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

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Outline

- Introduction of Research Problem
- 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 triggered → How drivers interpret and respond to the presence of the icons → How drivers understand the TSS systems and their capabilities

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*)
    - 500+ 1-min videos per vehicle per week:
      - 10-20 instrumented Toyota vehicles
      - 12 weeks participation per vehicle

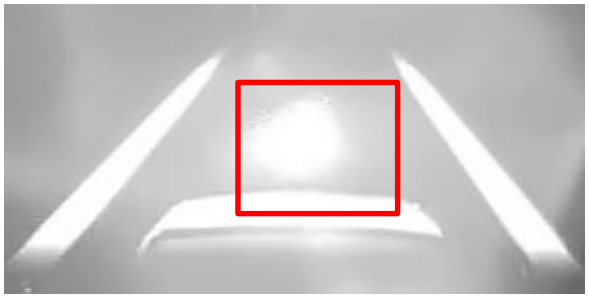
Nature of Data – Icons

- 10 icons
  - Adaptive Cruise Control
  - Lane Departure Alert
  - Pre-Collision System

Leading Car

Headway Bar Indication

Low resolution!
Glare!



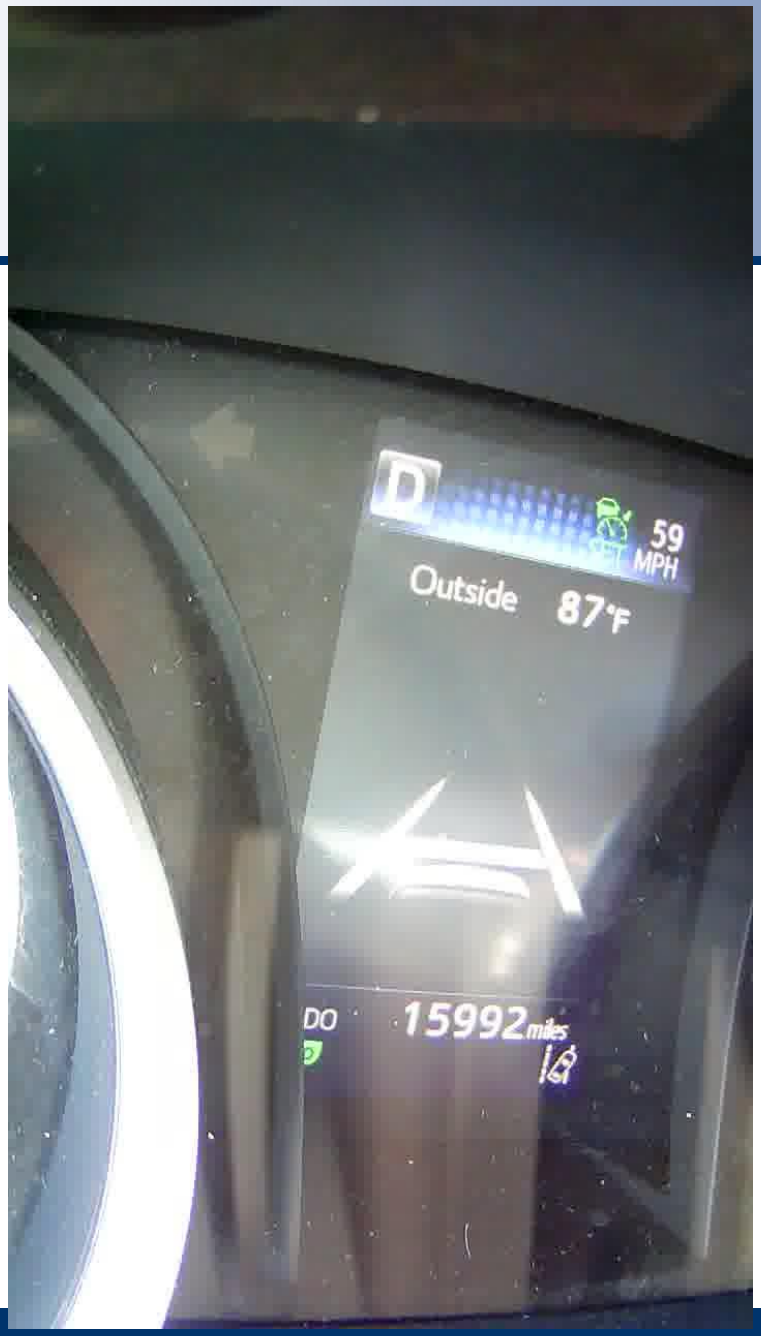
Lane Line Indication

Methodology

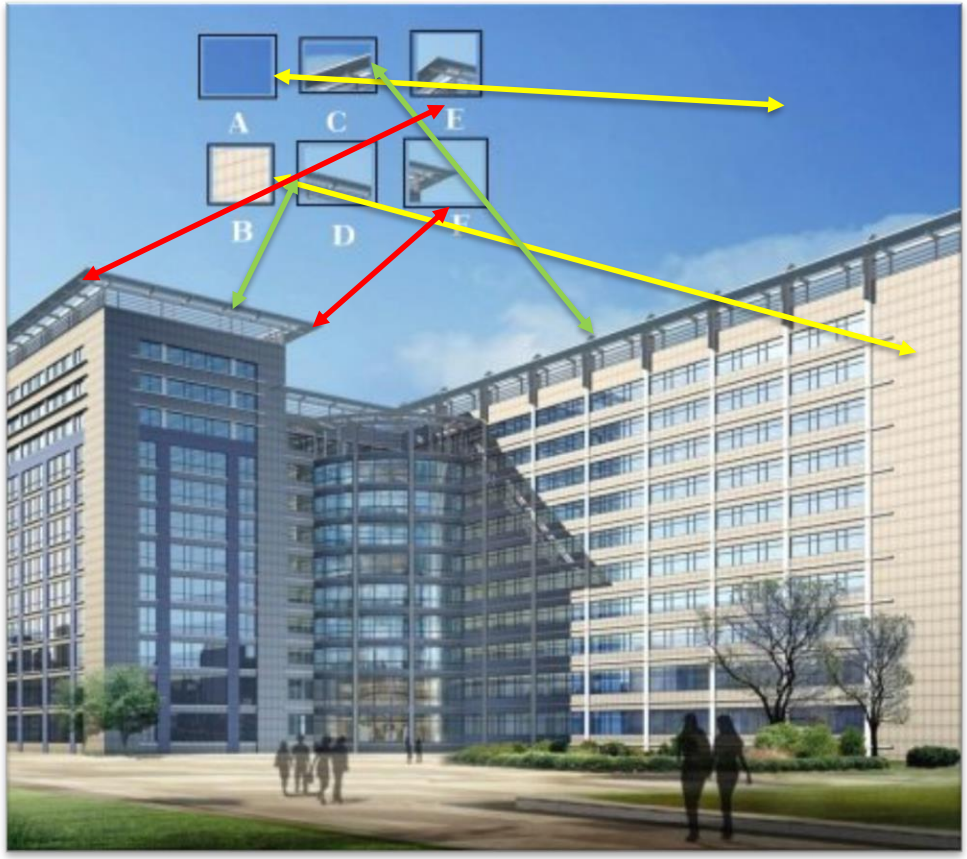
- Technique
  - OpenCV: open source computer vision library
- Machine learning Pipeline utilized OpenCV Python API and R Shiny

Methodology
– Frame Extraction

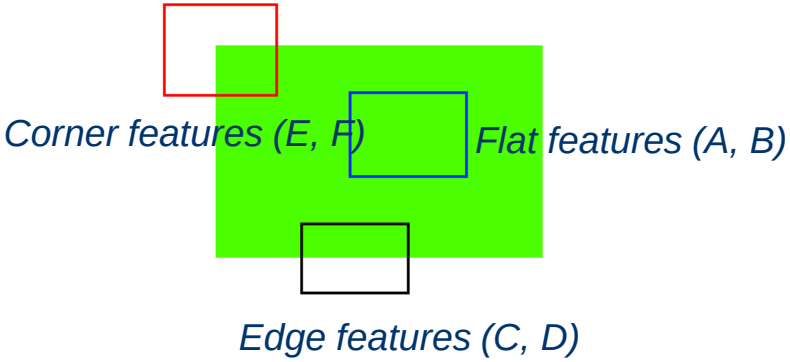
- Extract frames from videos per half-second



Methodology
– Feature Matching between Icons and Extracted Frames

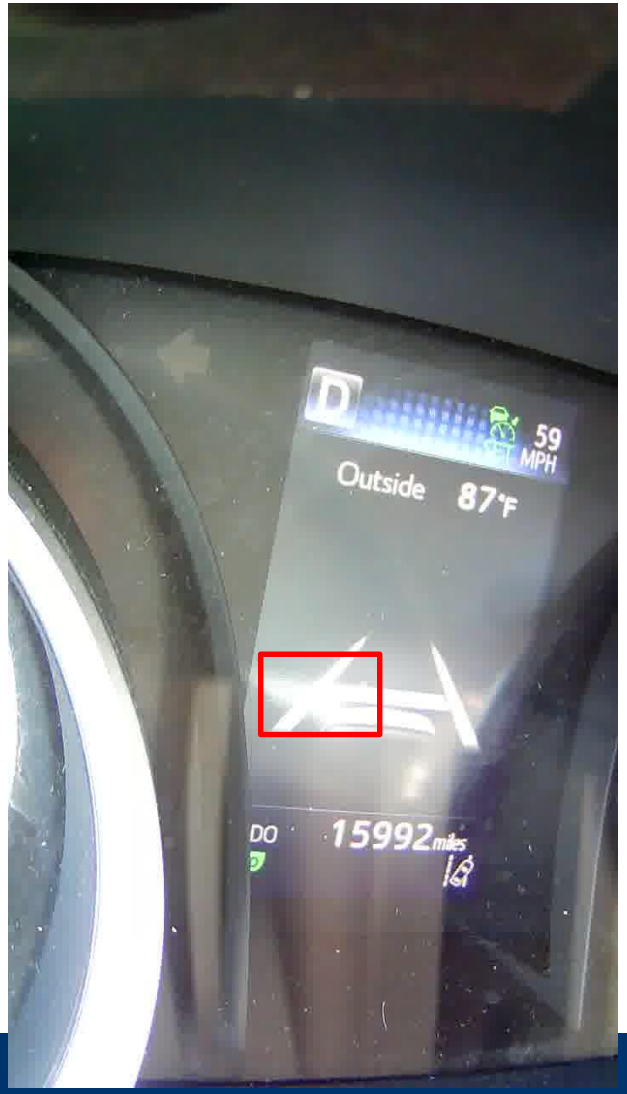


- Feature: distinct patterns
- Corner feature – good feature



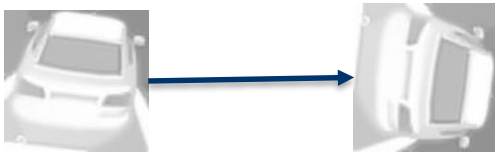
Methodology
– Feature Matching

- Feature detection
  - Corner features

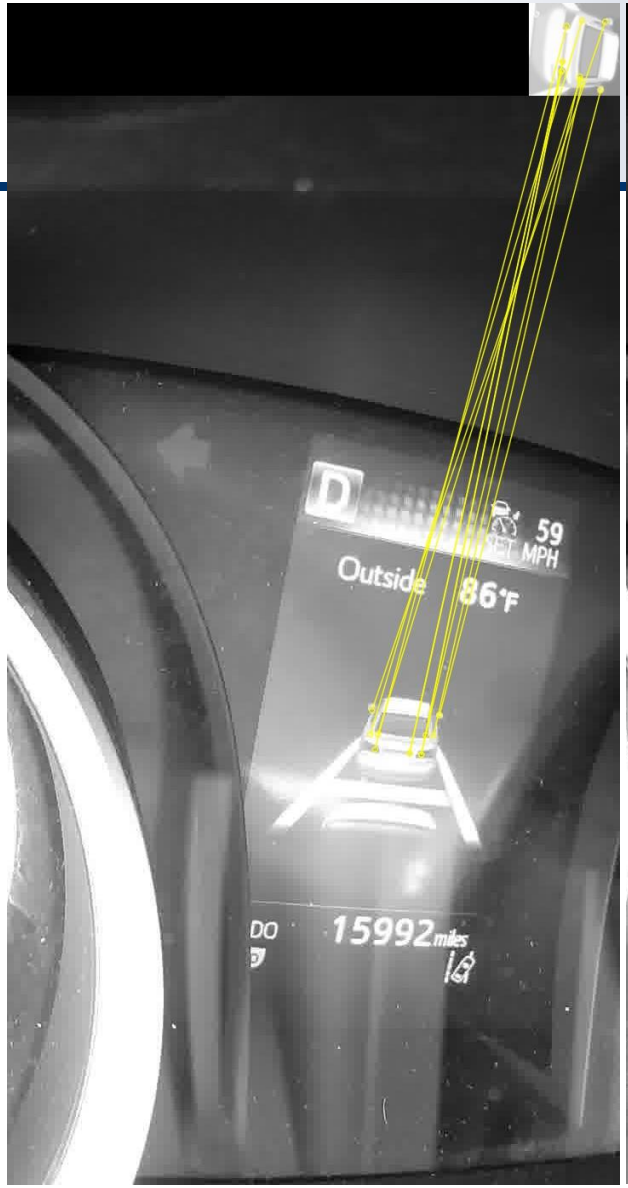


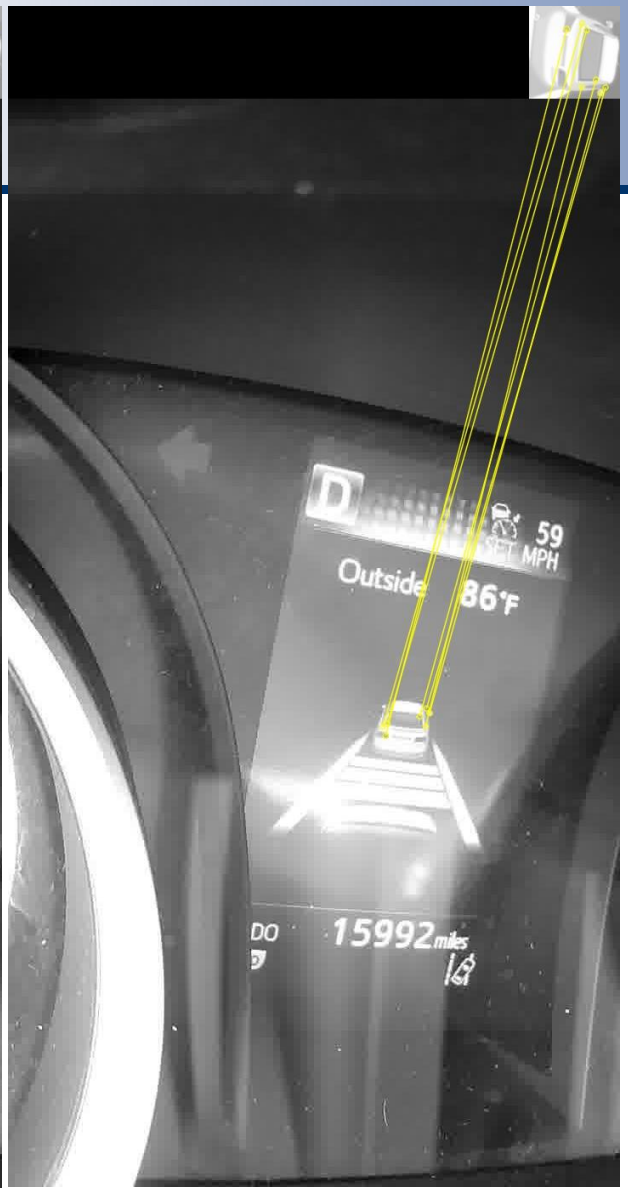
Methodology
– Feature Matching

- Feature description
  - Rotation and Scale invariant



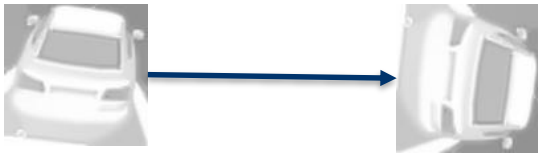
Leading Car



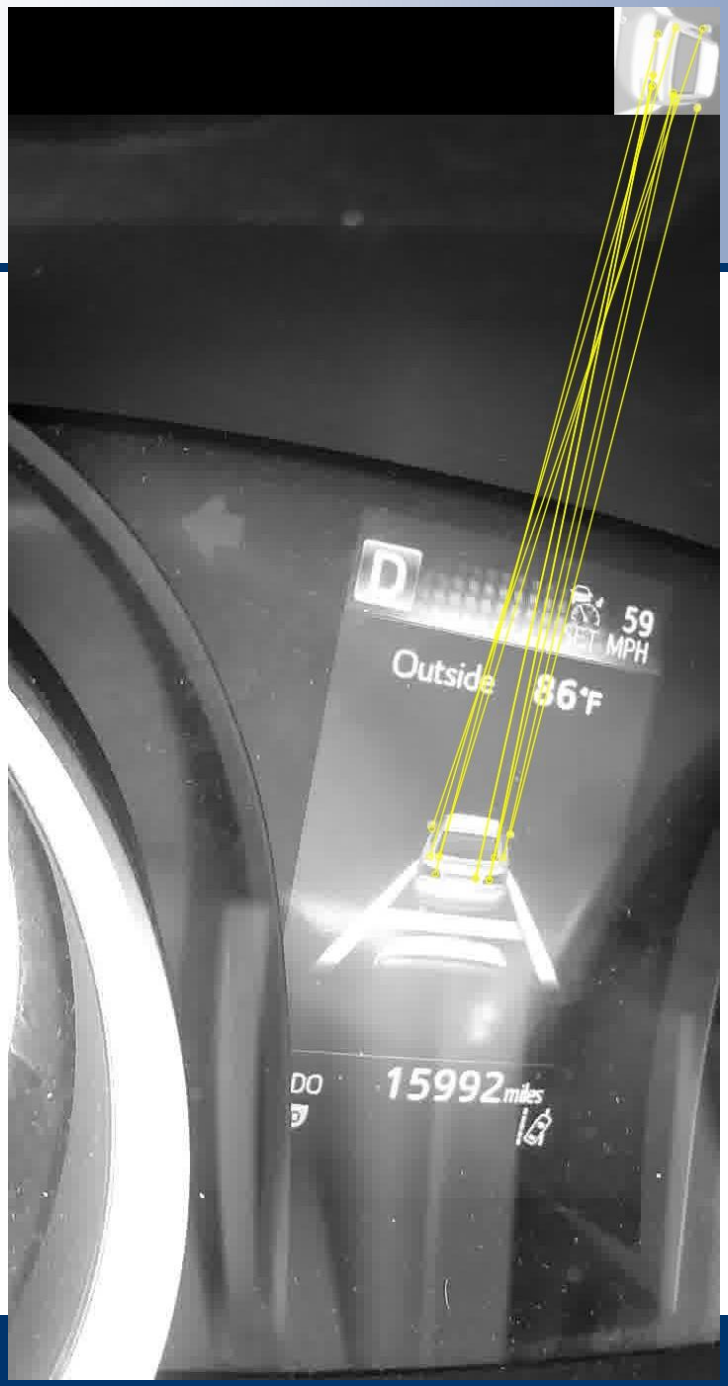


Methodology
– Feature Matching

- Feature matching between icons and extracted frames
  - matching criteria: 3 features matched (tunable)



Leading Car



Methodology
– Image Preprocessing before Feature Matching

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

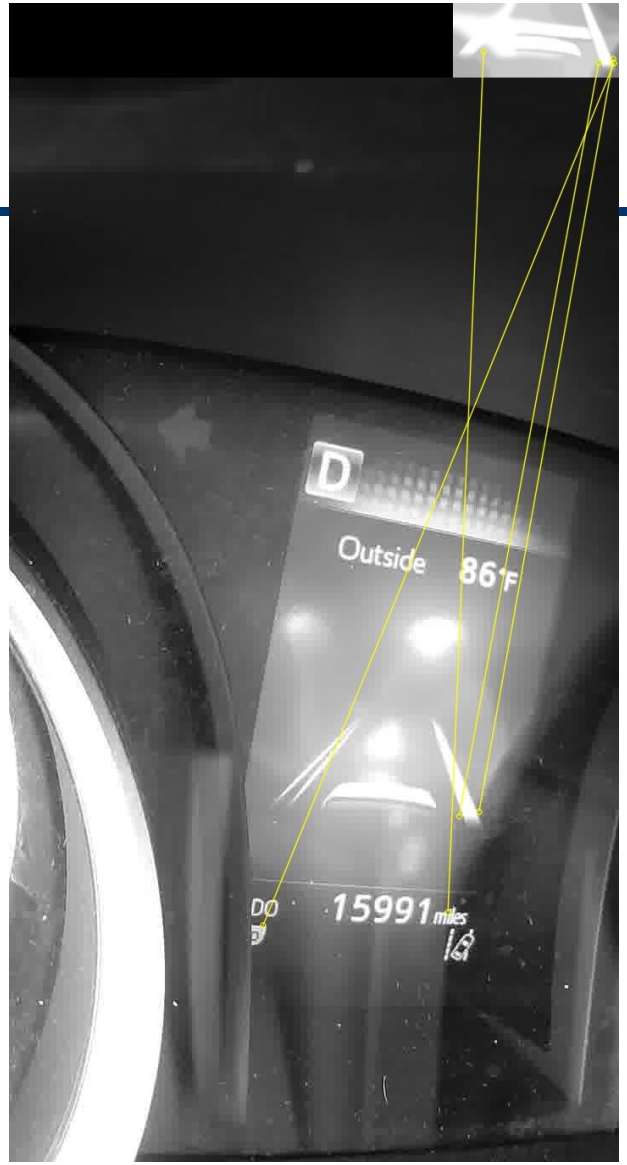
Methodology
– Image Preprocessing before Feature Matching

- Crop into 3 parts
  - Narrow down the target area

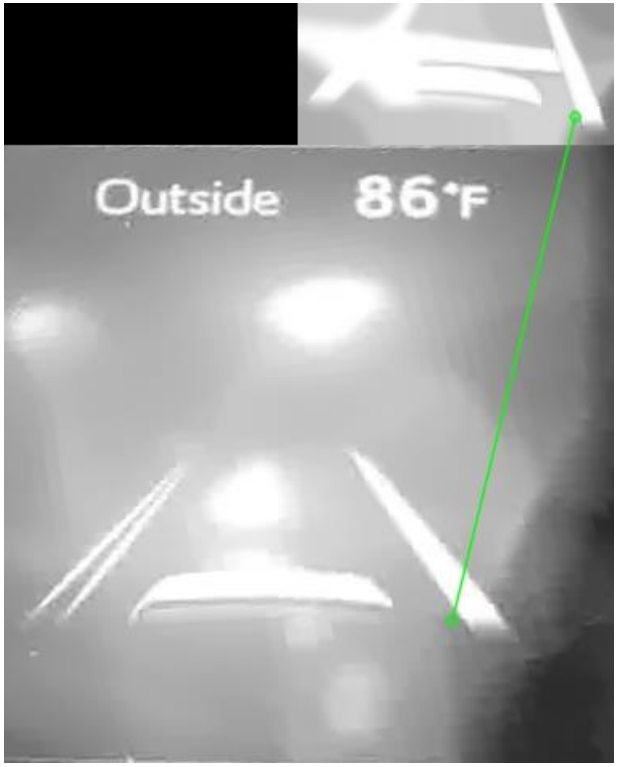
Adaptive Cruise Control

Lane Departure Alert

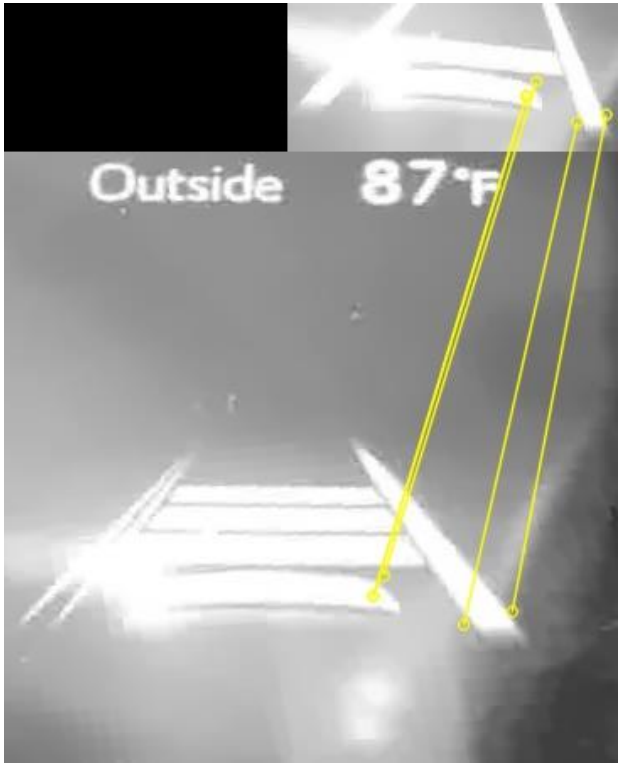
Methodology – Feature Matching (after Image Preprocessing)



False Positive



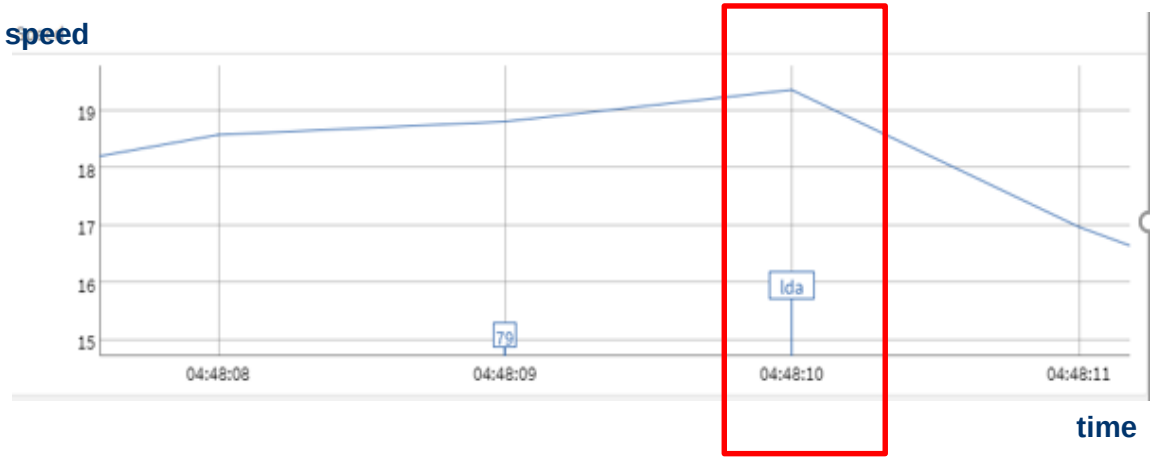
< 3 matched features
True Negative

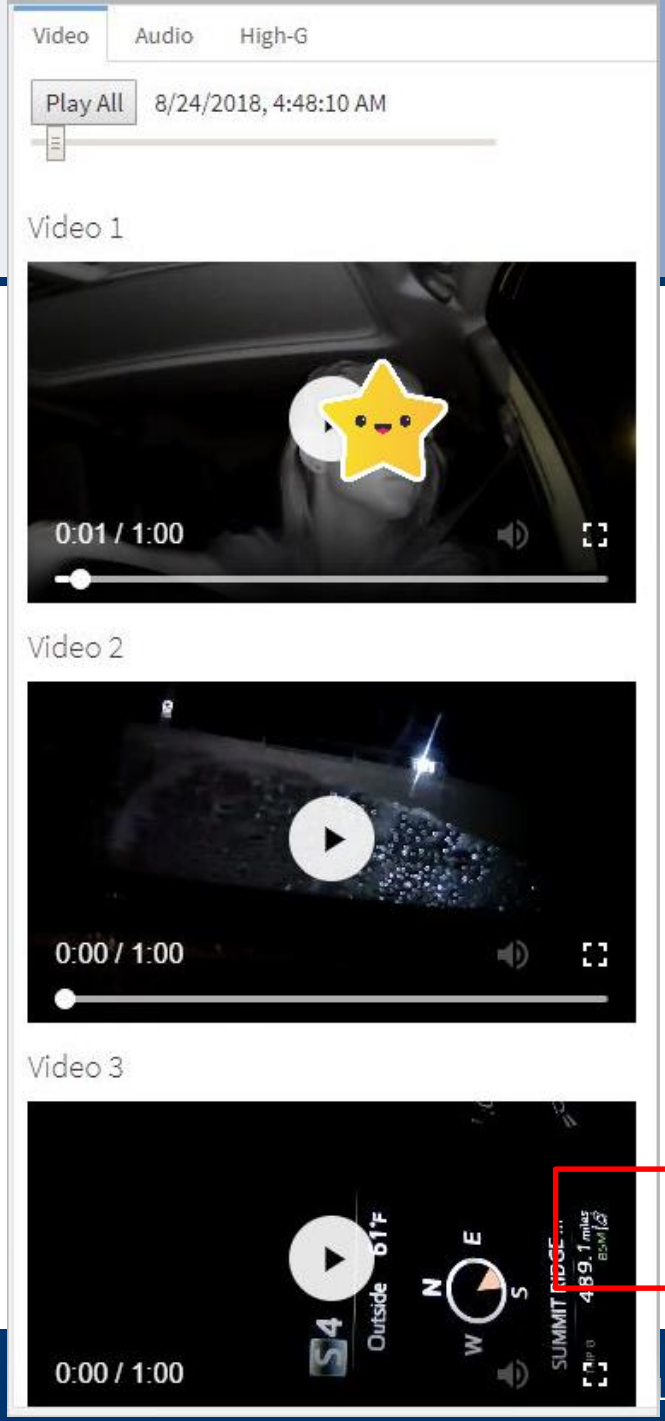


> 3 matched features
True Positive

Methodology
– Visualization

- Interactive tool to visualize matching results and other information about drivers and road conditions





Results
– Model Performance

- Classification Accuracy: 0.9
  - Sample data: 10 icons, 29 *selected* frames, 290 combinations

n	Predicted Negative	Predicted Positive	
Actual Negative	213	4	217
Actual Positive	25	48	73
	238	52	290

  - True Positive Rate: 0.66 True Negative Rate: 0.98
  - False Positive Rate: 0.018 False Negative Rate: 0.342

- Runtime: ~ 4 hours with *4 threads multiprocessing*
  - Week 1 vehicle #1 Data: 10 icons, 57,000 frames, 570,000 combinations from more than 500 1-min videos
  - Frame extraction: 10 minutes
  - Image preprocessing: ~2 hours
  - Feature matching: ~2 hours

Results
– Conclusion & Future Research

- Current research
  - Tune 3-feature matching criteria to balance FN/FP error
- Future research
  - Train customized model
- Conclusion: Works well!
  - 90% accuracy
    - Leads to 66% true positive rate and 98% true negative rate
  - Reasonable computation time
    - Meets computation requirement when data scales up

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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