Stay In Your Lane!

Automated Bike Lane Enforcement With Neural Network Image Classification

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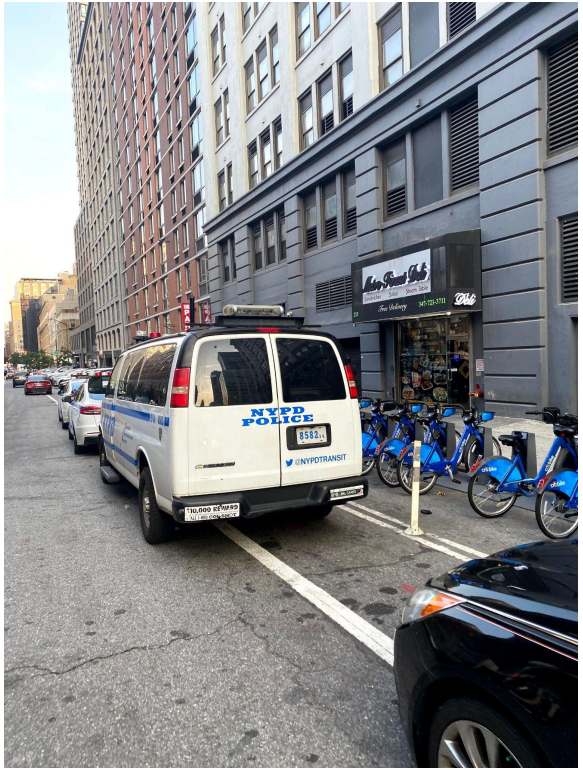
Outline:

- The Problem
- Business Understanding
- Purpose of Analysis
- Data
- Methods & Results
- Recommendations
- Next Steps

What's the problem?

Insufficient enforcement of bike lane traffic laws creates serious safety issues for cyclists.

- Cyclists forced to weave through traffic
- Increased risk of "dooring"



Business Understanding:

NYC Dept. of Transportation: “Request for Expressions of Interest” (9/15/21)

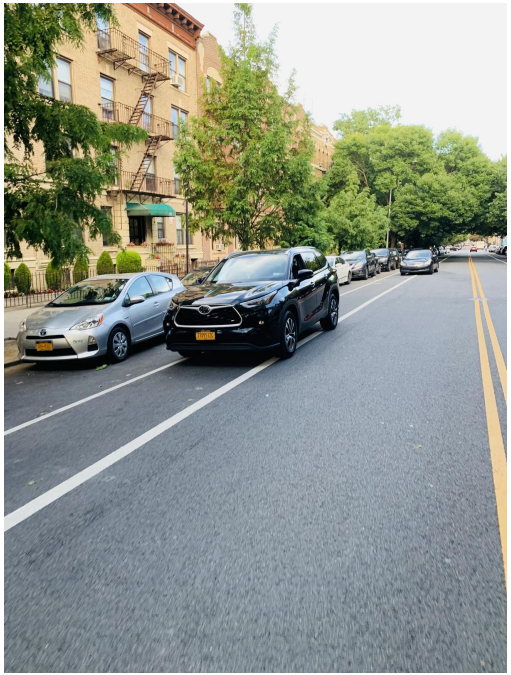
“discourage vehicles from illegally stopping...or otherwise blocking bike lanes throughout the City”

Perhaps similar to ABLE system for bus lanes (see Appendix)

Purpose of Analysis

Image classification: Is there a car in the bike lane?

- Empty bike lane vs. Vehicle in bike lane
- First step toward automation
- Use case: stationary cameras on the street

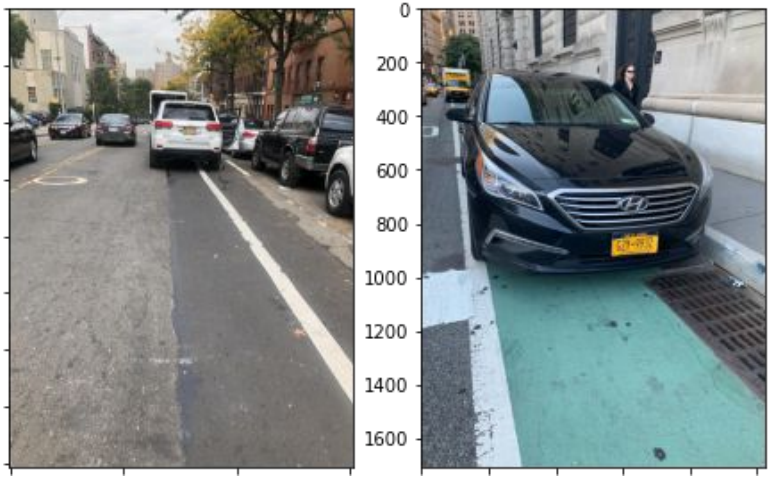


Data: Collection

Lots and lots of photos of bike lanes:

- Manual collection
- Reported app (Twitter and Ryan Gravener)
- Google Maps Street View

Obstructed by vehicles



Empty

(Examples of unused images in Appendix)

Data

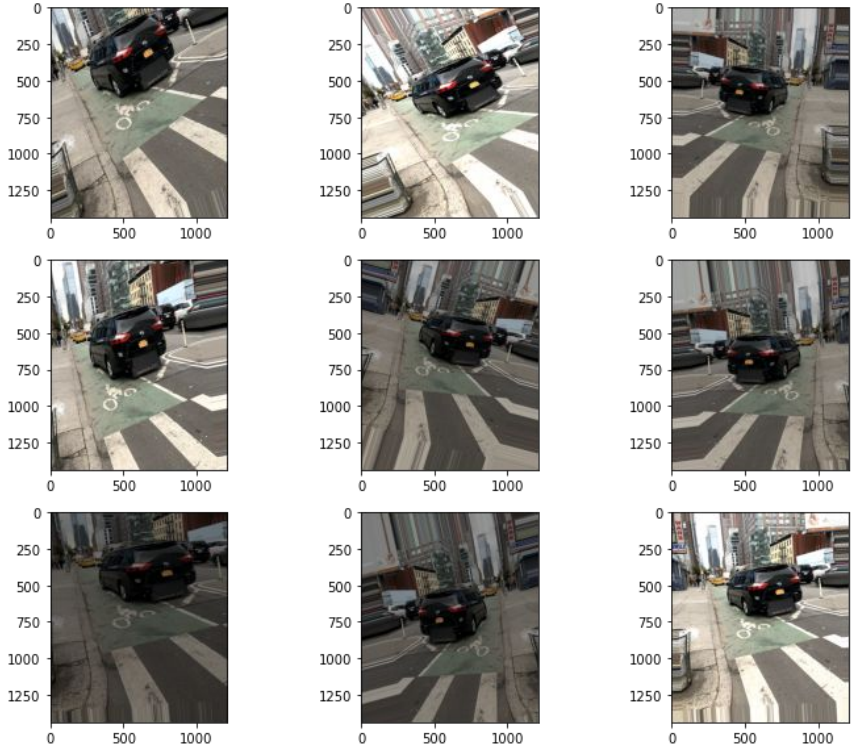
Over 1,800 images in total

- Fairly even class balance
- Validation and holdout/test sets of 100 (50 of each class)

Data

Image augmentation

- Artificially increase size of dataset
- Avoid overfitting
- “On the fly” during model training



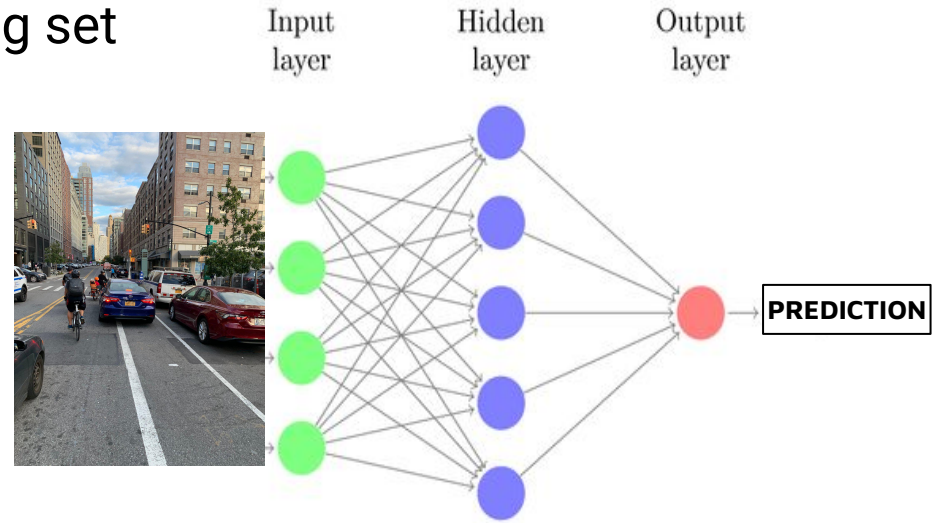
First Simple Model

Fully Connected Dense Neural Network

- Single layer
- Evaluated on smaller initial training set

Validation accuracy: 70.63%
Validation precision: 65.3%

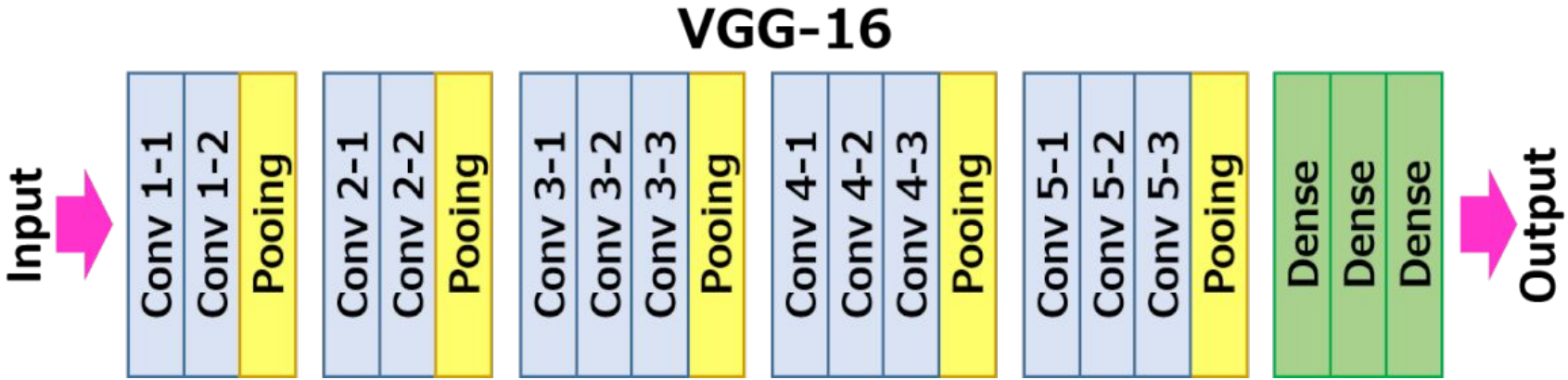
Precision = minimizing false positives



Method & Results:

Transfer learning from pre-trained model

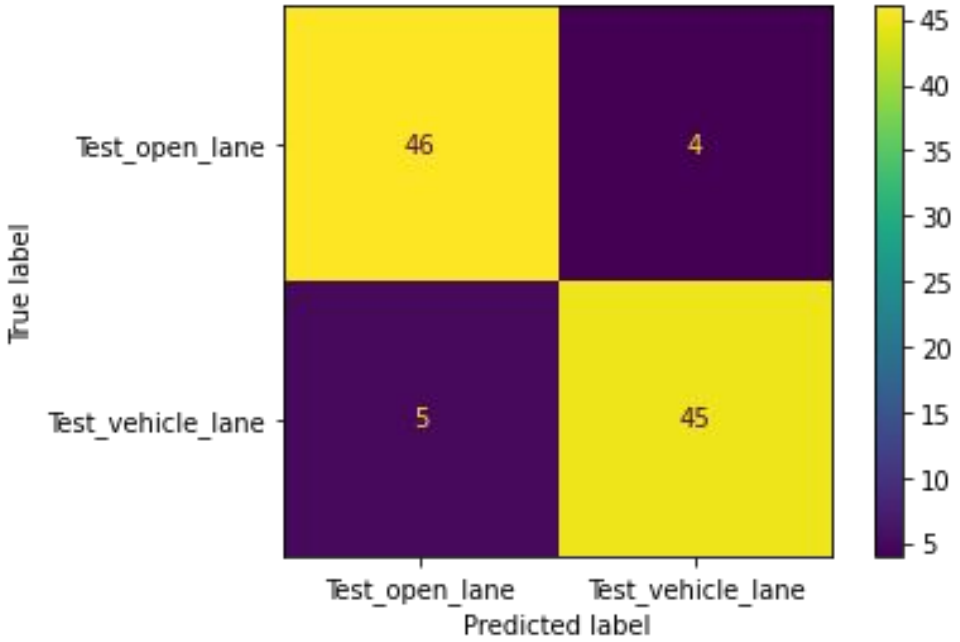
- VGG-16 base model
- Dense layers added on top



Method & Results:

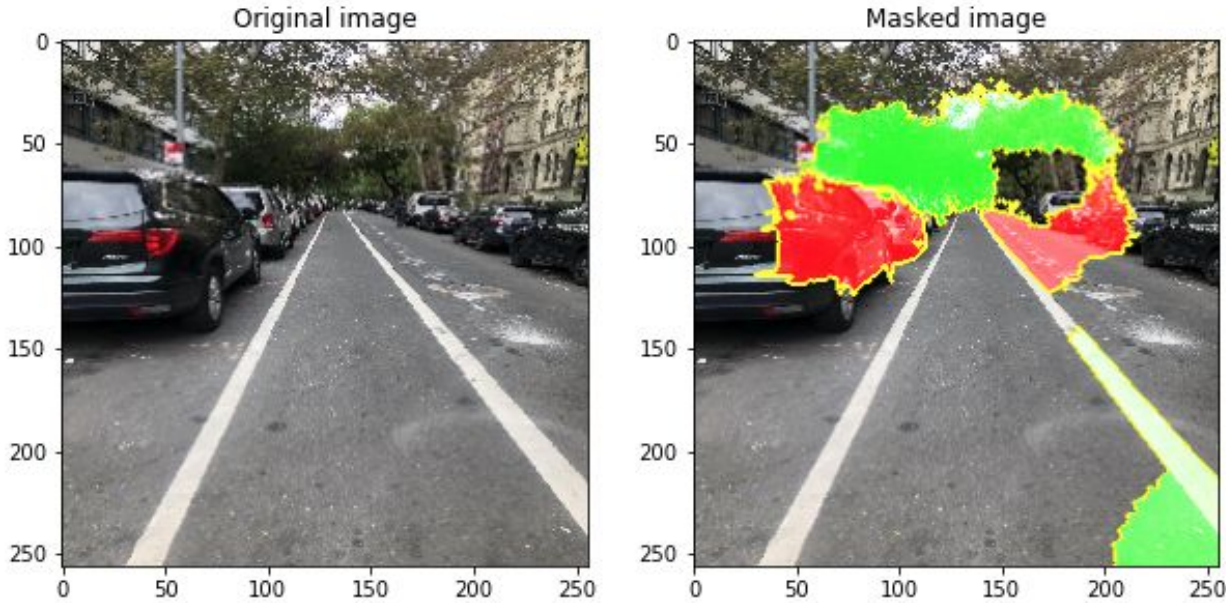
Validation accuracy: 94%
Validation precision: 100%

Testing accuracy: 91%
Testing precision: 92%



Method & Results:

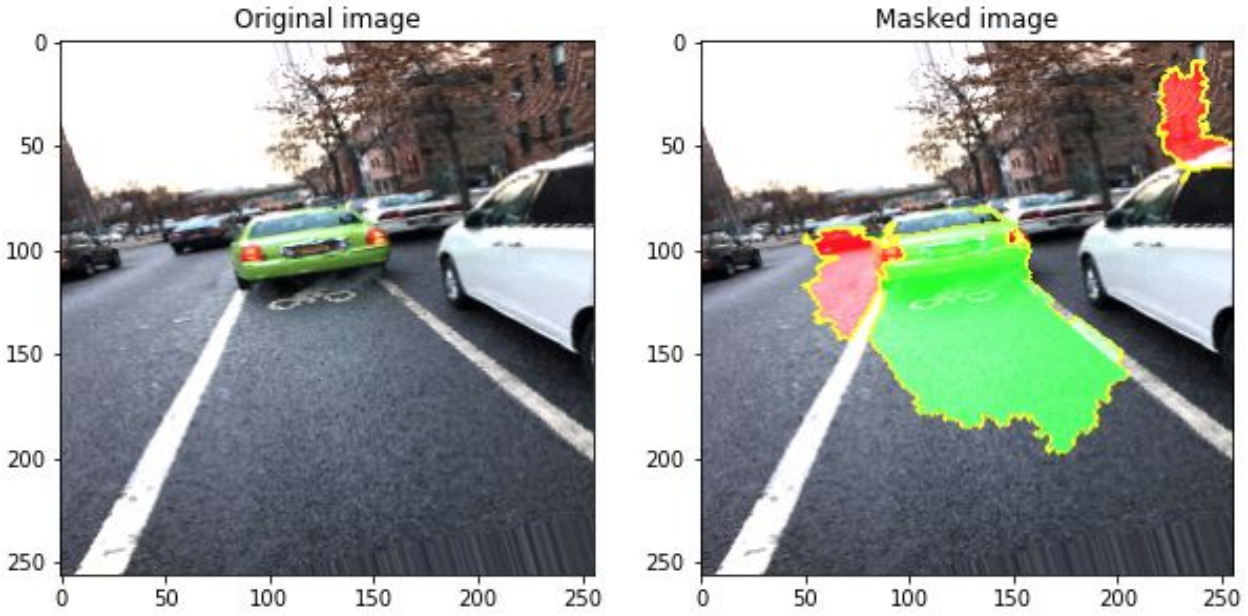
Using Lime to inspect model decision-making: Empty bike lanes



https://github.com/marcotcr/lime

Method & Results:

Using Lime to inspect model decision-making: Obstructed bike lanes



https://github.com/marcotcr/lime

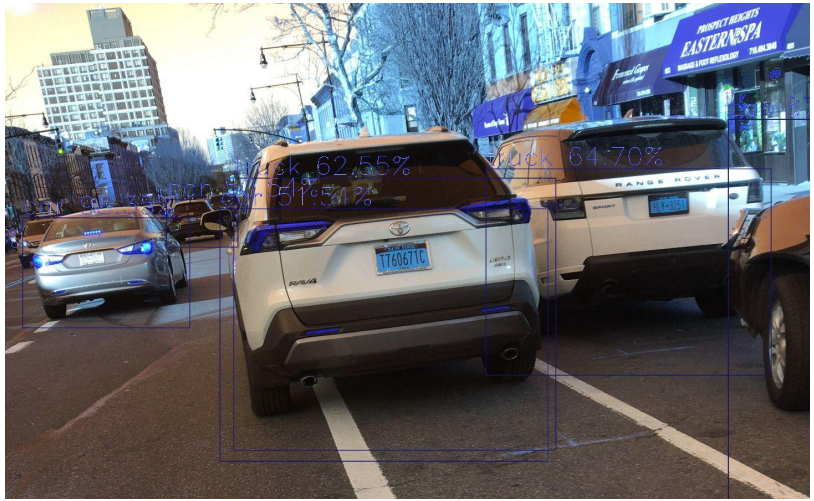
Recommendations

Automated enforcement can make streets safer for cyclists

- Increase ticketing efficiency, consistency
- Decrease active police engagement
- Stationary cameras pointing down bike lanes
  - Tickets vehicles stopped for >30 seconds
  - ID problematic areas with 311 submission location data

Next Steps

- **More data**
- Usage at night *(preliminary results in appendix)*
- Detection: ID/locate *which* vehicle is blocking the bike lane
- Connect to Reported app



Thank you!

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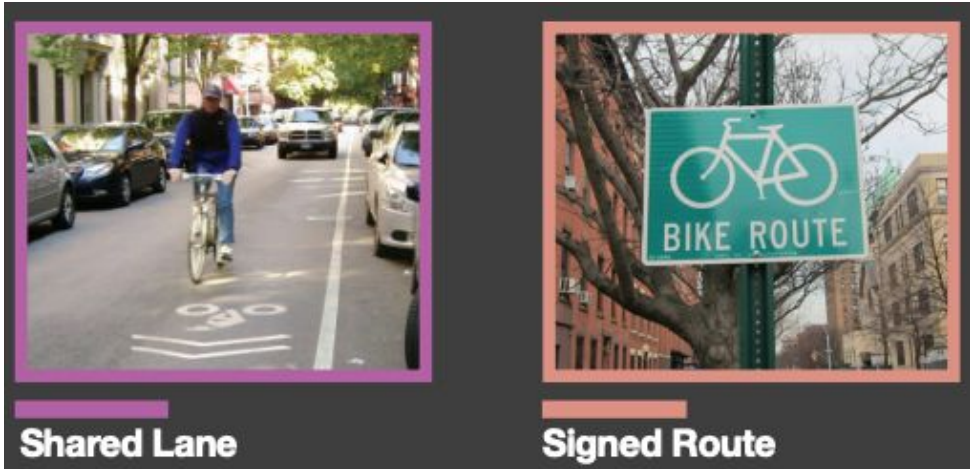
Appendix: Types of Bike Lanes

Targeted for enforcement:

Not included in proposal:



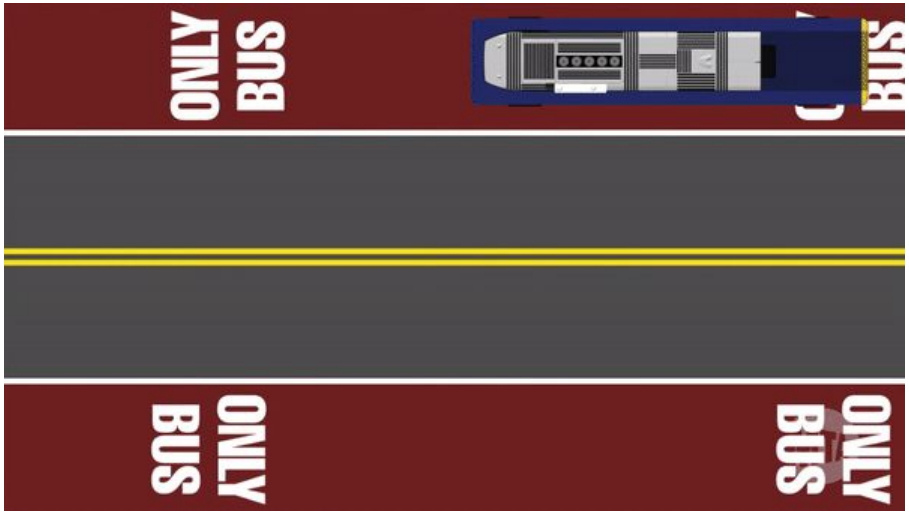
Details from Addendum #3 of DOT's RFEI, downloadable at https://passport.cityofnewyork.us/bare.aspx/en/fil/download_public/EF457A44-4ADD-4367-AC3F-6AFF6C0F3DEA

Images take frrom legend of NYC bike map, accessible at: https://www1.nyc.gov/html/dot/html/bicyclists/bikemaps.shtml

Appendix: ABLE

“Automated Bus Lane Enforcement” (ABLE) system:

- Implemented by Siemens Mobility starting in 2010
- Expanded to several routes
- Cameras on buses automatically capture violators
- Increase in routes’ speed and ridership



https://www.youtube.com/watch?v=vtCtdualqJ4

Appendix: ABLE

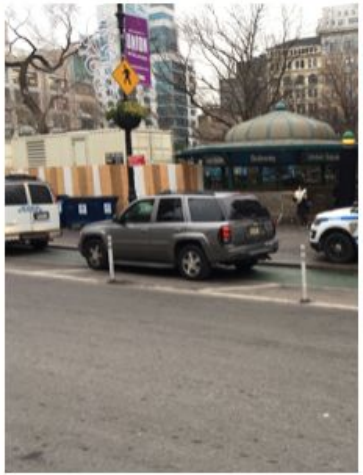
“Automated Bus Lane Enforcement” (ABLE) system:

https://www.mobility.siemens.com/us/en/company/newsroom/short-news/first-ever-mobile-bus-lane-enforcement-solution-in-new-york.html

Appendix: Unused Images

Over 200 images were removed from the original dataset after being deemed inappropriate for this task.

Too close; can't see lane lines



Wrong perspective

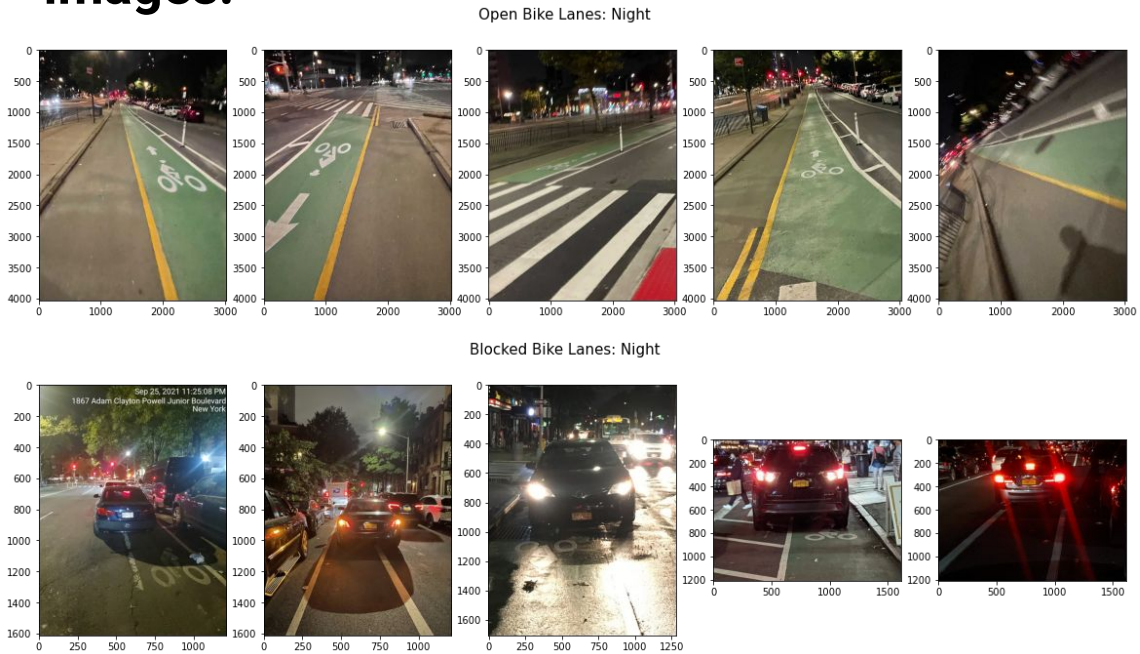
Cyclists obscure view of lane

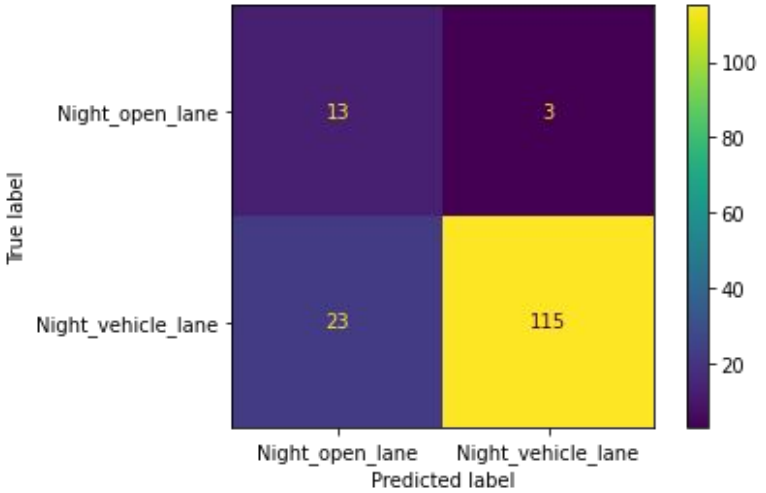
Nighttime

Ambiguous in far distance

Appendix: Bike Lanes at Night

Final model was also tested on an imbalanced dataset of nighttime images:





Thanks to Seth Kaufman for the images of open lanes at night