



Interaction in Urban Traffic – Insights into an Observation of Pedestrian-Vehicle Encounters

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Observation of Pedestrian-Vehicle Encounters

5th Enabler
Methodology for assessing the quality of interaction

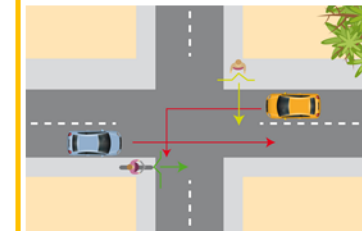


The challenge

1st Enabler
Psychological models



4th Enabler
Novel HMI elements



2nd Enabler
Intention recognition & behavioural predictions

3rd Enabler
CCPU & safety layer



Key Objectives



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- **Model interaction** using different approaches
 - Interaction vocabulary: *How do TPs communicate and anticipate intent*
 - Interaction sequences: *What is the general interaction process in specific use cases, scenarios and scenes?*
 - Quantitative models: *How can interactions be mathematically formulated to allow model-in-the-loop simulations?*



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Observe, Model, Predict

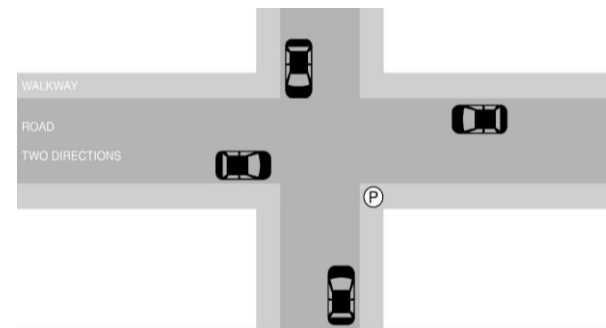
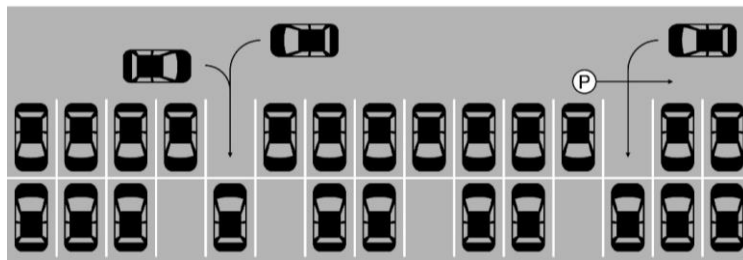


Methodology

- 3 Countries



- 4 Use Cases



Methodology



Naturalistic observation of urban traffic

- Video
- Observation Protocols
- Questionnaires
- LiDAR



interACT Pedestrian Questionnaire

1. Participant No. _____

2. Age _____

3. Gender _____

4. Transporting Item:
(Mark with 0 or 1 if this has been tested)

Phone	Shopping
_____	_____

5. Going to:
(Mark with 0 or 1 if this has been tested)

Home	Work
_____	_____

6. How regularly do you use the:
(Mark with 0 or 1 if this has been tested)

Phone	_____
_____	_____

7. How safe do you feel during:
(Mark with 0 or 1 if this has been tested)

Street crossings	_____
_____	_____

Why? _____

8. What information from the vehicle, if any, did you use to decide it was safe to cross?
(Mark with 0 or 1 or more of the boxes below)

Speed	_____
Distance	_____
Braking	_____
Fronting lights	_____
Turn signals	_____
Turn indicator	_____
Headlight for visibility to pass	_____
None	_____

9. What information from the driver did you use to decide it was safe to cross?
(Mark with 0 or 1 or more of the boxes below)

Blinking indicator	_____
Actual eye contact	_____
Headlights	_____
Head nod	_____
Head movement to the side	_____
None	_____

Was there any other information you used to determine how safe it was to cross?
(To be completed if there is checked in response to Q8 or Q9)

10. How long did you feel you were waiting to find a suitable crossing?

Longer than usual	_____
Average	_____
Shorter than usual	_____

11. Did the presence of other people affect your decision of when to cross?
Yes No

Was it what way?

12. How often do you...
Forget to look properly because you are talking to a friend who is with you
Cross from between parked cars when there is a car behind you
Forget to look properly because you are thinking about something else
See a small gap in traffic and "go for it"
Run across a road without looking because you are in a hurry
Cross whether traffic is coming or not, thinking the traffic will stop for you
Get past one across the road and then have to run the rest of the way to avoid traffic
Cross from behind a stationary vehicle
Cross when you cannot see both ways very well (e.g. at a bend or top of hill)
The task (shopping, errands) has any traffic around
Use a mobile phone and forget to look properly
Run across a gap in traffic not seen from a pedestrian and walk in front of it
Cross without waiting for the "green man"
Cross over barriers or set-ups that separate the road from the pavement
Walk in the road rather than on the pavement

How often do you...	Rarely	Sometimes	Often	Very Often
Forget to look properly because you are talking to a friend who is with you				
Cross from between parked cars when there is a car behind you				
Forget to look properly because you are thinking about something else				
See a small gap in traffic and "go for it"				
Run across a road without looking because you are in a hurry				
Cross whether traffic is coming or not, thinking the traffic will stop for you				
Get past one across the road and then have to run the rest of the way to avoid traffic				
Cross from behind a stationary vehicle				
Cross when you cannot see both ways very well (e.g. at a bend or top of hill)				
The task (shopping, errands) has any traffic around				
Use a mobile phone and forget to look properly				
Run across a gap in traffic not seen from a pedestrian and walk in front of it				
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Methodology

Video:

- Birds eye view perspective of locations chosen to represent the use-cases
- Algorithmic analysis of the videos to derive positions and velocities of various traffic participants



Methodology

LiDAR:

- Stationary LiDAR giving additional information on traffic participants and increasing tracking range
- Collected data is synchronized in time enabling a holistic overview of observed interactions



WebCam

GNSS Receiver

Ibeo Lux Laser Scanner

SSD Drive

Laptop Power Bank

Raspberry Pi

WiFi Access Point

Methodology



Manual Observation:

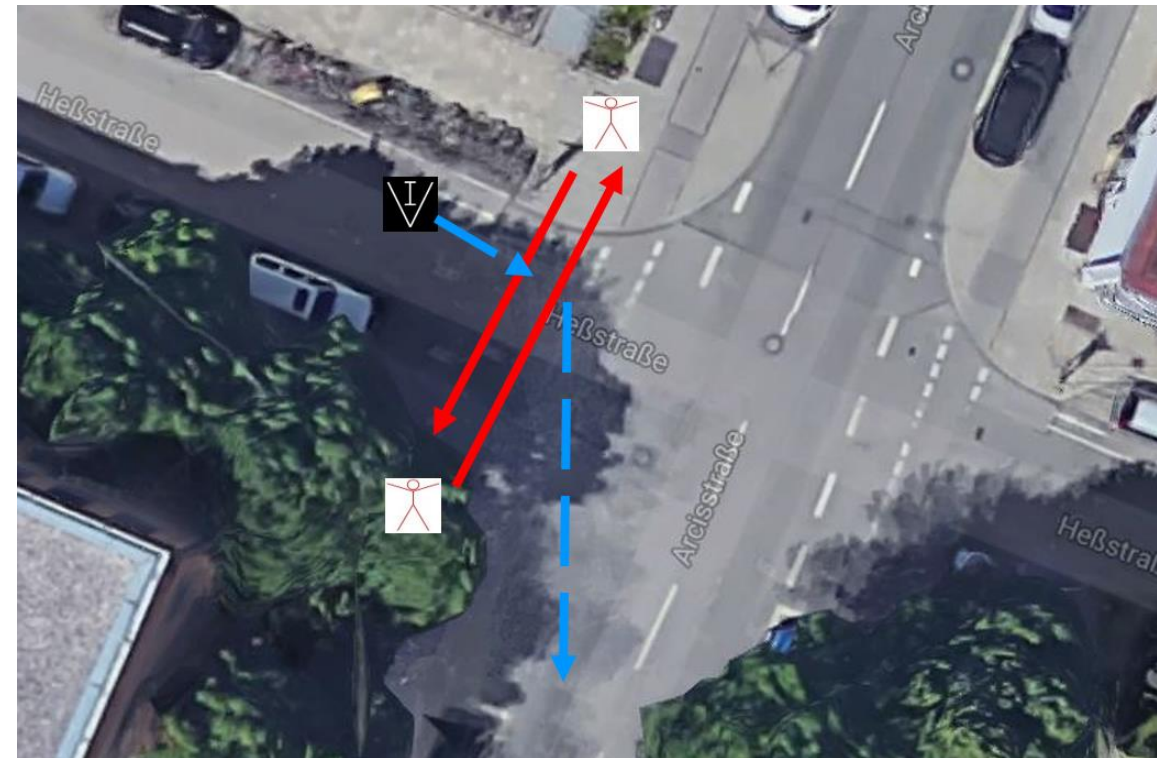
- Observers protocolling individual observed interactions from the ground
- HTML based app for tablets observing pedestrian and driver behaviour, including head rotation, eye contact, etc.
- Questionnaires

The screenshot displays the interACT manual observation app interface. The top section is a data entry form for 'Vehicle 1 Analysis' and 'Vehicle 2 Analysis'. The form includes fields for 'Participant #', 'Date', and 'Time'. Below these are two main sections: 'Vehicle 1 Analysis' and 'Vehicle 2 Analysis'. Each section has a table with columns for 'Vehicle Movement', 'Used Signals (elaborate in notes)', and 'Head Movements'. The 'Vehicle 1 Analysis' table has columns for 'Decelerated for vehicle 2', 'Decelerated due to other reason', 'Kept pace', 'Creeped into the intersection', 'Turned left', and 'Passed vehicle 2'. The 'Vehicle 2 Analysis' table has columns for 'Decelerated for Vehicle 1', 'Decelerated for other reason', 'Kept pace', 'Creeped into the intersection', 'Turned left', and 'Passed vehicle 1'. The bottom section shows a map view of an intersection with vehicle and pedestrian icons. The legend on the right side of the map view includes symbols for 'Pedestrian', 'Group', 'Movement', 'Braking', and 'Intentional Movement'. Both views include 'START', 'STOP', 'Back', and 'SAVE CSV' buttons.



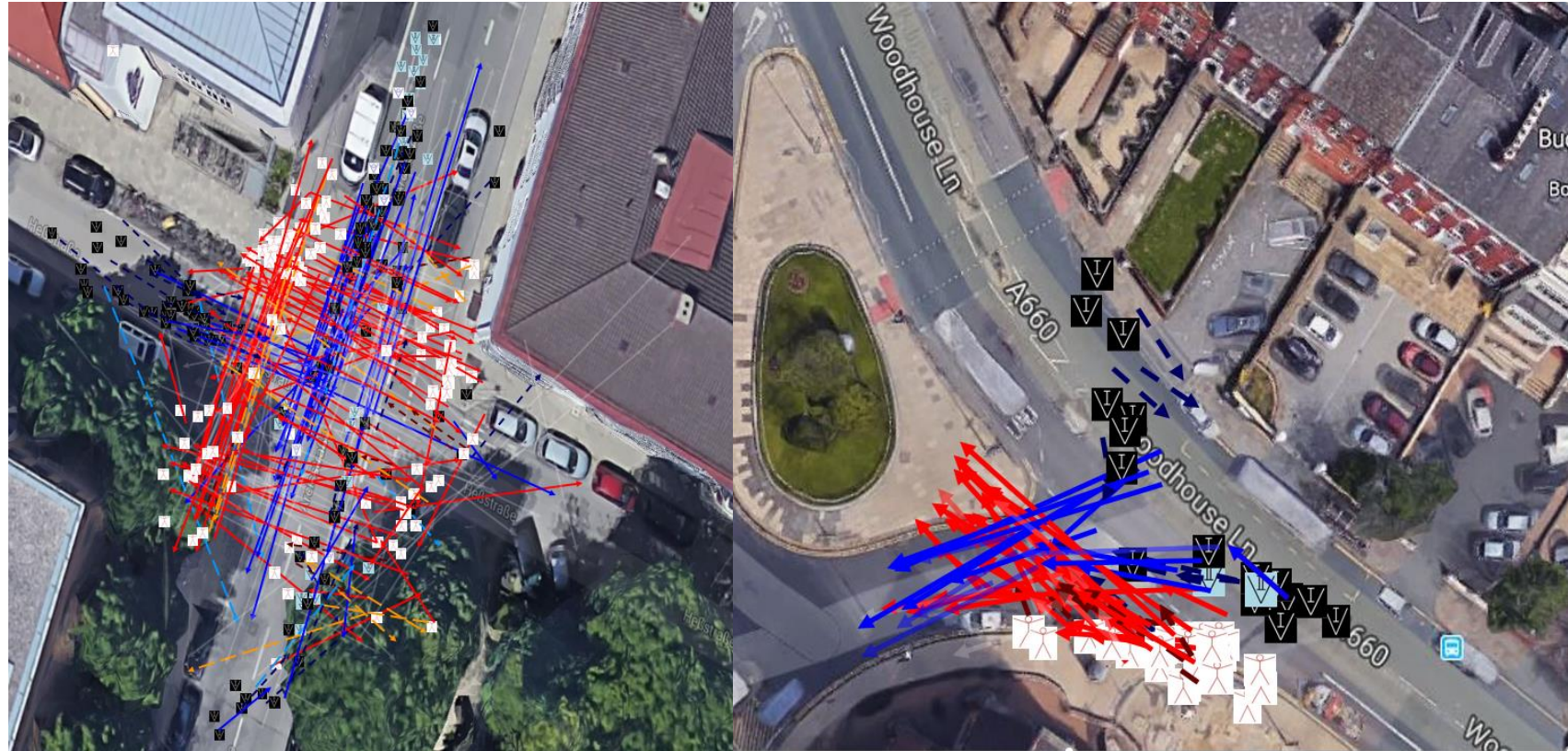
Preliminary Results – Manual Observation

- Observers were advised only to record interaction-demanding situations
- In these situations both traffic participants would have a conflict, if neither of them changed their behaviour
- If there was some sort of interaction between pedestrian and driver, observed pedestrians were asked to fill out a questionnaire.



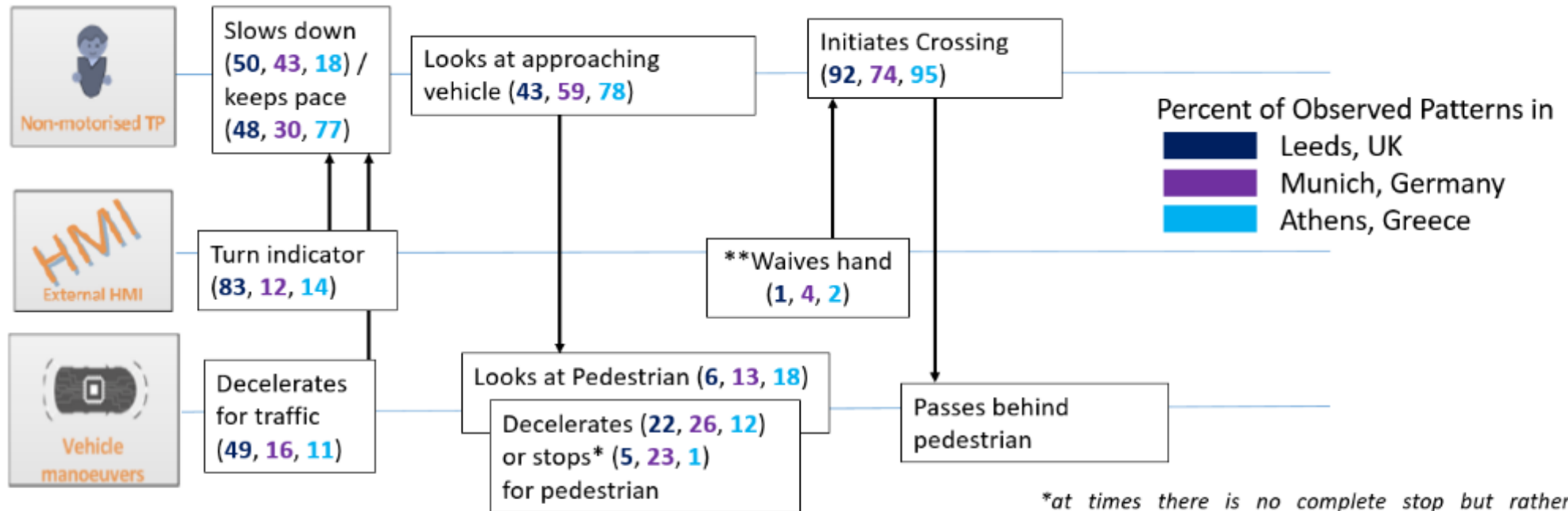
Preliminary Results – Manual Observation

- Over 100 Protocols per use case and country
- Also: combined 100+ hours of videos, 20+ hours of LiDAR Data and 150+ people interviewed



Preliminary Results – Manual Observation

Intersection – pedestrian goes first:

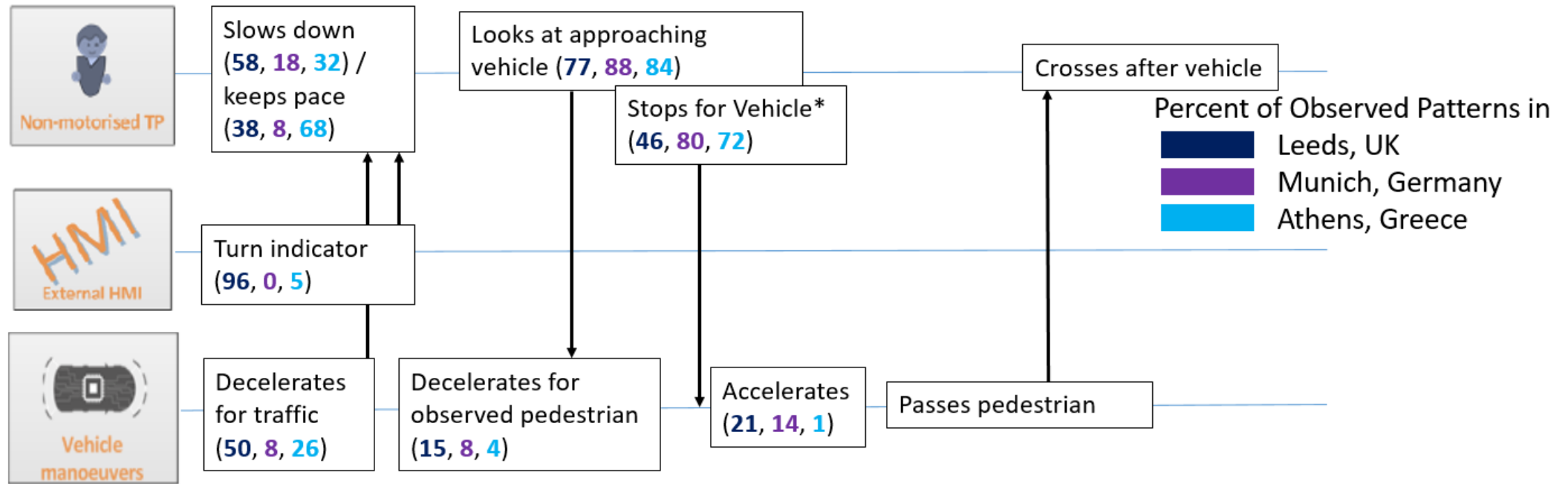


**at times there is no complete stop but rather a continuation of the movement at a very slow pace*

***in some cases there was no hand waving and the scenario played out comparably*

Preliminary Results – Manual Observation

Intersection – vehicle goes first:



**at times there is no complete stop but rather a continuation of the movement at a very slow pace*

Overall Findings



- Occurrence and **necessity of interactions** highly depends on the situation and a variety of **other influences**, such as traffic density, time of day and specific traffic conditions
- **Explicit communication (e.g. gesturing, flashing lights etc.) happens rarely** - most potential interaction-demanding situations are resolved before they actually arise, mostly by adjusting kinematic motion
- **Cooperation, communication and thus interaction** between human road users takes place at **low speeds**, usually below 20 km/h
- At **higher speeds conflict avoidance** is predominant – pedestrians use large enough inter-vehicle gaps to cross without expecting the second vehicle to adapt
- **Self reports ≠ reality**: About 50% of pedestrians reported to use some sort of visual information from the driver – even when the driver could not have been physically perceived



Overall Findings

- Human road users seem to **avoid active communication with others** by adapting their movement behavior early
- Only in **ambiguous situations** (e.g. deadlocks) **communication** is used to let the other traffic participant go first, mostly **using gestures**
- In the rare case that pedestrians waved a driver through, the **“Thank You” hand gesture** always followed by the driver.



(First) Conclusions

- Automated Vehicles do not need to communicate much using external Human Machine Interfaces if the **idea is to replace a human driver** – only in ambiguous situations explicit communication is really necessary
- **BUT** – Automated Vehicles could **enhance the vehicle by communicating early** in addition to adapting their movement possibly increasing **Acceptance, Safety and Traffic Flow**



Thank you!



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