5-18-2023

Webinar: Collecting and Analyzing Pedestrian Behaviors at Intersections Using LiDAR Tracking Technologies

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Pedestrian Behavior Study to Advance Pedestrian Safety in Smart Transportation Systems using Innovative LiDAR Sensors

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NITC Webinar

05/18/2023

UNIVERSITY OF TEXAS ARLINGTON

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Outline

- Introduction
- Literature and technology Overview
- LiDAR solutions
- Field Data Collection and findings
- A demo
- Future work

Introduction

- NHTSA reported that pedestrian fatalities increased by 44% from 2010 to 2019 and more than 20% of pedestrian fatalities occurred at intersections .

- This results in
  - Huge social, economic losses
  - Lack of transportation equity because "*Transportation Equity means safety for Everyone*" *(C. Walker, FHWA Associate administrator for Safety, 2021)*

6,590 pedestrian deaths in 2019, the highest in 30 years, 18% at intersections

The fatalities are still increasing in 2020~2022

Road map of Pedestrian Safety Improvement

Pedestrian Behavior Observation

- Most literature on this topic is out of date right now

Revisit the guideline for pedestrian facility design

- To examine if the guideline is still suitable for the latest pedestrian patterns

Innovative vehicle-pedestrian control measures

- Completely separate left-turn vehicles from crossing pedestrians

Integrate with other physical systems

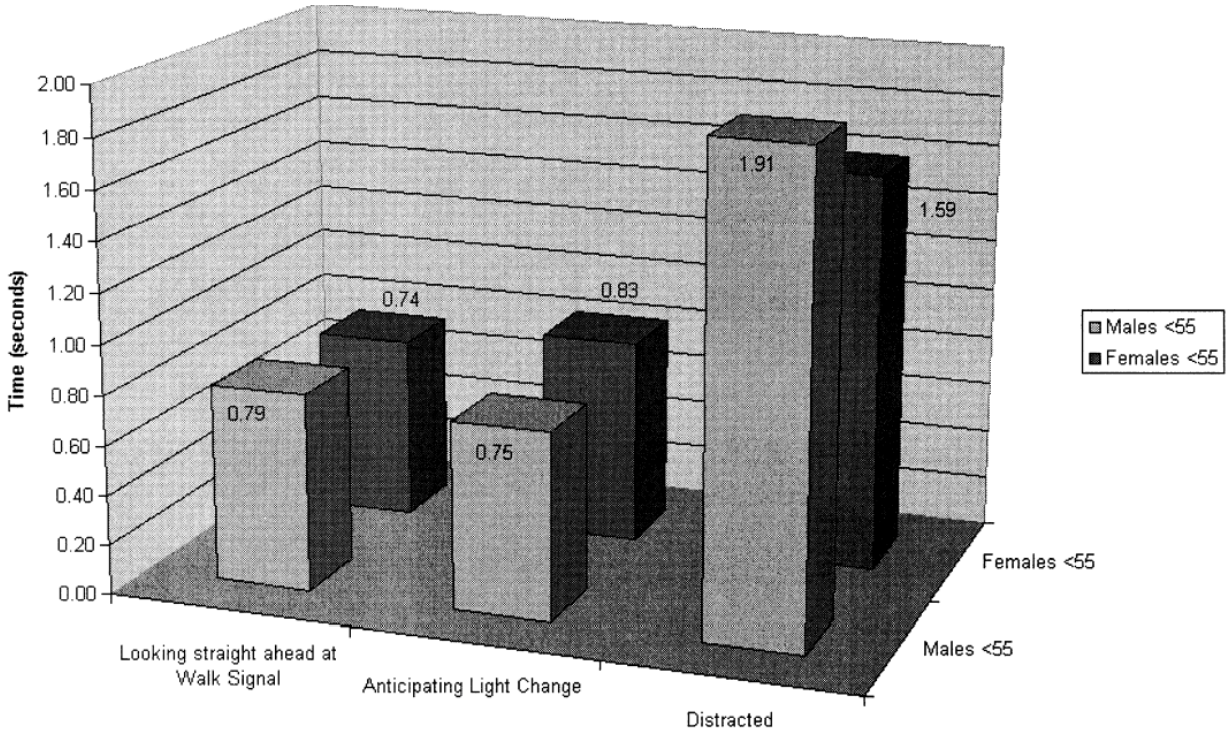
- Connected vehicle infrastructure
- Supplemental streetlights for crossing pedestrians
- Flashing road studs
- Supplemental RRFB flasher

Today's focus

Literature and technology review

Perception-Reaction Time

- Pedestrian study data collected in the field are lacking.
- Average P-R time used is 1 sec
- 85th percentile time is 1.33 sec (McGee et al. 2012)
- Does not factor individuals that are slower to respond to a WALK signal or account for distraction due to mobile devices etc.



Source: Fugger et al. 2000

Pedestrian Delay

- Important performance measure, rarely considered for signal timing purposes
- Higher delays can negatively impact pedestrian safety
- Not readily available, however it can be measured or estimated
- Part of ATSPMs, yet still not widely adopted

Pedestrian Detection Solution: Effective but Old

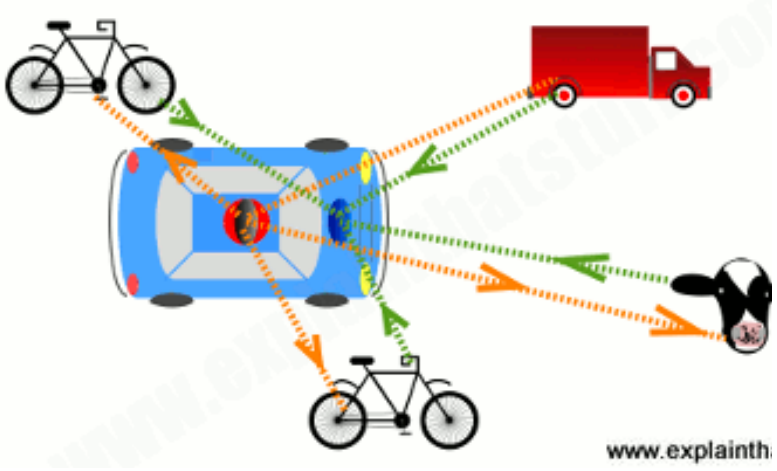
- Push buttons are generally used to detect pedestrians at intersections
  - Design had not changed much until development of Accessible Pedestrian Signals (APS)
  - Fixed walk time and clearance intervals (slower peds may get stuck in the crosswalk)
  - Most pedestrians do not push the button
  - Installing pushbuttons with visible and audible cue increased percent of pedestrians who press the button and wait for the walk sign (Van Houten et al. 2006)

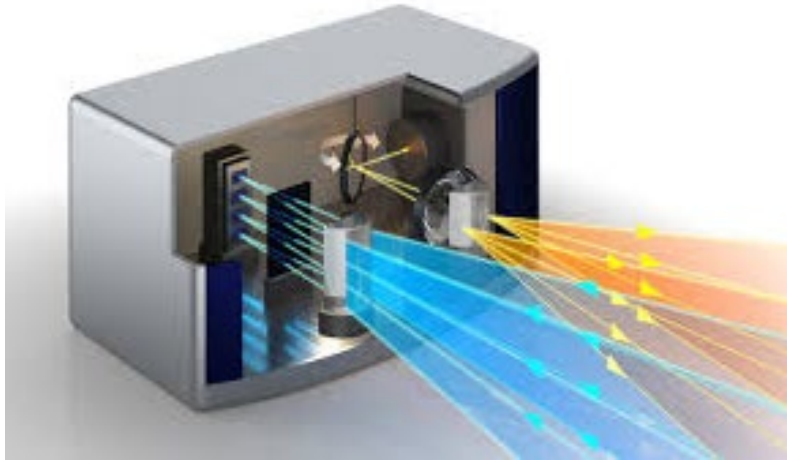
Automated Pedestrian Detection

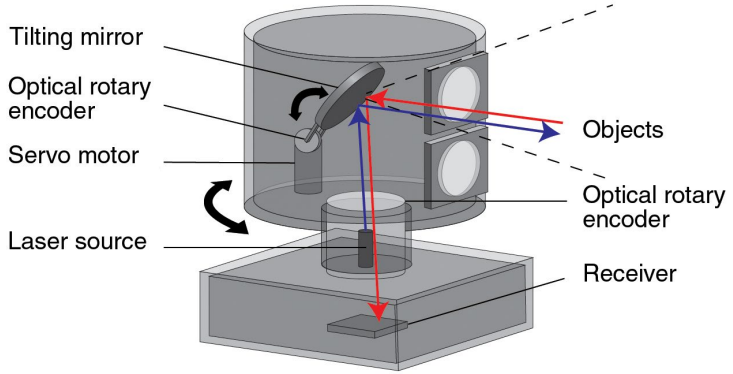
- Automated pedestrian detection trials in US (Infrared and Microwave)
  - Results revealed that pedestrians were less likely to begin crossing during the clearance phase
  - Detection zone needed fine tuning
- PUFFIN crossings tested in the UK with extended WALK phase
- Advances in technology have led to new sensors for detection
  - Radar
  - Microwave
  - Thermal
  - Infrared
  - LiDAR

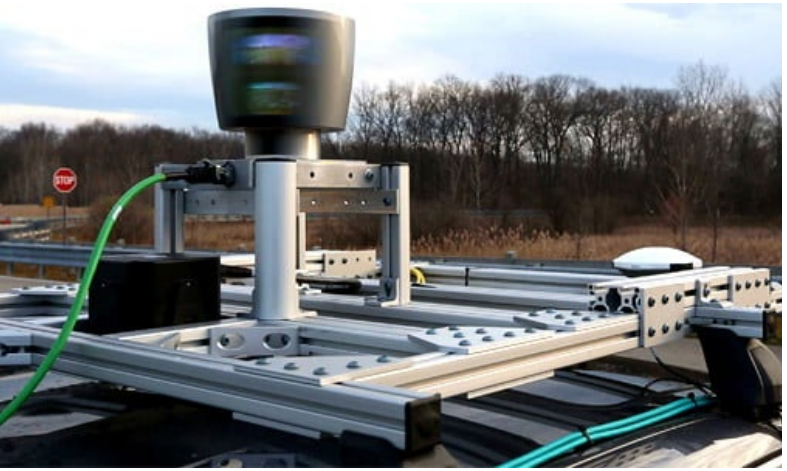
Traffic sensor type	Performance of Pedestrian tracking
LiDAR sensors	Reliable pedestrian tracking in most conditions
Video sensors	Performance deteriorates in dark or foggy conditions
Radar sensors	Not suitable for pedestrian tracking

LIDAR-based Pedestrian safety solution





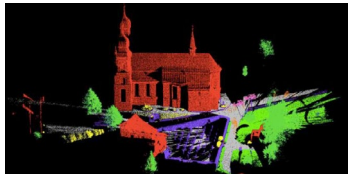




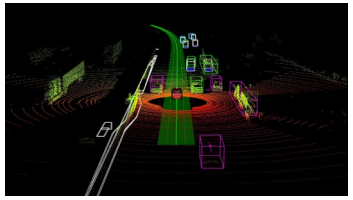
What is LIDAR?

- LIDAR is a method for measuring distances (ranging) by illuminating the target with laser light and measuring the time the reflection of the light takes to return to the sensor. Two types in terms of point cloud generation:
  - Mechanical LIDAR sensors: cove 360 degree
    - (16 lines ~128 lines) (e.g., Ouster)
  - Quasi-solid-state LiDAR sensors: directional, no rotating parts
    - SCHOTT/Cepton/LSIS/HESAI, etc.
    - Very active market to meet the enormous demand for Avs
- Cannot penetrate mental frame or human body
  - The point cloud will be bounced back.

Three levels of algorithms for LIDAR sensors



- Hardware algorithms:
  - *To make the LIDAR sensors efficient and reliable to generate raw point clouds. It is concerns of LIDAR sensor manufacturers*



- Perception and classification algorithms:
  - *Cluster the point clouds into objects*
  - *Identify the objects characteristics (types, behaviors, etc.)*
  - *OEM or 3rd-party*
- *Integration algorithms:*
  - *Domain-specific applications*
  - *For instance, we integrate the LIDAR tracking algorithm with real-time traffic signal status at intersections*

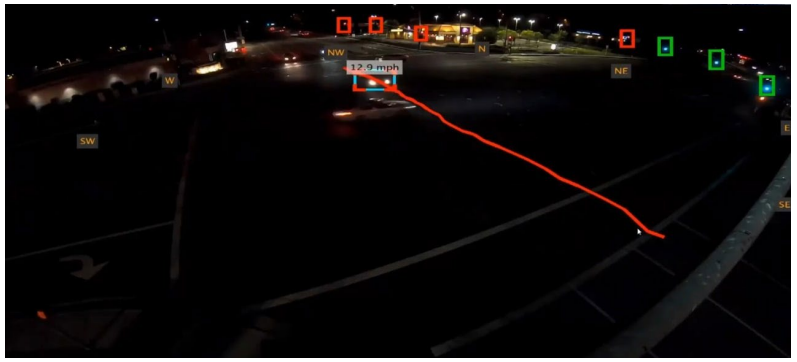
New trend of LIDAR sensors and algorithms

- LIDAR manufacturers are facing some challenges in 2023
  - Some may not survive

- The target markets are more diverse
  - AV
  - Intelligent intersections
  - Toll roads, height detection
- OEM/third-party perception software is becoming available
  - Open an avenue for multimodal smart-city applications

Comparison with computer-vision solutions

- The technical concerns are the same:
  - Clustering algorithm, machine learning algorithms, etc.
- LiDAR is commonly considered more robust
  - In extreme weathers (foggy, storm, snowstorm, dark etc.)



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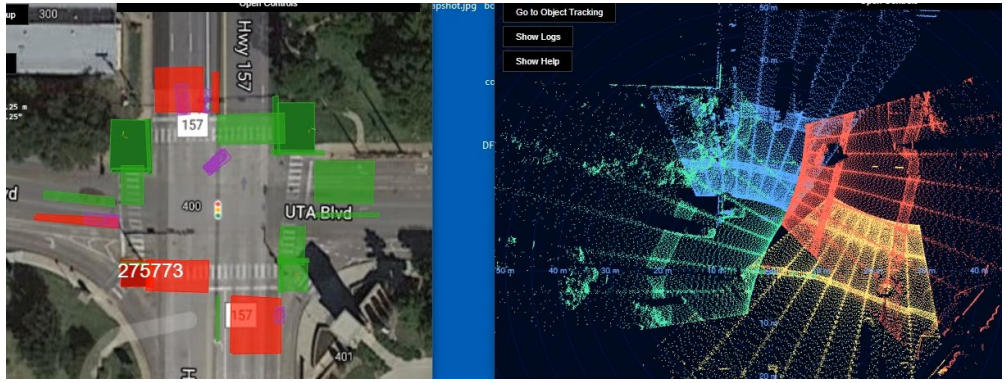


- LiDAR does not have concerns of privacy
  - Privacy concern is being raised at the national level.
    - E.g., Bill S.1214 - Privacy Bill of Rights Act (116th congress)

System Architecture

Traffic Signal Controller

Project Development

LIDAR Hub Node

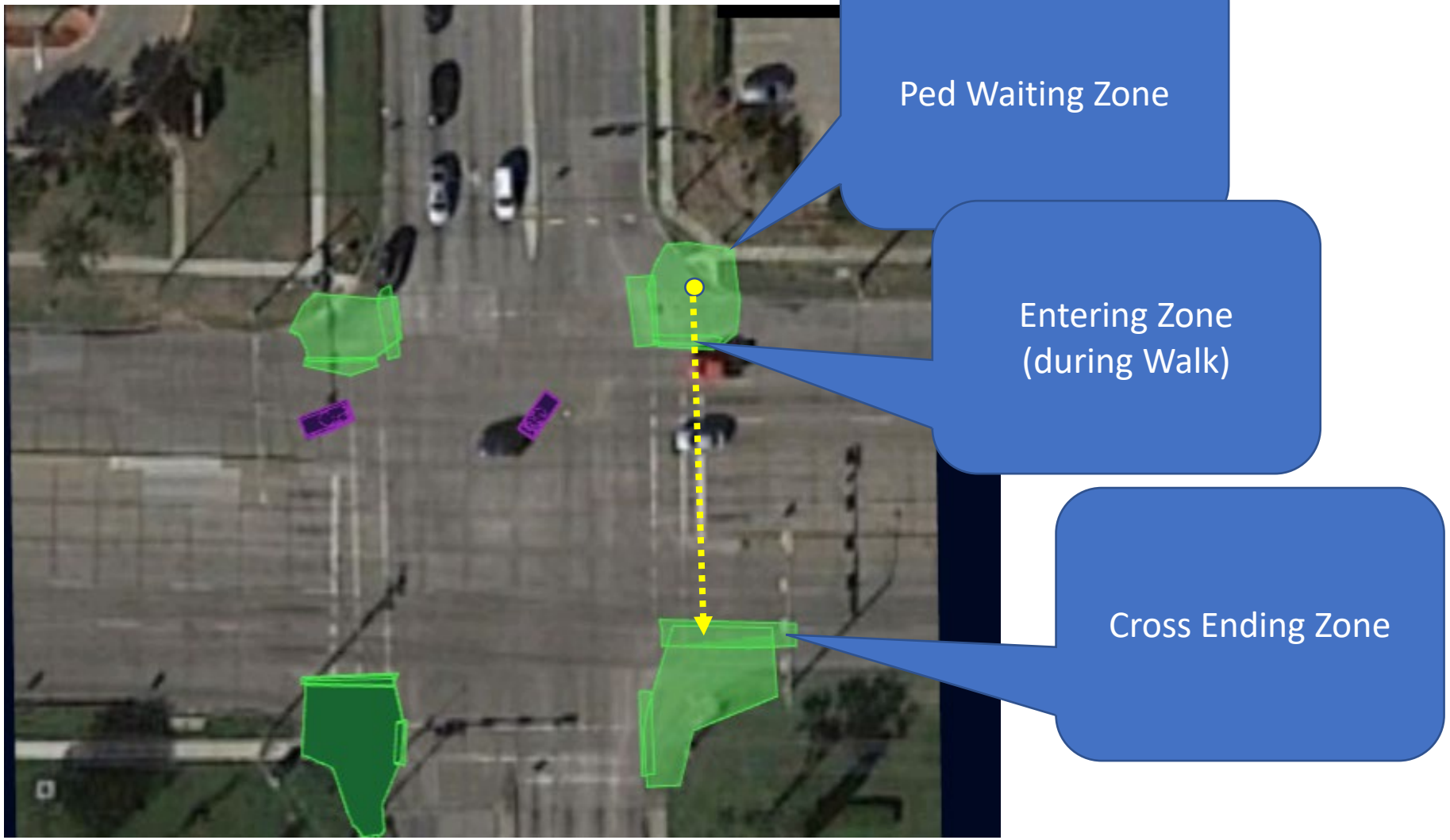
Project Development

Central Data Analytics

LIDAR sensors

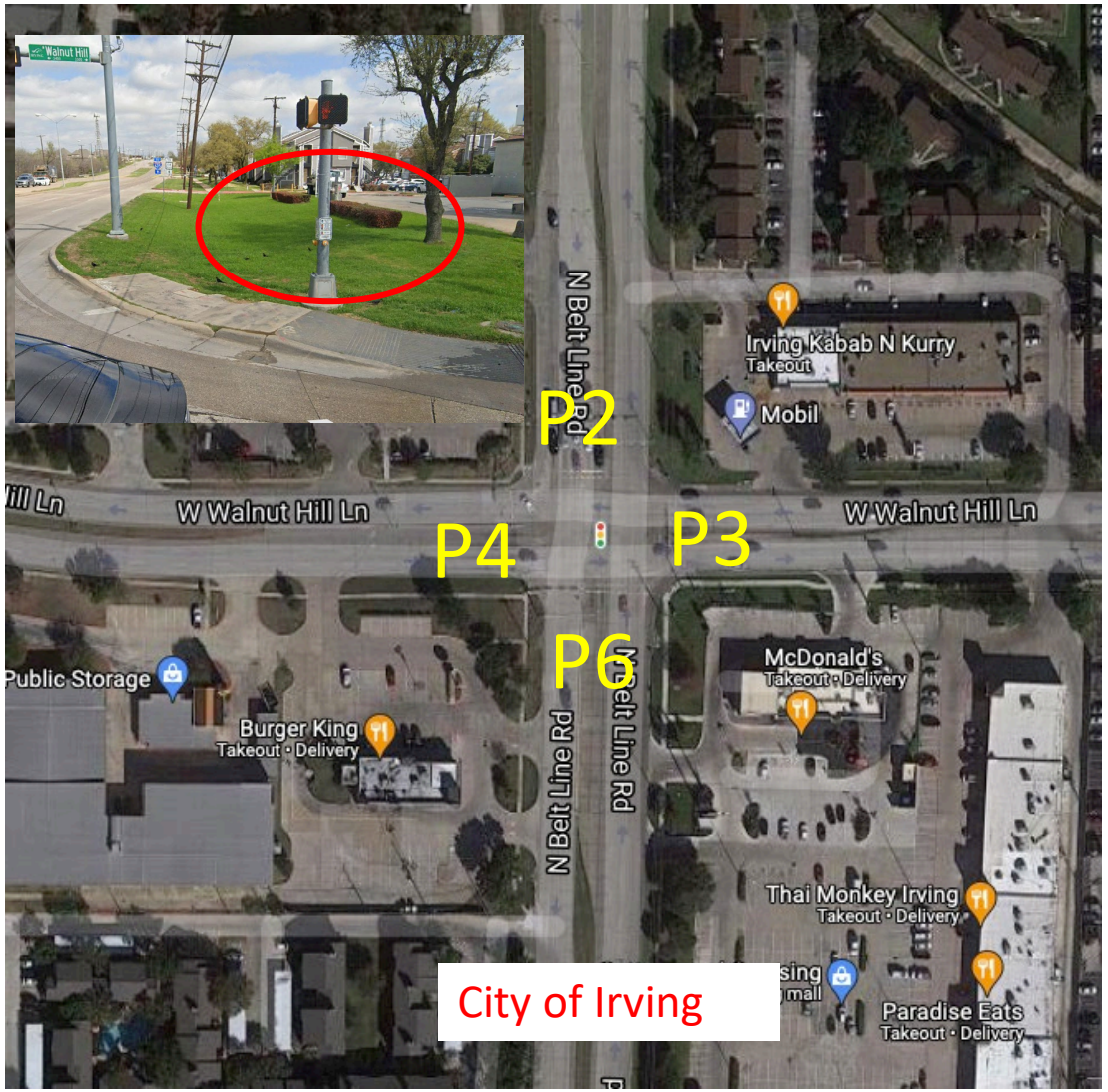
Case Study and Findings

Pedestrian tracking process

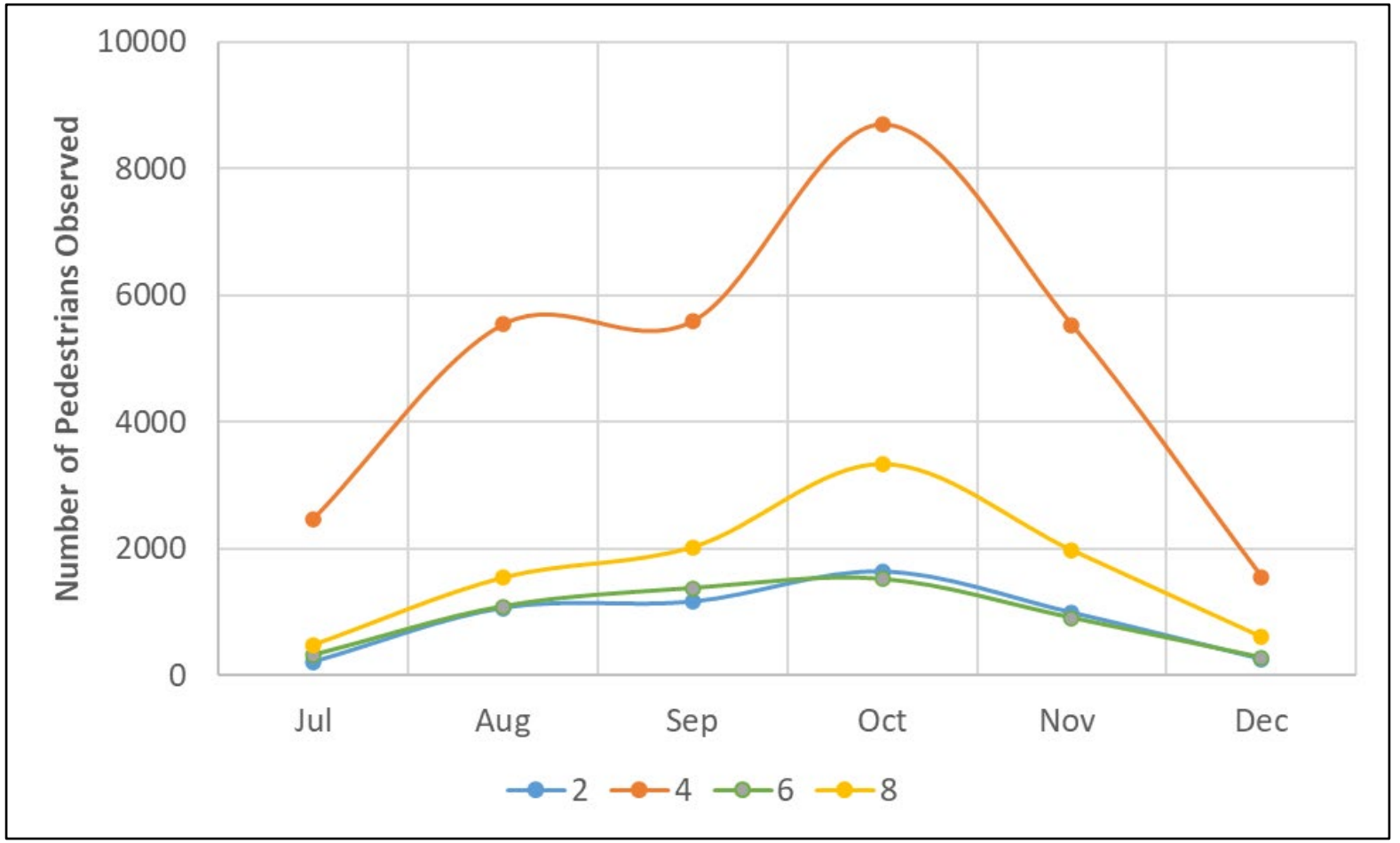


Site Selection

ADA-compliant and smaller waiting areas

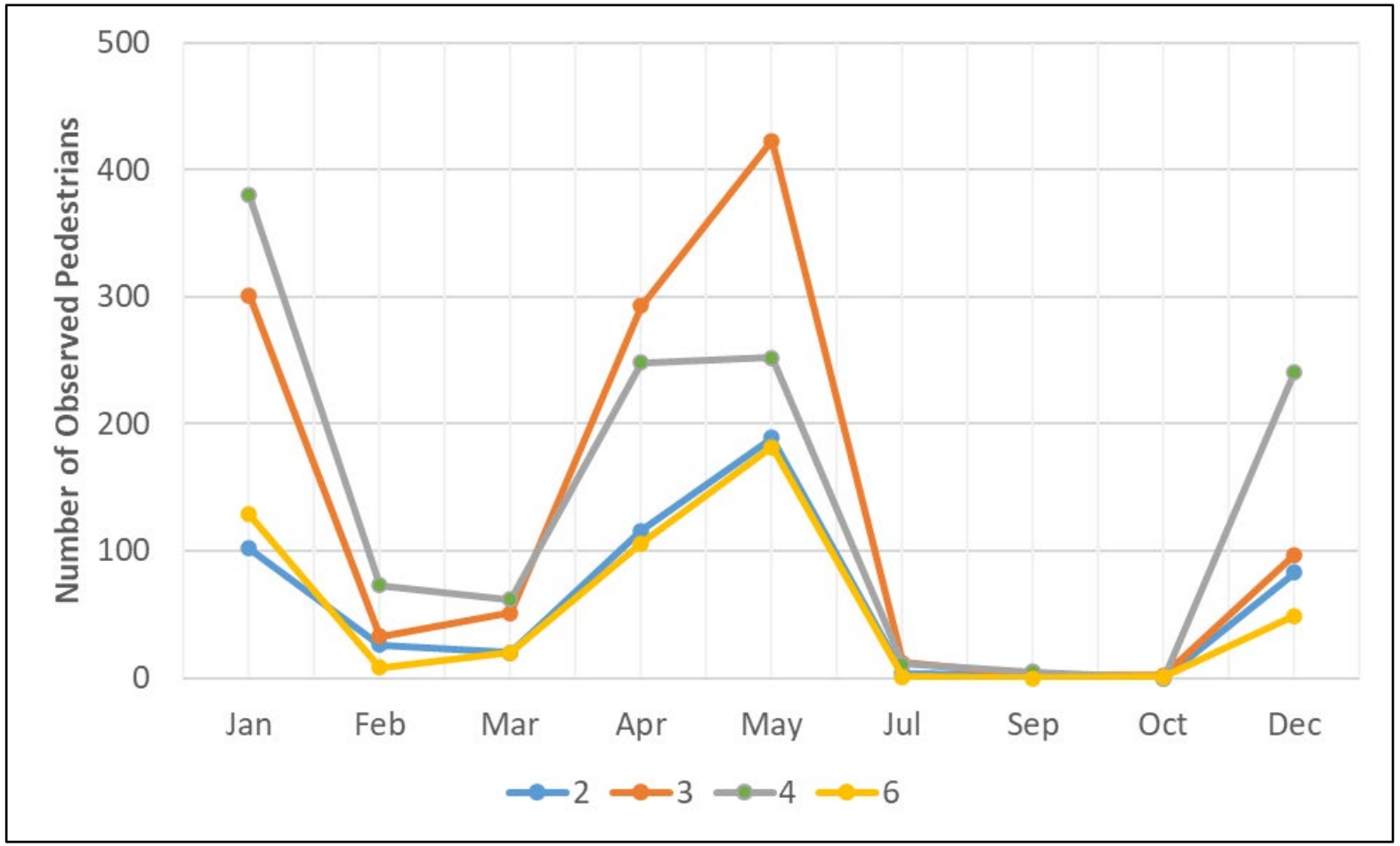


Pedestrian Volume -I



UTA Blvd. and S Cooper St.

Pedestrian Volume -II



W. Walnut Hill Ln. and N. Beltline Rd.

Results - S Cooper St. & UTA Blvd.

Phase	Number of Pedestrian Observations	Average of Effective Perception- Reaction Time (s)	Average of crossing time (s)	Average of Pedestrian Delay (s)
2	5,326	**2.2**	13.0	31.6
4	29,397	**1.7**	16.4	48.2
6	5,485	**2.7**	11.2	32.2
8	9,959	**2.8**	16.5	48.7
Total	**50,167**	**2.1**	**15.5**	**44.8**

Lower PRT due to presence of APS

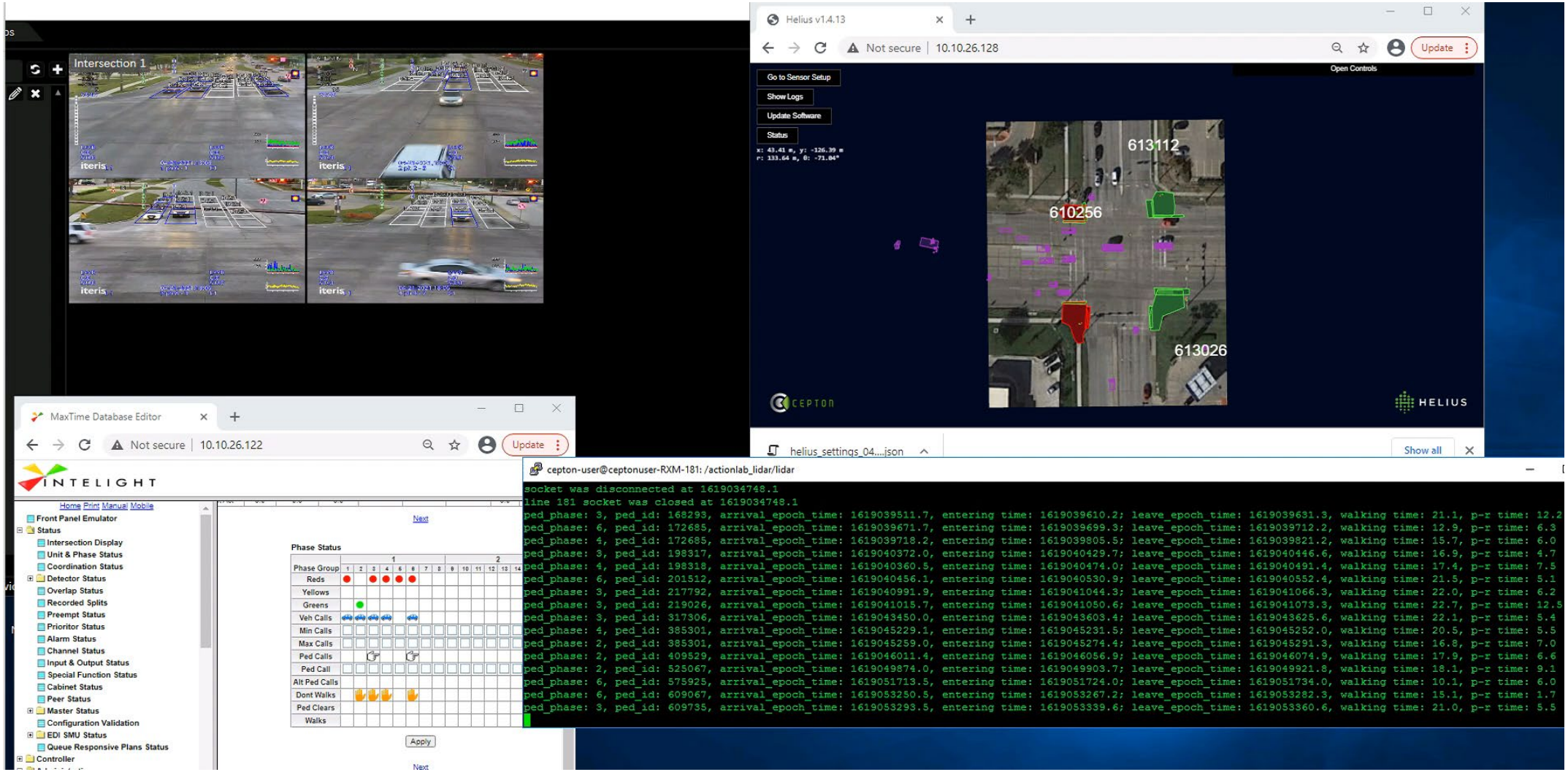
Results - W Walnut Hill Ln. & N. Beltline Rd.

Phase	Number of Pedestrian Observations	Average of Effective Perception- Reaction Time (s)	Average of crossing time (s)	Average of Pedestrian Delay (s)
2	542	**6.7**	16.9	29.5
3	1,214	**5.6**	20.4	43.6
4	1,272	**5.8**	19.2	42.6
6	496	**5.3**	16.9	28.4
Total	**3,524**	**5.8**	**18.9**	**38.9**

Findings

- Our LiDAR solution can detect and track pedestrians effectively
- Average delay, crossing time and E-PRT were measured for each pedestrian
  - Some findings can be helpful for revisiting the pedestrian facility design guideline like P-R time, walking speed, etc.
- Average PRT times were lower at the intersection equipped with APS and smaller waiting area
  - Measured PRT was higher than the value used in the literature

Demonstration



Current Work

Pedestrian Behavior Observation

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- To examine if the guideline is still suitable for the latest pedestrian patterns

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Questions?

- Acknowledgement:
  - This project is funded by National Institute for Transportation and Communities at Portland State University, a national UTC center
  - We thank the cities of Arlington and Irving, Texas for their support on the sensor installation and their insightful comments.

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