

# Stay In Your Lane!

Automated Bike Lane Enforcement  
With Neural Network Image  
Classification

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# Outline:

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- 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.**

- Cars parked in bike lanes force cyclists to weave through traffic
- Apparent lack of enforcement by the police



# Business Understanding:

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## Intent for automated bike lane enforcement:

NYC Dept. of Transportation: “Request for Expressions of Interest”  
announced September 15, 2021

- Reduce police involvement while increasing enforcement
- Target problem areas efficiently

*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 (target class)
- First step toward automation
- Easy for humans, but time consuming
- Use case: stationary cameras on the street



# Data: Collection



## Target class: Bike lanes obstructed by vehicles

- Reported app Twitter
- Manual collection
- Google Maps Street View



# Data: Collection



## Non-target class: Empty bike lanes

- Mostly manual collection
- Google Maps Street View

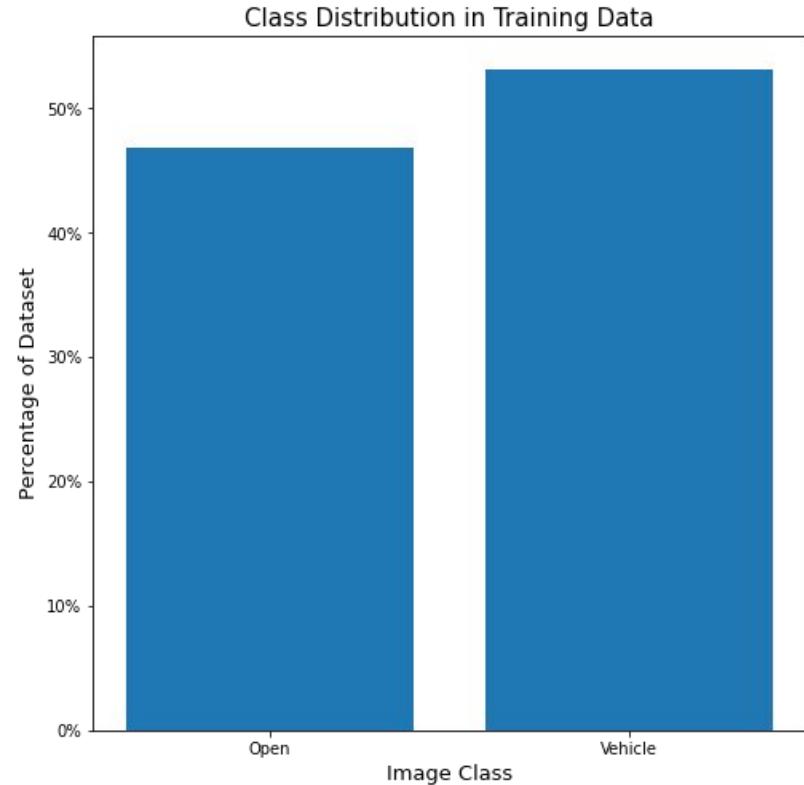


# Data



**Over 1,600 images in total**

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

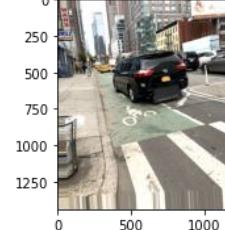
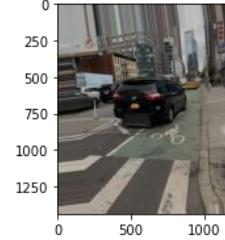
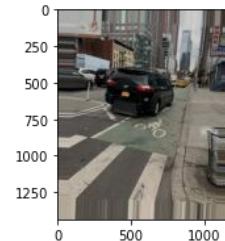
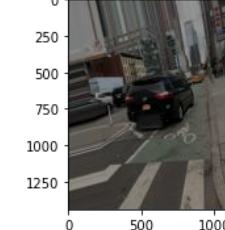
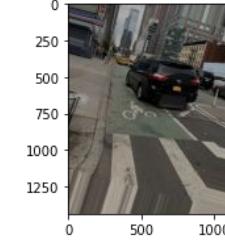
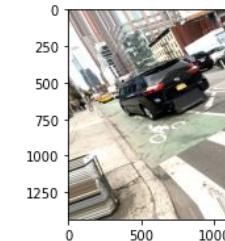
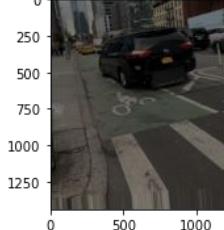
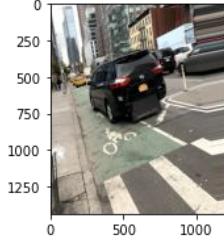
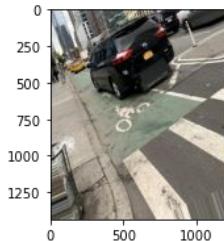


# Data



## Image augmentation

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



# First Simple Model



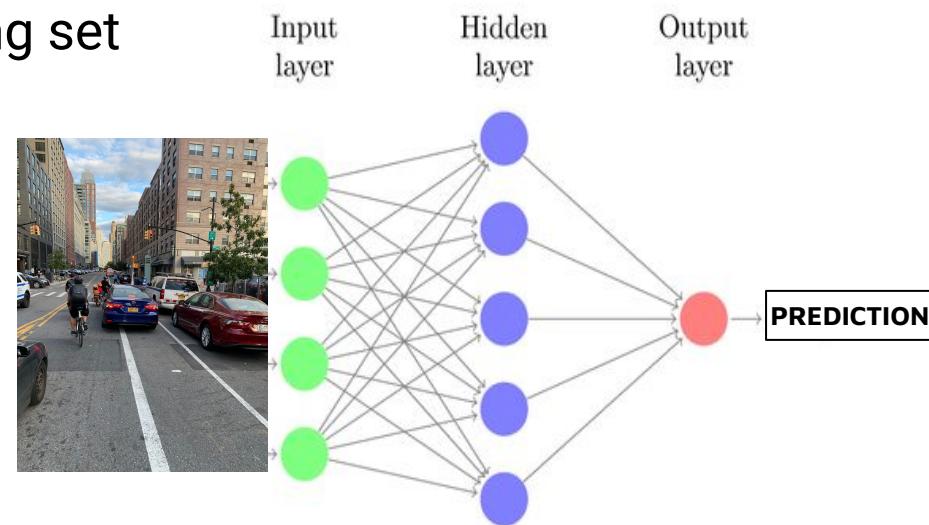
## Fully Connected Dense Neural Network

- Single layer
- Evaluated on smaller initial training set

**Validation accuracy:** 70.63%

**Validation precision:** 65.3%

*Precision = minimizing false positives*



# Modeling



## Convolutional Neural Network

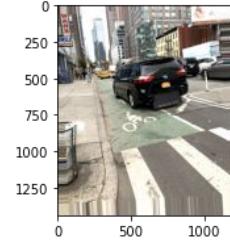
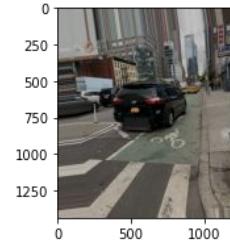
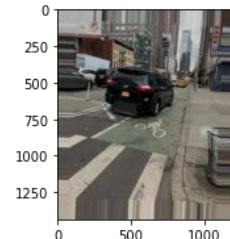
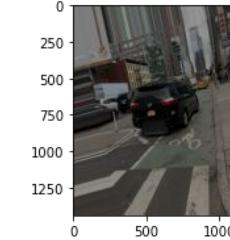
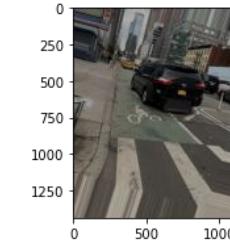
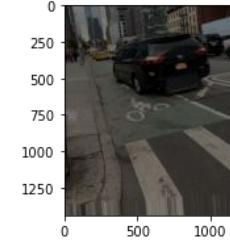
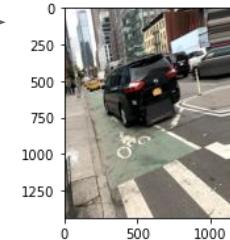
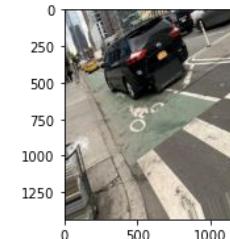
- Multiple layers
- Regularization to avoid overfitting
- Image augmentation



**Validation accuracy:** 94.07%

**Validation precision:** 96.88%

Misclassified only 11/135 images

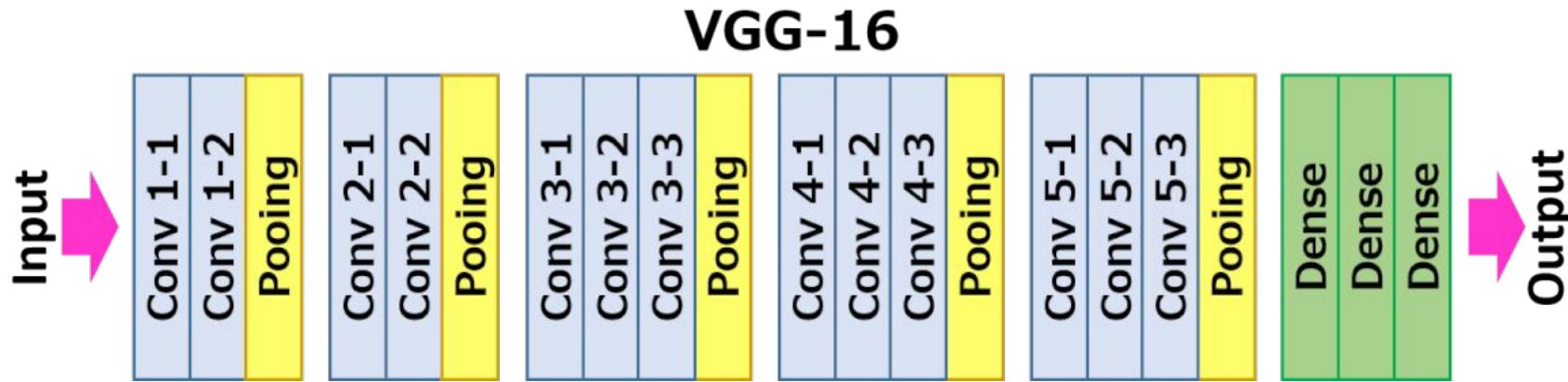


# Method & Results:



## Transfer learning from pre-trained model

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



# Method & Results:

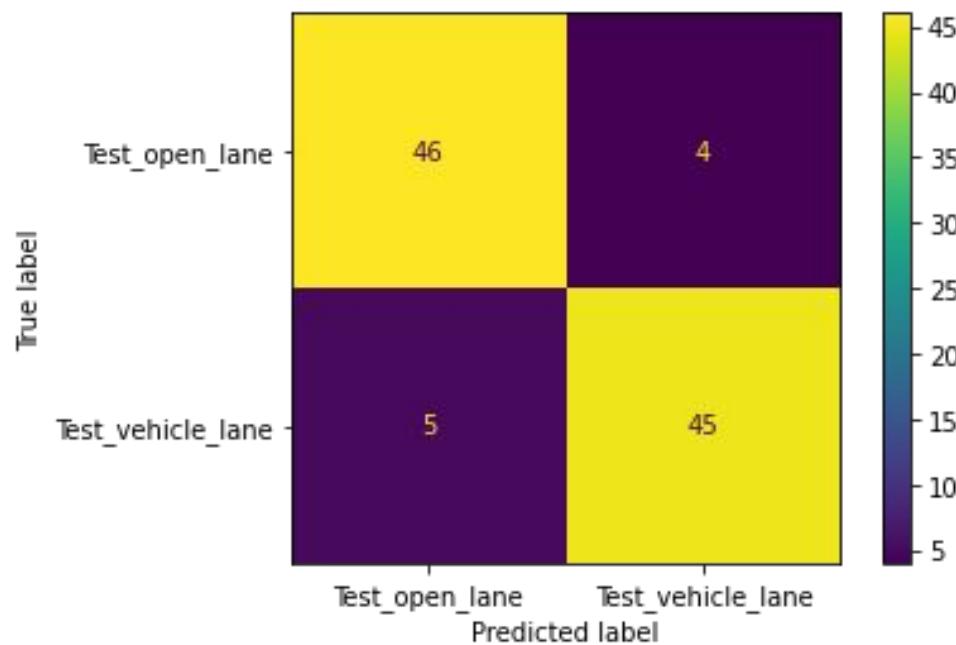


**Validation accuracy: 94%**

**Validation precision: 100%**

**Testing accuracy: 91%**

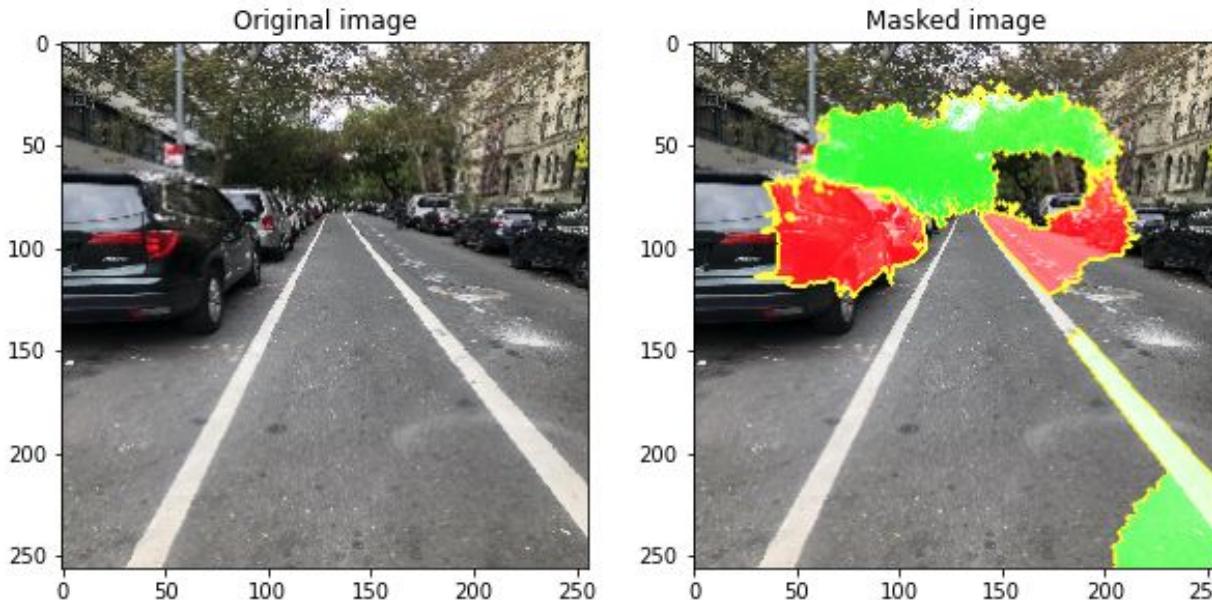
**Testing precision: 92%**



# Method & Results:



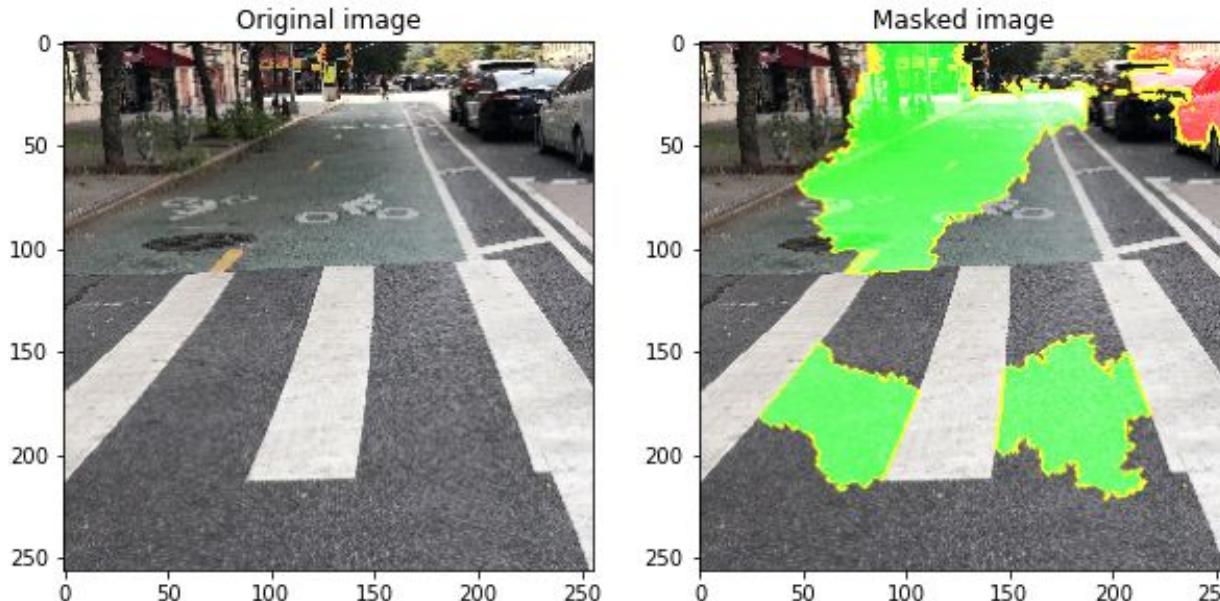
**Using Lime to inspect model decision-making: Empty bike lanes**



# Method & Results:



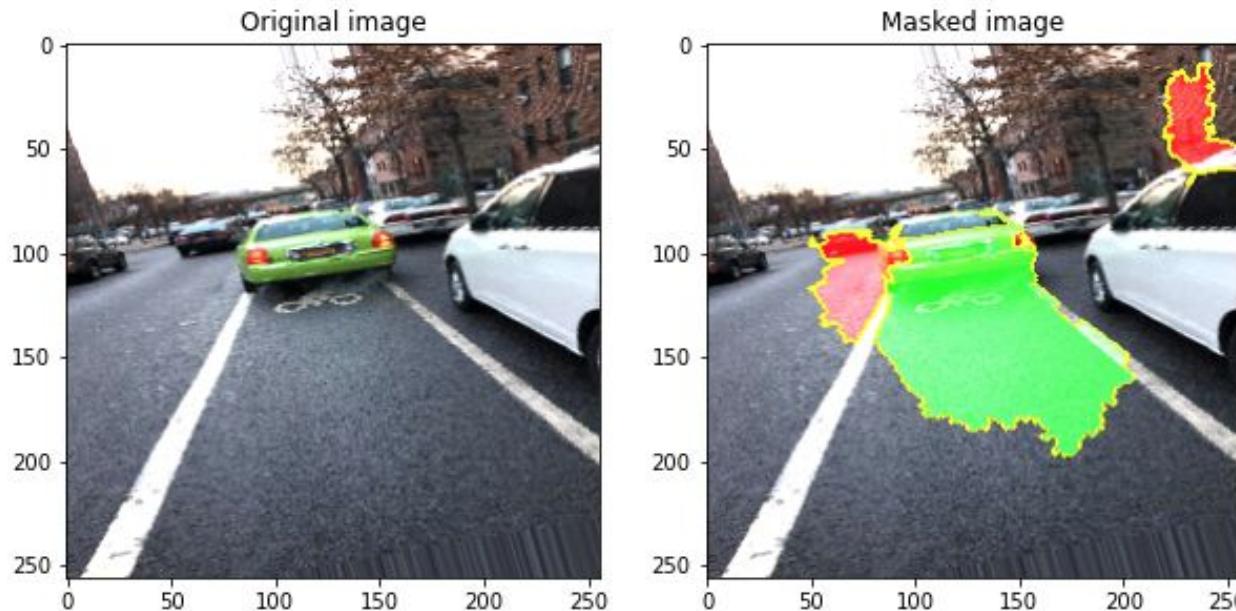
**Using Lime to inspect model decision-making: Empty bike lanes**



# Method & Results:



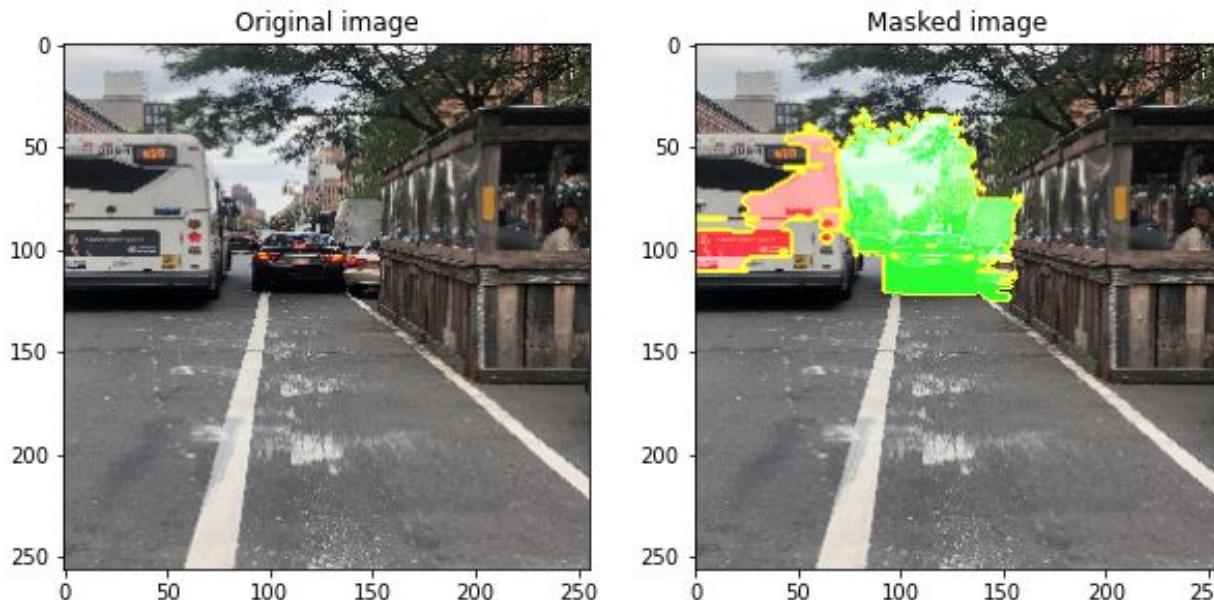
**Using Lime to inspect model decision-making: Obstructed bike lanes**



# Method & Results:



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



# Recommendations



## Automated enforcement can make streets safer for cyclists

- Stationary cameras pointing down bike lanes
  - ID problematic areas (311 submission location data)
  - Tickets vehicles stopped for >30 seconds
- Increase ticketing efficiency, consistency and reduce the need for active police engagement
- Similar to existing systems (red-light, speeding, tolls, bus lanes)

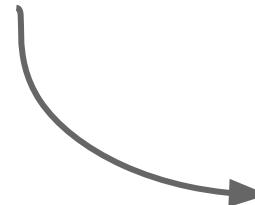


# Next Steps

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- More data
- Additional classes (bike, motorbike, types of vehicles, other obstructions)
- 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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LINKEDIN:  
[www.linkedin.com/in/jmarkowi](https://www.linkedin.com/in/jmarkowi)

# Appendix: Unused Images



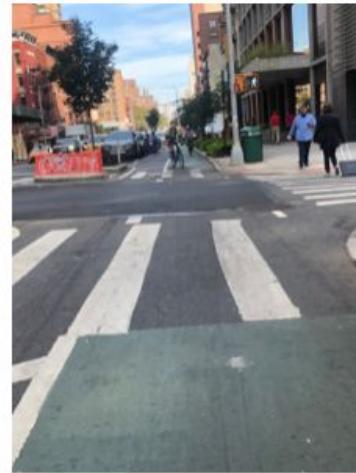
Over 200 images were removed from the original dataset after being deemed inappropriate for this task.



Too close; can't see lane lines



Wrong perspective



Cyclists obscure view of lane



Nighttime



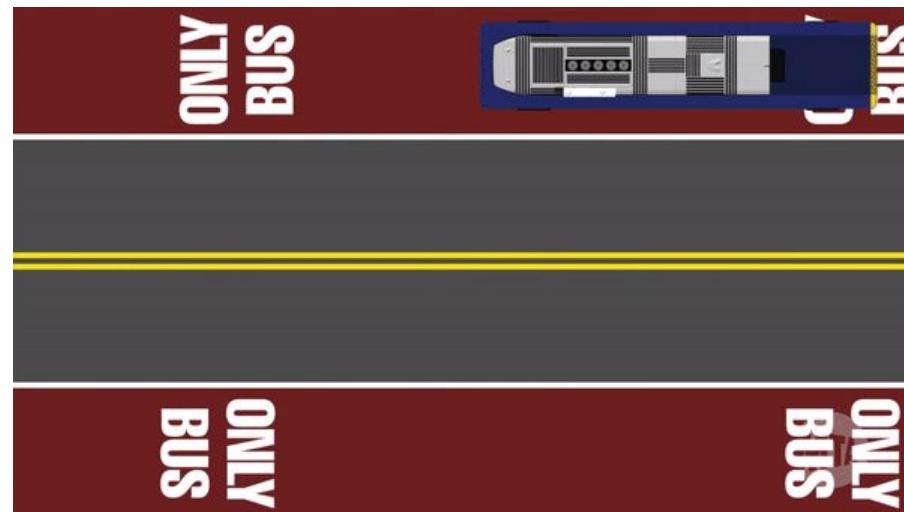
Ambiguous in far distance

# Appendix: 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



# Appendix: ABLE



“Automated Bus Lane Enforcement” (ABLE) system:

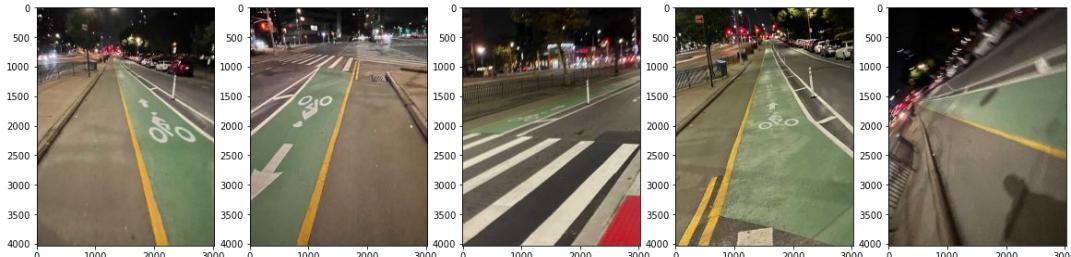


# Appendix: Bike Lanes at Night



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

Open Bike Lanes: Night

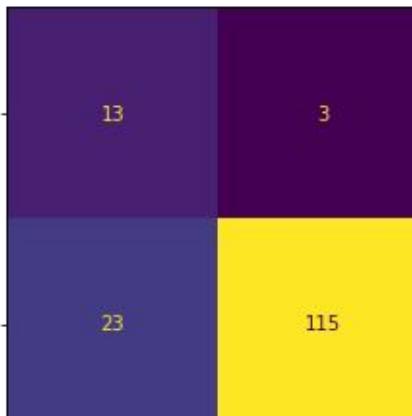


Blocked Bike Lanes: Night



True label

Night\_open\_lane



Night\_vehicle\_lane

Thanks to [Seth Kaufman](#) for the images of open lanes at night