Transport Systems & Logistics Laboratory

Well what About us? Incorporating Humans and their Behaviour in a World of AEVs using VR!

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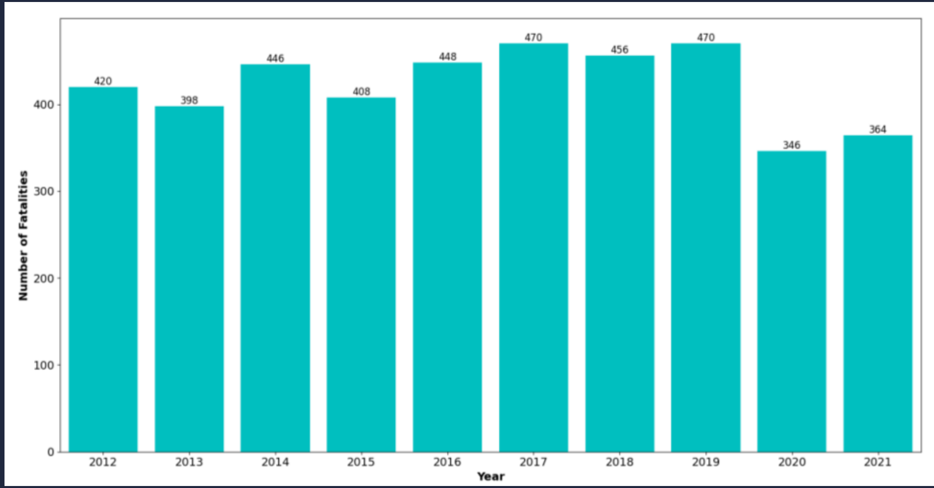
Background

Introduction

AVs have been lauded as the next stage in independent mobility but have been consistently delayed. This is partly due to the complexity of autonomous navigation of urban environments as a result of human-car interactions.

One major issue revolves around road-crossing events. There are several important elements, including predicting when pedestrians will cross into the road, their path, and the critical factors that can impact these variables.



Previous Approaches

AV research topics have included trajectory and discrete road-crossing prediction. Recent efforts have identified the major unresolved questions within this area including suggesting that complex, multi-pedestrian scenarios are not yet fully understood, especially as there is more qualitative than quantitative data.

Machine learning approaches use numerous data sources for training machine learning models for trajectory prediction. Most common is the extraction of trajectory data from video footage. These data sources suffer from several limitations, such as the scope of the camera's viewport, limiting spatial and temporal data.

Previous Approaches to pedestrian-AV interaction

Interaction between pedestrians and automated vehicles: A Wizard of Oz experiment (Palmeiro et al. 2017) – not VR
i) Clamann et al. (2017) experimentally investigated pedestrians' response times to a Wizard of Oz AV carrying a forward facing sign that showed a message (e.g., 'Walk', 'Do not walk'). Found legacy behaviors, such as gap distance, are more important for pedestrians in deciding whether to cross the road than the message displayed on the AV.
ii) Malmsten Lundgren et al., (2017) participants' willingness to cross was assessed while encountering a traditional vehicle or a Wizard of Oz AV. recommended that it may be beneficial to provide information to pedestrians by means of an external vehicle display.

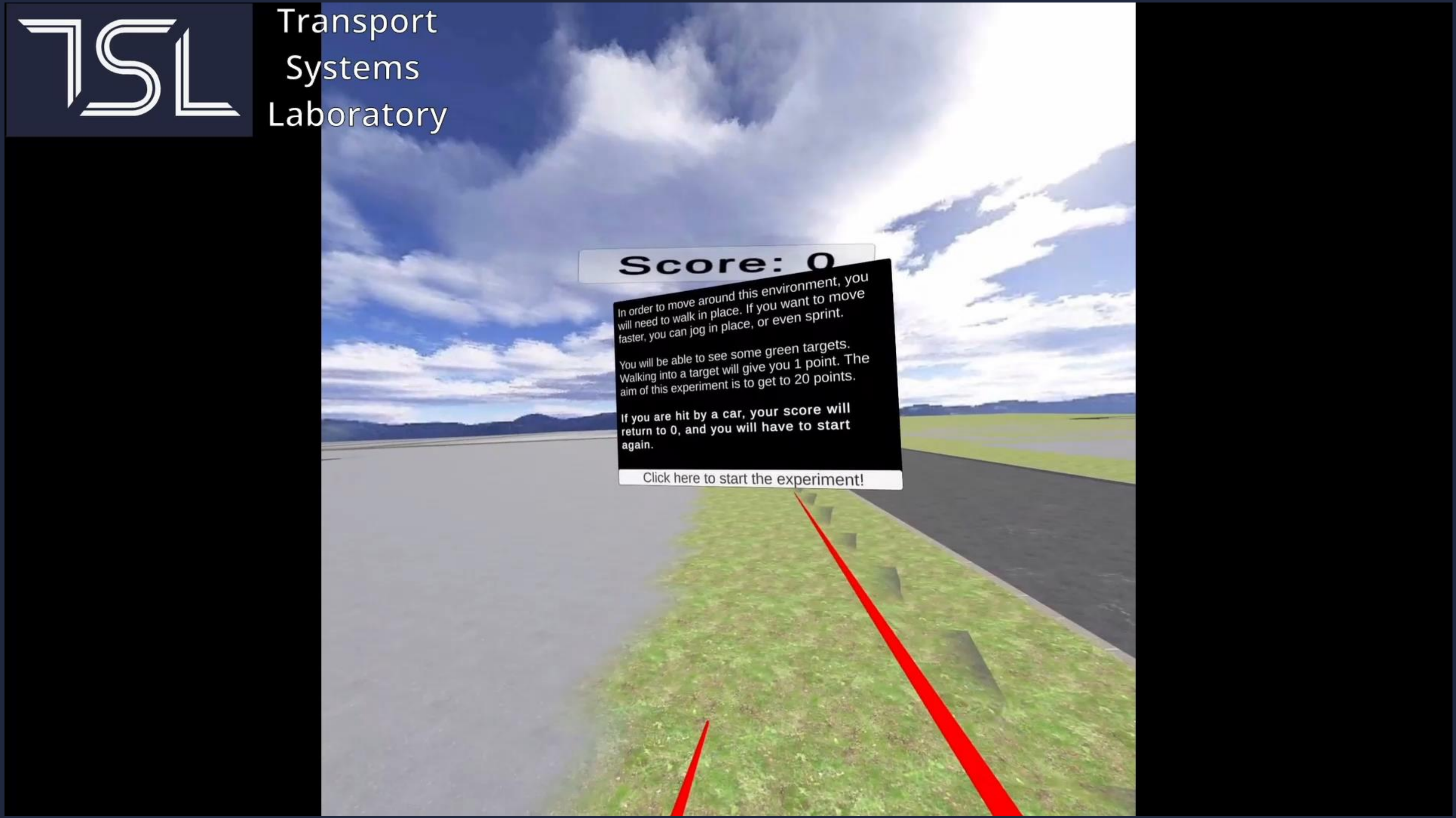
Kitazaki and Myhre (2015), interviews provided a list of eight tentative recommendations for communication between pedestrians and AVs, e.g. recommended that autonomous vehicles should identify themselves on the body of the vehicle so that others can form an understanding and trust in AVs.

Experimental Data Collection

Participant Recuritment

- 97 participants
- 17 sessions
- 3-13 people in groups
- December 2021
- Walk-in-place locomotion
- Multiplayer setup
- Asked to cross road, reach twenty green points
- Must start again if hit by a car

VR Environment



Data Preparation

Data Visualisation

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Watch as the participants (triangles) walk from dot to dot, avoiding cars (rectangles).

We can also see where they are looking (crosses)

Feature Parameters

Feature list:

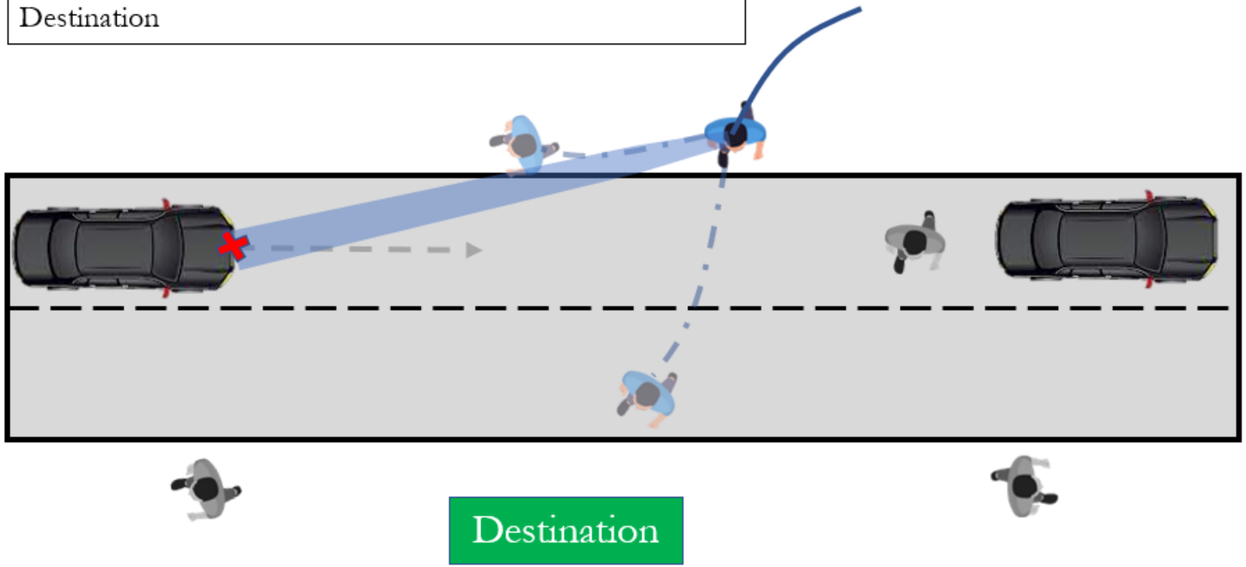
Position
Gaze point
Position of neighbour pedestrians
Position of neighbour cars
Time to closest approach of nearest upstream car
Destination

Input data:

2s of previous trajectory

Output data:

2s of predictions



Data Cleaning

- Isolate road crossing events
- Extract 4s data (2s before, 2s after)
- For each crossing event, data of all participants within the scene are exported

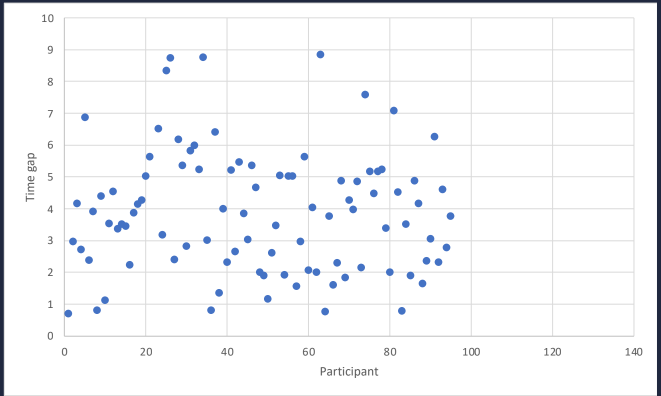
Results & Discussion

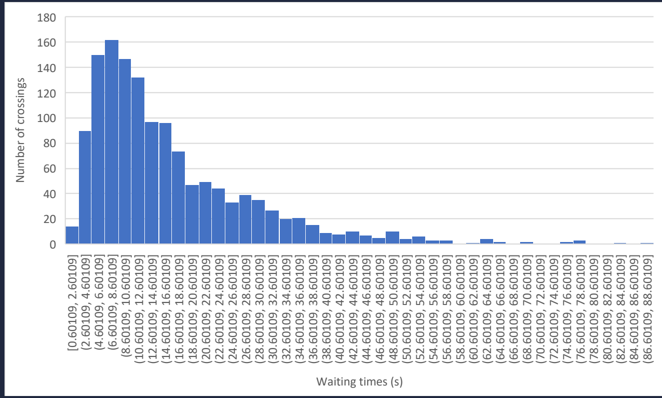
Time gaps

Minimum time gap accepted by participants is 0.7 seconds.

Minimum gap accepted by everyone (maximum of minima) is 8.84 seconds.

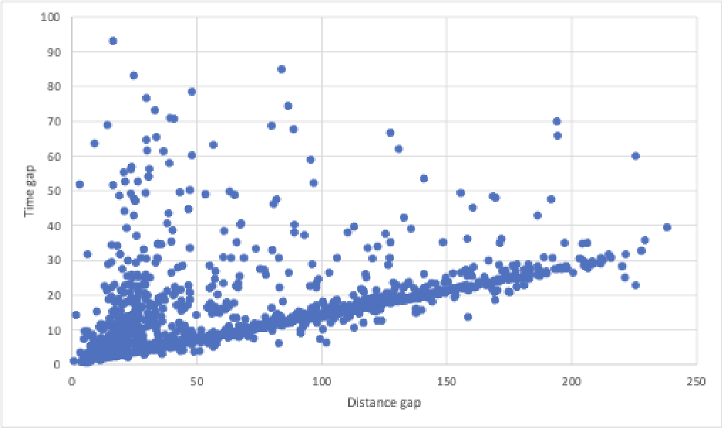
As the size of the gap available increases, people will be more likely to accept it. (2021).

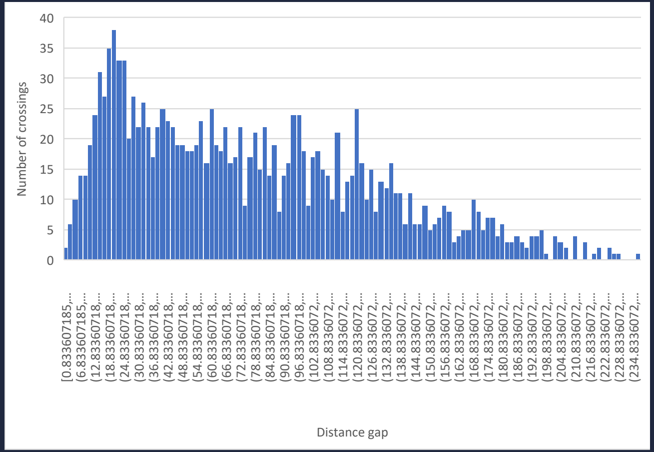




Distance Gaps

- Most people cross at lower vehicle speeds (2-4) mainly and (0-2)
- As vehicle speed increases, the maximum time gap accepted by participants decreases
- Participants seem to use the distance separating them from the vehicle rather than its speed to determine whether it is safe to cross



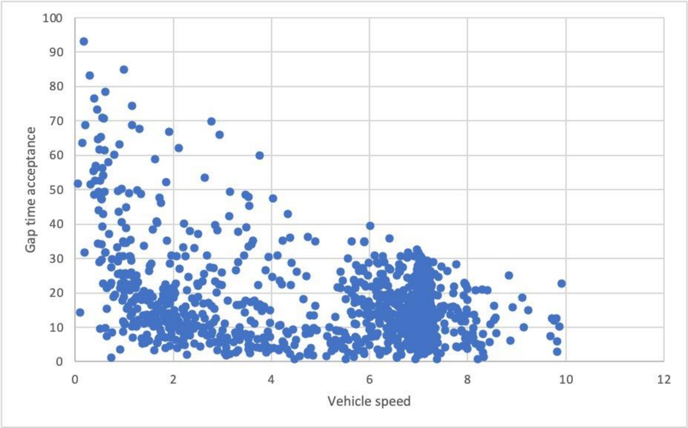


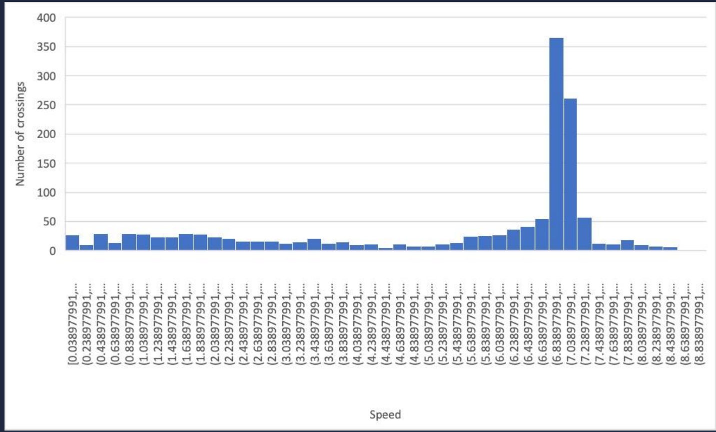
Vehicle Speed

Upto 24 meters gap people tend to cross more as the gap increases. Then willingness to cross decreases

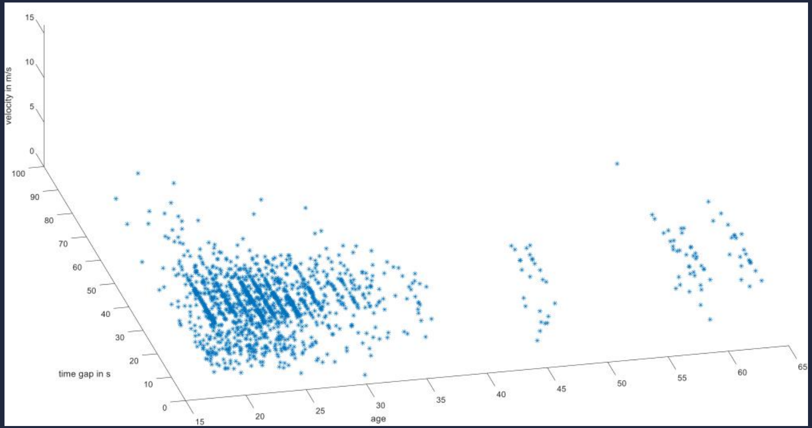
0.365 correlation coefficient between time gap and distance gap accepted by pedestrians

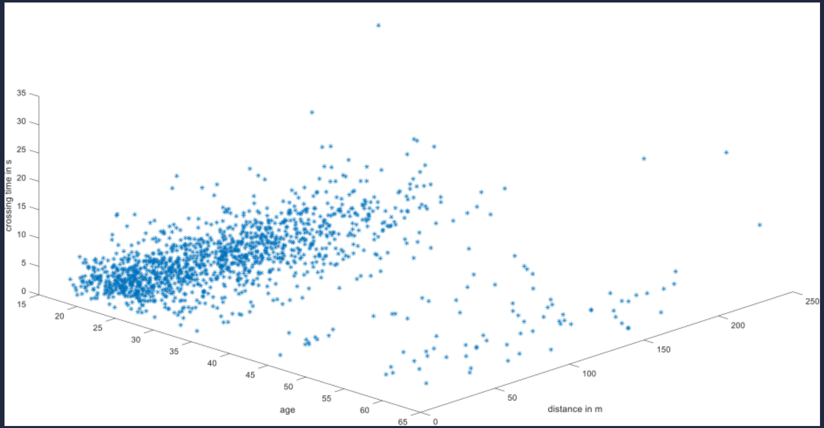
0.52 correlation coefficient between distance gap accepted and vehicle speed





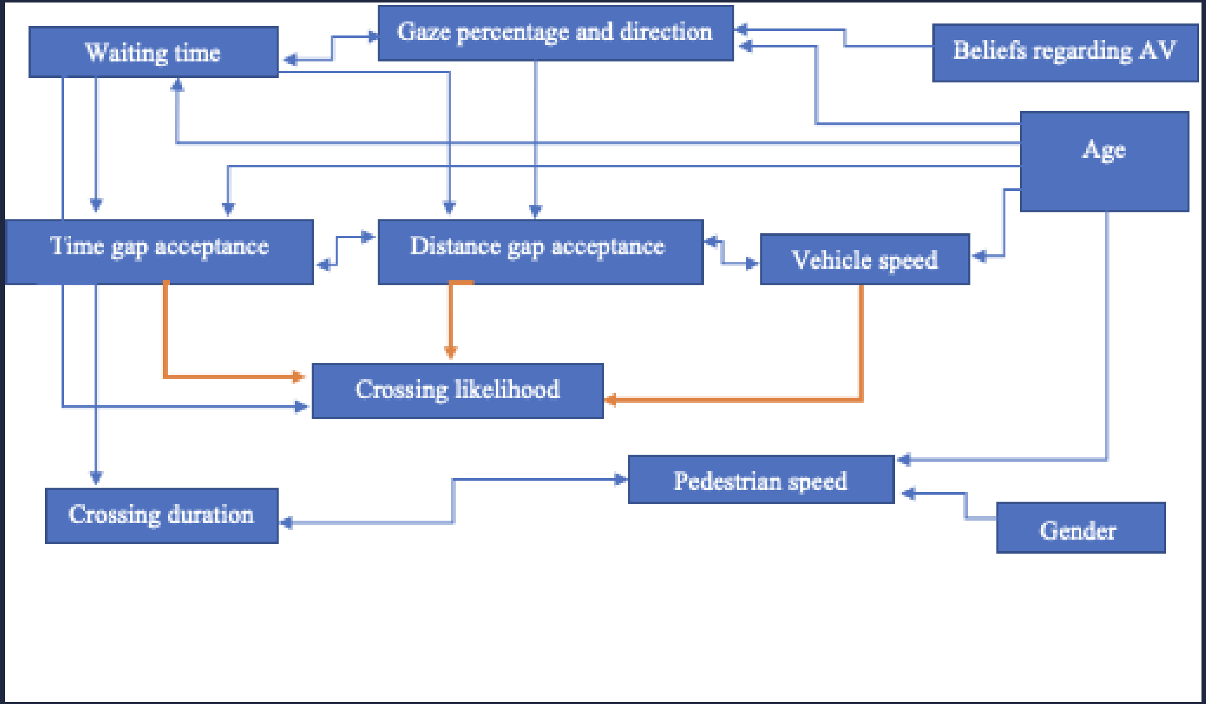
Gaps effects with age



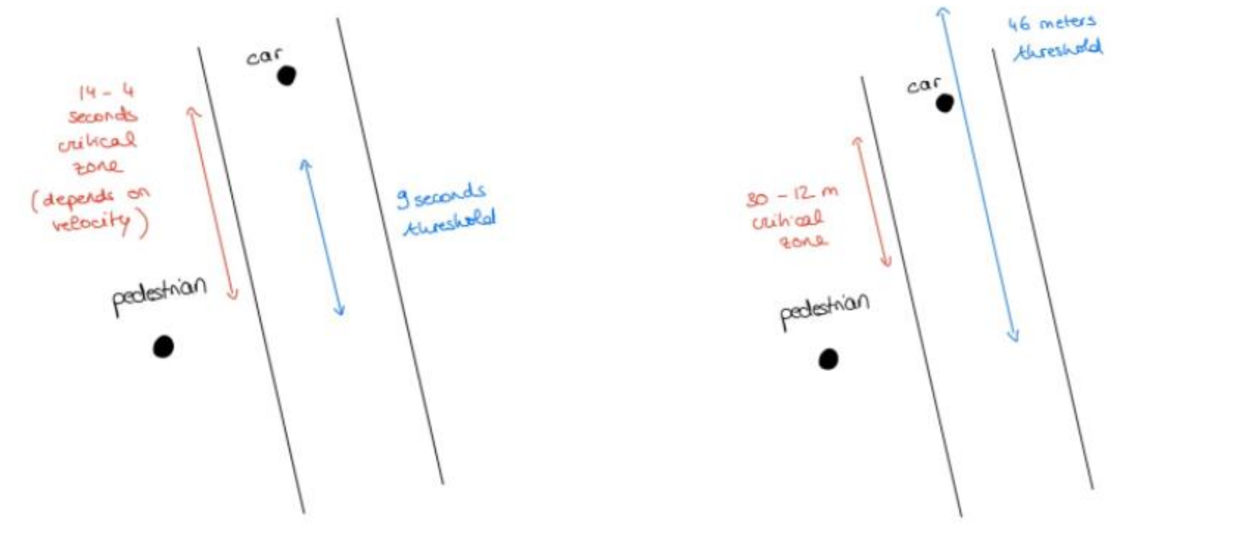


Conclusion

Proto-type model of crossing decision



Critical Zone for pedestrian safety



(a) Critical zone (seconds)

(b) Critical zone (meters)

- Also AVs with visual indicators?

Contributions

- Develop a VR environment for pedestrian – AV interactions
- Focus on semi-rural AV-Pedestrian interactions
- Present a new, complete dataset for pedestrian-AV interaction

Future experiments Feb 2024 onwards

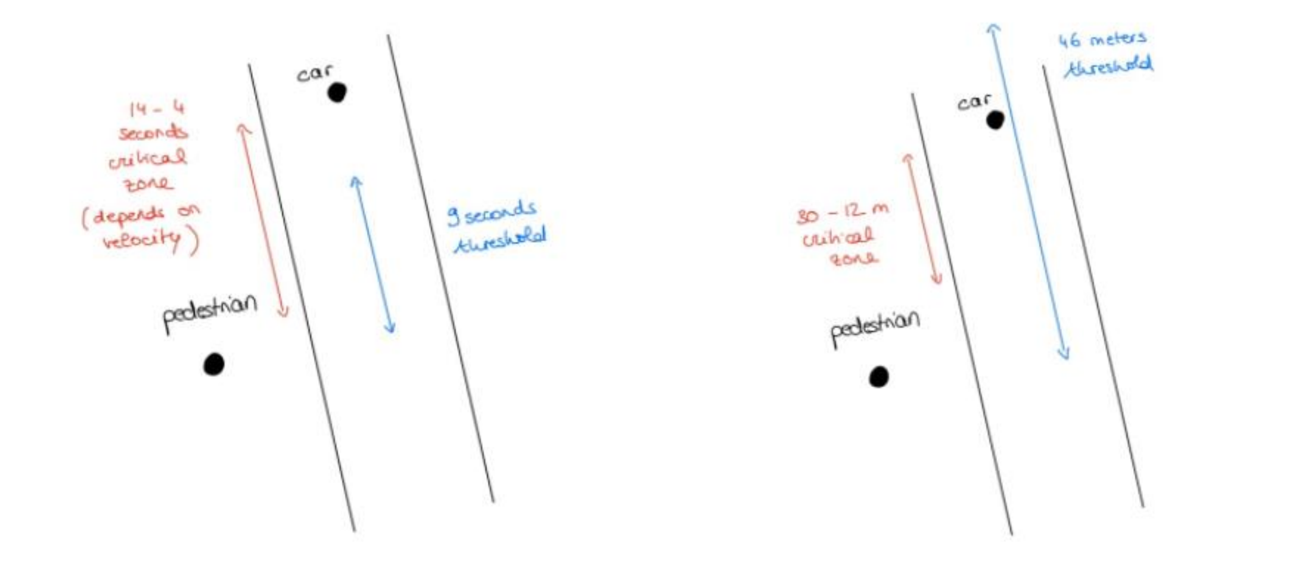
- In semi-rural area, when the design of road crossing facilities includes the decision of type and location which depend on: 1) pedestrian traffic needs (decided by population density, road types, pedestrian traffic, and nearby destinations), 2) road widths, 3) traffic volume, 3) speed limits, and 4) visibility.
- The types include: zebra crossings, pedestrian islands, raised crosswalks, zebra crossings with traffic signal.
- If zebra crossings or pedestrian islands (without signals) are selected, then, traffic calming facilities should be designed to protect pedestrian safety.
- The experiment results have an implication on the design of traffic calming facilities:

Current and future experiments

- In semi-rural area, design of road crossing facilities includes the decision of type and location which depend on:
- 1) pedestrian traffic needs (decided by population density, road types, pedestrian traffic, and nearby destinations),
- 2) road widths,
- 3) traffic volume,
- 4) speed limits, and
- 5) visibility.

Experimental results

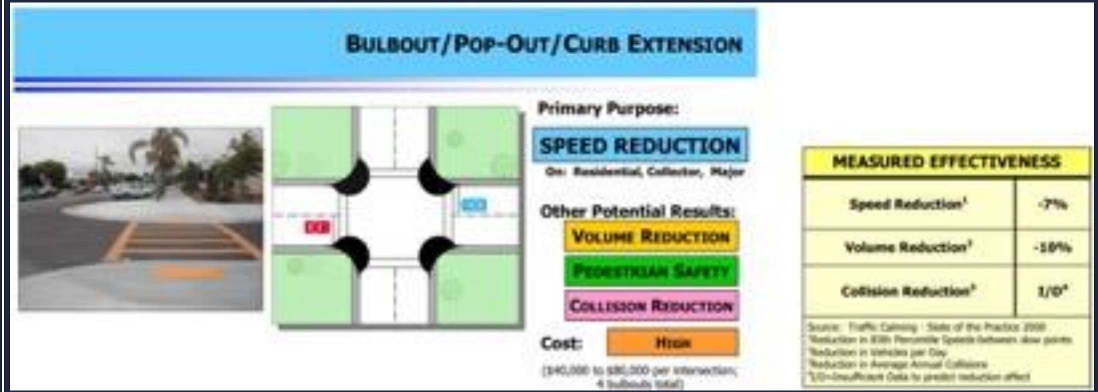
- The experiment results have an implication on the design of traffic calming facilities:



(a) Critical zone (seconds)
(b) Critical zone (meters)

- Using the critical zones => convert to designs

Possible Traffic Calming Approaches



Designs to be tested

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Thank you!

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