C19 Mobility and Health
Investigating COVID-19 data trends in North Carolina

Trends in N.C. Mobility and Health Data During the COVID-19 Pandemic

Wes Kumfer, PhD, RSP1
UNC Highway Safety Research Center
Kumfer@hsrc.unc.edu

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www.C19MobilityAndHealth.unc.edu

Project Team

- PI - Randa Radwan, PhD
- Co-PI – Raghavan Srinivasan, PhD
- Task Lead – Wes Kumfer, PhD, RSP1
- Analyst – Katie Harmon, PhD
- Subject Matter Expert – Tabitha Combs, PhD
- Analyst – Duncan Richey
- Analyst – Cheng Ma

Project Overview

- The goal of the C-19 Mobility and Health Project is to investigate COVID-19 data trends in North Carolina.
- Two research questions:
  - Have shelter-in-place policies, emergency declarations, and general news and events reduced movement within North Carolina? Is this slowing the spread of COVID-19?
  - What are the differences in mobility between urban and rural counties and how do these trends vary through time?

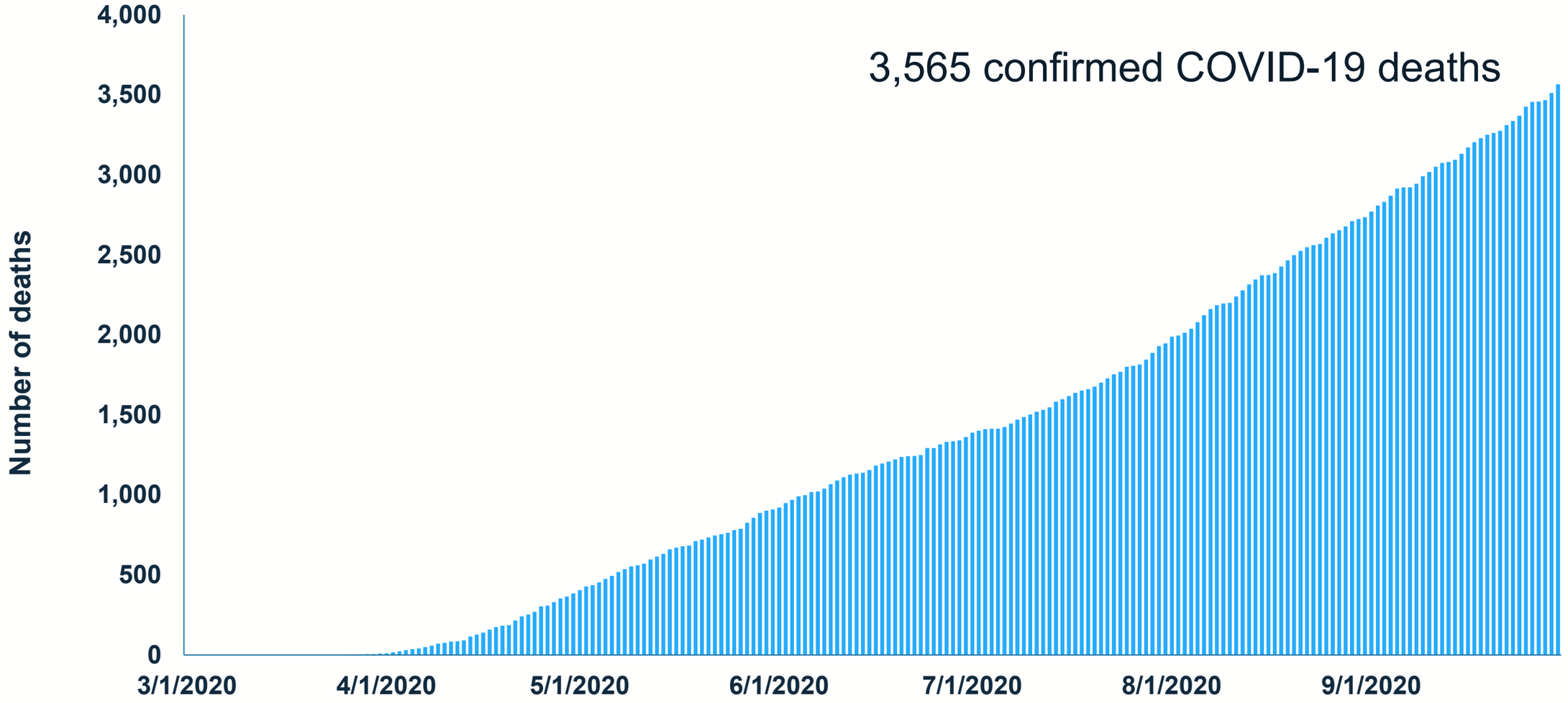
Methodology – Joinpoint Regression

- Simplified time series analysis.
- Developed for health surveillance applications.
- Compared to linear regression, can identify statistically significant ($p<0.05$) trend changes.
- Can finetune model to transform the data or account for variance over time (heteroskedasticity).
- Can compare cohorts over time.

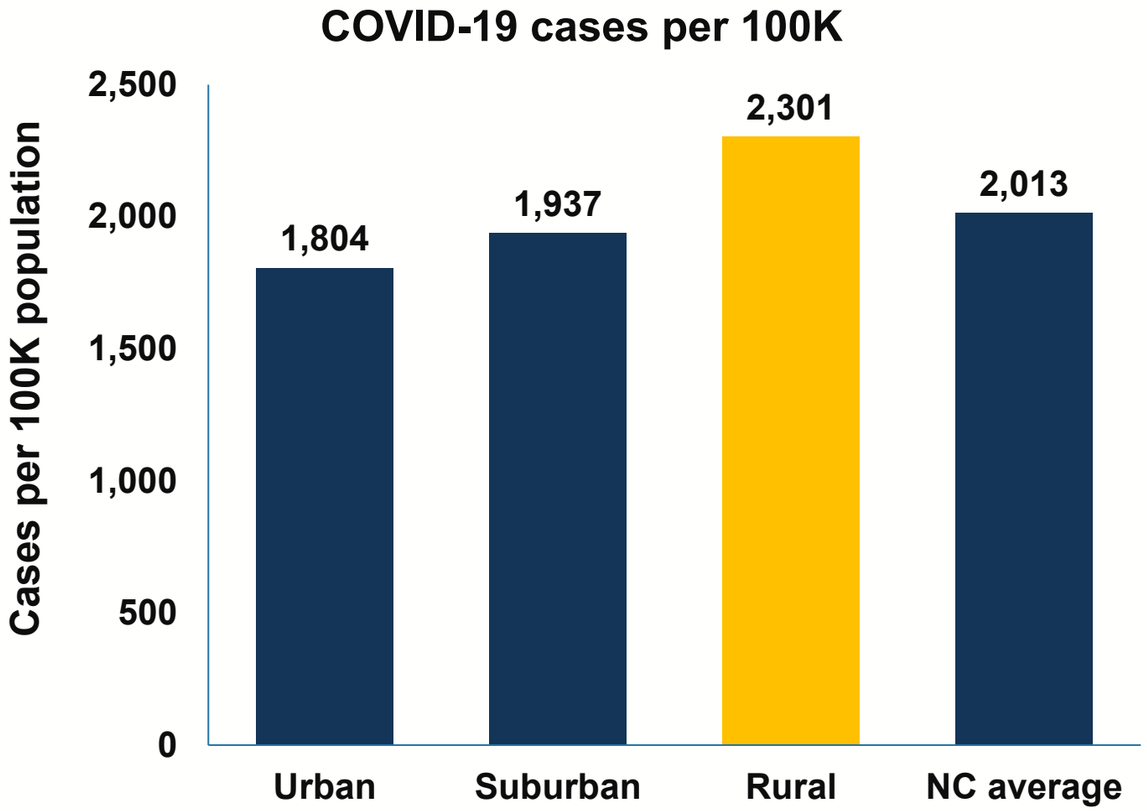
Poll Question

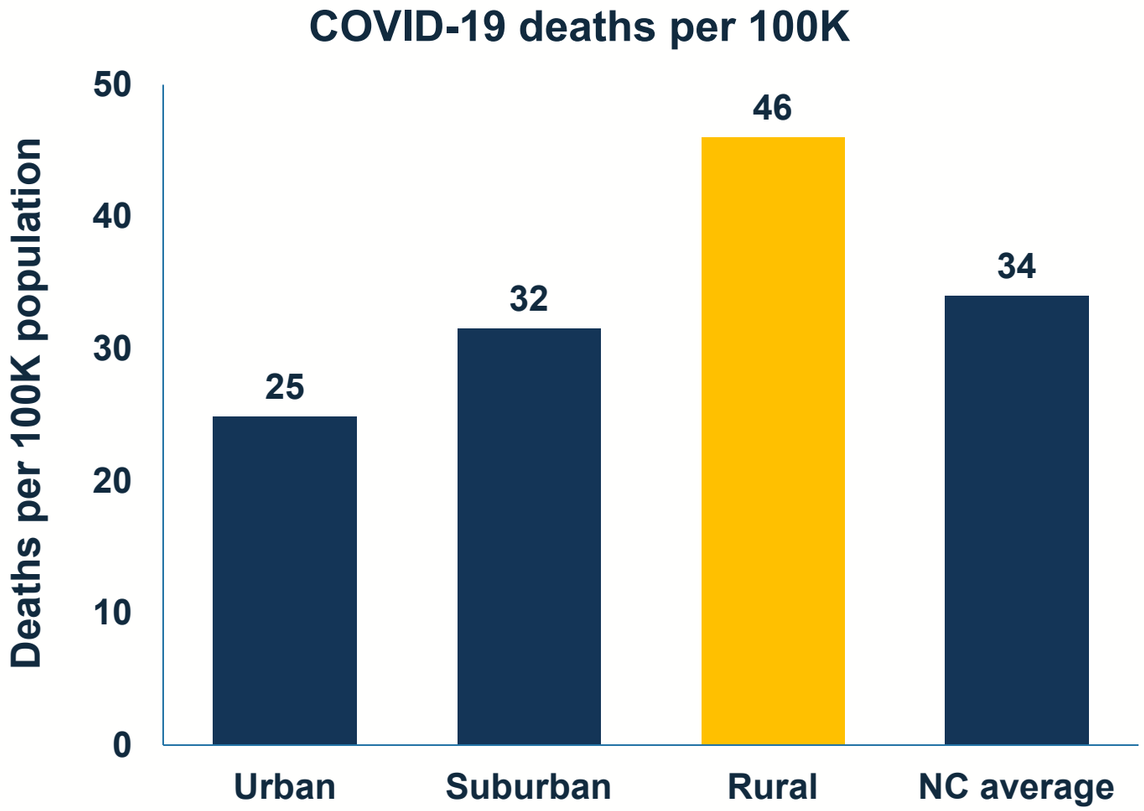
- Since March, have you…
  - Traveled more?
  - Traveled less?
  - Traveled about the same?

Cumulative Confirmed COVID-19 Deaths to September 30, 2020

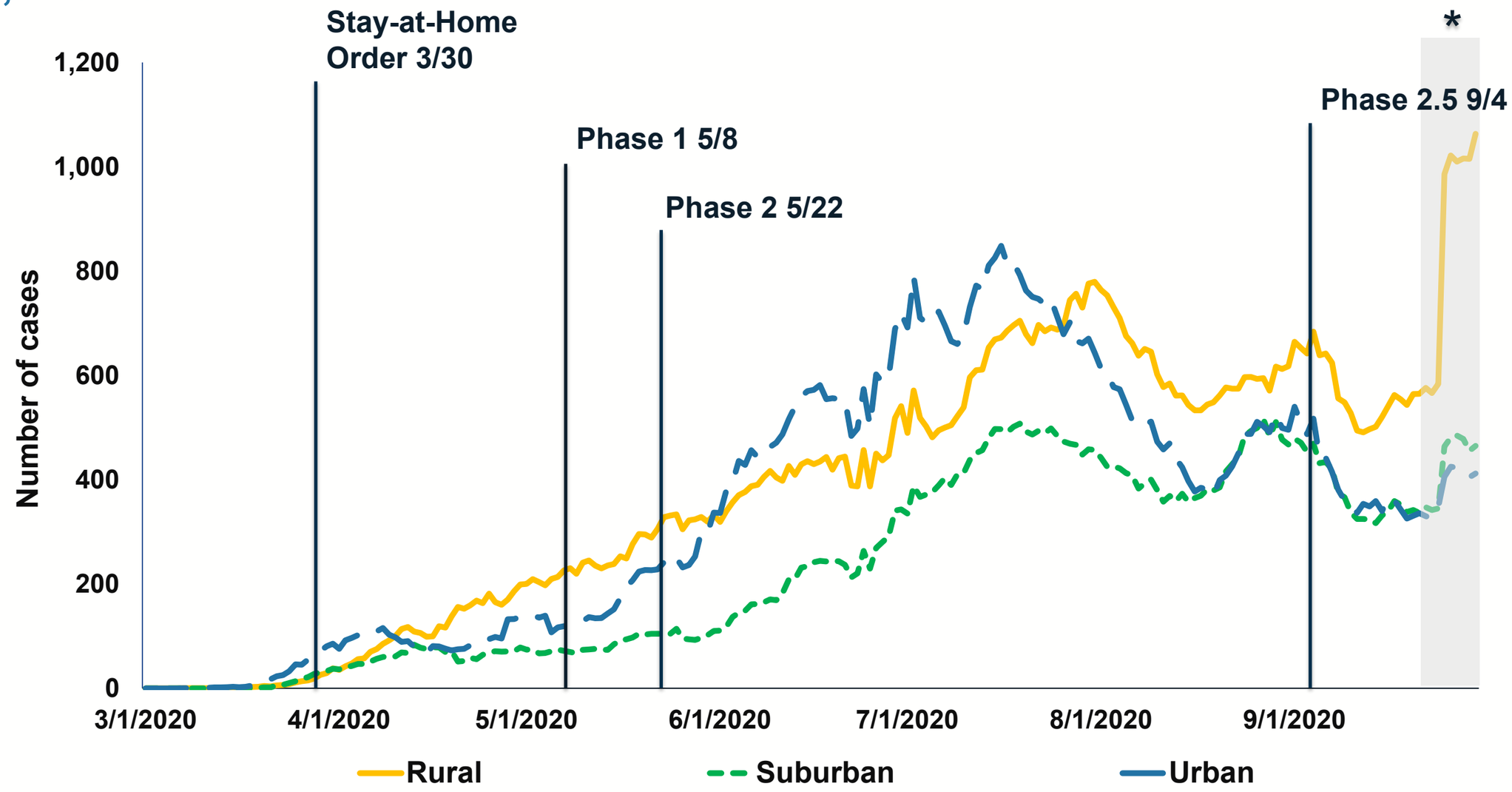


In North Carolina, Confirmed NC COVID-19 Cases and Deaths are More Common in Rural Counties



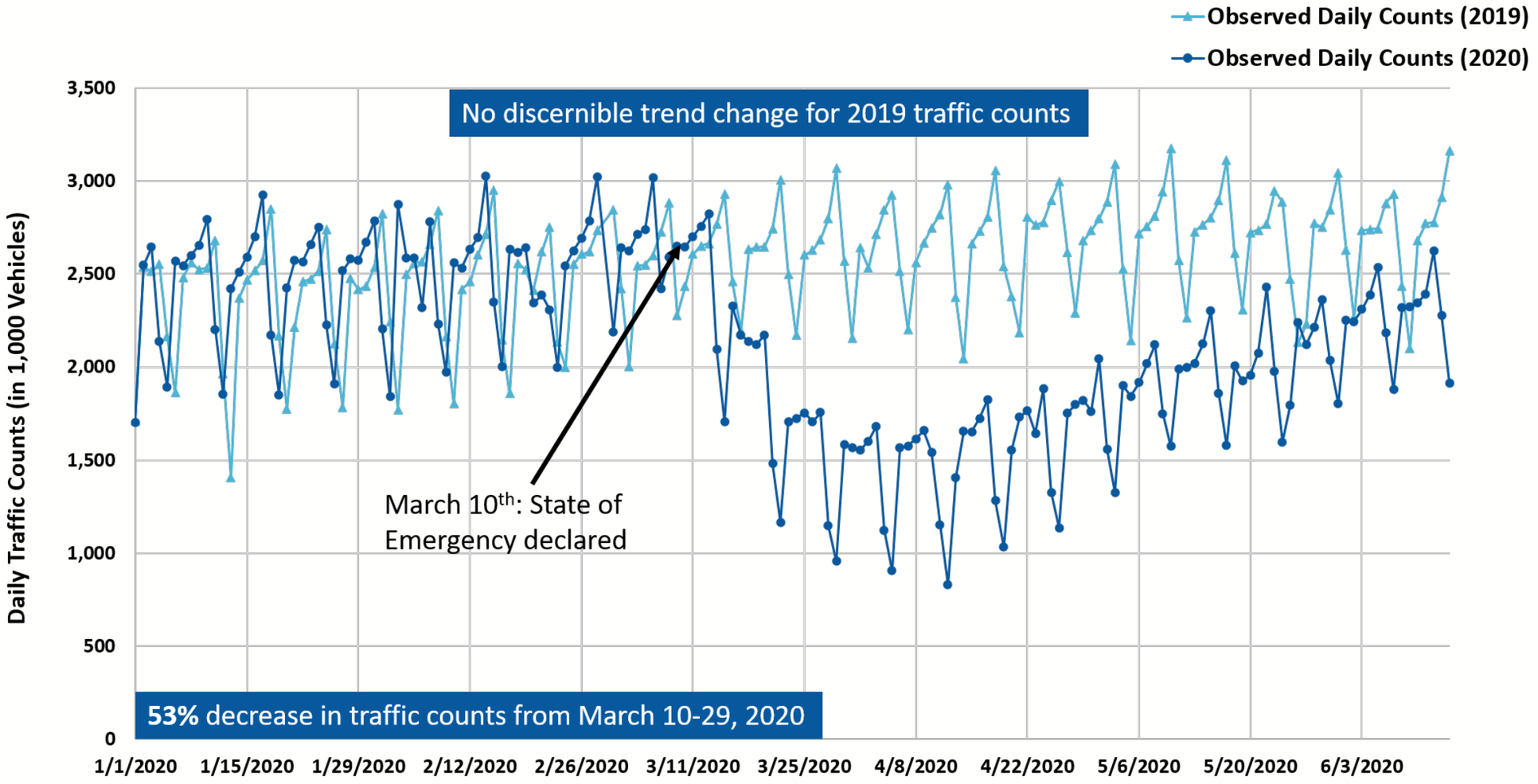


7-Day Rolling Average of New COVID-19 Cases to September 30, 2020



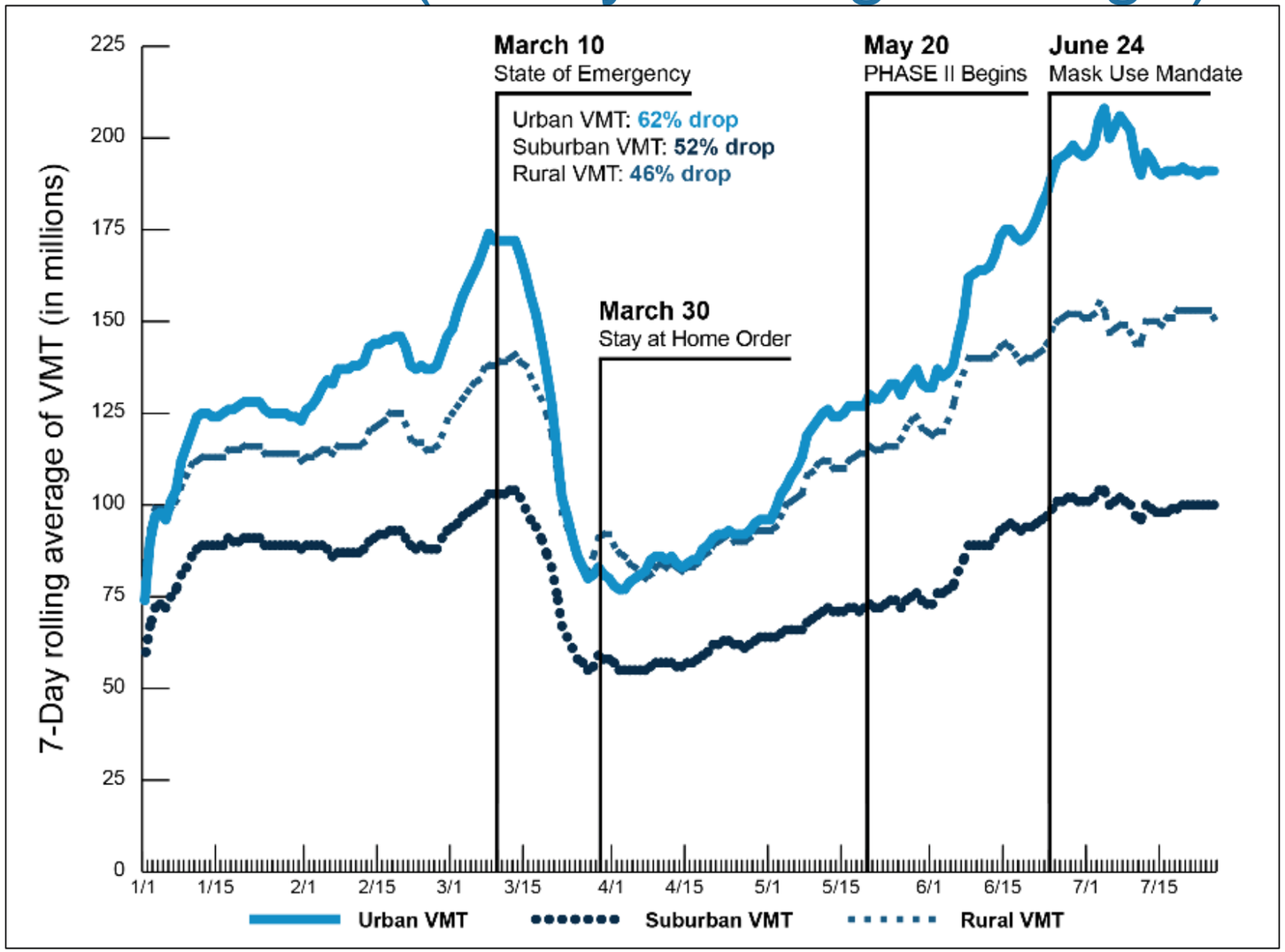
*Results of COVID-19 antigen testing released (spike reflects historical cases).

ATR Station Vehicle Counts



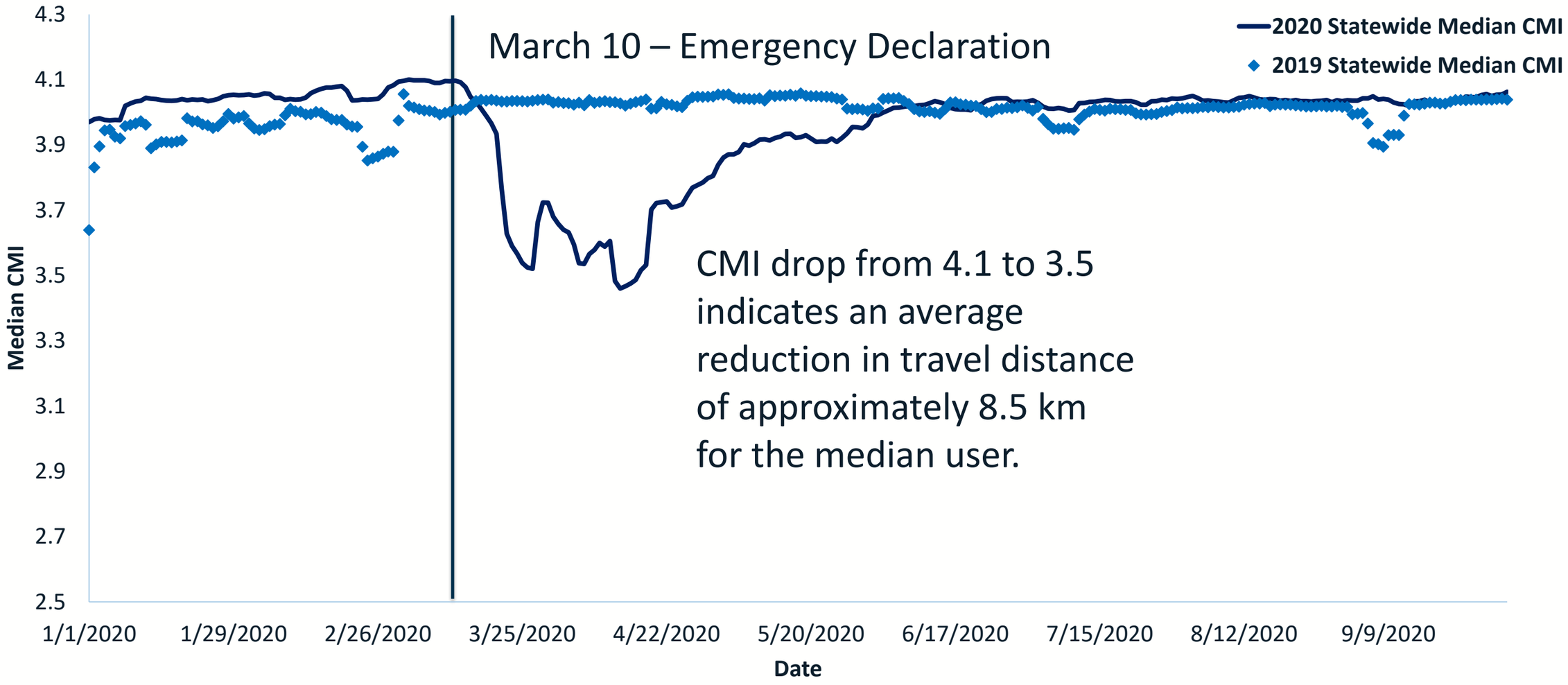
*Data source: NC DOT

Vehicle Miles of Travel (7-Day Rolling Average)



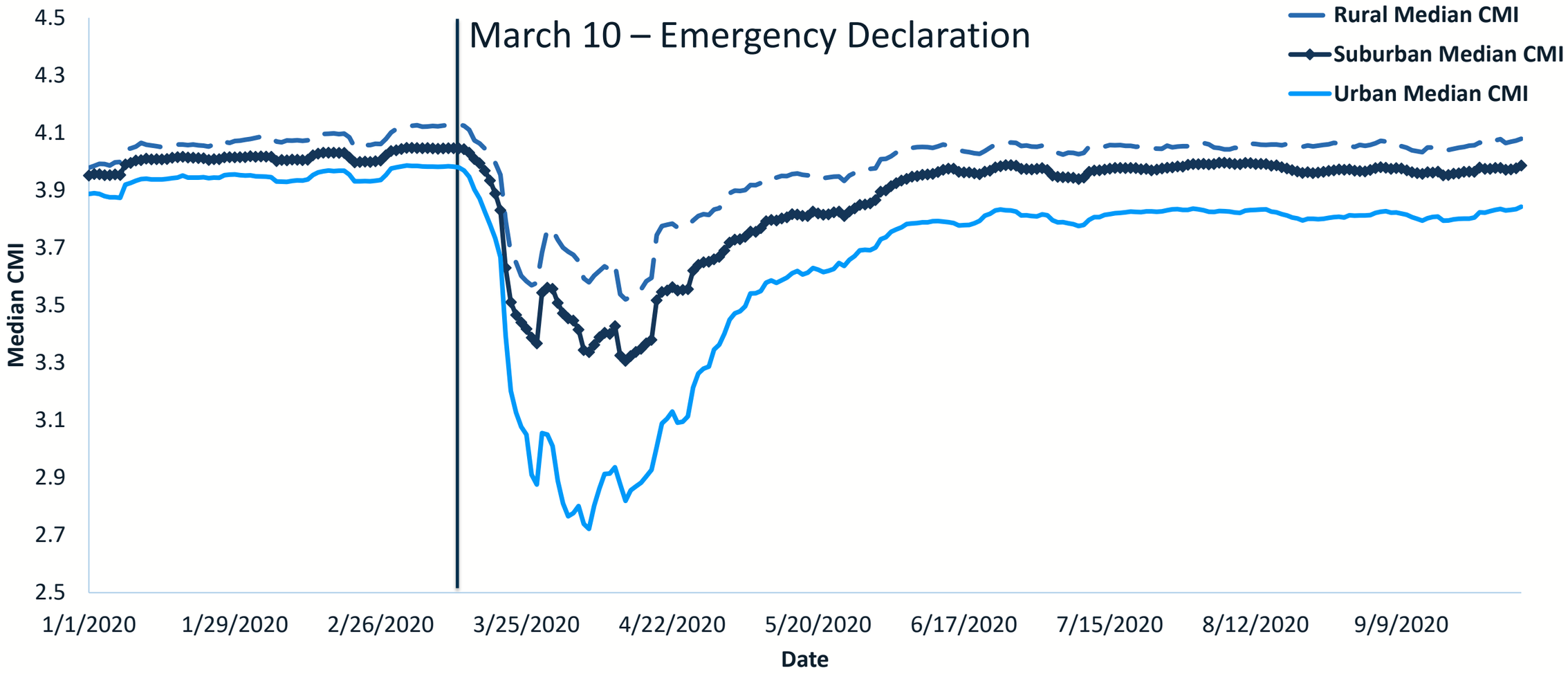
NC Statewide Vehicle Miles Traveled (VMT) Trends for Urban, Suburban, and Rural Areas, ***Data Source:*** ***Streetlight***

Mobility Index (7-Day Rolling Average)



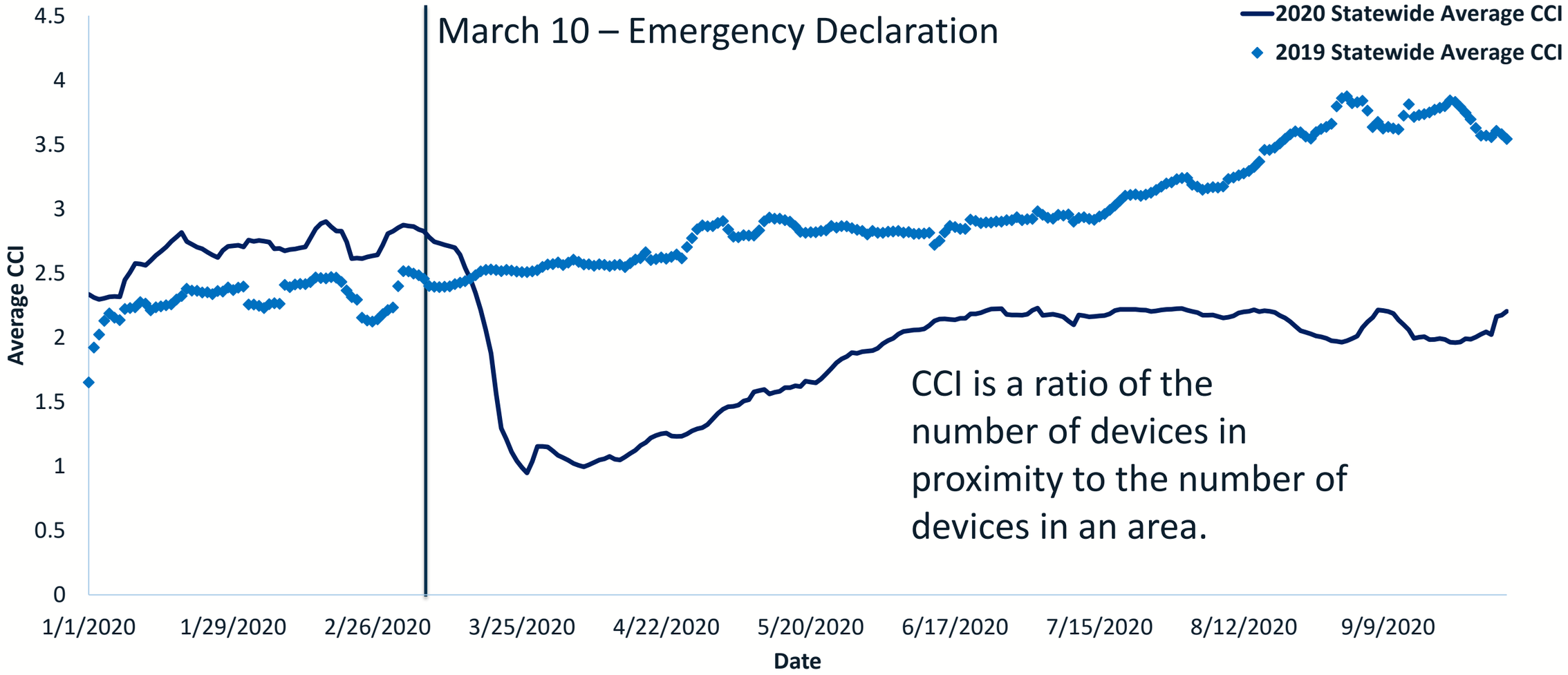
NC Statewide Mobility Index Trends (7-day Rolling Average): January 1, 2020-October 2, 2020, ***Data Source: Cuebiq***

Mobility Index (7-Day Rolling Average)



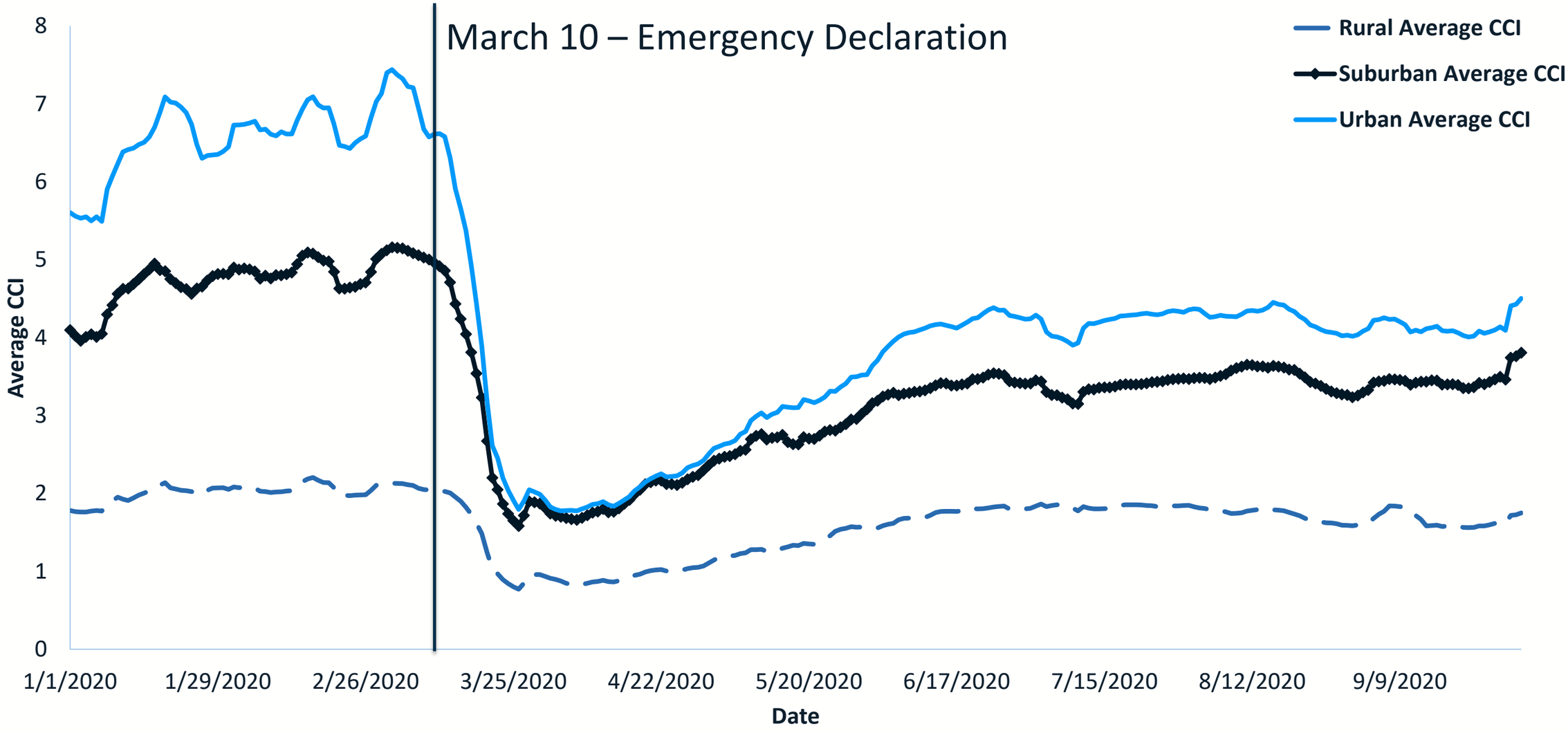
NC Statewide Mobility Index Trends (7-day Rolling Average) for Urban, Suburban, and Rural Areas: January 1, 2020-October 2, 2020, ***Data Source: Cuebiq***

Contact Index (7-Day Rolling Average)



NC Statewide Contact Index Trends (7-day Rolling Average): January 1, 2020-October 2, 2020, ***Data Source: Cuebiq***

Contact Index (7-Day Rolling Average)



NC Statewide Contact Index Trends (7-day Rolling Average) for Urban, Suburban, and Rural Areas: January 1, 2020-October 2, 2020, ***Data Source: Cuebiq***

Key Results

- All area types (urban, suburban, and rural) showed statistically significant decreases in every mobility metric after the State of Emergency Declaration on March 10th.
- Urban work trips had a more pronounced response to the pandemic than rural or suburban work trips.
- Travel stabilized in early June.
- Despite travel changes, contact index shows social distancing has taken effect.

Conclusions

- All measures of mobility consistently show the same trends, with travel decreasing after March 10th State of Emergency and returning to normal early June.
- Urban responses tended to be more sensitive to policy changes than rural and suburban responses, perhaps due to discretionary trips.
- While travel statewide returned to “normal,” contact between travelers has declined below 2019 trends.
- The differences between CCI and mobility metrics may indicate an increase in single-person trips.

Further Discussion

- Research implications for NCDOT:
  - On average, travelers are responsive to policy measures, but the impact is greater in places where travelers have more mobility options.
  - The relationship between mobility and transmission of disease will become more complicated.
  - Large-scale disruptions to travel patterns will affect budgeting and resource allocations.
  - There is a need for resilience modeling.
- Next steps:
  - Model flows between counties to predict spread of future pandemics.
  - Assess how changes in traffic patterns affect safety.

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https://collaboratory.unc.edu/

NC Policy Collaboratory

Data Snapshot

- Mobility Data

Name	Importance	Type	Scope	Time Range	Time Scale	Unit
Cuebiq	Primary	Mobility Index and Contact Index Data visualizations through the Clara platform	All of N.C. by county	Dec 21, 2019 – Aug 7, 2020	Daily	CMI, CCI
Teralytics	Primary	Origin - Destination	All of N.C. by zip code	All of 2019, Jan-Apr 21 2020	Daily	Trips
NCDOT ATR	Primary	Traffic Counts	All State-owned highways (~58 counties)	Jan-Jun 15 2018, Jan-Jun 15 2019, Jan-Jun 15 2020	Hourly and daily	Vehicles
Streetlight	Primary	VMT	All counties in U.S.	Jan 1, 2019 – Sep 15, 2020	Daily	Vehicle miles of travel
GoTriangle	Tertiary	Transit Activity	All routes in Research Triangle operated by GoTriangle	Jan 1, 2019 – Sep 17, 2020	Daily	Boardings, passenger miles per trip, and trips
Apple	Tertiary	Driving/ Walking/Transit Routing	Select counties and cities in N.C.	Jan 13 – Sep 19, 2020	Daily	Directions requests

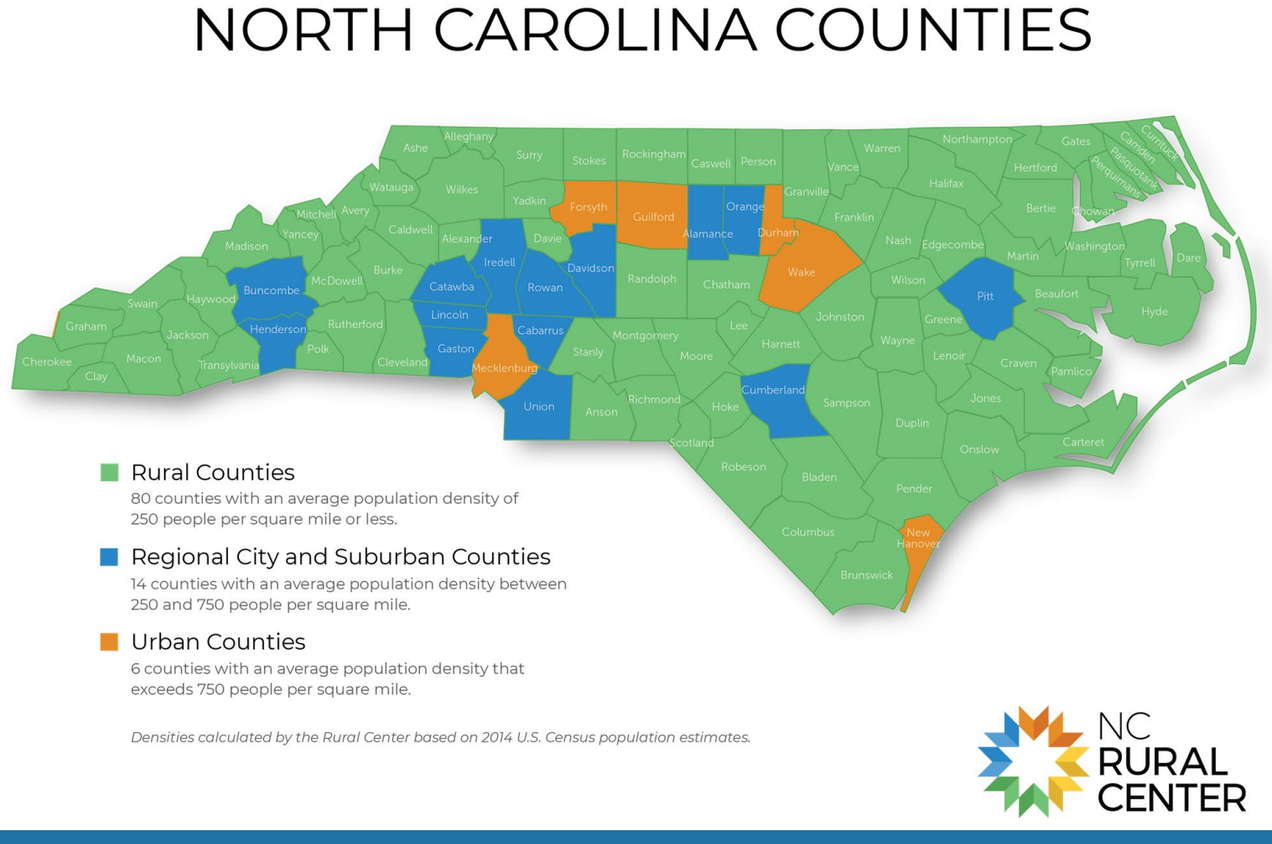
Data Snapshot

- Health Data

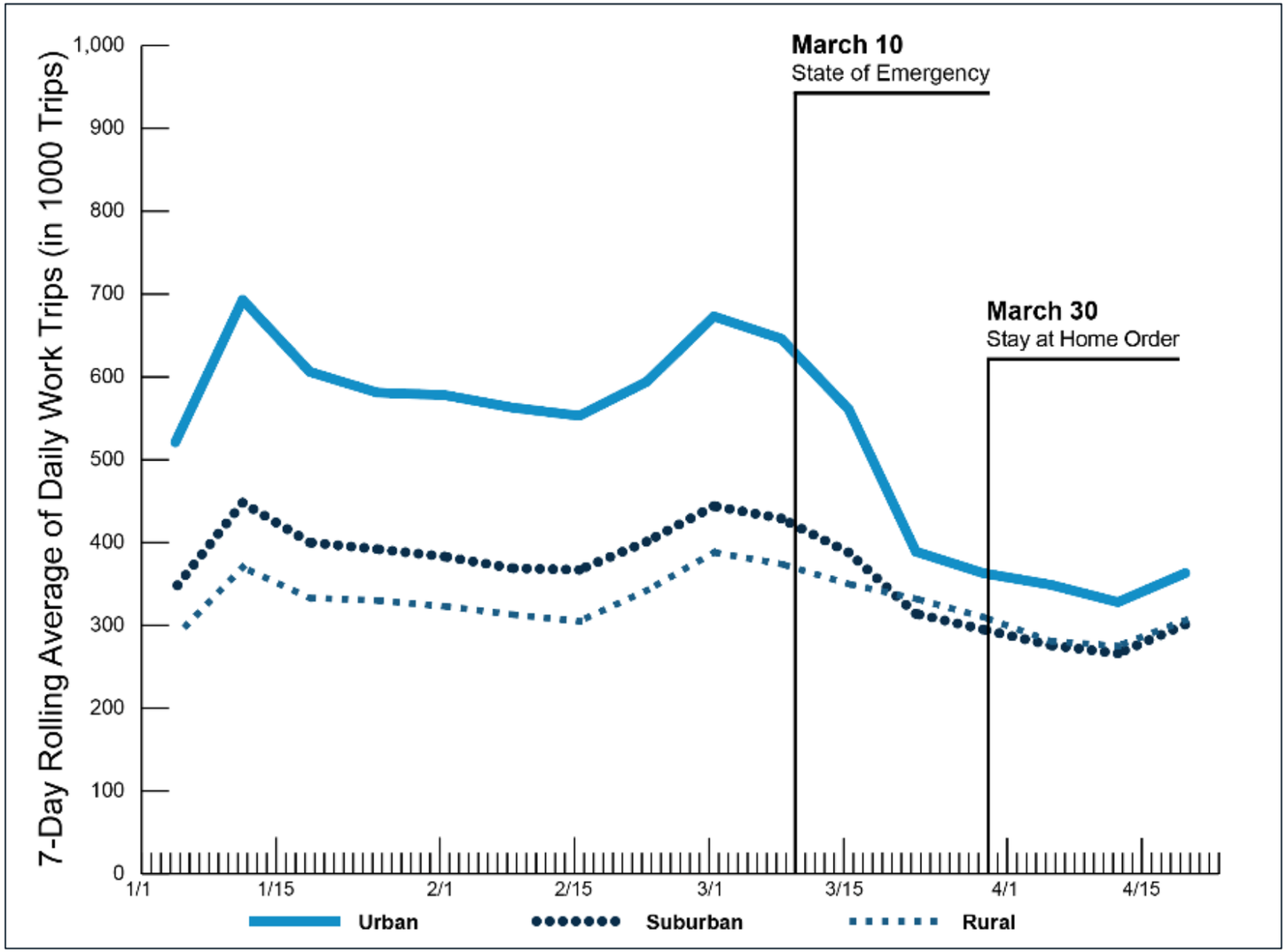
Name	Importance	Type	Scope	Time Range	Time Scale	Unit
New York Times Covid-19 Case Counts	Primary	COVID-19 case and death counts	All counties in U.S.	March 1 – Sept 30, 2020	Daily	Number of confirmed COVID-19 cases & deaths
United States Census Population Data	Primary	Population estimates	All counties in U.S.	Base: U.S. Census 2010 Annual population projections available through July 1, 2019	Yearly	Population estimates

Data Snapshot

- To compare travel trends between different types of land contexts in the State, we aggregated our data into urban, suburban, and rural using designations from the NC Rural Center.



Work Trips (7-Day Rolling Average)



NC Statewide Work Trip Trends for Urban, Suburban, and Rural Areas: January 1, 2020-April 21, 2020, ***Data Source:*** *Teralytics*

Efficient and Robust Pedestrian Detection using Deep Learning for Autonomous Cars

Abdullah Al Redwan Newaz, Muhammad Islam, and Ali Karimoddini

Autonomous Cooperative Control of Emergent Systems of Systems (ACCESS) Laboratory

NC Transportation Center of Excellence on Connected and Autonomous Vehicle Technology (NC-CAV)

North Carolina Agricultural and Technical State University

Self-driving cars closer to becoming reality

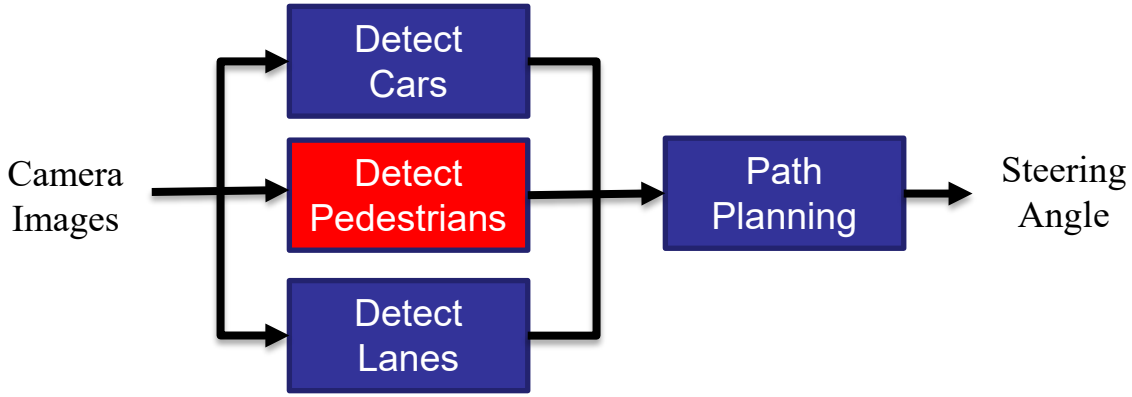
ACCESS Laboratory

- 10 million autonomous vehicles will hit the roads by 2021
- In 10 years fully autonomous vehicles will dominate the roads
- Widespread adoption of AVs could lead to a 90% reduction in vehicle crashes

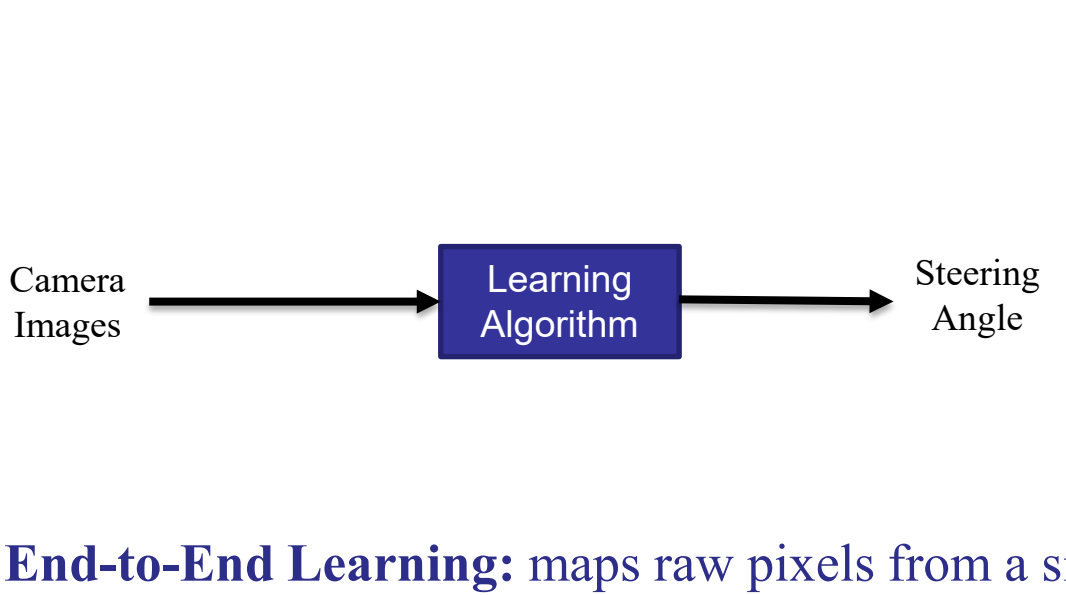
How do we judge the quality and the real autonomous nature of a car?

Deep Learning for Self-Driving Cars

There are two main streams:



Machine Learning Pipeline: generates steering commands using a set of components



End-to-End Learning: maps raw pixels from a single front-facing camera directly to steering commands

How would you do pedestrian detection/segmentation?

Pedestrian detection is a notoriously hard problem

* Images are taken from D. Tosato's presentation

- Different clothes color
- Changing size
- Aspect ratio
- Dynamic shape

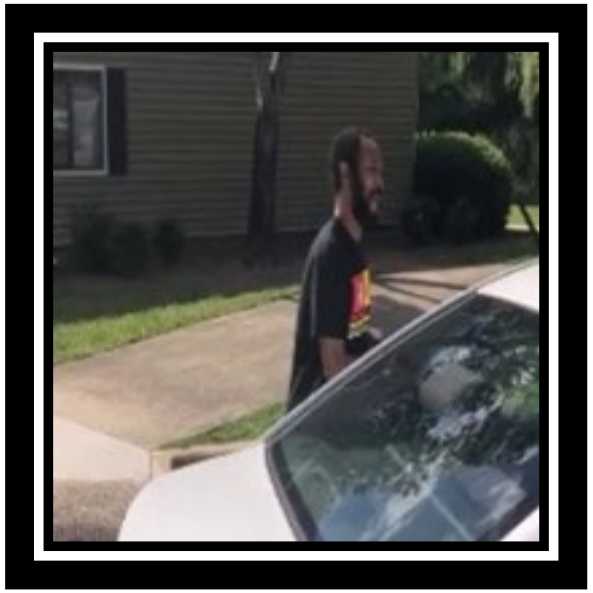
Camera sensitivity

* Images are taken from D. Tosato's presentation

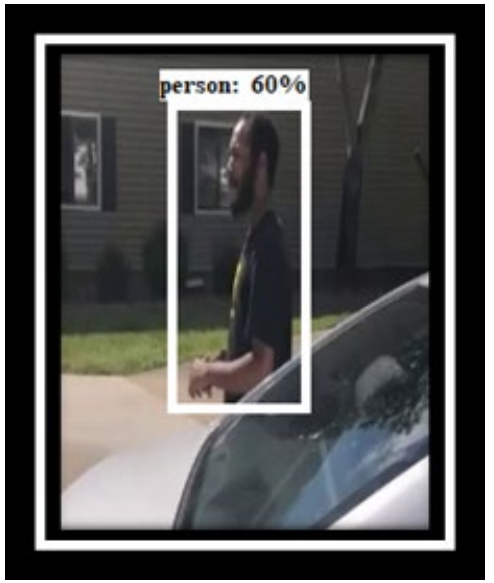
Should detect partially occluded pedestrians

Challenge in Detecting Occluded Pedestrian

Pedestrian blocked by Staller



Partially visible body parts



Low confidence score

- Occlusion happen very often in real world
- Performance of conventional methods for detecting partially occluded pedestrian are not satisfactory
- Conventional object detection method detect occluded pedestrian with low confidence score

Challenge in Detecting Pedestrian with Low Confidence

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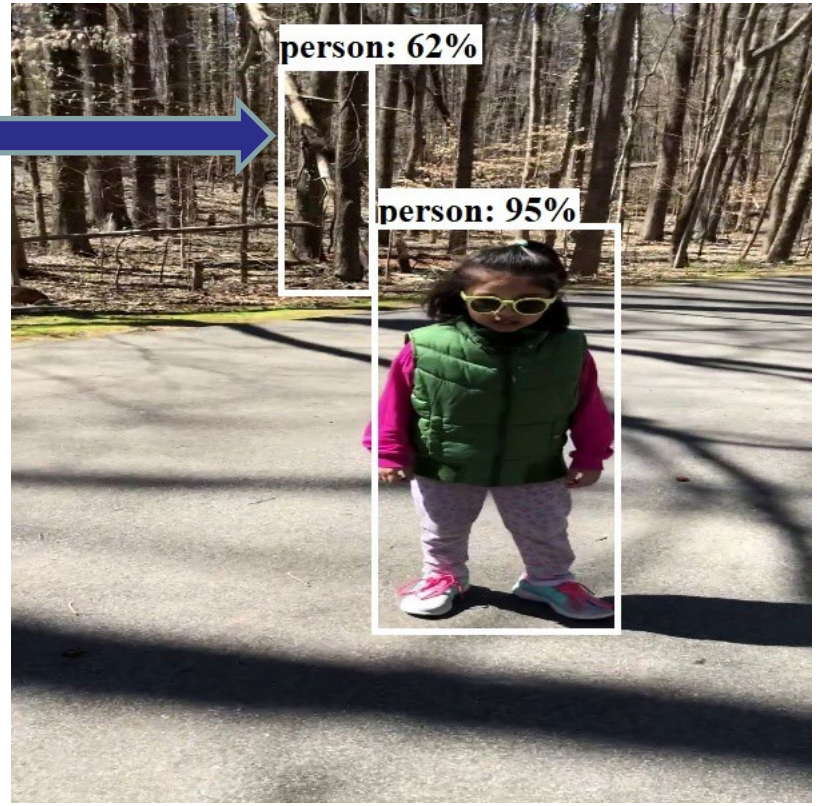
False detection



- Low confidence causes false detection.
- Model detect Tree as a person with a confidence score of 62%
- Setting of a high threshold can avoid such problems.

Objectives

To develop a reliable yet efficient techniques (high accuracy with reasonable computation cost) that can handle:

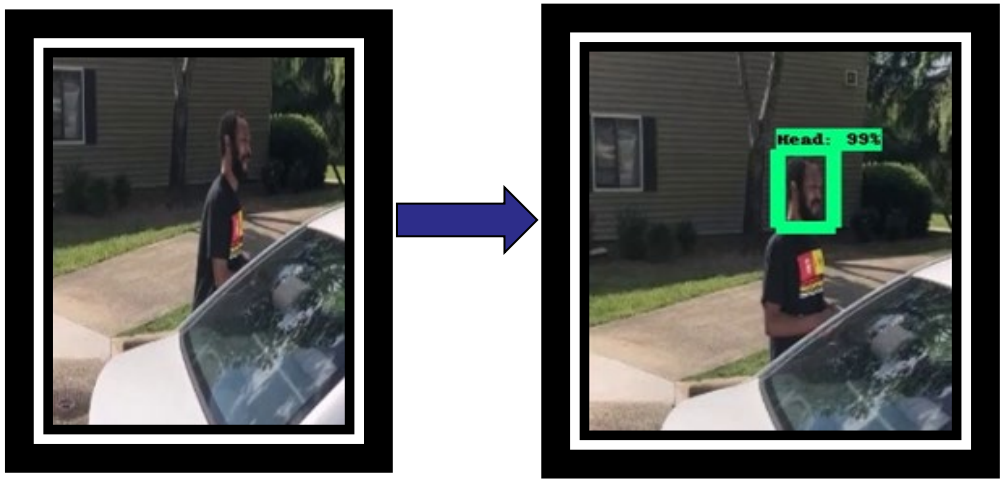
- Pedestrian detection under partial occlusion
- Pedestrian detection with low rate of false detection

Robust and efficient pedestrian detection even on the sidewalk and crosswalk in cluttered urban environments to improve the safety for autonomous driving

Proposed Methodologies

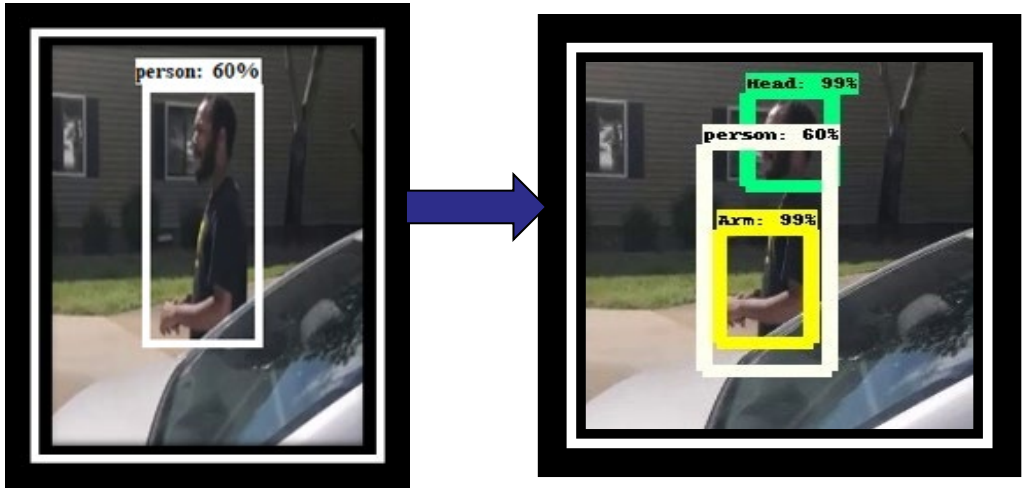
Proposed Solution

We expect our new method should detect some of the body parts for partially occluded pedestrian



Our proposed method utilizes body parts information to detect partially occluded pedestrian

The state-of-the-art method detect occluded pedestrian with low confidence



Our proposed method should detect not only the full body pedestrian, but also the visible body parts with high confidence score

Our Approach...

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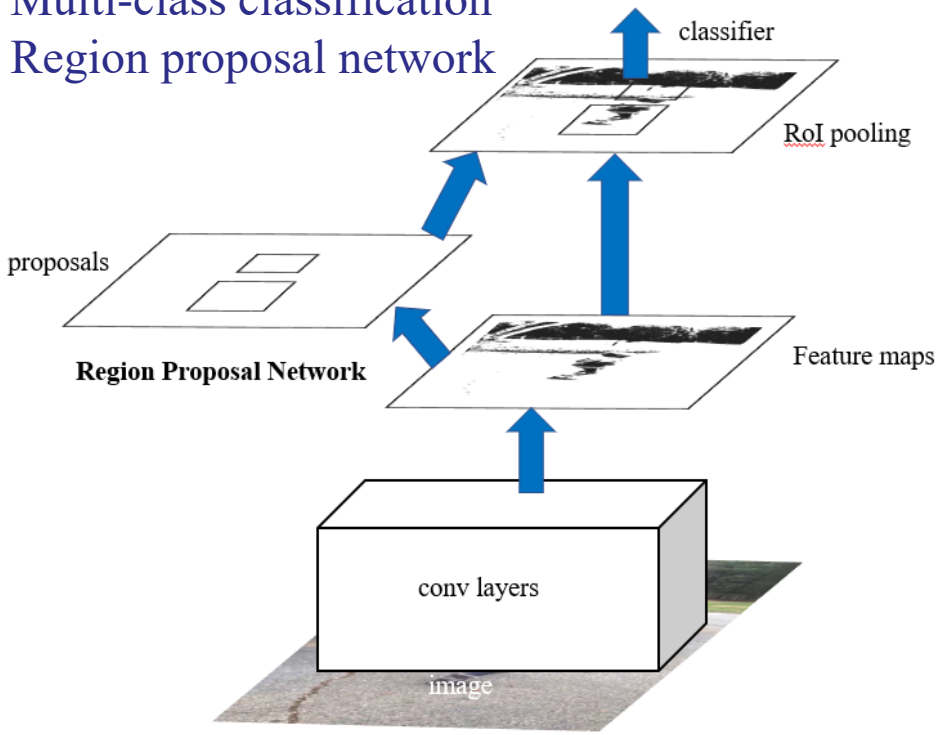
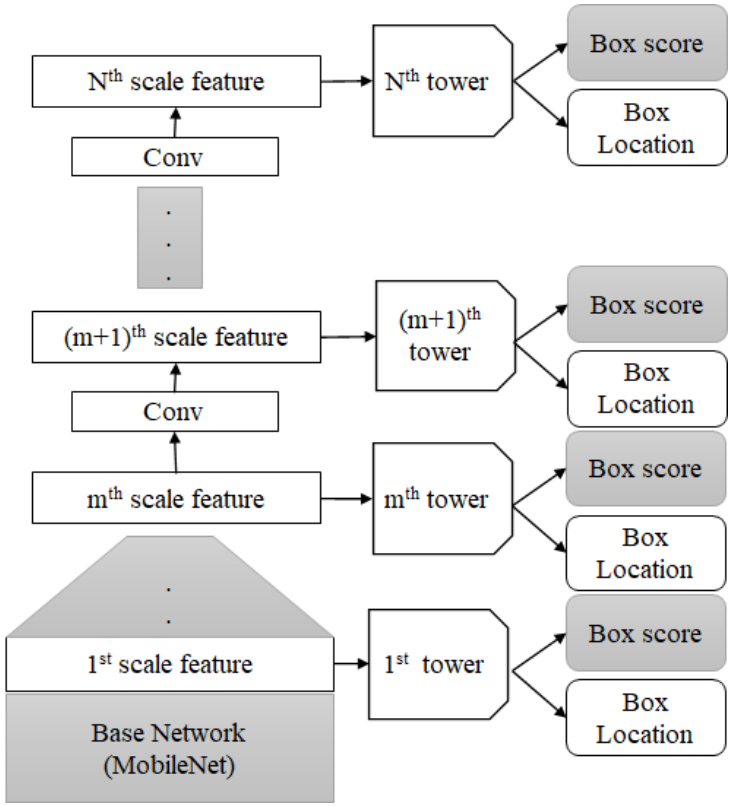
- Multi-class classification
- Region proposal network



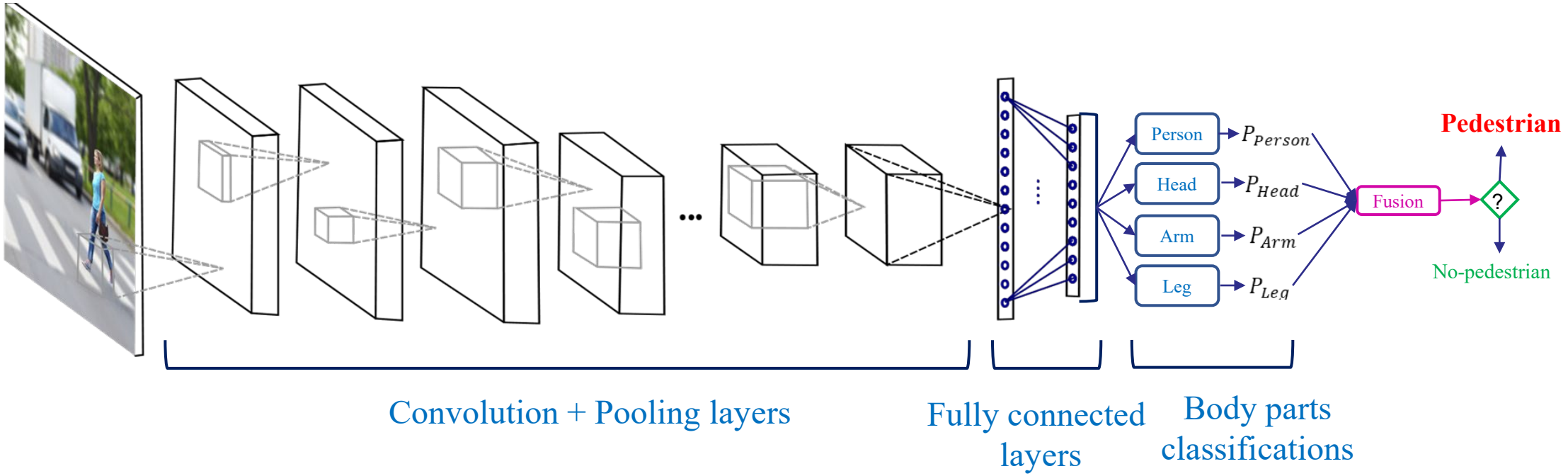
Faster R-CNN



SSD-Mobilenet

- Single Shot Detector
- Multi-class classification
- Depth and pointwise separable.

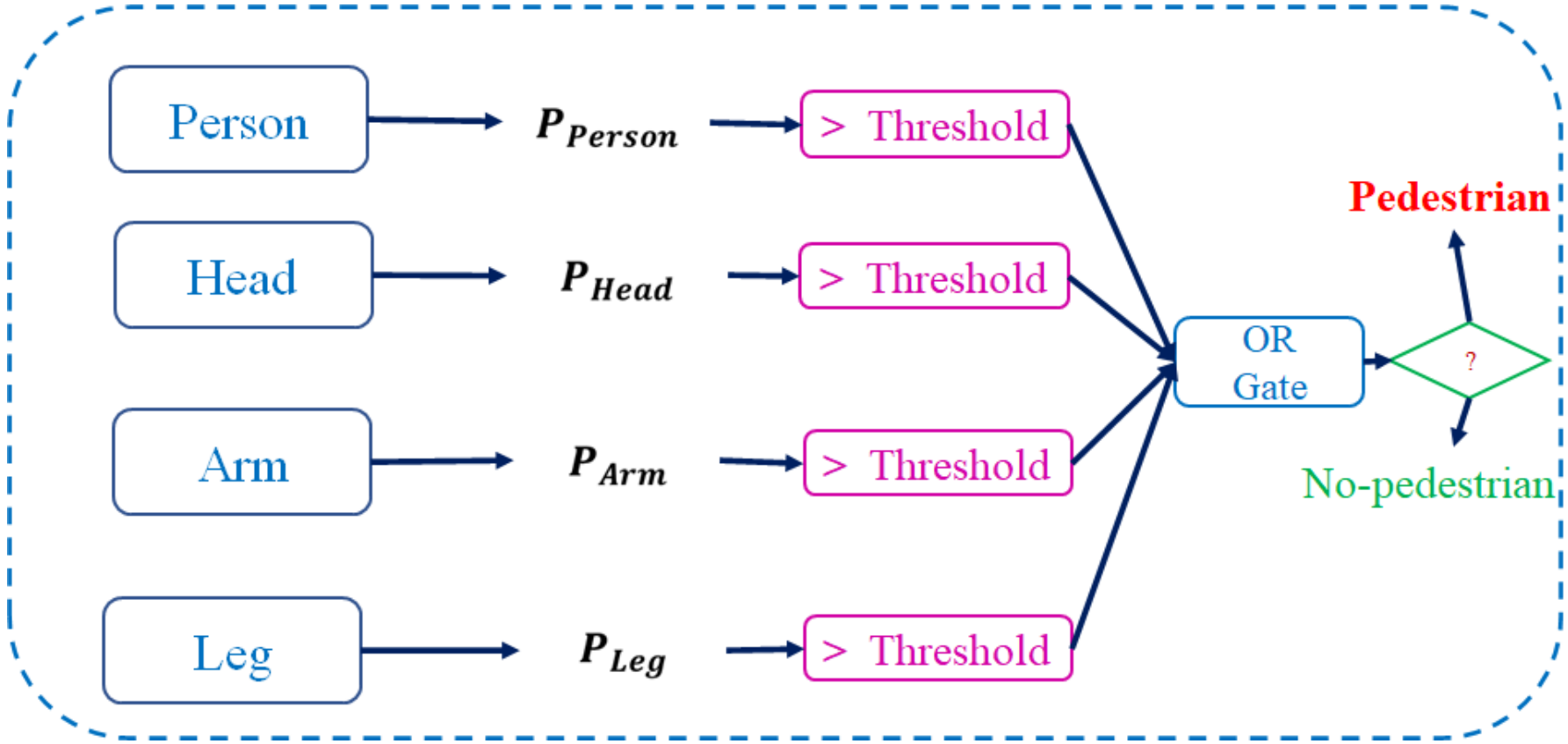
Our Approach...



- Trained two deep neural networks (Faster R-CNN and SSD-Mobilenet) with body parts data
- Developed a fusion method for detecting pedestrian efficiently

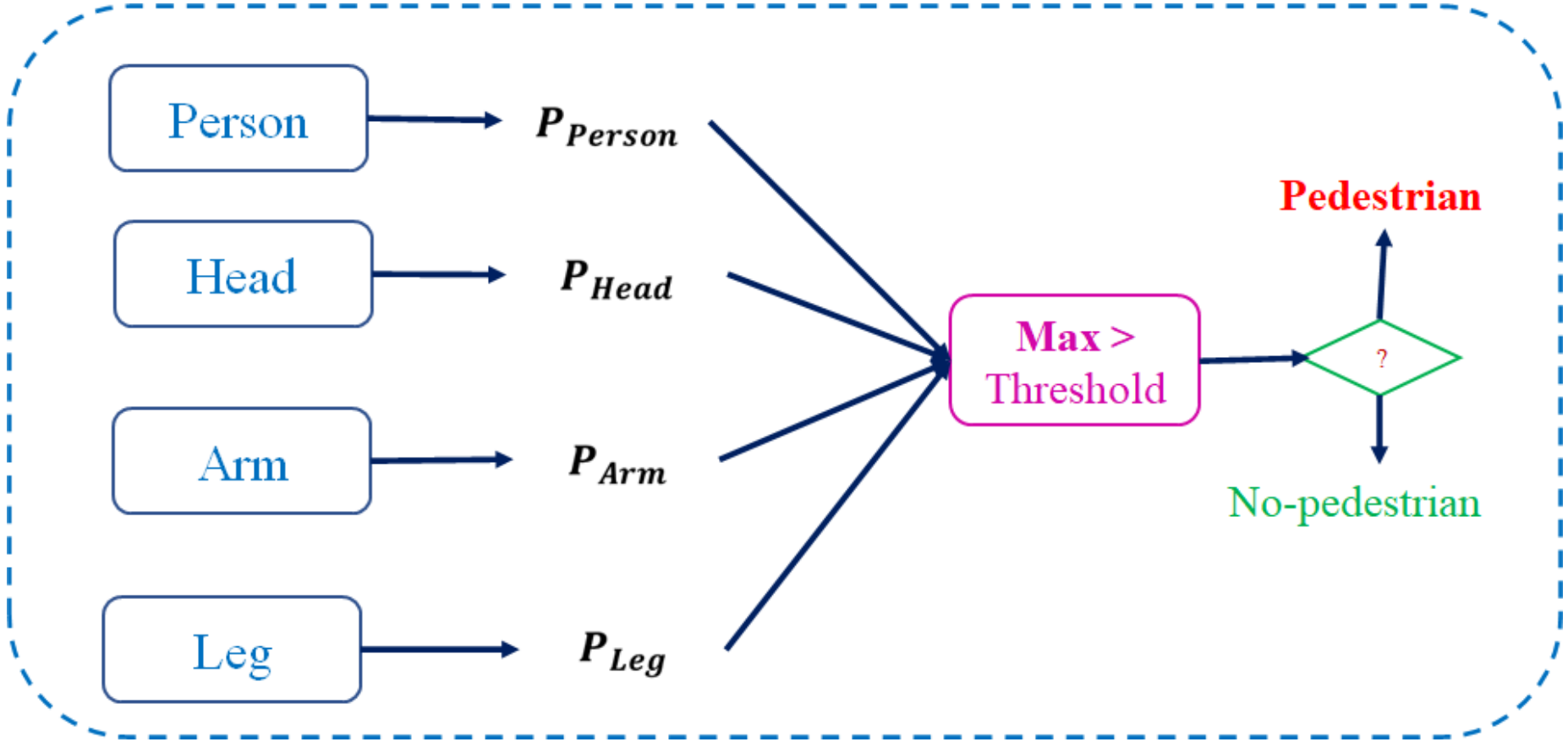
Proposed Methodologies

Fusion with a set of thresholds



Proposed Methodologies

Fusion with a maximum confidence



Experimental Results

Datasets for Pedestrian Detection By body parts

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- We have created a body part-based data set, along with full body data label
- Created a rich dataset of four different body parts with 3397 annotations
- We merged our dataset with a public (Penn-Fudan) dataset

Benchmark: SSD-mobilenet and Faster R-CNN

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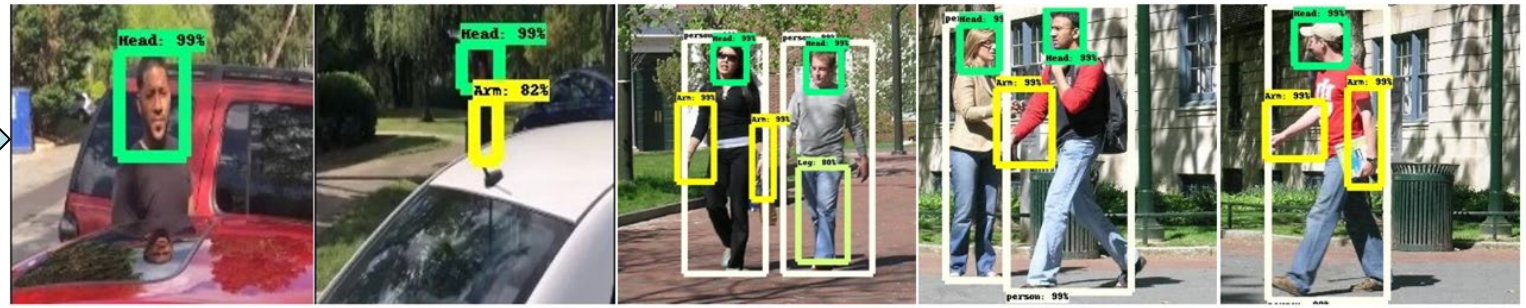
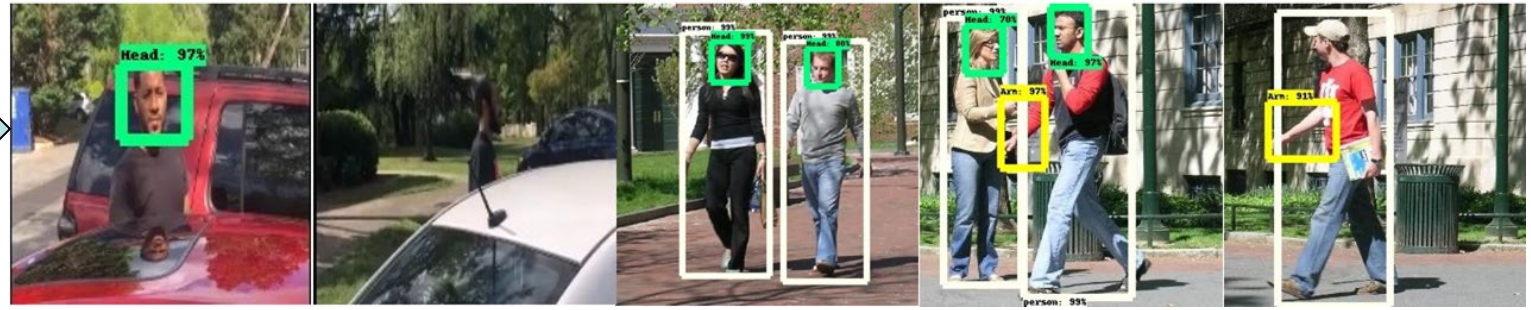
Faster R-CNN with fusion method



SSD-Mobilenet with fusion method



Proposed model detects body parts with full body labels

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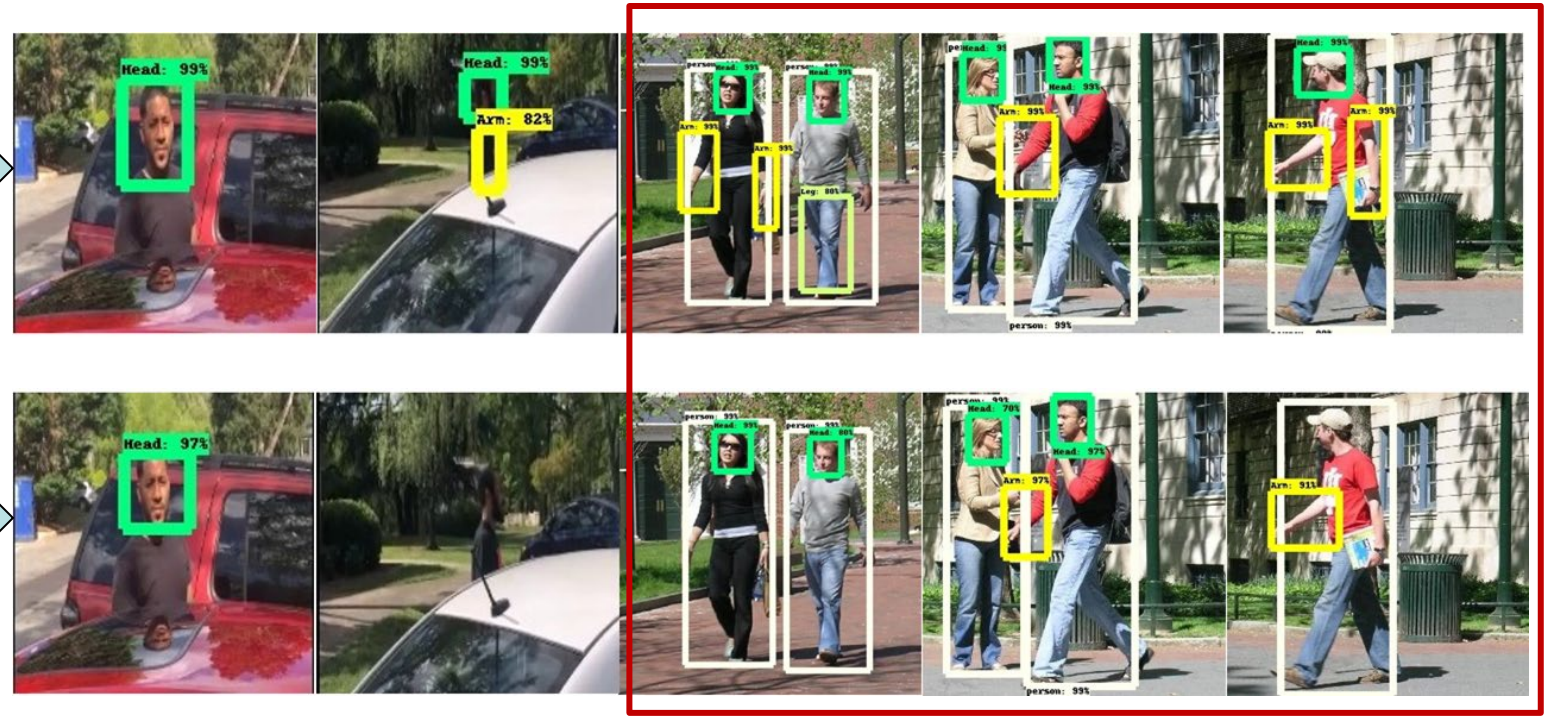
Faster R-CNN with fusion method

SSD-Mobilenet with fusion method



Faster R-CNN has better detection performance

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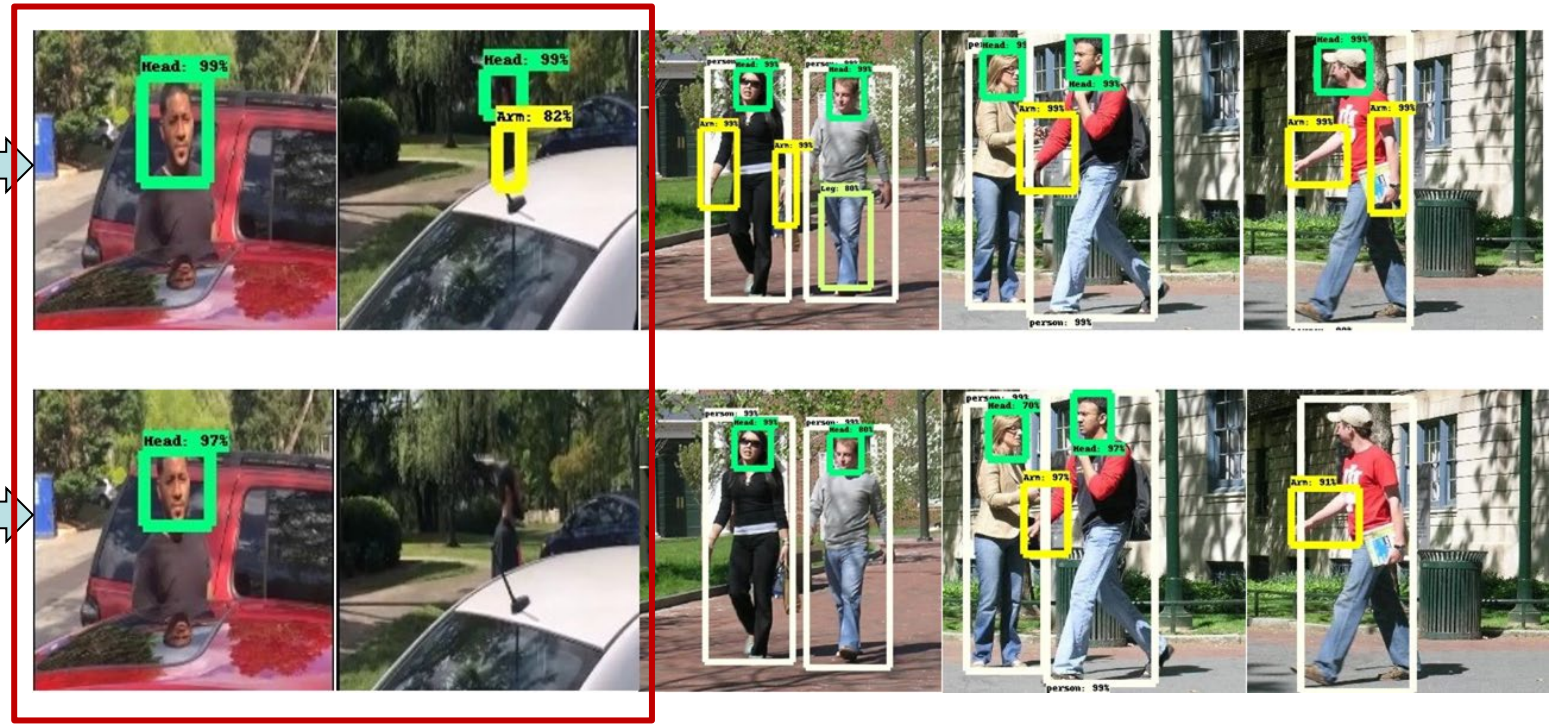
Faster R-CNN with fusion method

SSD-Mobilenet with fusion method



Experimental Results:

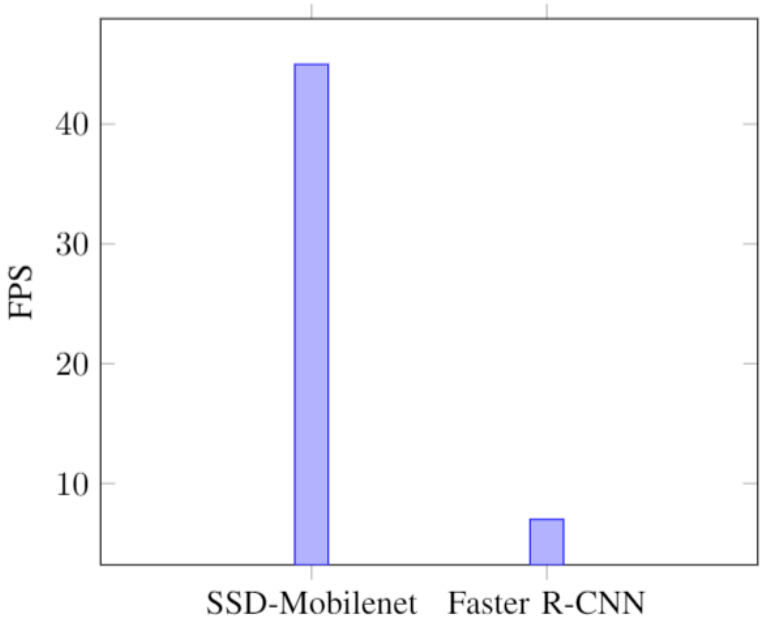
Analysis of Video Demonstration

Faster R-CNN

SSD-Mobilenet

SSD-Mobilenet exhibits better runtime efficiency

	# images (full-body pedestrians)	# images (occluded pedestrians)	# images (No pedestrians)	Accuracy	Precision	Recall	F1-score
SSD-Mobilenet	65	17	5	0.845	0.985	0.846	0.910
Faster R-CNN	65	17	5	0.919	0.937	0.974	0.955



- Faster R-CNN has better accuracy, recall and F1-score.
- SSD-Mobilenet has better precision.
- Faster R-CNN performs at a speed around 7 FPS on a GPU
- SSD-Mobilenet performs at a speed of around 45 FPS on a GPU

Applied to the ECO-PRT Shuttle

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"*Enhancing Autonomous Vehicle Traffic Safety through Pedestrian Detection, Classification and Communication*," $199,396 ,
Thomas Chase (NCSU/ITRE), A. Karimoddini (NCAT), S. Hollar (NCSU), J. Feng (NCSU), A. Homaifar (NCAT), NCDOT, 2019-2021.

https://youtu.be/56_ii67qBzs

https://youtu.be/pGLh0FrF_cA

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STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Acknowledgement

- My teammates at ACCESS Laboratory
- Support from NC Department of Transportation (NCDOT) under the award numbers RP2019-28 and TCE2020-03
- National Science Foundation under award numbers 1832110 and 2018879.

Conclusion:

- We have created a dataset with body parts
- We proposed fusion methodologies for detecting occluded pedestrians
- We train two deep neural networks with body parts data to detect occluded pedestrians

Future work:

- In future, we will be improving dataset for pedestrians and occluded pedestrians
- We will propose a Deep Neural Network Model that balances detection performances and runtime efficiency
- Sensor Fusion with Lidar and get the depth information

Questions?

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Efficient and Robust Pedestrian Detection using Deep Learning for Autonomous Cars

Abdullah Al Redwan Newaz, Muhammad M Islam, and Ali Karimoddini
aredwannewaz@ncat.edu, mmislam@aggies.ncat.edu, akarimod@ncat.edu

ACCESS Laboratory

https://www.accesslab.net/

https://www.nccav.com/

Autonomous Cooperative Control of Emergent Systems of Systems (ACCESS) Laboratory
NC Transportation Center of Excellence on Connected and Autonomous Vehicle Technology (NC-CAV)

NORTH CAROLINA
Department of Transportation

Research & Innovation Summit - 2020

Quantitative Analysis of Pedestrian & Bicycle Facilities at Intersections

Shannon Warchol, PE, Kittelson and Associates

Intersection and Interchange Projects

- SPOT continues to churn up lots of intersections and interchanges
  - Capacity and safety problems
- Pedestrians and bicyclists are important at those intersections and interchanges
  - Too many crashes
  - Insufficient past attention
  - Complete Street policy
  - Popular, livable, healthy, good for business,…

Which is Better for Peds and Bikes?

Conventional intersection

Reduced conflict intersection (RCI)

Which is Better for Peds and Bikes?

Conventional intersection

Continuous flow intersection (CFI)

Ways to Measure Pedestrian and Bicyclist Quality of Service

- Opinions
- Highway Capacity Manual Level of Service
  - Delay, corner crowding
- Travel distances
- Conflict points
  - Free-flow vehicle streams
  - Speeds, volumes, turns
- Microsimulation

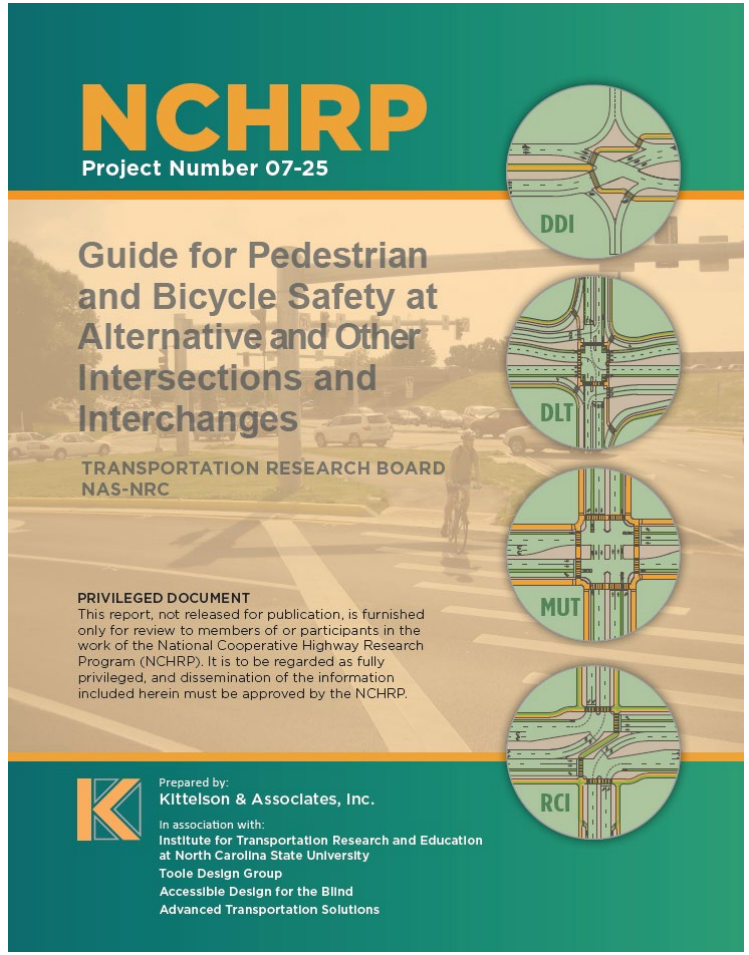
There are no good design-level crash models

A New Assessment Method

- Focus groups
  - 70 participants in four cities around US reacted to many different intersection scenes
- On-line surveys
  - 356 completed surveys, 35 states and 6 countries, mostly transportation professionals, 91% ped and bike advocates, over 8,000 comments
- Field observations of NC RCI and DDI
- Panel and expert input

NCHRP 7-25

- Research overseen by panel of state DOTs
  - Including NCDOT's Dr. Joe Hummer
- "Guide for Safety at (Alternative) Intersections and Interchanges" approved for circulation now, publication later 2020
  - Look for NCHRP Report 948



Assess a Design Using 20 Flags

Motor Vehicle Right Turns	Uncomfortable/Tight Walking Environment	Non-intuive Motor Vehicle Movements	Crossing Yield- or Uncontrolled Vehicle Paths	Indirect paths
Executing Unusual Movements	Multilane Crossings	Long Red Times	Undefined Crossing at Intersections	Motor Vehicle Left Turns
Driveways and Side Streets	Sight Distance for Gap Acceptance	Grade Change	Riding in Mixed Traffic	Bicycle Clearance Times
Lane Change Across Motor Vehicle Lanes	Channelized Lanes	Turning Motorists Crossing Bicycle Paths	Riding between travel lanes	Off-tracking trucks in multi-lane curves

A New Assessment Method

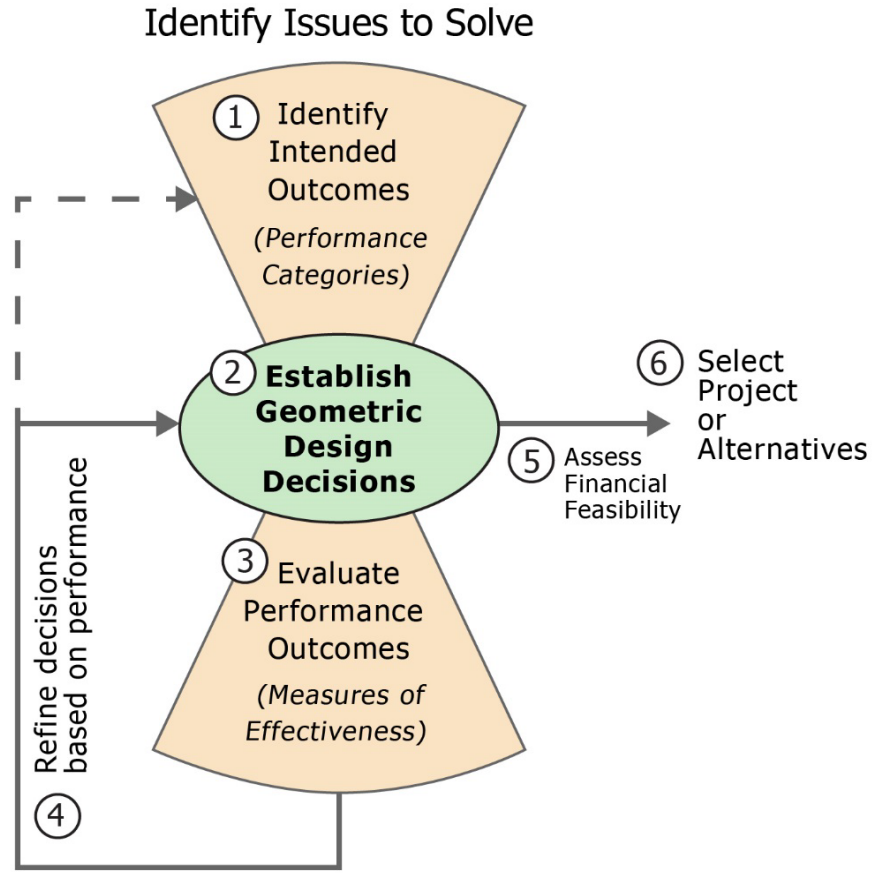
- Pedestrians: Check each of the four crosswalks
  - 13 Possible Flags
- Bicycles: Check each of the 12 movements
- 16 possible flags

Yellow Flags, for design elements negatively affecting user comfort (in other words, increasing user stress) or the quality of the walking or cycling experience.

Red Flags, for design elements that are directly related to a safety concern for pedestrians or bicyclists.

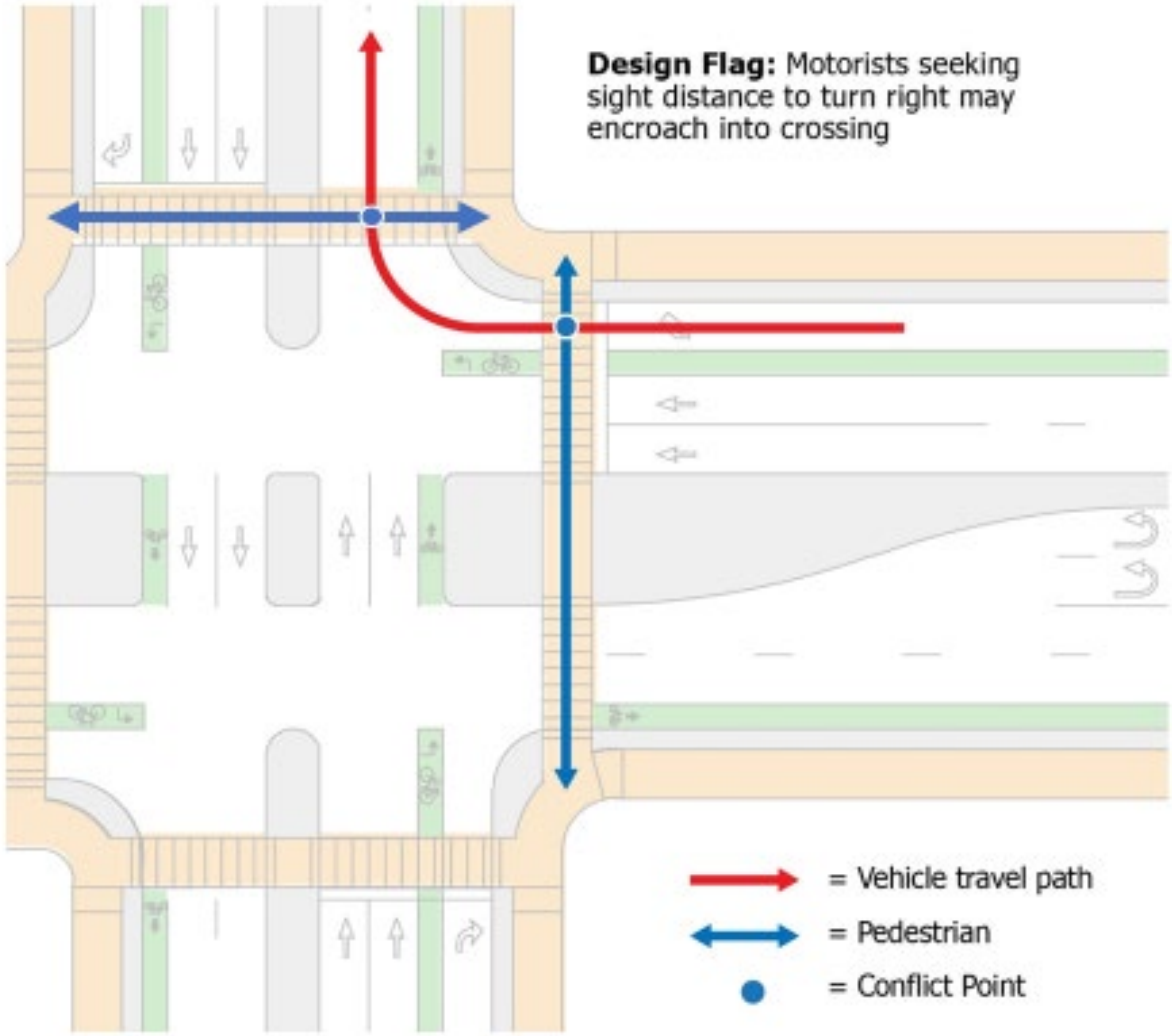
Performance-Based Design Process

- Identify intended outcomes
- Establish geometric design decisions
- **Evaluate performance outcomes**
- Refine decisions based on performance
- Assess financial feasibility
- Select project or alternatives



NCHRP Report 785 – Performance-Based Design Process

Example: Flag 1



Flag Criteria

No.	Flag	Applicable Mode	Measure of Effectiveness	Yellow Flag Threshold	Red Flag Threshold
1	Motor Vehicle Right Turns	Pedestrian	Vehicle Turning Speed & Vehicle Volume	<=20 mph **&** <= 50 vph	>20 mph **OR** >50 vph
2	Uncomfortable/Tight Walking Environment	Pedestrian	Walkway width	< 5' if traffic present on one side; <10' if traffic present on two sides	N/A
3	Nonintuitive Motor Vehicle Movements	Pedestrian	Vehicle acceleration profile	Vehicle decelerating	Vehicle accelerating or free-flowing
4	Crossing Yield-Controlled or Uncontrolled Vehicle Paths	Pedestrian & Bicycle	Vehicle Speed & Vehicle Volume	<=20 mph **&** <= 50 vph	>20 mph **OR** >50 vph

Application to U-5768, Division 10

- Widen NC-49 (University City Drive) from John Kirk Drive to I-485
- Realign Back Creek Church Road
- Close existing Back Creek Church Road at-grade rail crossing

Summary

- NCHRP 7-25 provides a consistent and quantitative way to evaluate the quality of pedestrian and bicyclist service at any intersection or interchange.
- Published soon, available to use now
- Could help at any stage of project development
- Not difficult or expensive
- More training from NCHRP soon

Questions & Discussion

Shannon Warchol
swarchol@kitteslon.com