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Using Computer Vision to Process Vehicle Dashboard Displays in Transportation Safety Research

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Outline

- Introduction
- Nature of data
  - Videos
  - Icons
- Methodology – Machine learning pipeline with OpenCV
- Results
  - Model performance
  - Future research

Introduction – Background of the Overall Study

- Understand driver behavior in the context of driver-assist systems in Toyota Safety Sense system (TSS)
  - Driver-assist systems

Adaptive Cruise Control *Lane Departure Alert* *Pre-Collision System*

    - when the systems are triggered, related driver-assist icons appear on the vehicle dashboard displays

When driver-assist icons were presented → When driver-assist systems were used → How drivers interpret and respond to the presence of the icons → How drivers understand systems over time

Introduction – Research Problem

- Problem
  - Identify the presence of icons on the vehicle dashboard displays
- Pilot study
  - Collect data by recording the central dashboard displays while driving instrumented Toyota vehicles

Nature of Data - Videos

- Video recordings of central dashboard display
  - Pilot study data
    - 200+ 1-min videos
  - Study data (*estimated*)
    - 10-20 instrumented Toyota vehicles
    - 12 weeks participation per vehicle
      - 500+ 1-min videos per week

Nature of Data - Icons

- 10 icons

Brake

Adaptive Cruise Control

Lane Departure Alert

Headway Bar Indication

Leading Car

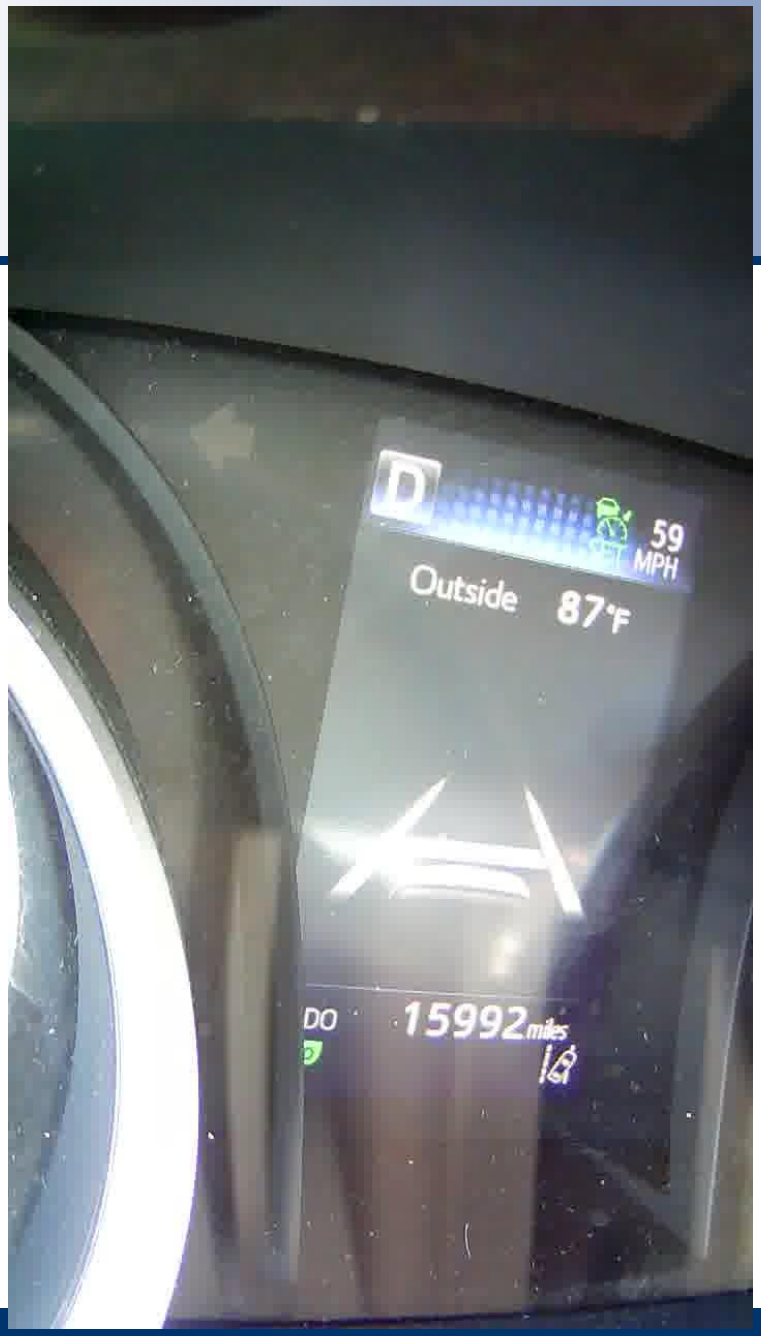
Lane Line Indication

Methodology

- Technique
  - OpenCV: open source computer vision library
- Machine learning Pipeline utilized OpenCV Python API and R

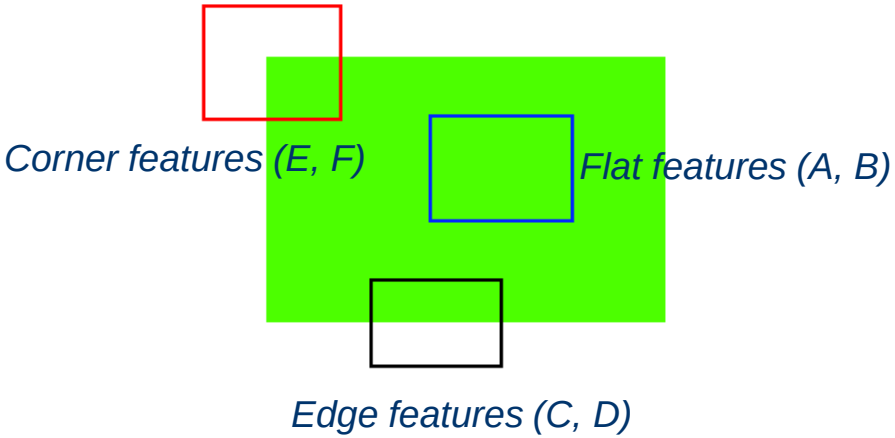
Methodology – Frame Extraction

- Extract frames from videos per half-second



Methodology – Feature Matching

- Feature
- Good feature – corner feature



Methodology – Feature Matching

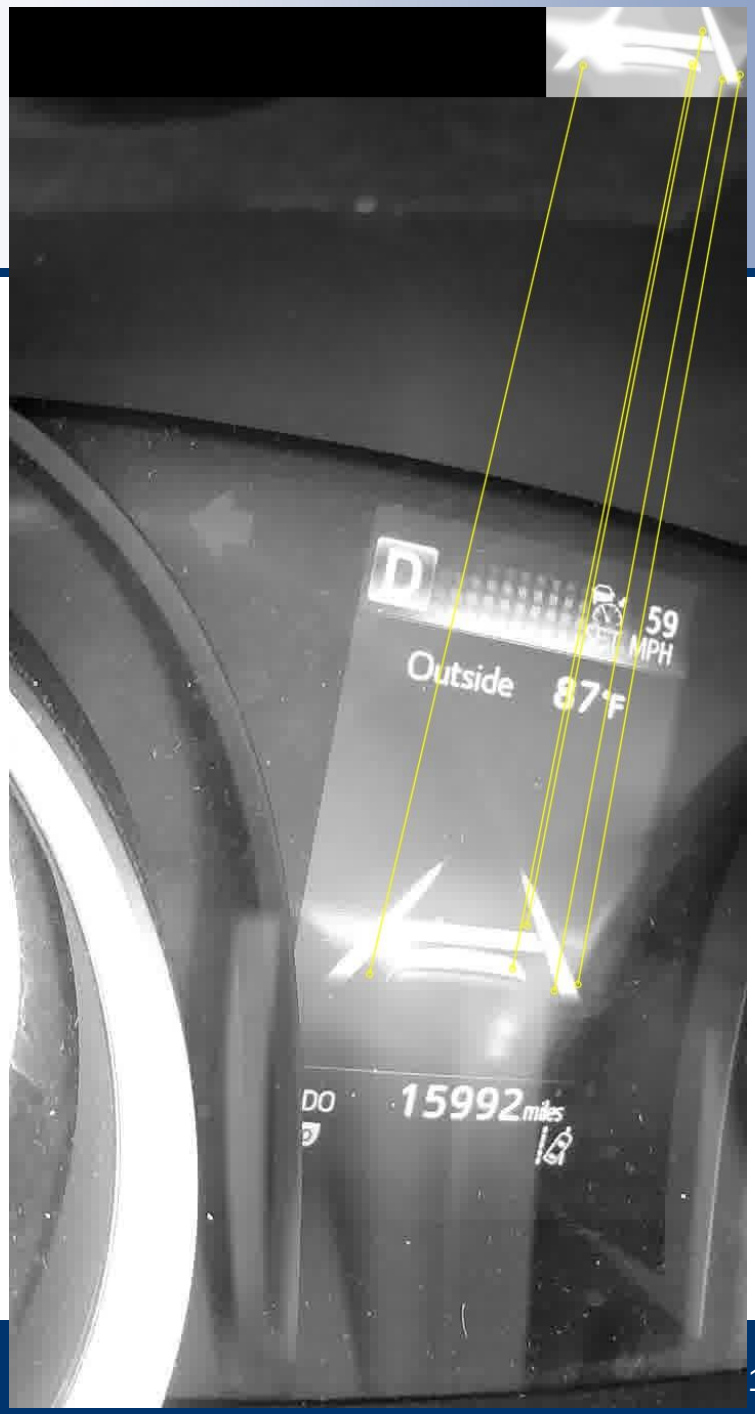
1. Detect features in icons

2. Match same features between two images

1. Detect features in frames

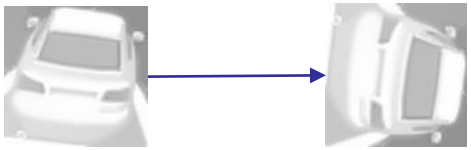
Methodology – Feature Matching

- Matching Criteria
  - 3 matched features between two images

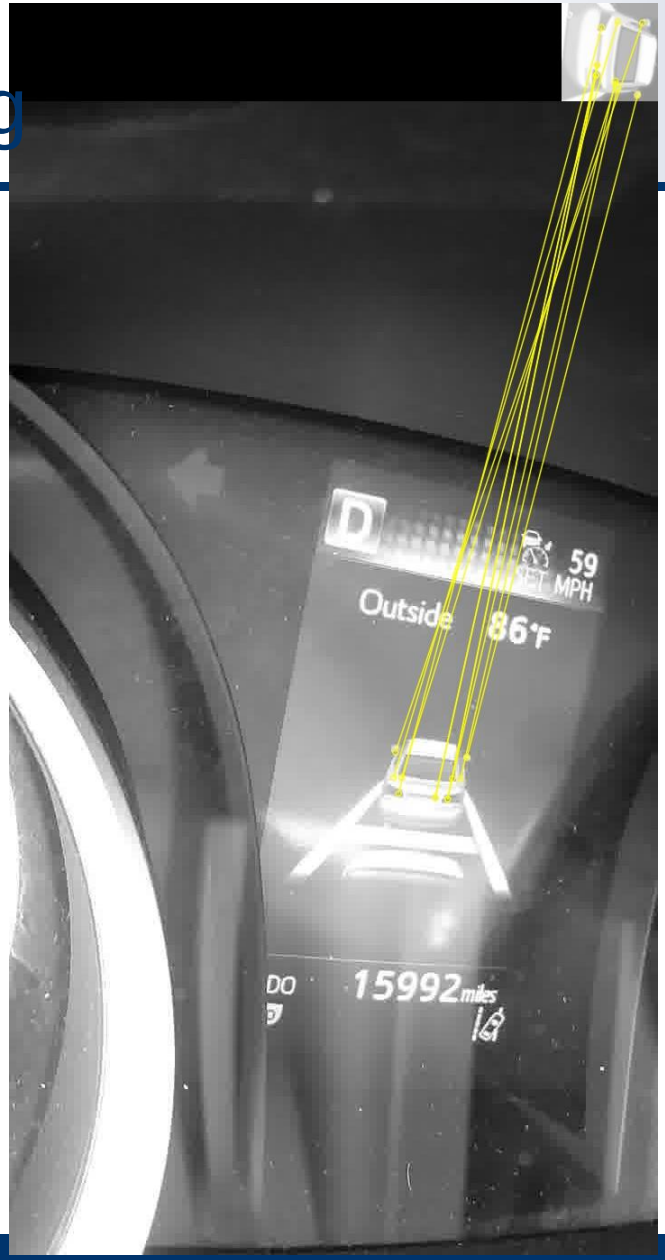


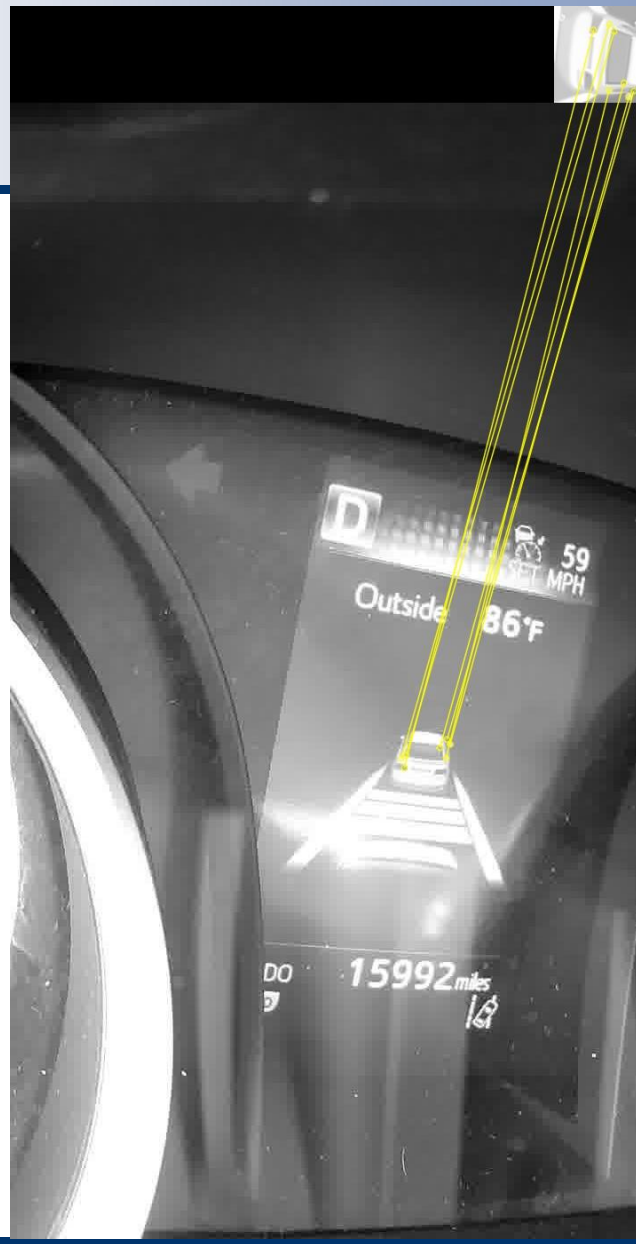
Methodology – Feature Matching

- Scale invariant
- Rotation invariant



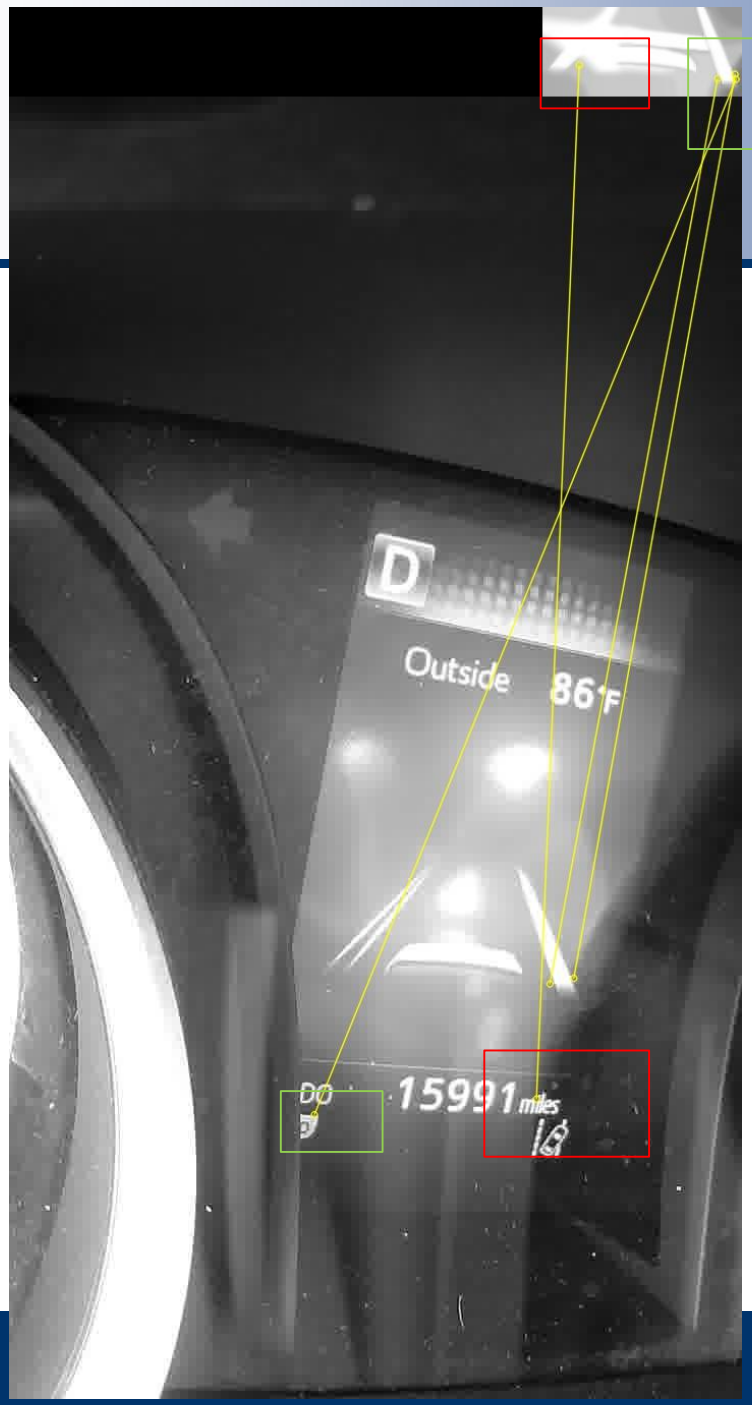
Leading Car





Methodology – Feature Matching

- Mismatching
  - Local features detected in the frames are noise
- Strategy
  - Lower noise and narrow target areas for feature matching



Methodology – Image Preprocessing

- Crop the dashboards from the frames - focus on region-of-interest
- Deskew the dashboards
- Denoise

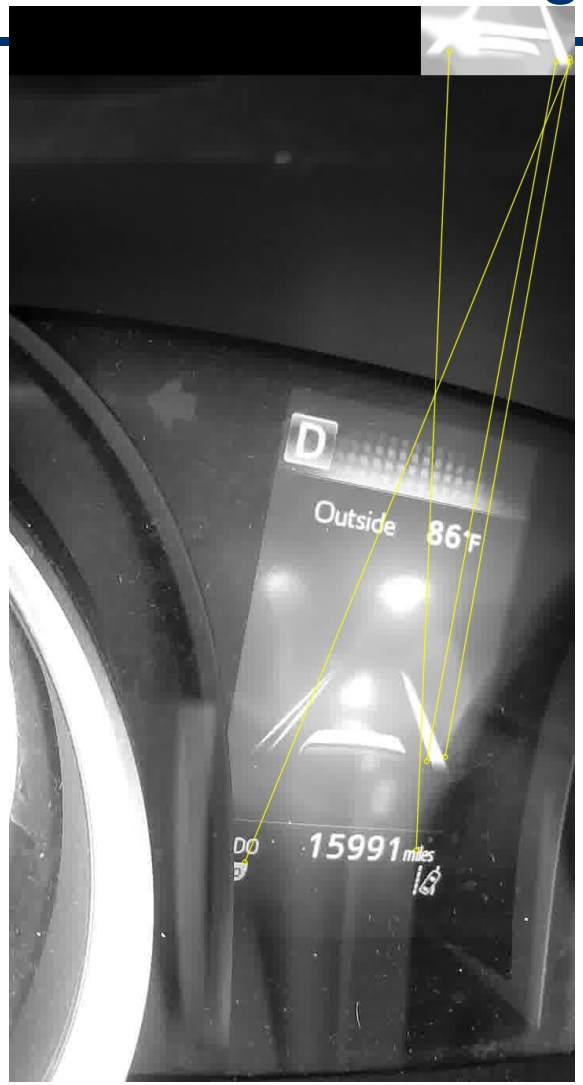
Methodology – Image Preprocessing

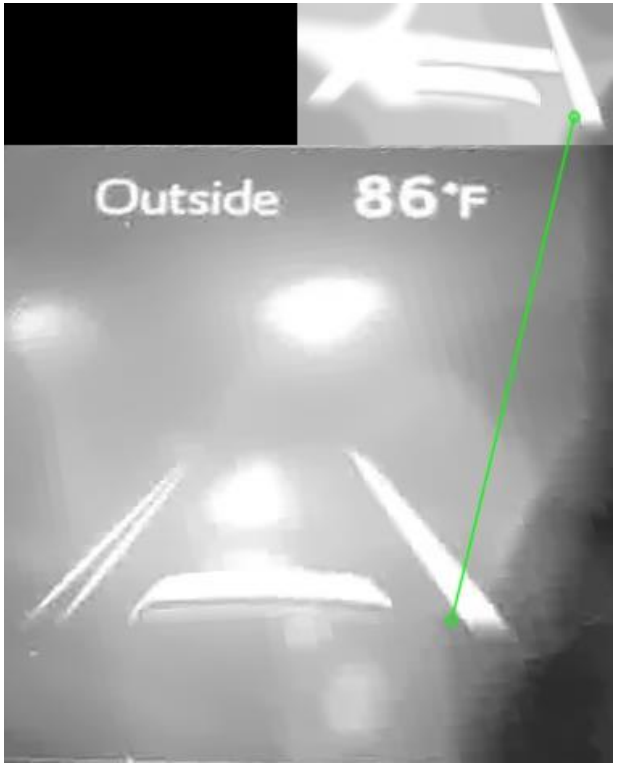
- Crop into 3 parts
  - Narrow down the target area

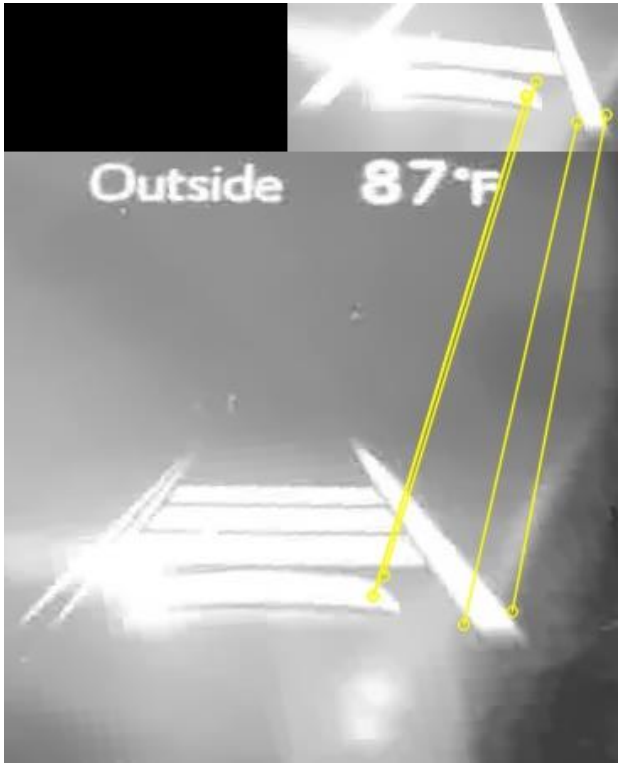
Adaptive Cruise Control

Lane Departure Alert

Methodology – Feature Matching

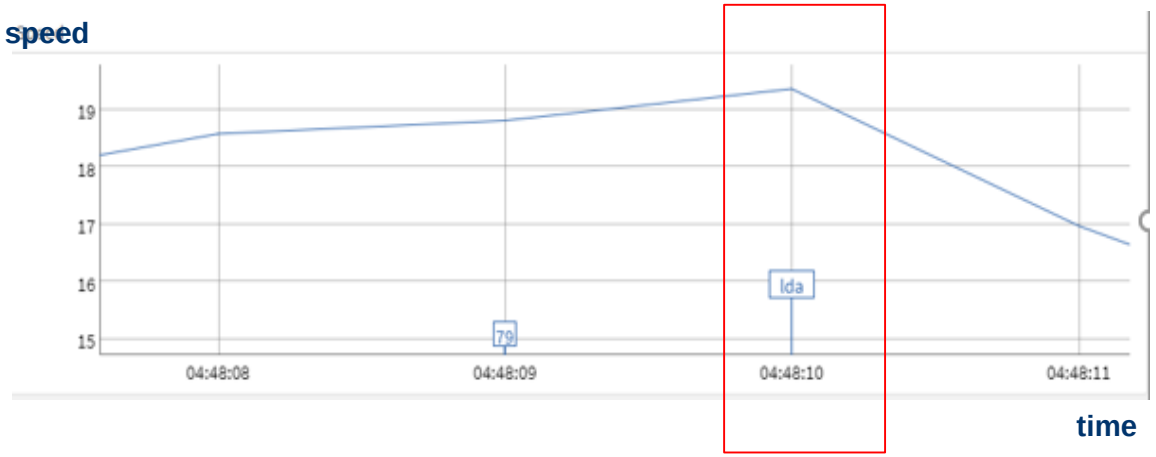


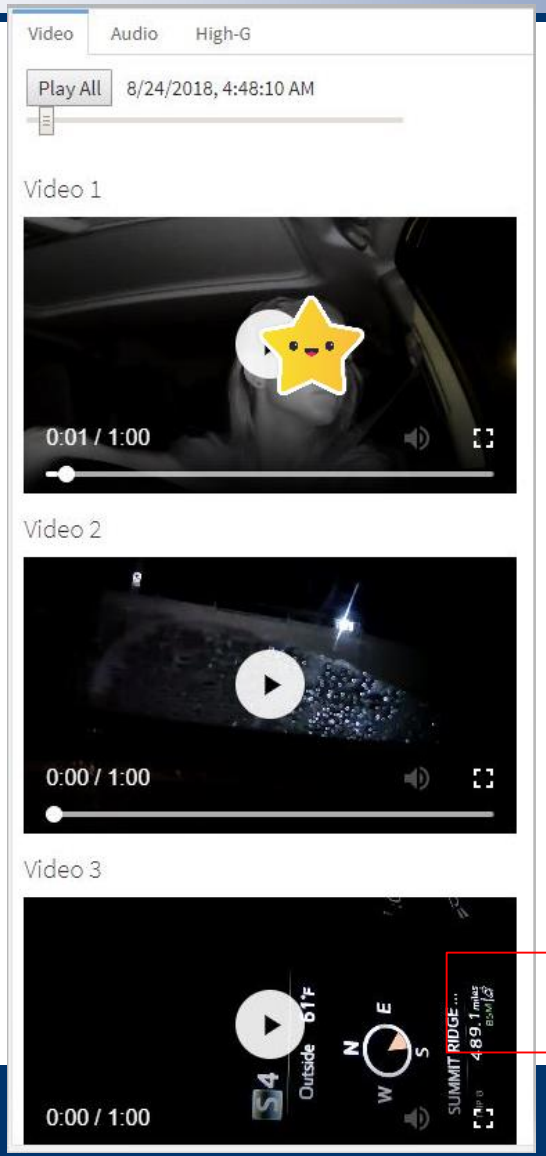




Methodology – Visualization (R Shiny)

- Interactive time series plots





Results – Modeling Performance

- Sample data: 10 icons, 29 *selected* frames, 290 combinations
- Confusion Matrix

n = 290	Predicted Negative	Predicted Positive	
Actual Negative	TN = 213	FP = 4	217
Actual Positive	FN = 25	TP = 48	73
	238	52	

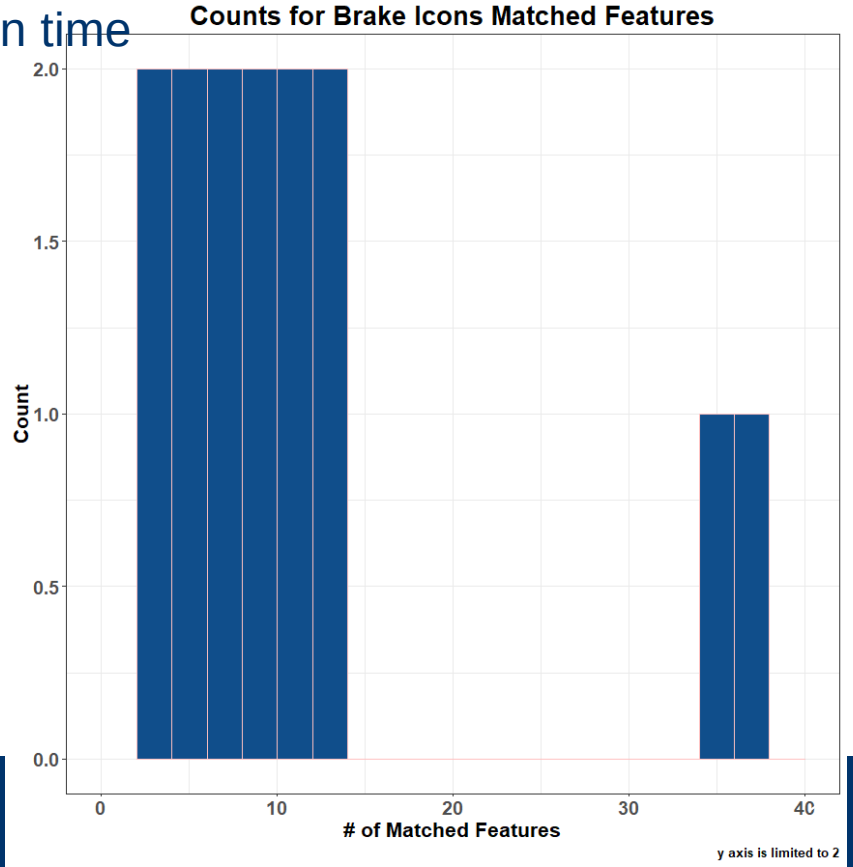
TPR: 0.66 *TNR: 0.98* *FPR: 0.018* *FNR: 0.342*

- Runtime (*4 threads multiprocessing*)
  - Week 1 subject 1 real study data: 10 icons, 57,000 frames, 570,000 combinations (500+ 1-min videos)
  - Computation time

Frame extraction: 10 mins *Image preprocessing: 2 hours+* *Feature matching: 2 hours+*

Results – Conclusion & Future Research

- Conclusion: Works well!
  - Leads to 66% true positive rate and 98% true negative rate
  - Meets computation requirement when data scales up
  - Processes with reasonable computation time
- Current research
  - Customizes matched features criteria for each icon
    - Balance FP/FN error
- Future research
  - Train customized model



Thank you for listening!

- Contact information

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- Citation

ANN ARBOR. Mich, (2017, November 15). *Toyota's Collaborative Safety Research Center to Study Societal Acceptance of Connected and Automated Vehicle Technologies*. Retrieved from https://corporatenews.pressroom.toyota.com/releases/toyota+collaborative+safety+research+center+study+societal+acceptance+connected+automated+vehicle.htm

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