Institute of Automated Mobility

Shaping the future of transportation safety, science, and policy

NIST Workshop

September 8, 2023

Digital Infrastructure Research in AZ

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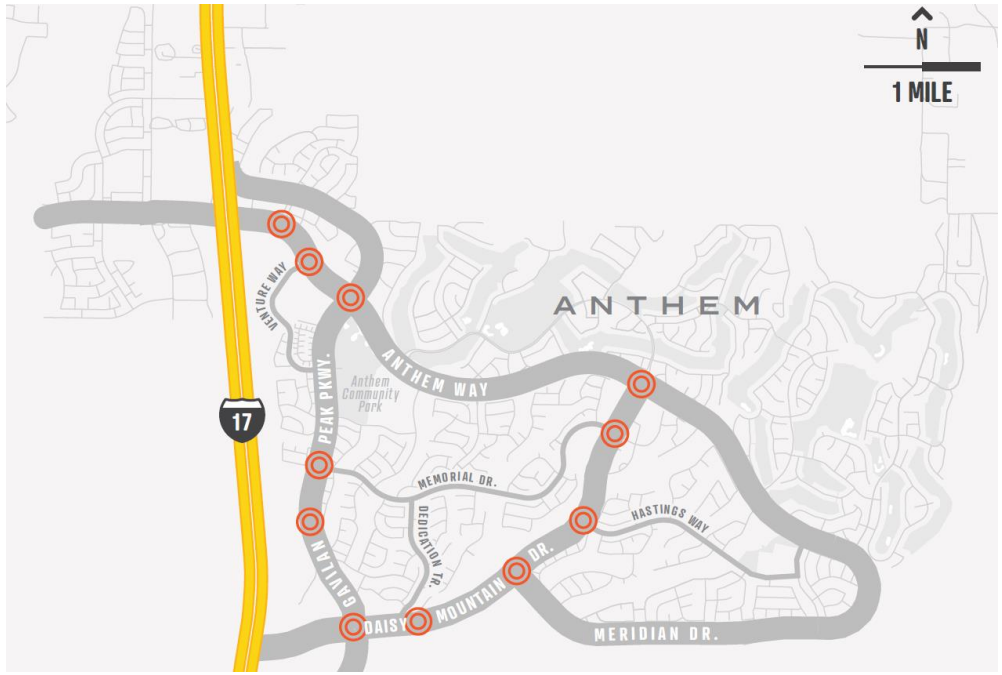
Overview

- The IAM has been researching Digital Infrastructure and how it can be used to improve intersection safety.
- SMARTDRIVE Testbed in Anthem, AZ. Data collected from:
  - Infrastructure-based cameras
  - Drone-based camera
  - Ground-based cameras
  - Differential GPS
  - Infrastructure-based LIDAR
  - SPaT
- Next Data Collection Day: October 31, 2023
  - Infrastructure-based RADAR
  - ADS-equipped vehicle perception system

MCDOT SMARTDrive Program™



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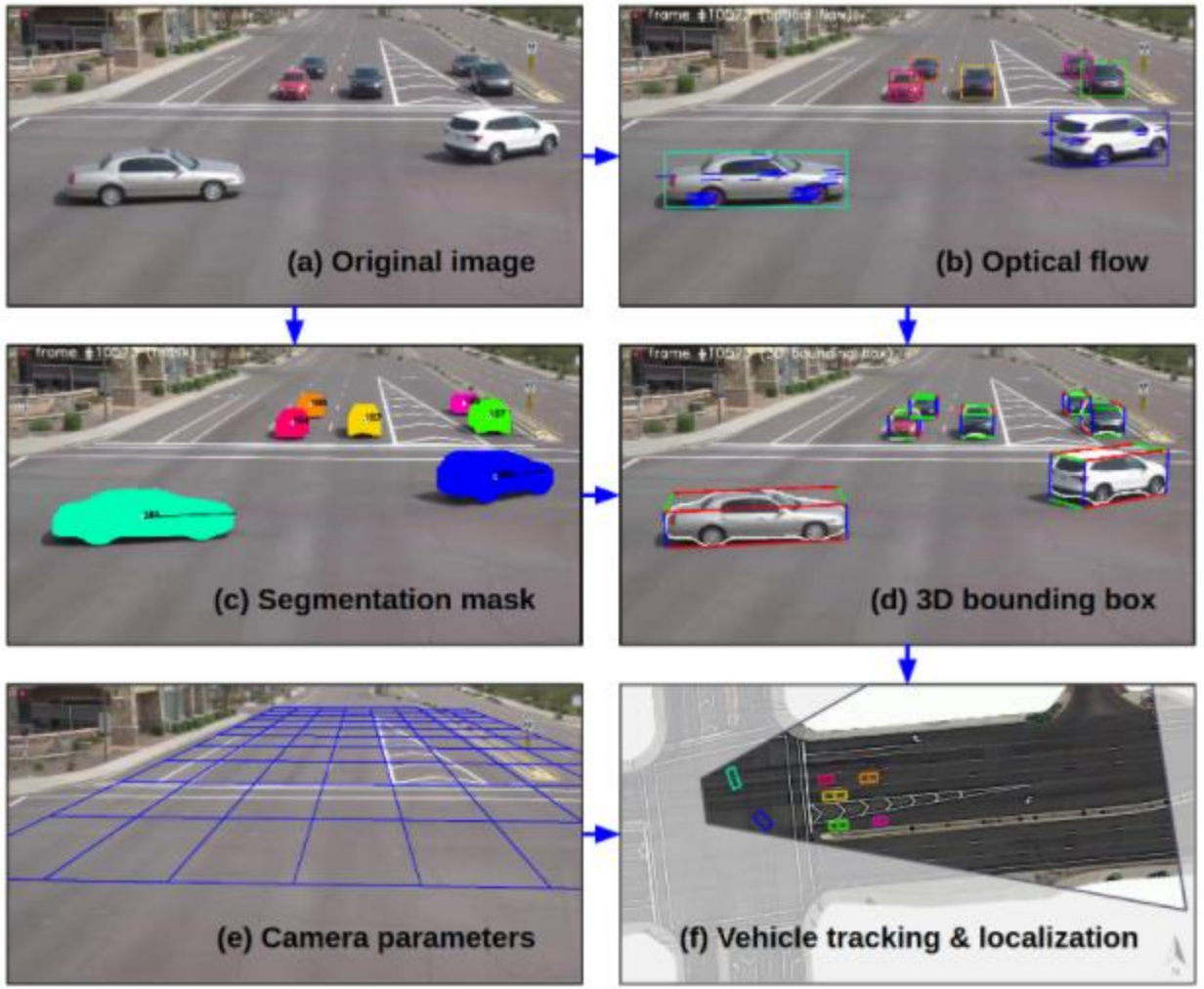
Camera-Based Detection and Tracking Algorithm



https://youtube.com/clip/UgkxBlIia4F2ZbxM7NbNLLrlWliTRNB1jBIc

SAE J3237 Driving Assessment Metrics

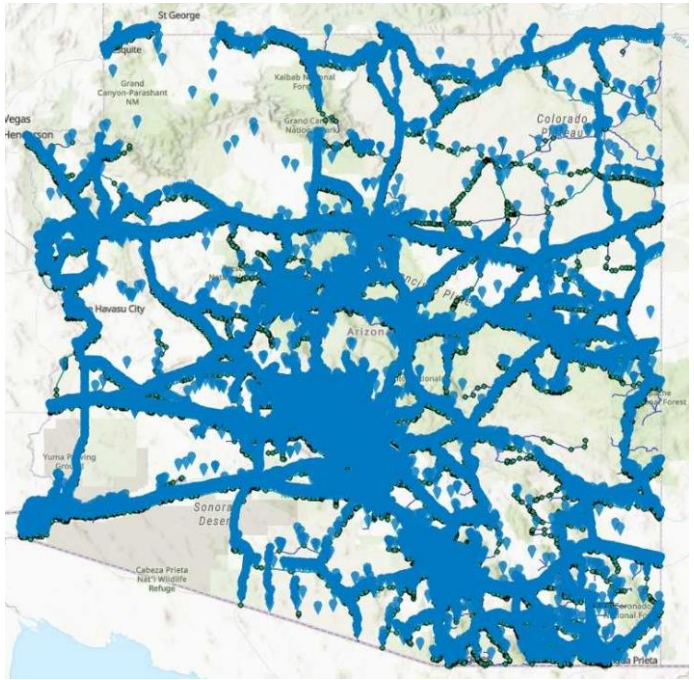
- Defined set is a mix of existing, adapted, and novel metrics
- Each metric has:
  1. Taxonomy (Black/Grey/White)
  2. Leading/Lagging
  3. Origin
  4. Definition
  5. Observable Variables
  6. Formulation
  7. Subjective Assumptions/Thresholds
  8. Applicability
  9. Example Usage
- SAE J3237 Recommended Practice (V&V TF under ORAD Committee)
- Black Box Metrics can be used for human- and ADS-driven vehicles.

Taxonomy	Metric
Black Box	Safety Envelope Metrics: 1. Safety Envelope Infringement 2. Safety Envelope Violation 3. Safety Envelope Ratio 4. Safety Envelope Restoration Time
	Collision Incident
	Lane Stability Violation
	Traffic Law Violation
	Evasive Maneuver Incident
	Compliance Error Rate to Human Traffic Controller Directions
	OEDR Reaction Time Violation
Grey Box	ADS DDT Execution (Inside ODD)
	ADS DDT Non-Execution (Outside ODD)
	Feature Level of Automation
	Intervention/Takeover Request
White Box	Demonstrated Behavioral Competency
	Identification Error Rate to Human Traffic Control Directions
	ODD Recognition Violation
	Safety Envelope Calculation Error Rate

* The Safety Envelope Metrics are intended to be neutral to the Safety Envelope Formulation selected to calculate the spatio-temporal boundaries.

Location Selection

- The IAM is currently identifying additional, prioritized locations for future digital infrastructure.
  Criteria of interest include:
  - Equipped with infrastructure-based cameras
  - VRU prevalence
  - AV testing presence
  - Collision incidents
  - Traffic volume
  - Weather diversity
  - Extreme glare locations
- Some 3,262 signalized locations have been identified with existing cameras.
- Prioritized list being created, and locations currently being selected.



Intersection Data Collection Issues

There are several issues that must be considered when taking data at an intersection:

1. Measurement Objectives
2. Sensor Modalities
    i. Measurement Uncertainty
    ii. Lighting Conditions
    iii. Environmental Conditions
    iv. Sensor Fusion
3. Detection and Tracking Algorithms
4. Occlusions and Odd Shapes
5. Sensor Movement
6. Compute:
    i. Post hoc
    ii. Real time: Edge, Cloud, or NOC

Next Steps

- Trial additional sensor modalities and suites
- Refine sensor fusion and detection and tracking algorithms
- Identify additional AZ-specific use cases
- Install digital infrastructure at selected locations
- Identify and trial warning techniques
- Submit entry/application to ARPA-I Intersection Safety Challenge and USDOT SMART grant
- Support the development of a national database of use cases and validated digital infrastructure solutions

IAM Publications

1. Wishart, J., Como, S., Elli, M., Russo, B. Weast, J., et al. (2020). "Driving Safety Performance Assessment Metrics for ADS-Equipped Vehicles," SAE Technical Paper 2020-01-1206, 2020, doi:10.4271/2020-01-1206.
2. Elli, M., Wishart, J., Como, S., Dhakshinamoorthy, S., and Weast, J. (2021). "Evaluation of Operational Safety Assessment(OSA) Metrics for Automated Vehicles in Simulation," SAE Technical Paper 2021-01-0868, doi:10.4271/2021-01-0868.
3. Altekar, N., Wishart, J., Como, S., Bruyere, D., Head, L., and Saleem, F. (2021)., "Infrastructure-based Sensor Data Capture Systems for Measurement of Operational Safety Assessment (OSA) Metrics," SAE Technical Paper 2021-01-0175, doi:10.4271/2021-01-0175.
4. Lu, D., Jammula, V., Como, S., Wishart, J., Elli, M, Chen, Y., and Yang, Y., "CAROM – Vehicle Localization and Traffic Scene Reconstruction from Monocular Cameras on Road Infrastructure," 2021 ICRA conference.
5. Weast, J., Elli, M., Alvarez, I., and Kovesdy, S., "To Err is Human: The Role of Human Safety Metrics in an Age of Automated Vehicles", Accepted for 2021 SAE WCX.
6. Kidambi, N., Wishart, J., Elli, M., and Como, S. (2022). "Sensitivity of Automated Vehicle Operational Safety Assessment (OSA) Metrics to Measurement and Parameter Uncertainty," SAE Technical Paper 2022-01-0815, doi:10.4271/2022-01-0815.
7. Como, S., Wishart, J., Elli, M., Kidambi, N. (2022). "Evaluating the Severity of Safety Envelope Violations in the Proposed Operational Safety Assessment (OSA) Methodology for Automated Vehicles," SAE Technical Paper 2022-01-0819, doi:10.4271/2022-01-0819.
8. Jammula, V., Wishart, J., Yang, Y. (2022). "Evaluation of Operational Safety Assessment (OSA) Metrics for Automated Vehicles Using Real-World Data," SAE Technical Paper 2022-01-0062, doi:10.4271/2022-01-0062.
9. Srinivasan, A., Mahartayasa, Y., Jammula, V., Lu, D., Como, S., Wishart, J., Yang, Y., and Yu, H. (2022). "Infrastructure-Based LiDAR Monitoring for Assessing Automated Driving Safety," SAE Technical Paper 2022-01-0081, doi:10.4271/2022-01-0081.
10. Das, S., Yu, H., Rath, P., Wishart, J., Smith, T. (2023). "Comparison of Infrastructure- and Onboard Vehicle-Based Sensor Systems in Measuring Safety Metrics," SAE Technical Paper 2023-01-0858, doi:10.4271/2023-01-0858.
11. Como, S., Wishart, J. (2023). "Evaluating Automated Vehicle Scenario Navigation using the Operational Safety Assessment (OSA) Methodology," SAE Technical Paper 2023-01-0797, doi:10.4271/2023-01-0797.
12. Lu, D., Eaton, E., Weg, M., Wang, W., Como, S., Wishart, J., Yu, H., Yang, Y. (2023). "CAROM Air - Vehicle Localization and Traffic Scene Reconstruction from Aerial Video," 2023 ICRA conference.
13. Chen, X., Wang, H., Razi, A., Russo, B., Pacheco, J., Roberts, J., Wishart,, J., Head, L., Baca, A. (2022). "Network-level Safety Metrics for Overall Traffic Safety Assessment: A Case Study," *IEEE Access,* Vol. 11, pp. 17756-17778.

Thank You

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