecast and the current vehicle traffic situation via web applications, but there is no application to estimate traffic congestion over the next couple of days. The main objective of this research work is to predict hourly vehicular traffic density and flowrate up to two days into the future. To do this two subproblems must be solved: (1) estimates of actual hourly traffic density and flowrate must be made based on images from public web cameras, and (2) future hourly values for traffic density and flowrate must be predicted given prior traffic values and future weather, calendar, and special event data (Patel 2021).

To solve the first problem, CNN and LSTM networks are utilized to predict the number of new and the total number of vehicles from images captured by a Nova Scotia Webcams (NSw). A challenge with this image data is the varied time delay of 3 to 7 seconds between consecutive frames. We developed software to prepare a series of webcam images that focus on the region of interest containing only vehicles going in one direction (see Figure 1). Pre-processed images along with the inter-frame time data are used to train various ML algorithms to extract the vehicle counts.

A traditional CNN model is trained to estimate the total number of vehicles in the frame and this worked quiet well. To predict the number of new vehicles per frame requires a more complex approach because of the temporal aspect of the problem and the difference in time between the webcam frames. A CNN-LSTM approach was taken that accepts a sequence of two frames as well as the inter-frame time. After modest results, we trained a two-image input CNN model which statistically performed better. The best approach combined the problem of predicting the two vehicle counts values; a Multiple Task Learning (MTL)-CNN was developed that accepted two images and the inter-frame time and output both counts. The MTL-CNN performed with a mean absolute percentage error (MAPE) of 20.38% for the number of new vehicles per frame and 18.56% for the total number of vehicles per frame. The predicted values per frame are used to estimate the hourly traffic flowrate and density over 60 minutes of webcam images.

To solve the second problem, the estimated traffic metrics of hourly flowrate and density are used as target labels for training models to predict similar values for up to two days into the future. The hourly traffic data is combined with weather data, calendar data and special event data to create a time series sequence. We explore this time series problem with recurrent LSTM neural networks. A model is developed to predict the traffic for the next hour $t + 1$ given prior values i at times t of traffic flowrate $FR_t(i)$ and density $D_t(i)$, with weather $W_t(i)$, calendar and time and special event data $C_t(i)$ (see Figure 2). We explored the use of this model to predict traffic for up to two days by rolling the predictions forward. We investigate an MTL approach to predict both flowrate and density using an LSTM model (Figure 2). An MTL-LSTM model is trained and tested using a k-fold cross-validation approach. The MTL-LSTM model achieves a MAPE of 19.35% and 27.50% for flowrate and density using observed weather data, respectively. In the case of forecasted weather data, the MAPE for flowrate and density increases to 20.51% and 31.10%, respectively.

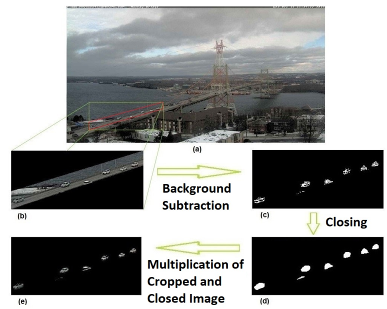

Figure 1: Image Processing

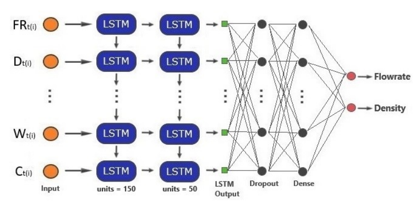

Figure 2: Architecture to predict traffic for next two days.

References

Nova scotia webcams. https://www.novascotiawebcams.com/en/webcams/mackay-bridge/.

Patel, M. 2021. Vehicle traffic estimation using deep learning. Master's thesis, Msc Thesis. Acadia University, Canada.