Amateur: Augmented Reality Based Vehicle Navigation System

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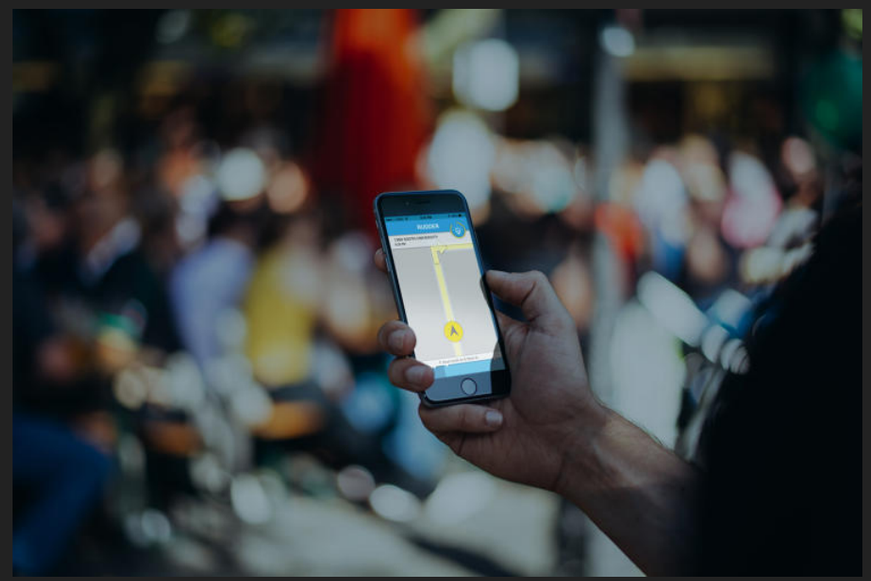
Transportation System

Vehicular navigation system



Mobile navigation service

Transportation System

Problem: display digital map

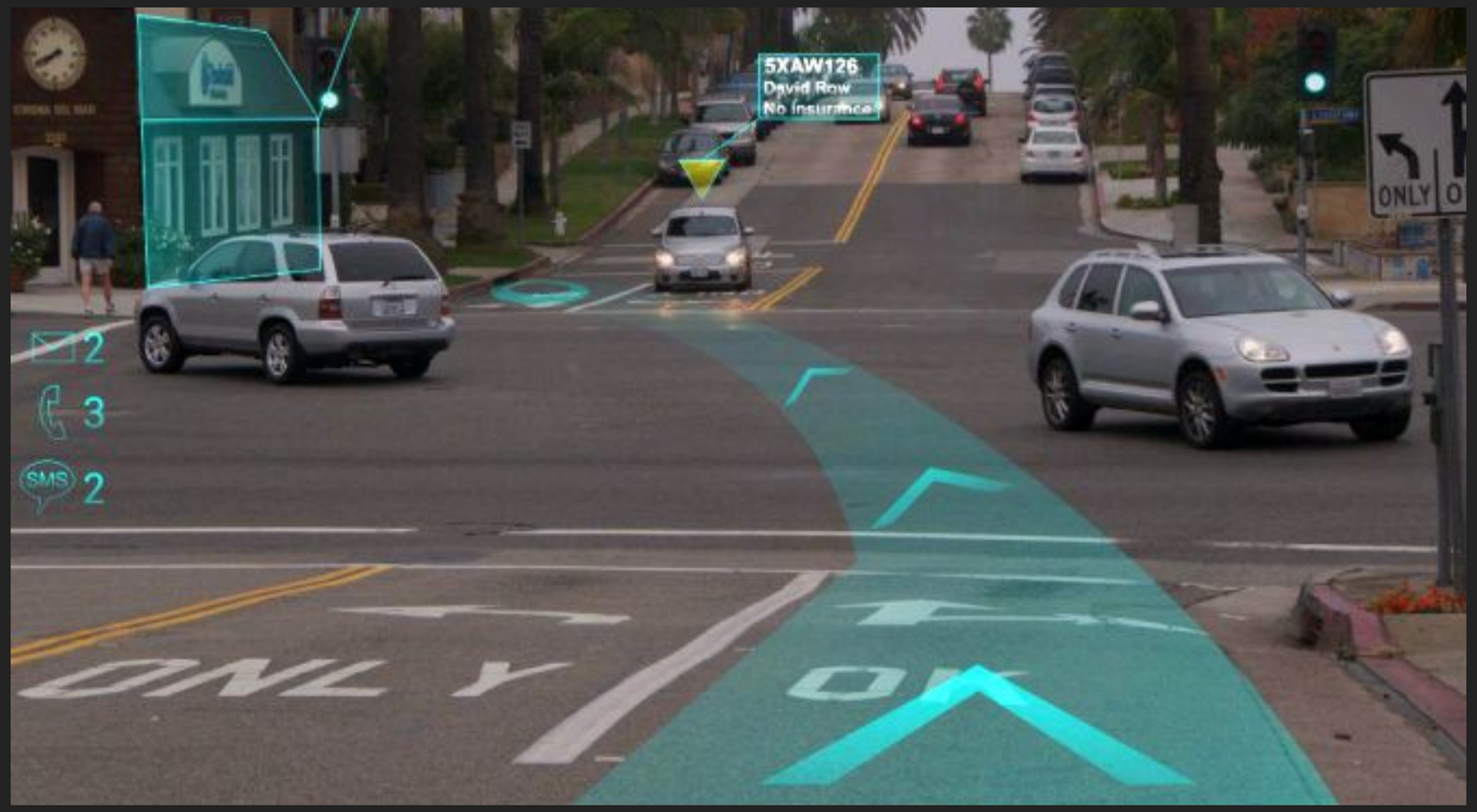
Gap: real v.s. virtual

AR-based Navigation Service

- Display front-view road condition
- Instructions on live world
- Comparable navigation
- Easy to deploy

AR-based Navigation Service

- **Challenges**

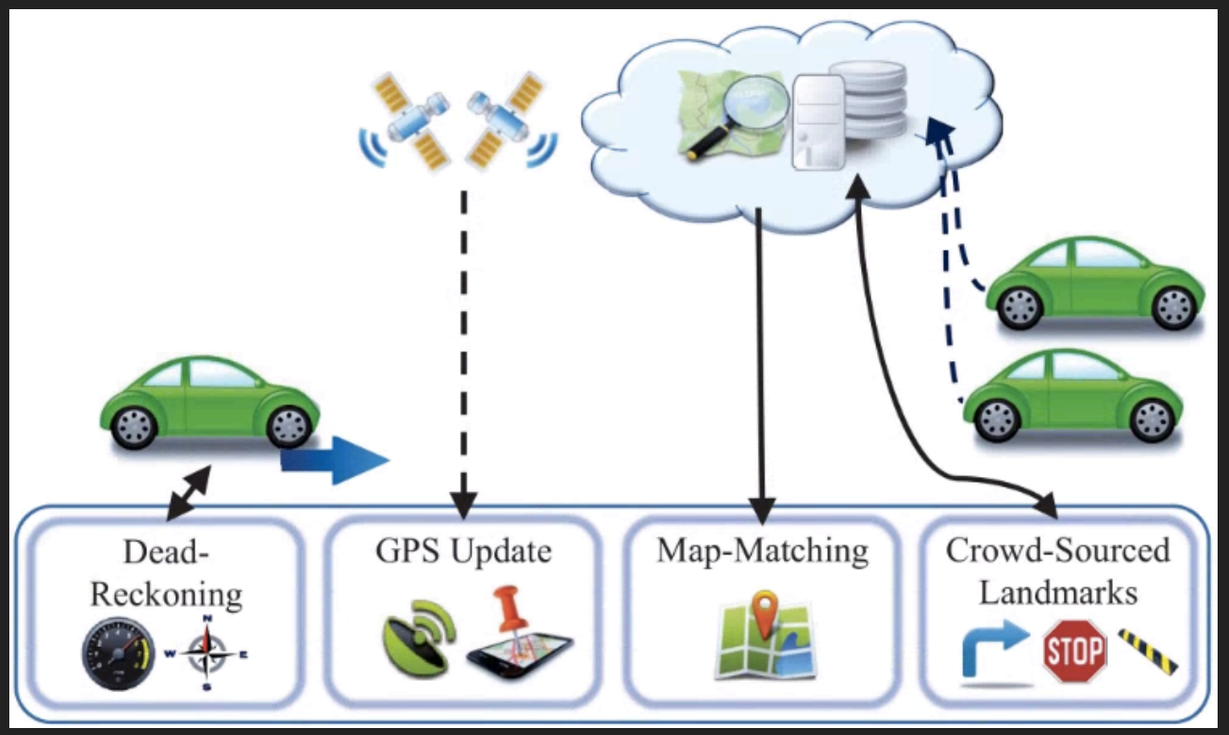


Determine the correct instruction at proper position on screen.

- Host-lane identifying
  Lane-level localisation accuracy
- Annotations placement
  Depth information in video

AR-based Navigation Service

- Related work



CarLoc: Precisely Tracking Automobile Position [SenSys'15]

Real time Detection of Lane Markers in Urban Streets [IVS'08]

- 20 built-in sensors
- Dead-reckoning

- Complicated image processing
- Too heavy to be affordable

AR-based Navigation Service

- Related work

Tesla autopilot 2.0

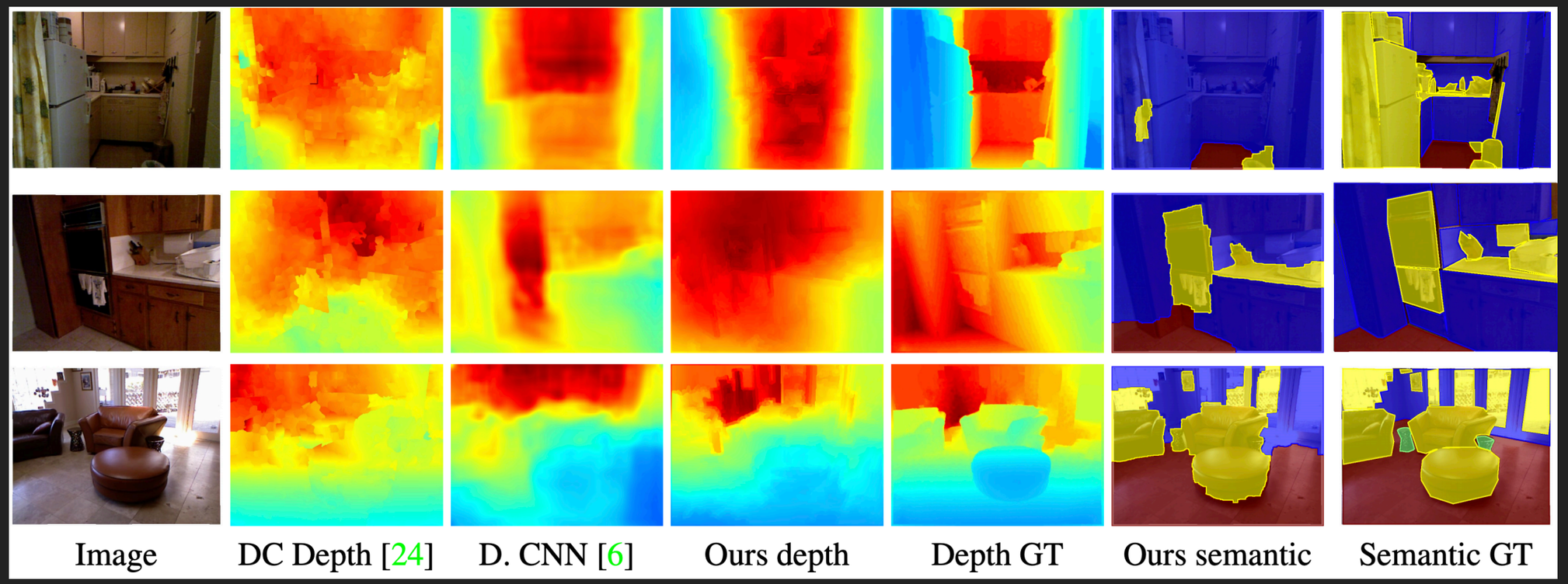
- Maintain on hostlane

Google automobile

- Rich sensor embedded

AR-based Navigation Service

- Related work

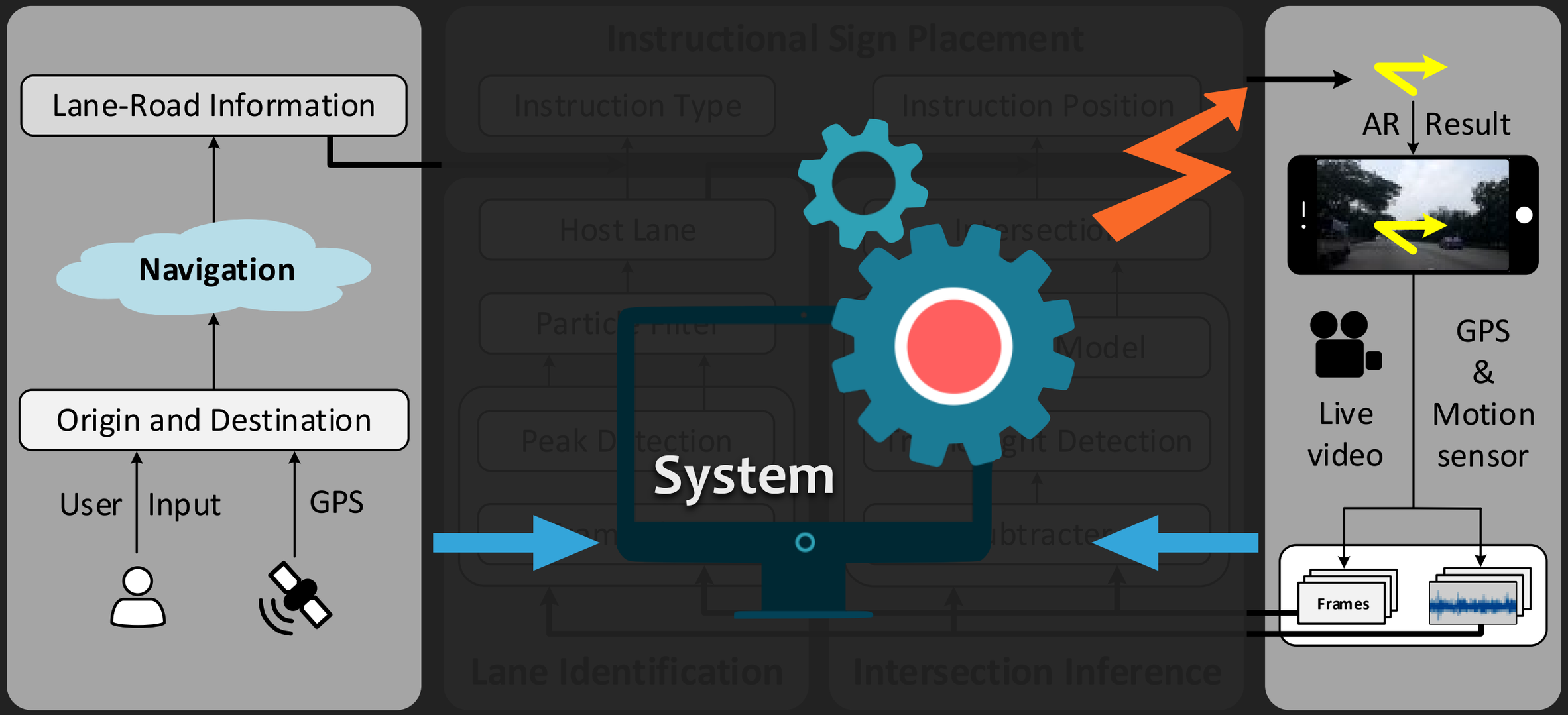


Towards Unified Depth and Semantic Prediction from a Single Image [CVPR'15]

- Three complicated neural networks
- Large volume of training data

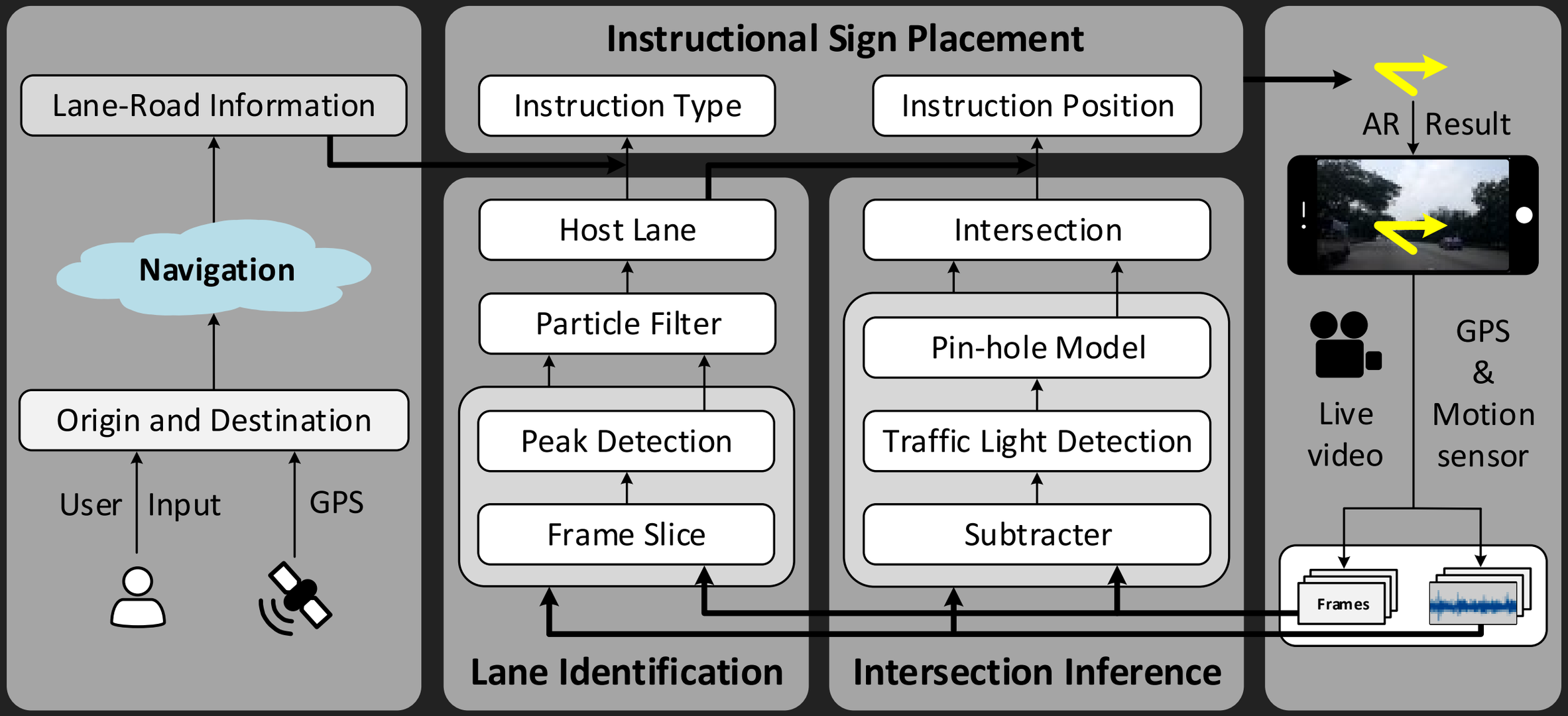
AR-based Navigation Service

❖ System architecture



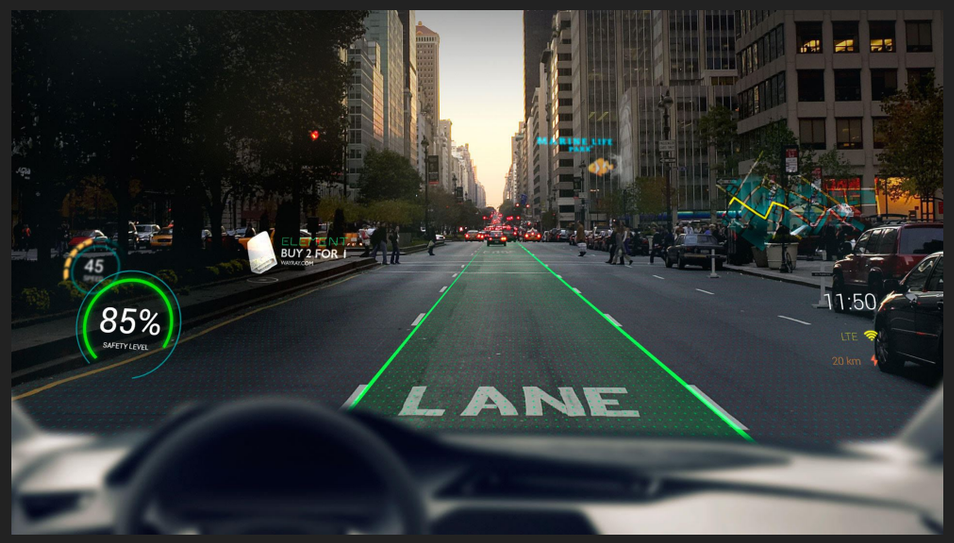
AR-based Navigation Service

❖ System architecture



AR-based Navigation Service

- System architecture — lane identification



Lane detection task.

Based on pure videos.

Avoid collisions for automobiles.

Lane identification task.

Based not only on videos…
IMU sensors on mobile phone &
Extra lane number information

Assistant for drivers.

AR-based Navigation Service

- **System architecture — lane identification**

One frame in video

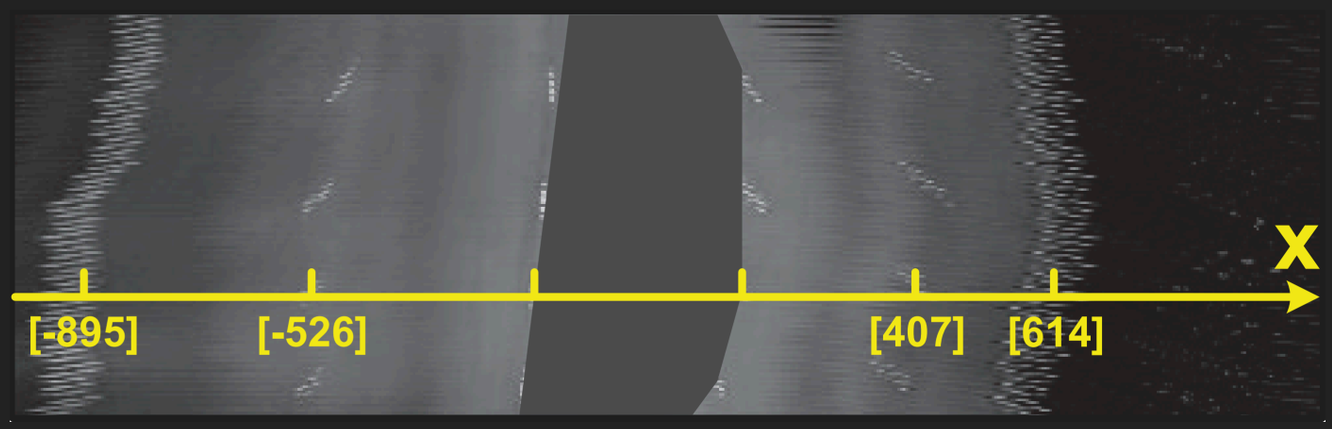
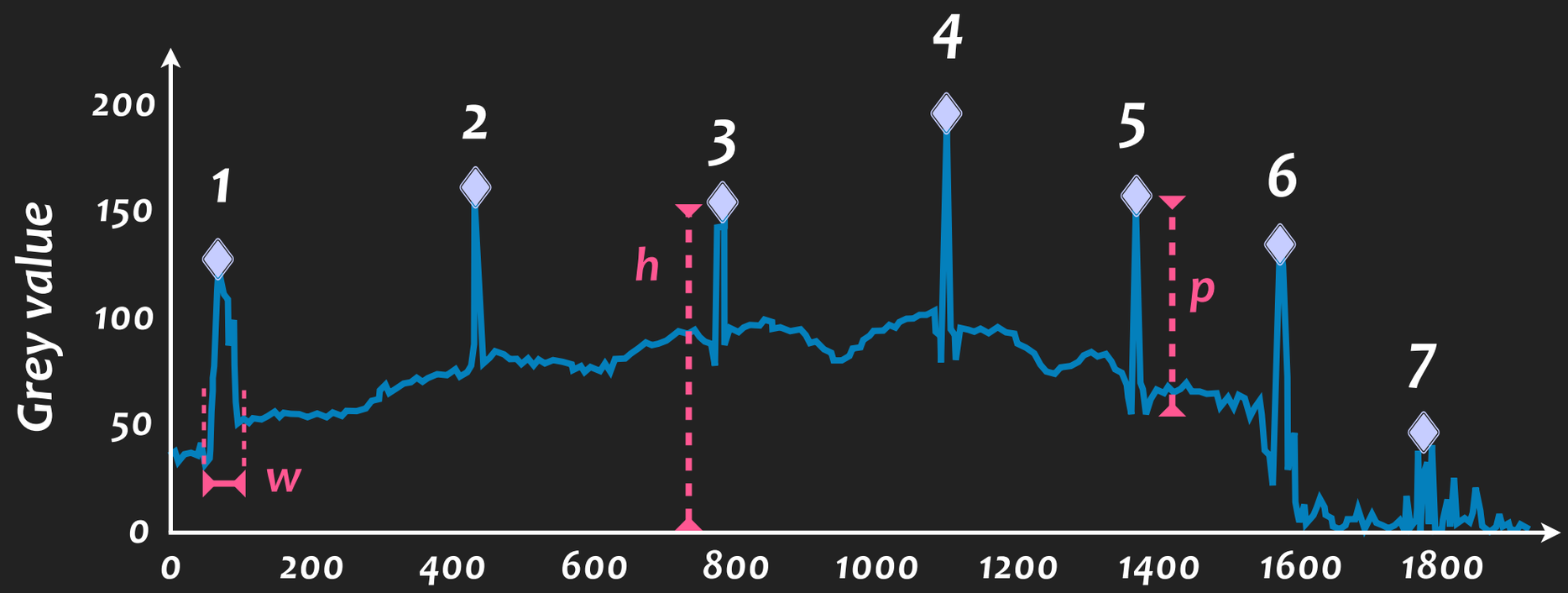


Image slicing of 60 frames

AR-based Navigation Service

- System architecture — lane identification



$$h \geq \frac{1}{2} max\{g_i\}_{i=1}^{n}$$

Brightness

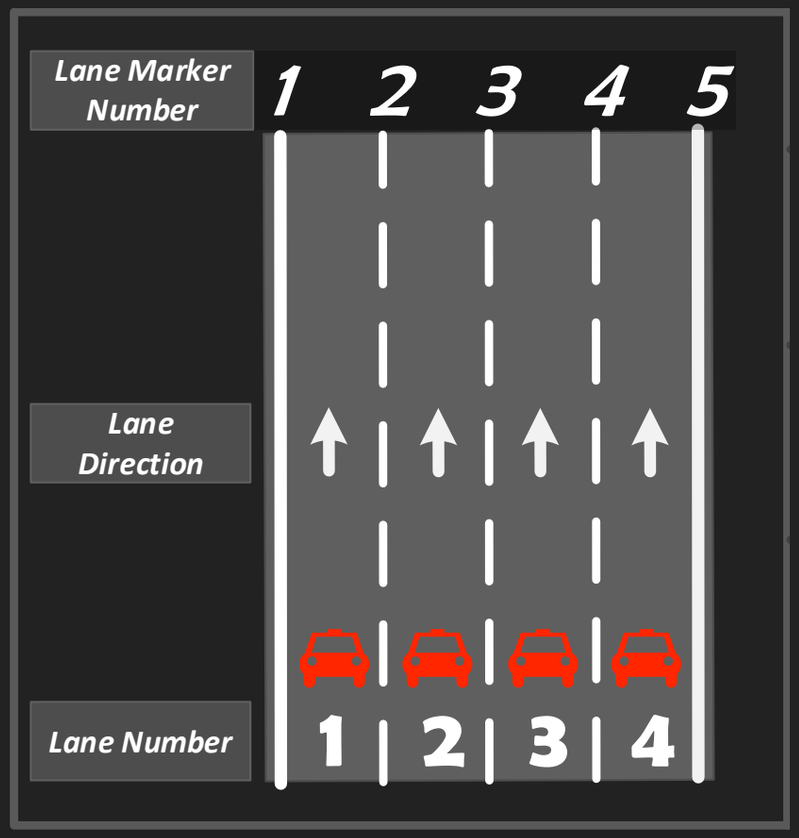
$$p = h - min\{g_i\}_{g^k - \frac{w}{2}}^{g^k + \frac{w}{2}}$$

$$\frac{1}{3}p \leq p - G_{10th}$$

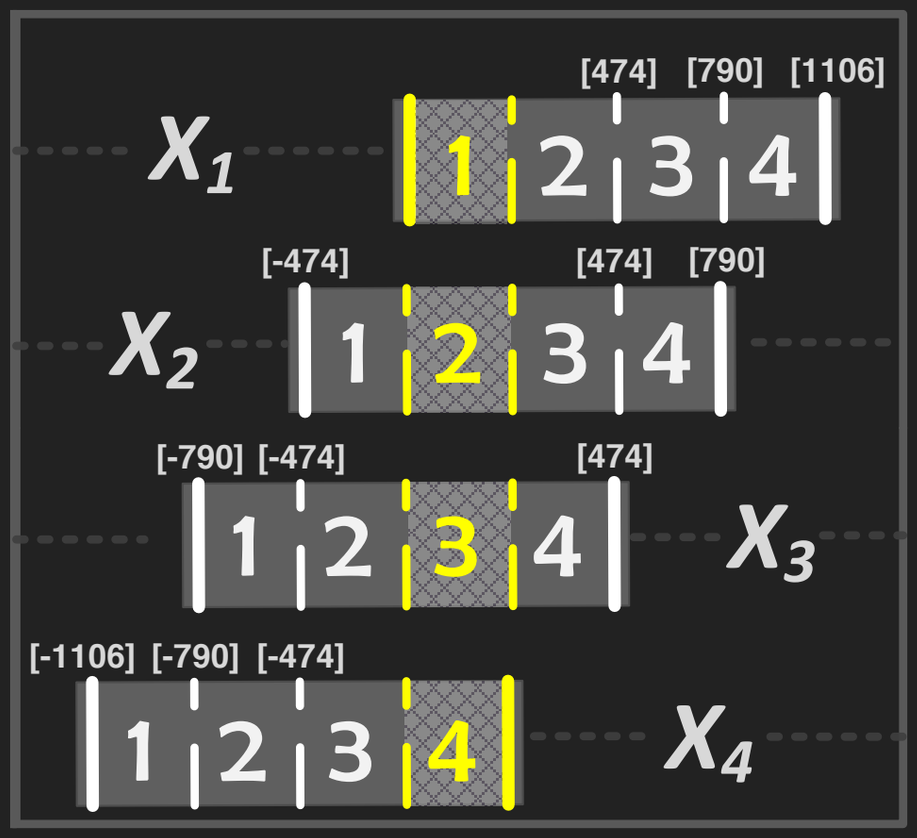
Sharpness

AR-based Navigation Service

- System architecture — lane identification



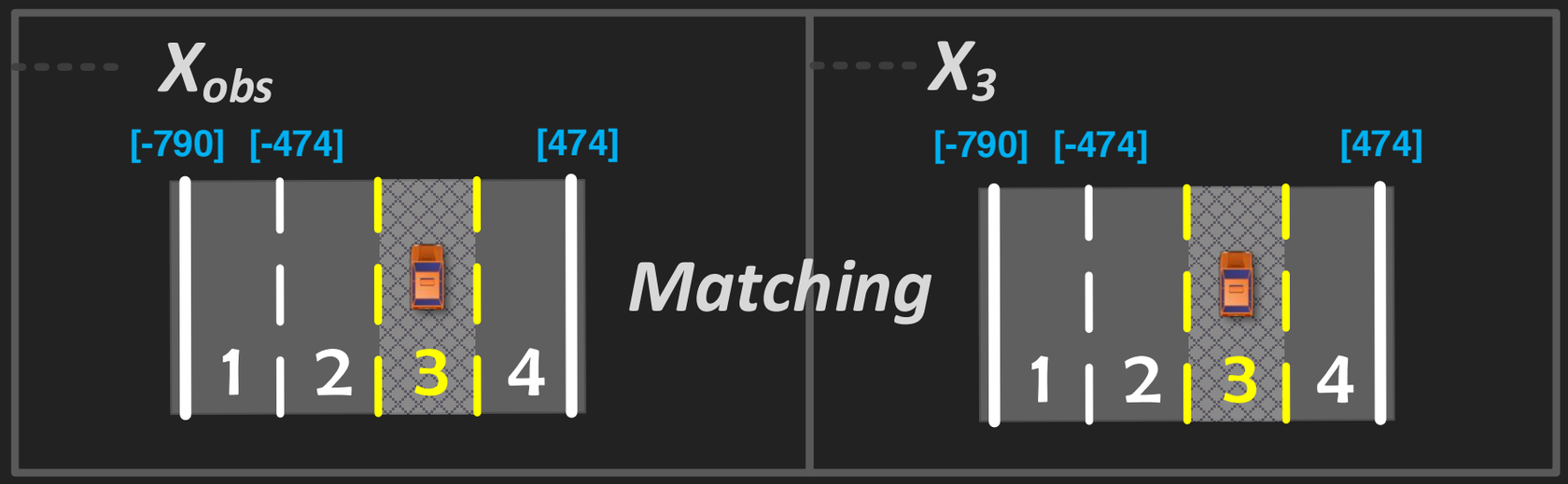
A road segment with 4 lanes



Templates of a 4-lane road

AR-based Navigation Service

- System architecture — lane identification



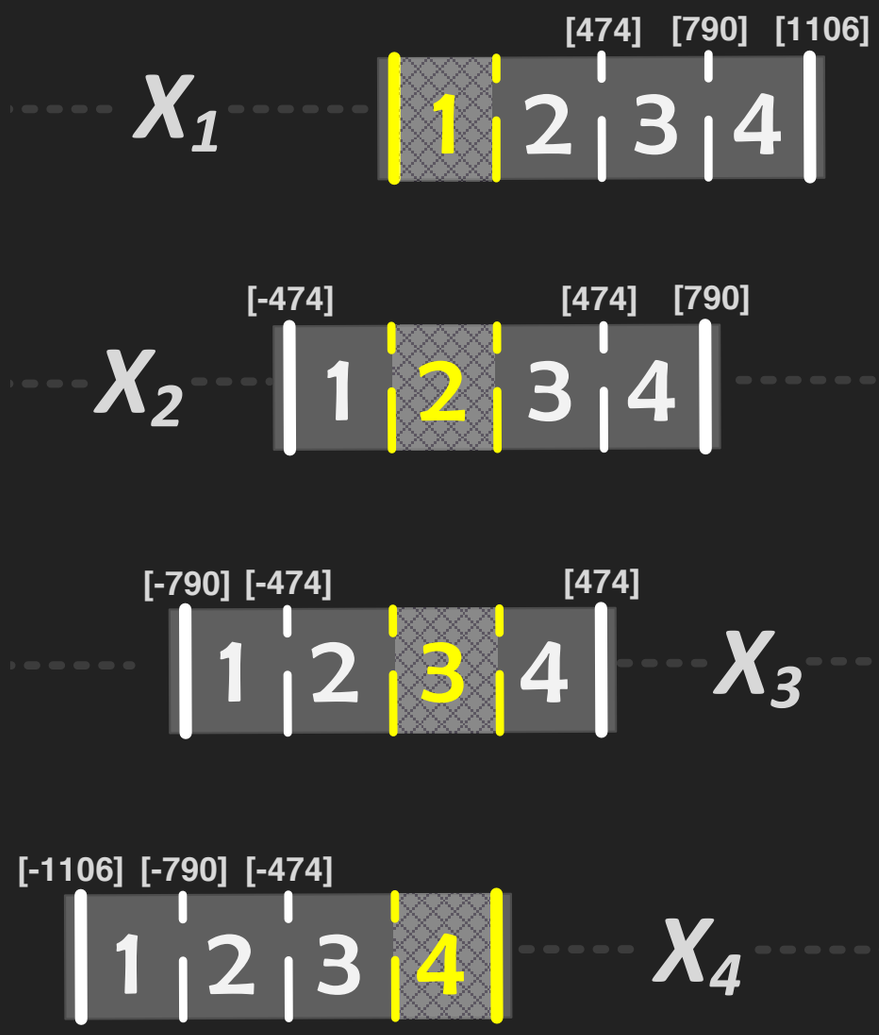
~~Ideally detect the peaks~~

1. Blockage of frontal vehicles
2. Reflection of lights
3. Bad condition of lane markers

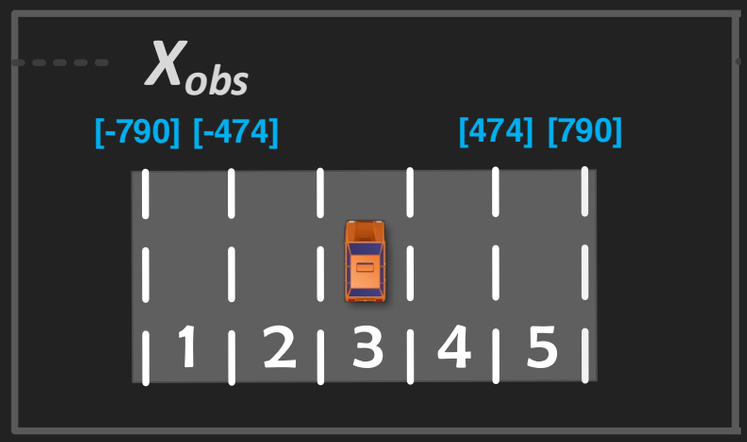
AR-based Navigation Service

❖ System architecture — lane identification

✦ Particle filter design



initialisation



Weight updating

↓

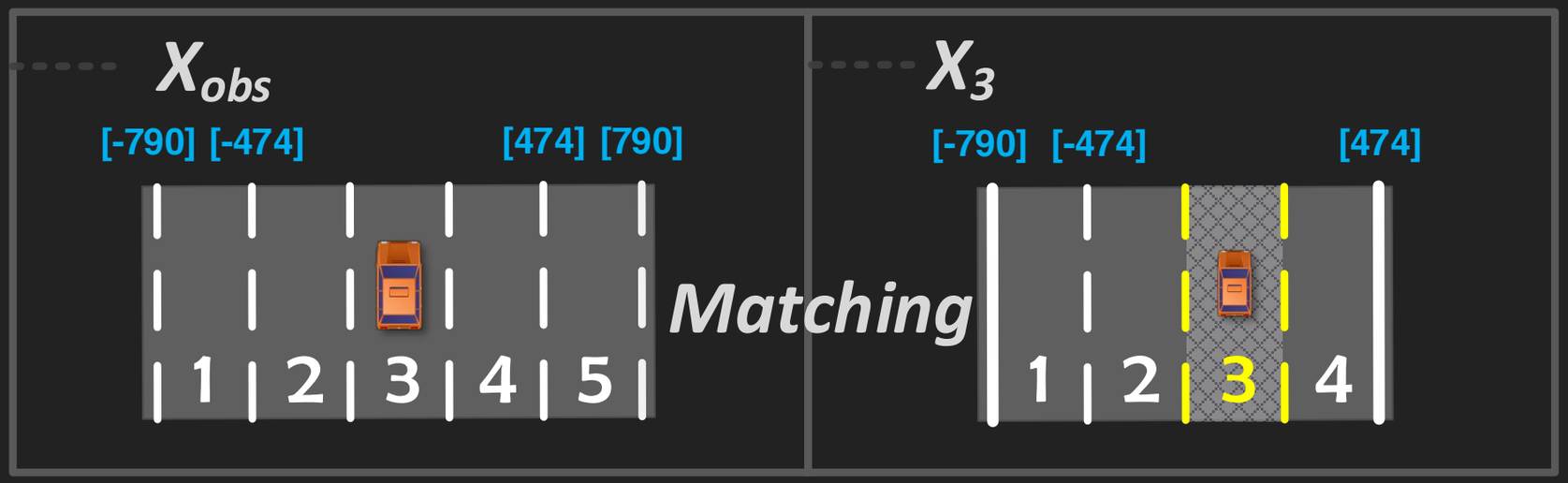
Dynamic time wrapping

AR-based Navigation Service

❖ System architecture — lane identification

✦ Particle filter design

Dynamic time wrapping under Euclidean distance



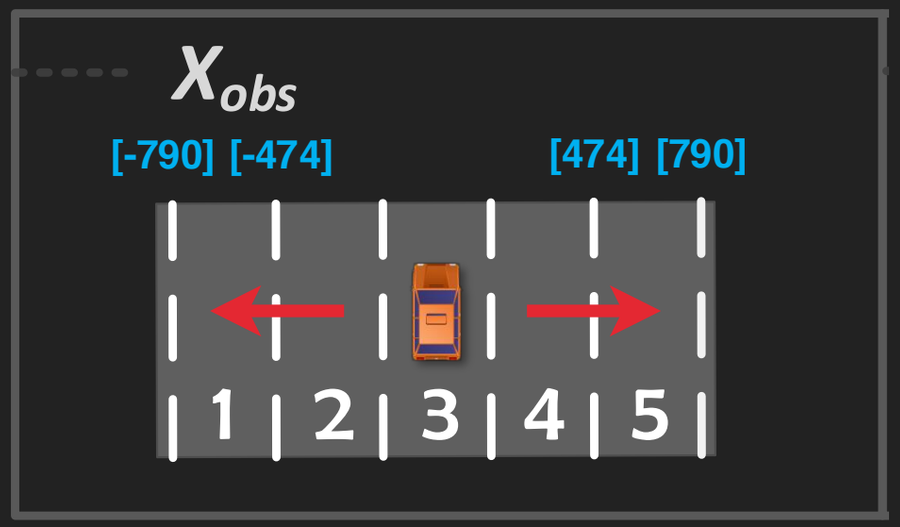
$$w_b^p = e^{-d_b}$$

AR-based Navigation Service

❖ System architecture — lane identification

✦ Particle filter design

Resampling based on importance



Movement: lane switching

AR-based Navigation Service

- **System architecture — lane identification**
  - Particle filter design

    Resampling based on importance

AR-based Navigation Service

- **System architecture — lane identification**
  - Particle filter design

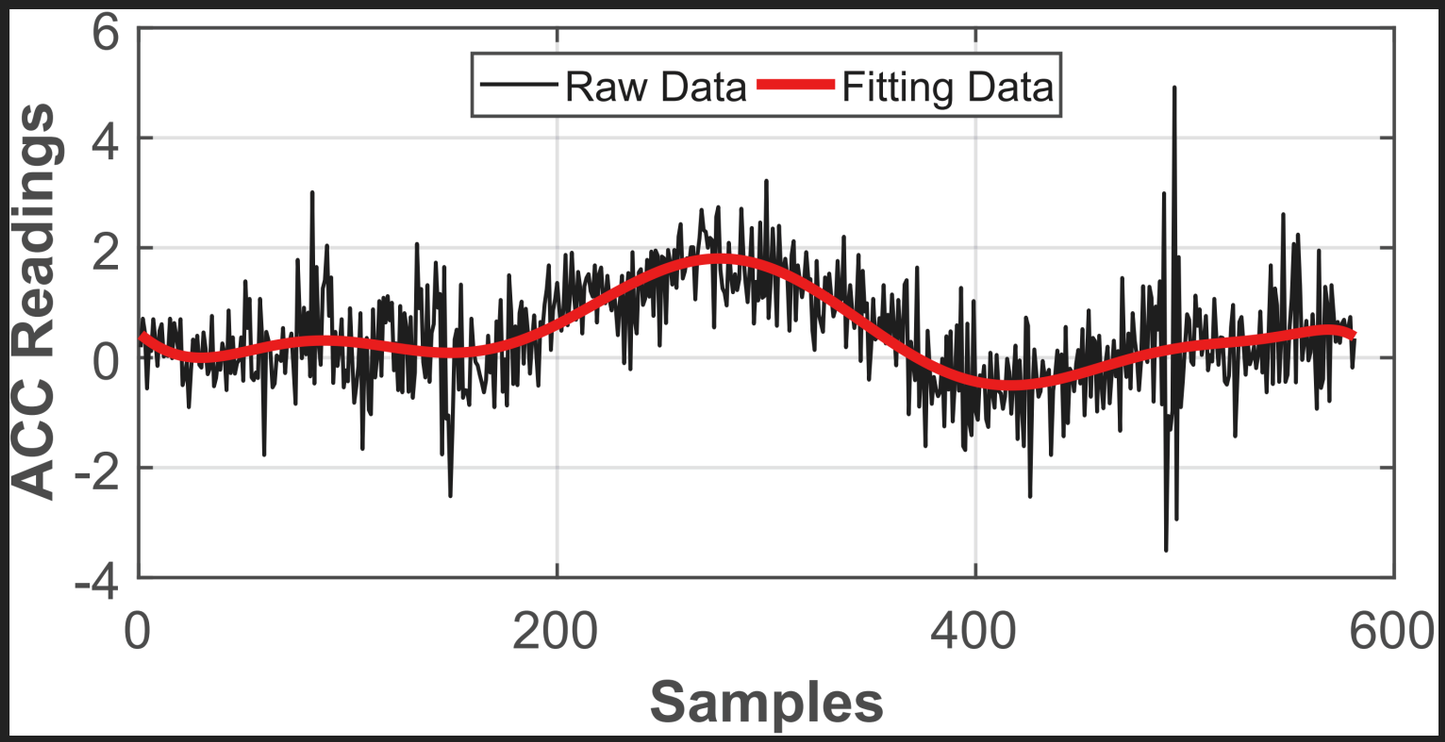
    Resampling based on importance

Lane marker of host-lane has a traversing phenomenon during lane switching.

AR-based Navigation Service

- **System architecture — lane identification**
  - Particle filter design

    Resampling based on importance



$$\mathcal{P}(\mathcal{L}_s|\mathcal{O}) = \frac{\mathcal{P}(\mathcal{O}|\mathcal{L}_s) \cdot \mathcal{P}(\mathcal{L}_s)}{\mathcal{P}(\mathcal{O})}$$

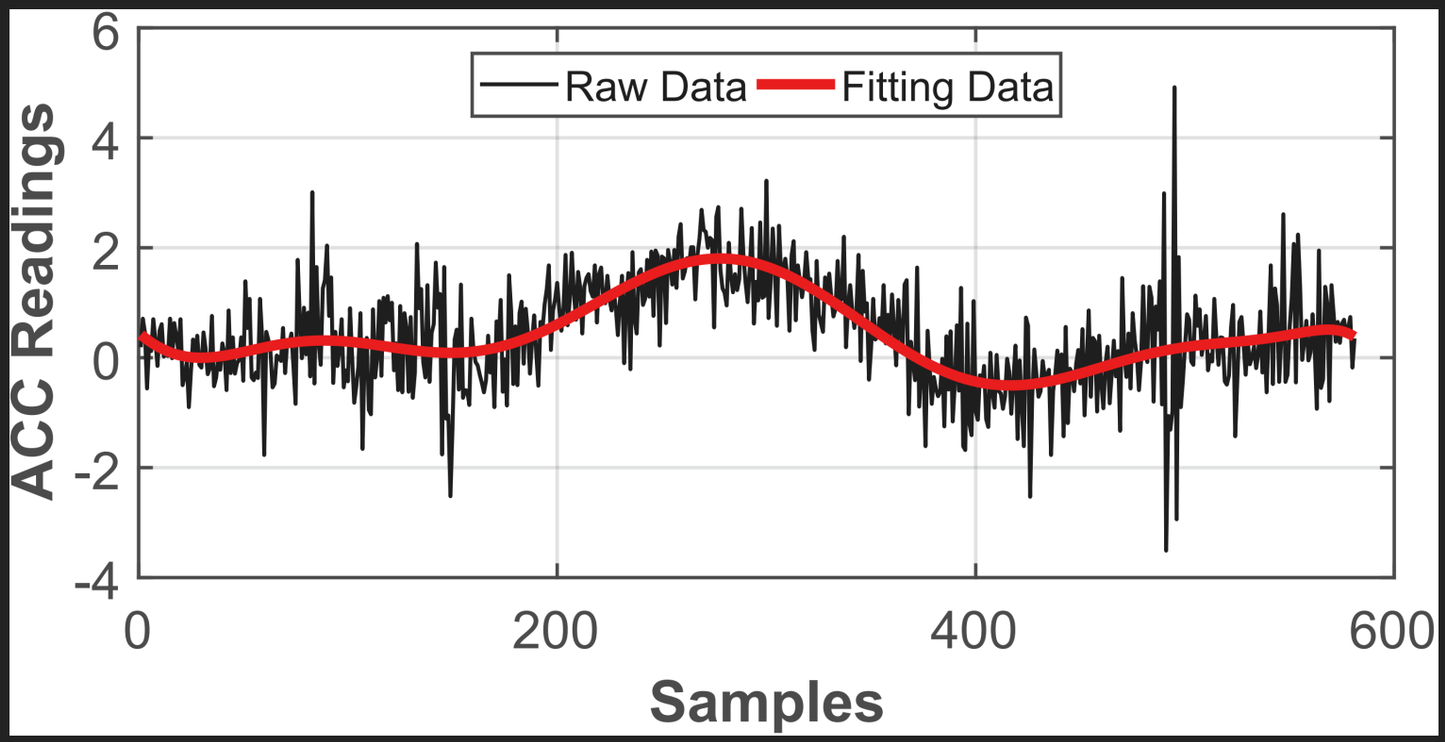
$$\mathcal{P}(\mathcal{L}_s|\mathcal{O}) = \mathcal{P}(\mathcal{O}|\mathcal{L}_s) \cdot \beta$$

$$\mathcal{P}(\mathcal{O}|\mathcal{L}_s) = e^{-d'_s}$$

AR-based Navigation Service

- **System architecture — lane identification**
  - Particle filter design

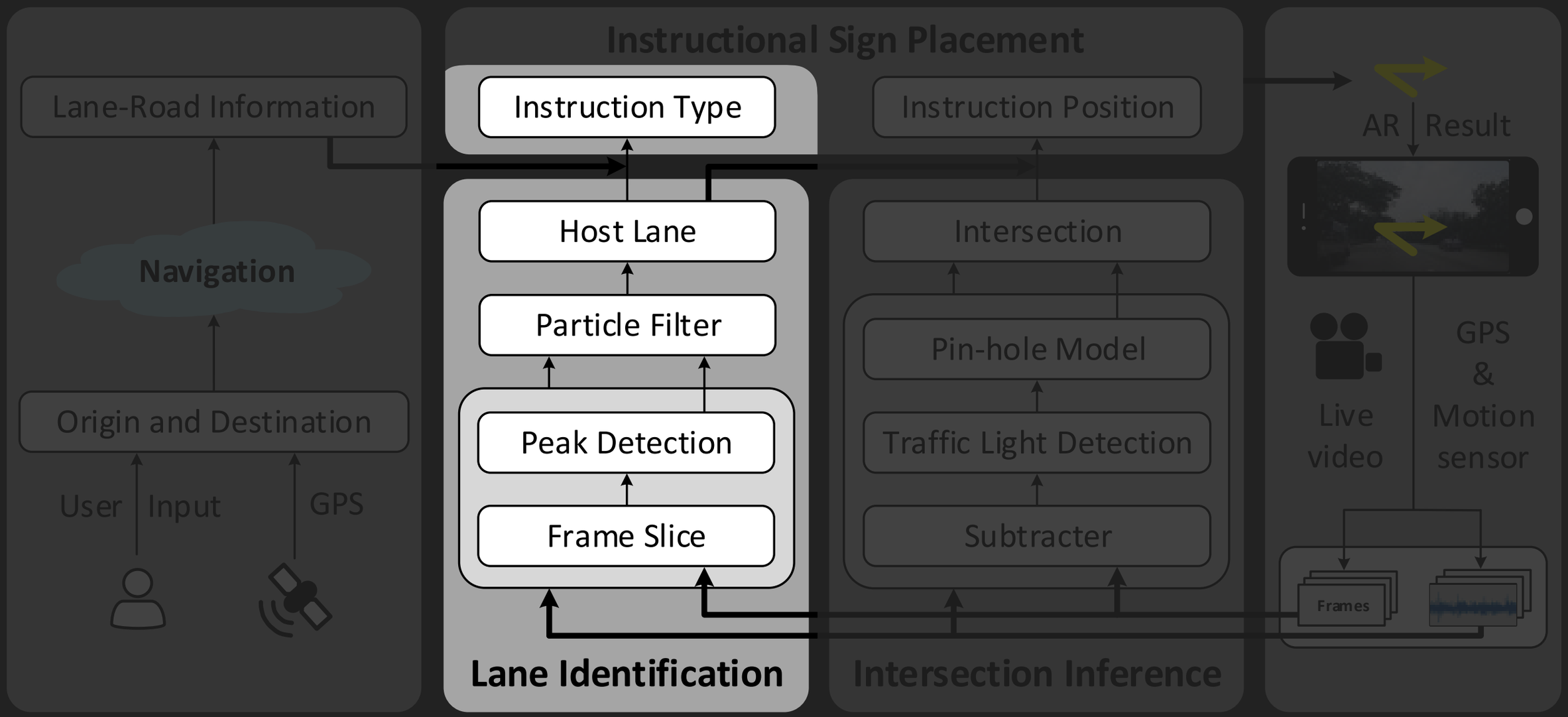
    Resampling based on importance



$$\hat{w}_l = \sum_{s+i=l} \mathcal{P}(\mathcal{L}_s|\mathcal{O}) \cdot w_i = \sum_{s+i=l} \beta \cdot \mathcal{P}(\mathcal{O}|\mathcal{L}_s) \cdot w_i$$

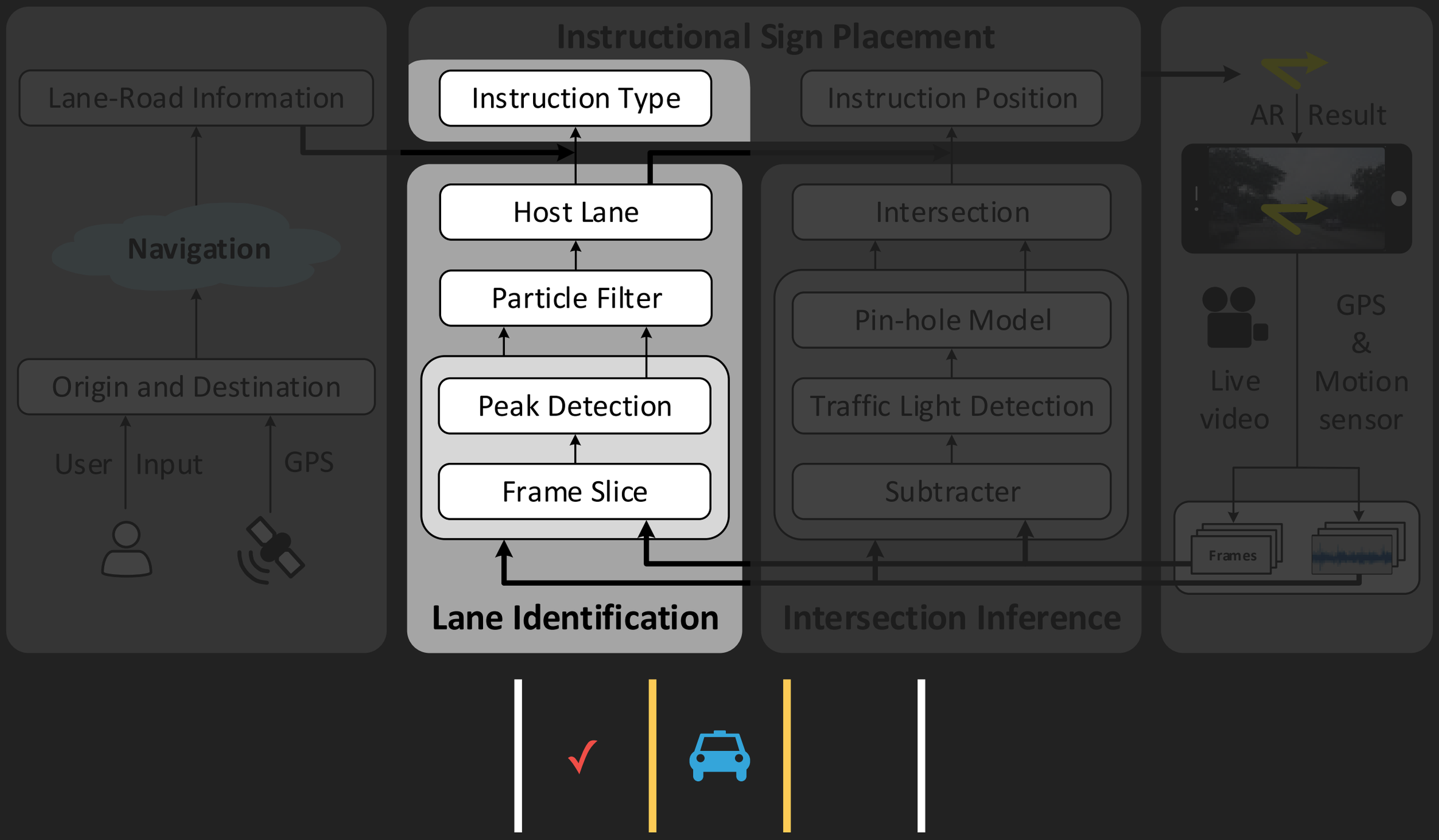
AR-based Navigation Service

❖ System architecture



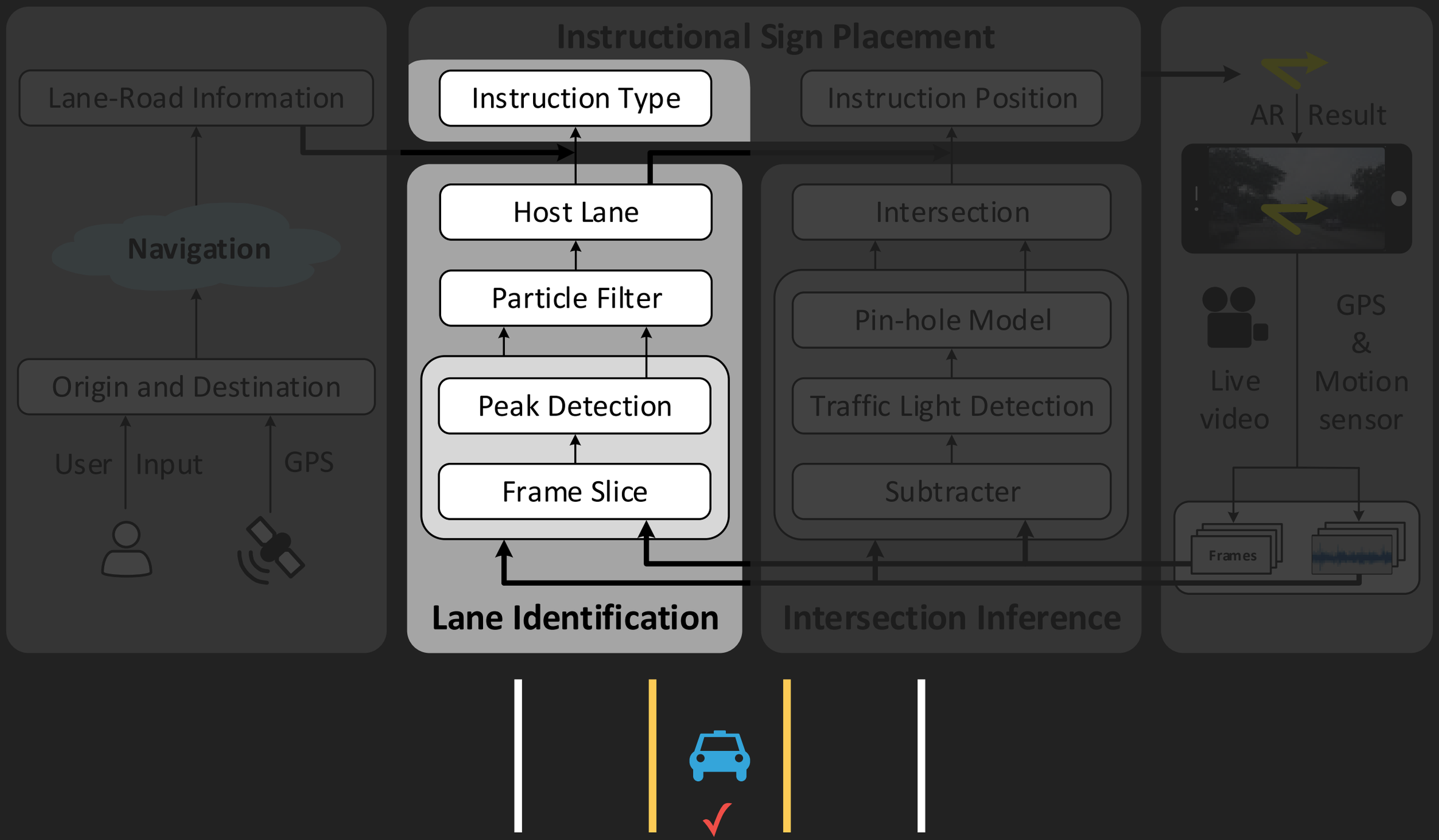
AR-based Navigation Service

❖ System architecture



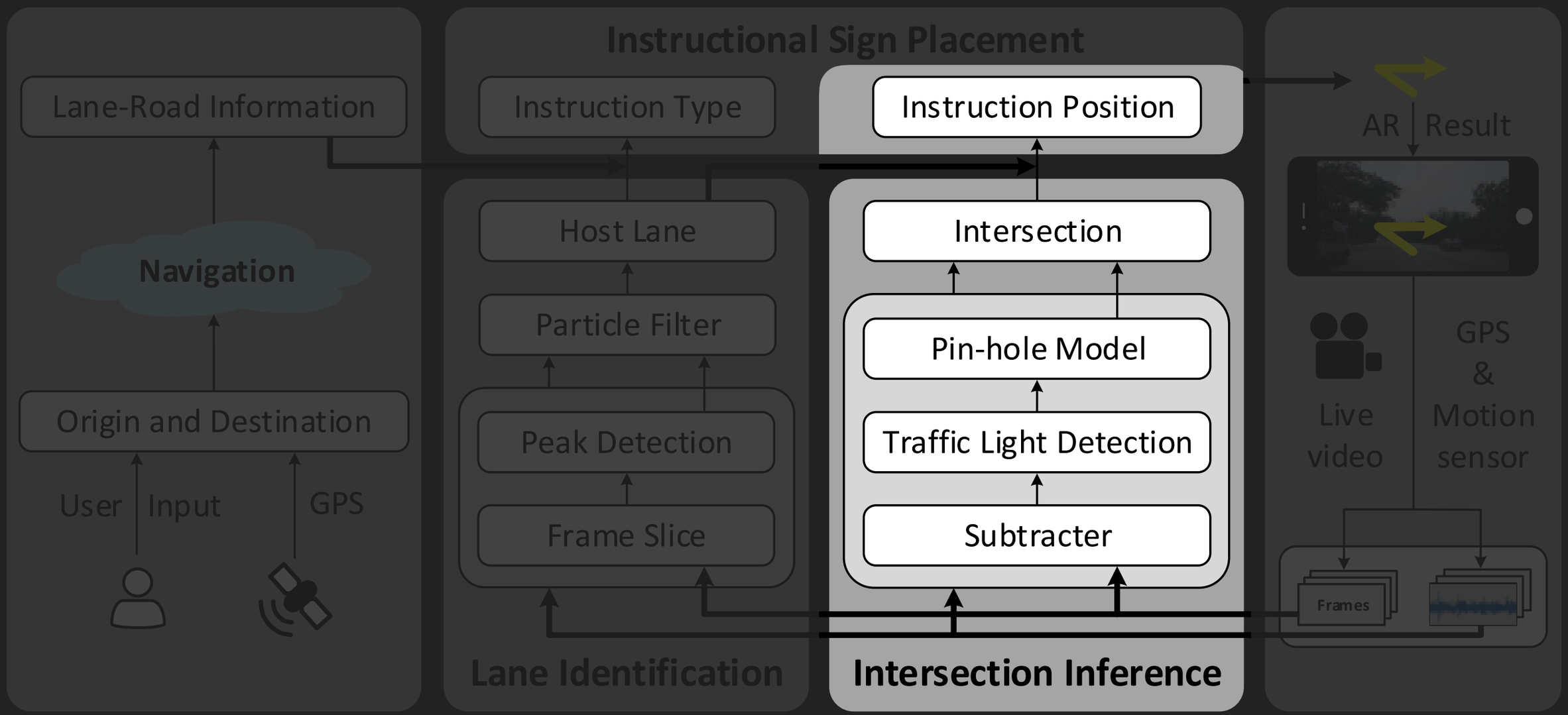
AR-based Navigation Service

❖ System architecture



AR-based Navigation Service

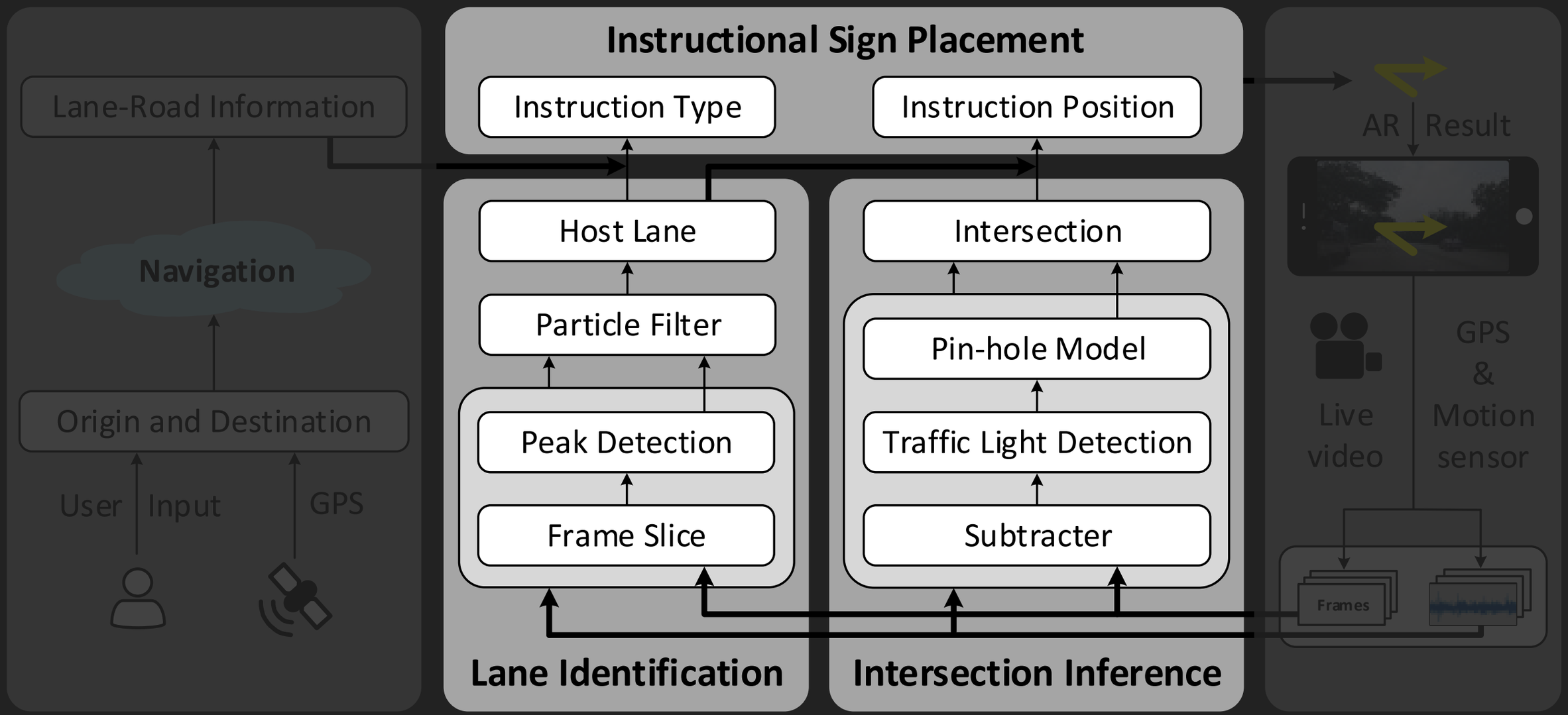
❖ System architecture



Please refer to our paper for more details.

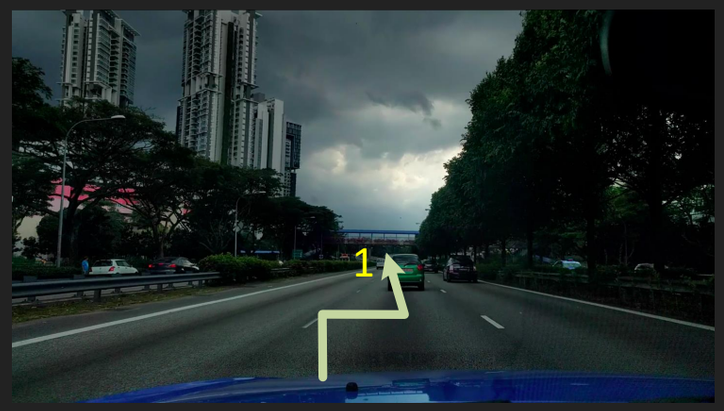
AR-based Navigation Service

- System architecture

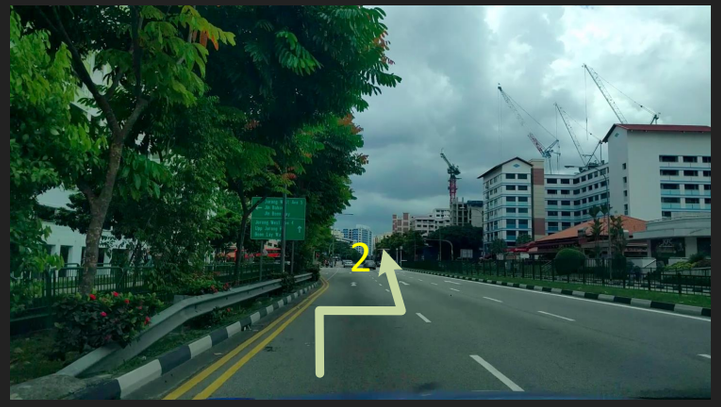


AR-based Navigation Service

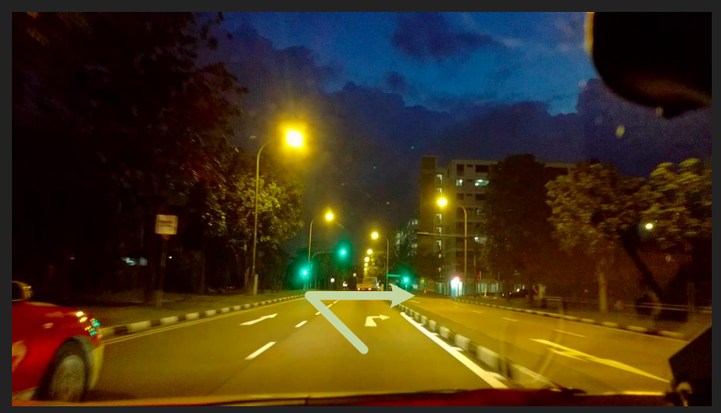
- **Examples**

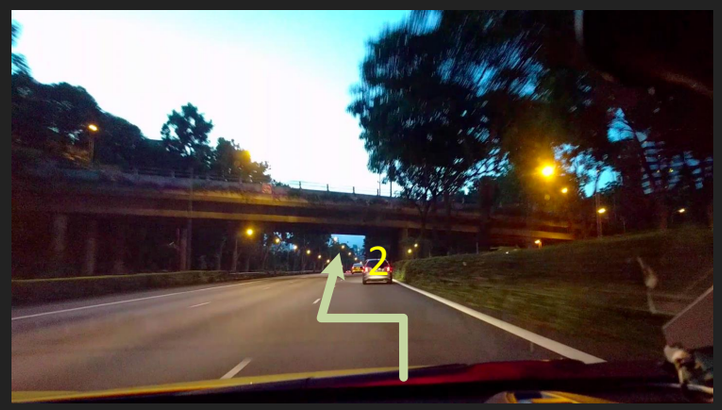


Cloudy



Daytime





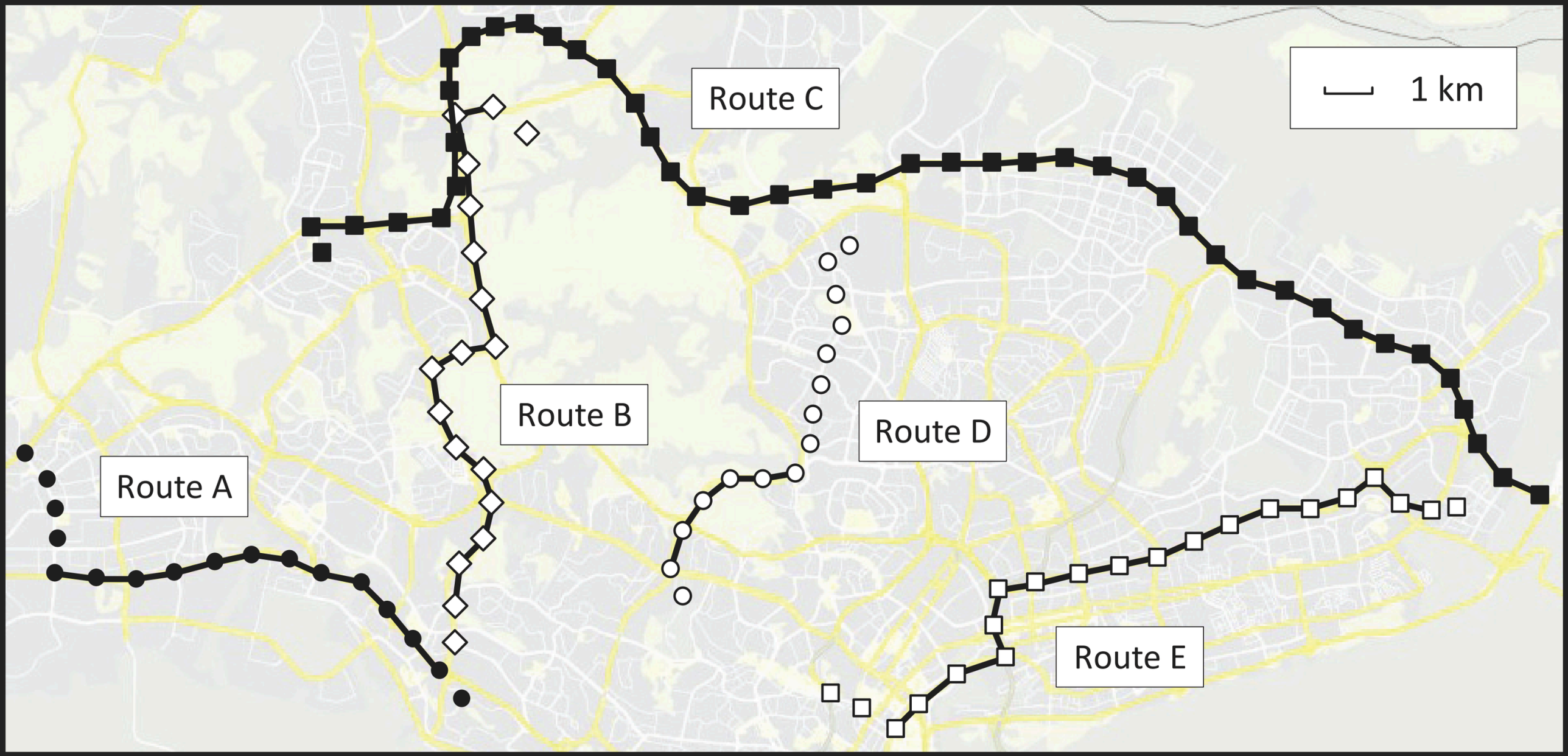
Nightfall

AR-based Navigation Service

- Demo

AR-based Navigation Service

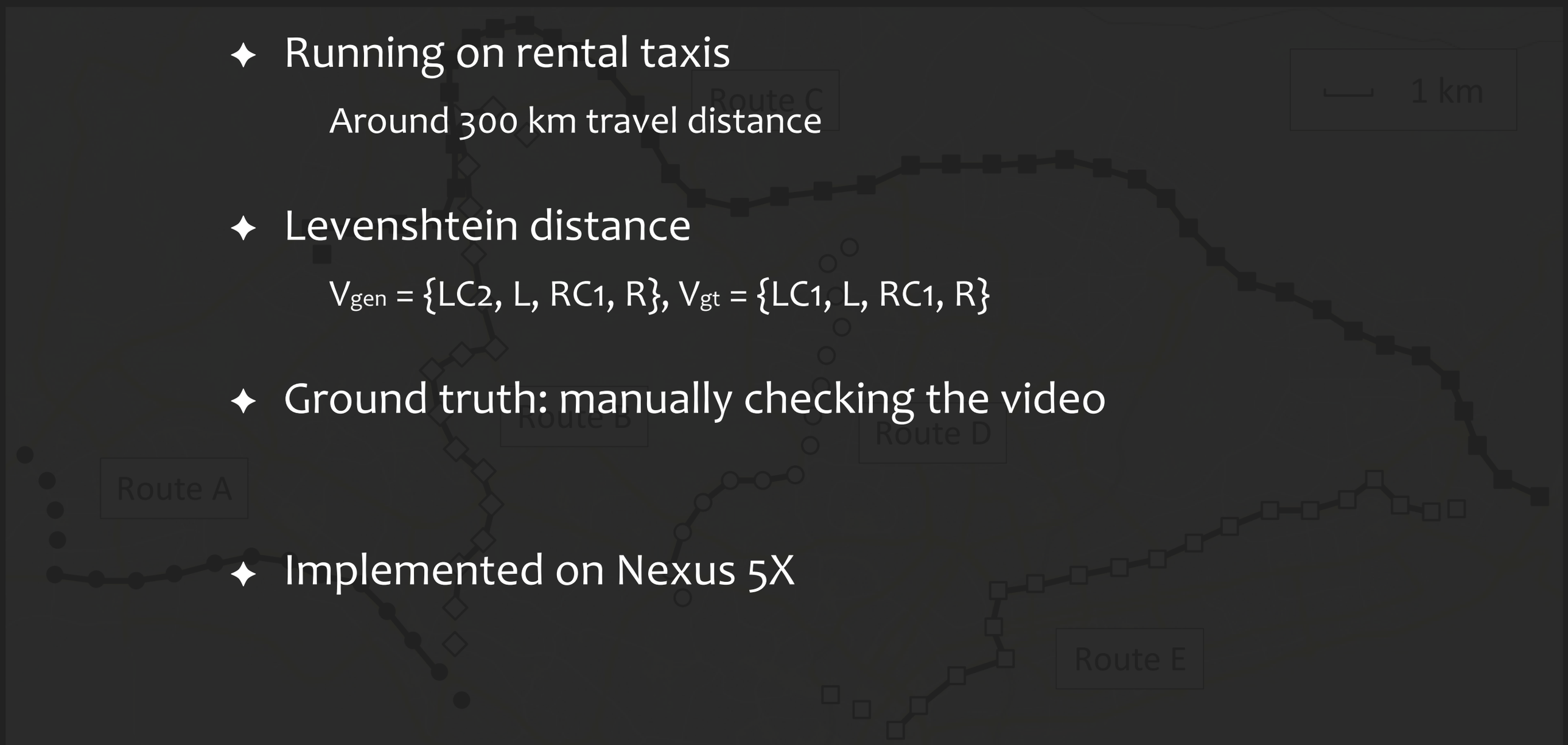
- **Evaluation**



AR-based Navigation Service

❖ Evaluation

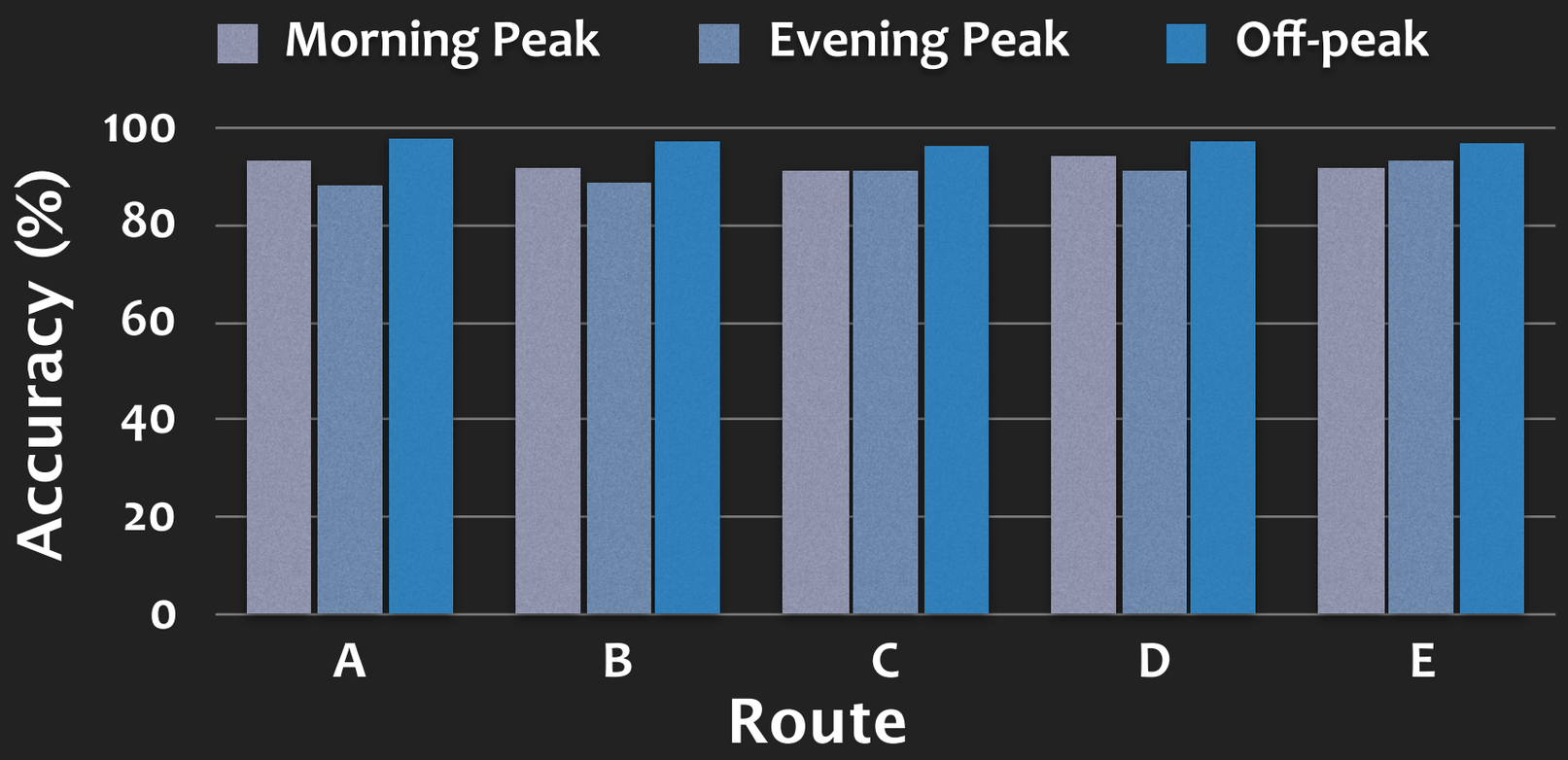
- ✦ Running on rental taxis
  - Around 300 km travel distance
- ✦ Levenshtein distance
  - V_{gen} = {LC2, L, RC1, R}, V_{gt} = {LC1, L, RC1, R}
- ✦ Ground truth: manually checking the video
- ✦ Implemented on Nexus 5X



AR-based Navigation Service

❖ Evaluation

$$acc = \frac{Levenshtein}{|V_{gt}|}$$



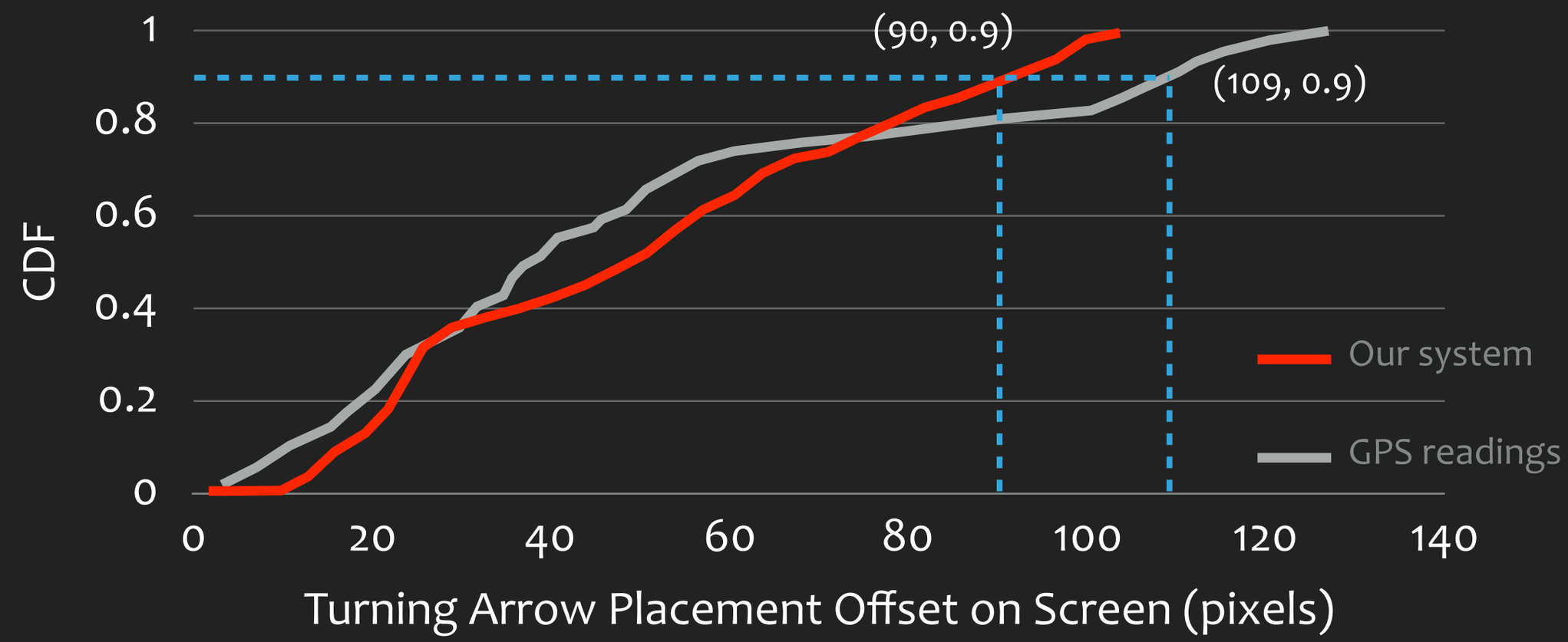
# of instructions	43	74	101	67	86

AR-based Navigation Service

- **Evaluation**

AR-based Navigation Service

- **Evaluation**



- Around 27m error (52m)
- 105 pixels offset on screen (127 pixels)

NANYANG TECHNOLOGICAL UNIVERSITY
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香港城市大學
City University of Hong Kong

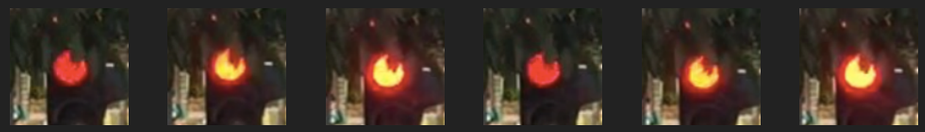
Q & A

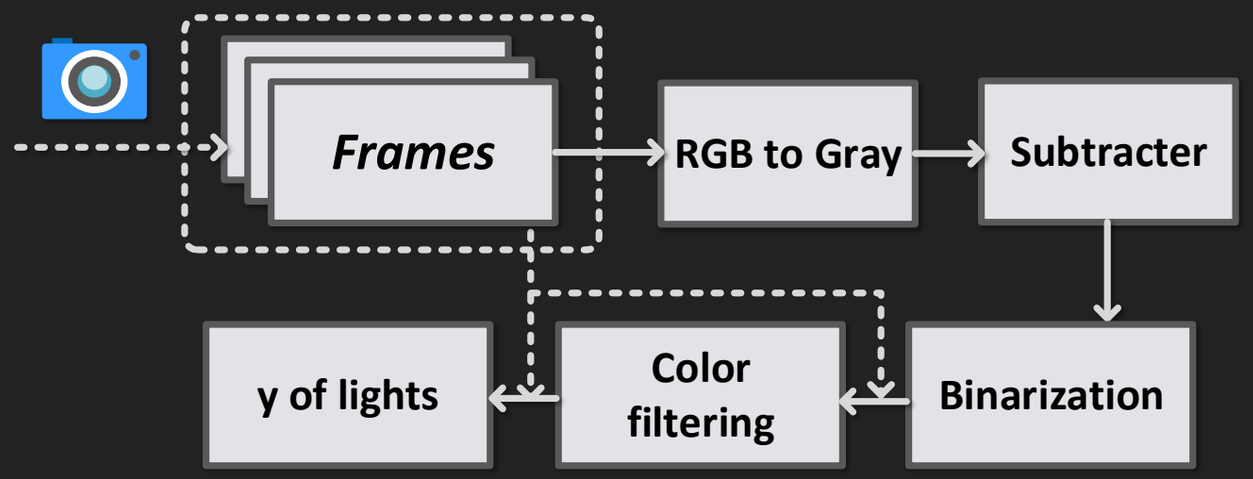
Thank you very much.

Backup slides.

AR-based Navigation Service

- System architecture — intersection inference

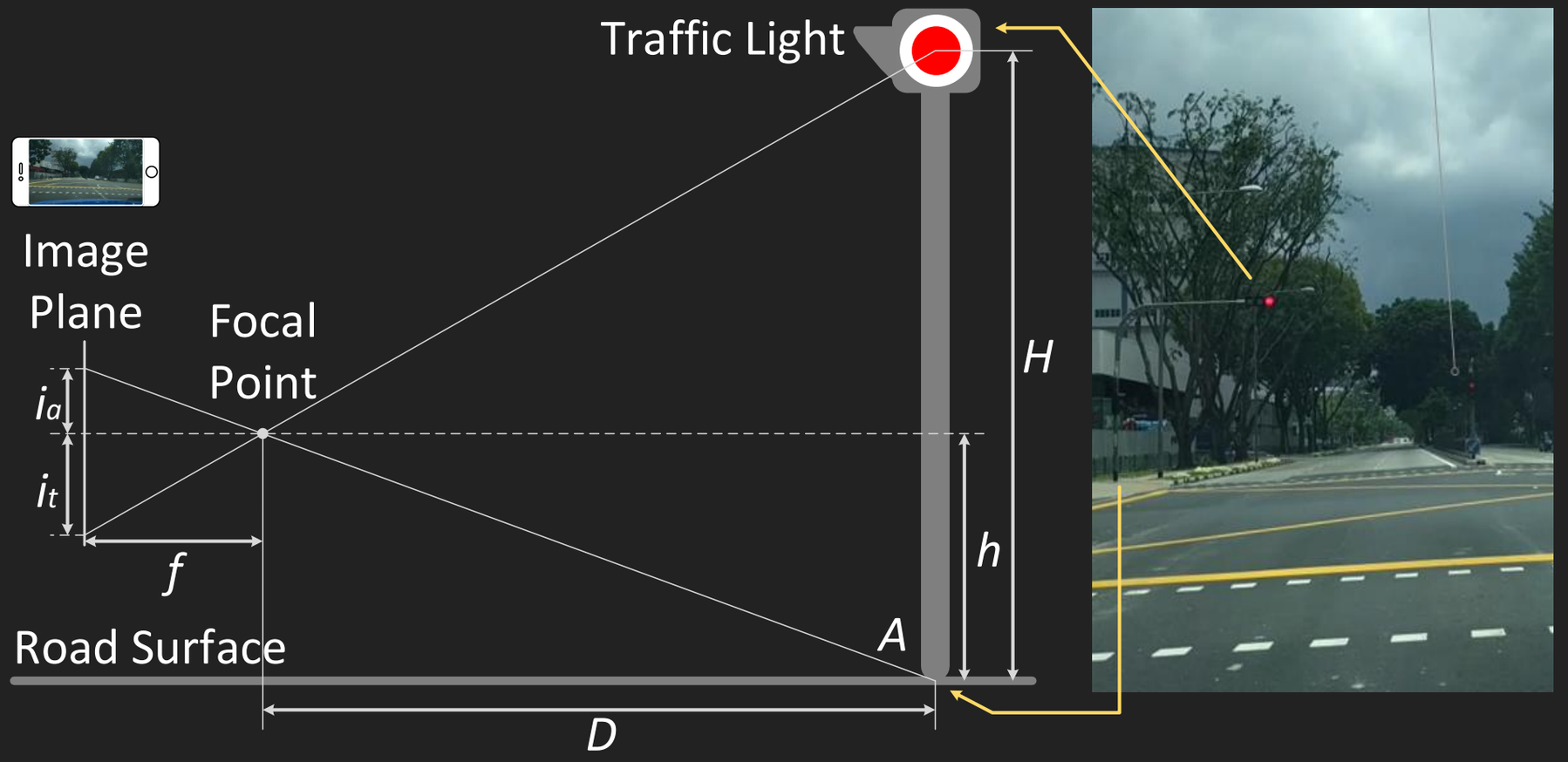




1. Flickering feature of LED bulbs
2. Rolling shutter effect on CMOS

AR-based Navigation Service

- **System architecture — intersection inference**

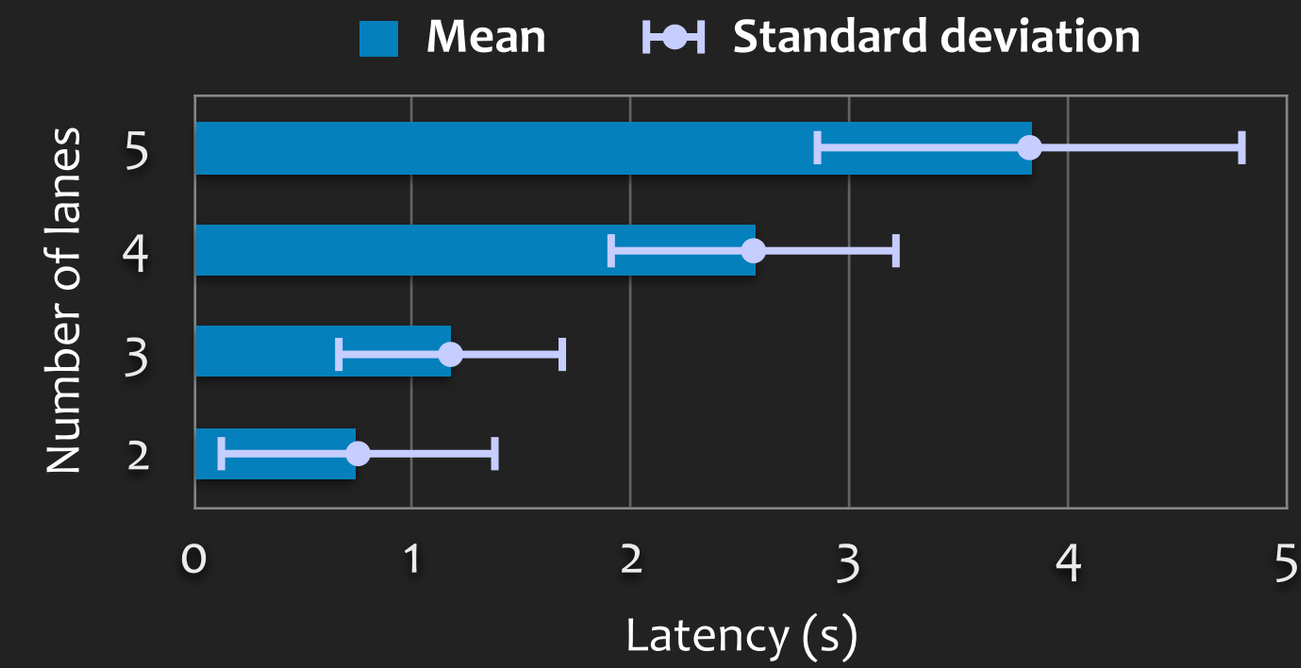


$$i_a = \frac{h}{h - H} i_t$$

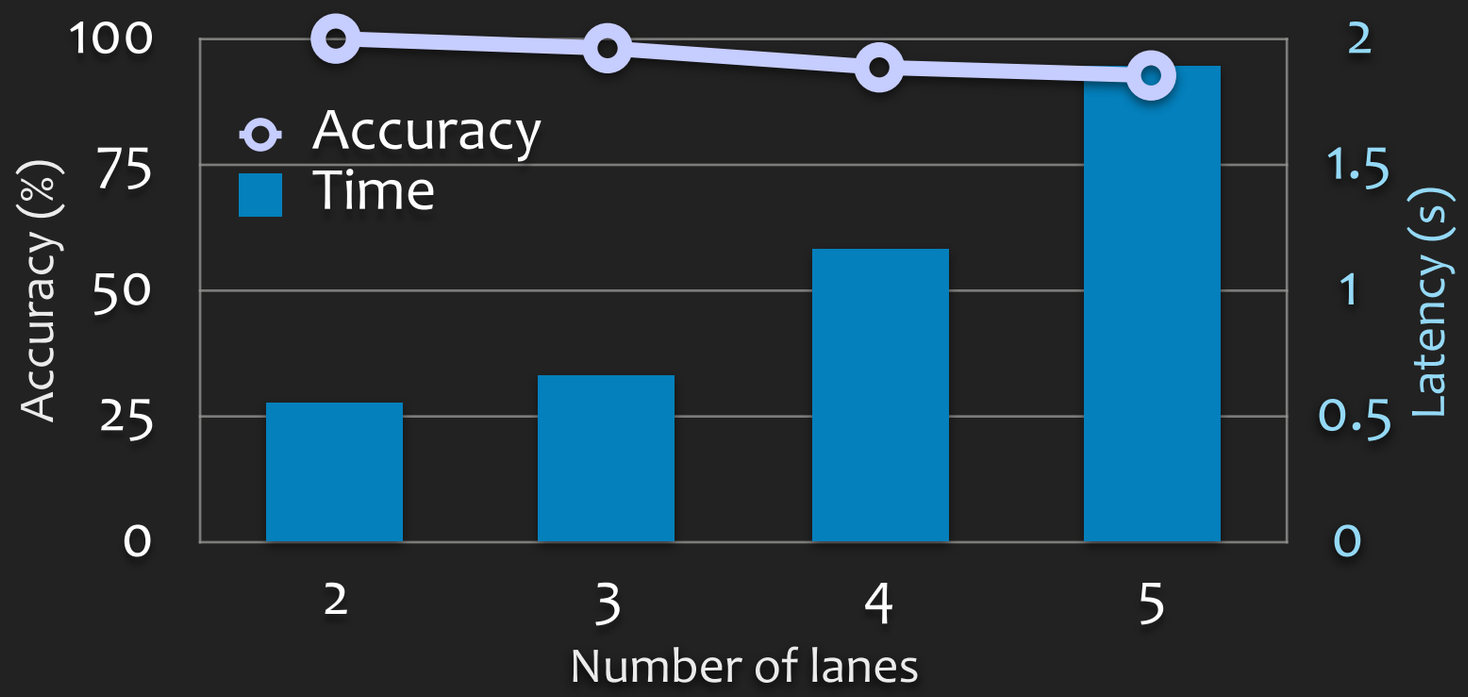
The position of traffic light on the screen is known.

AR-based Navigation Service

❖ Evaluation



- Until converging
- Accurately identifying in 5s



- Force output in 2s
- More observations -> better performance

AR-based Navigation Service

❖ Evaluation

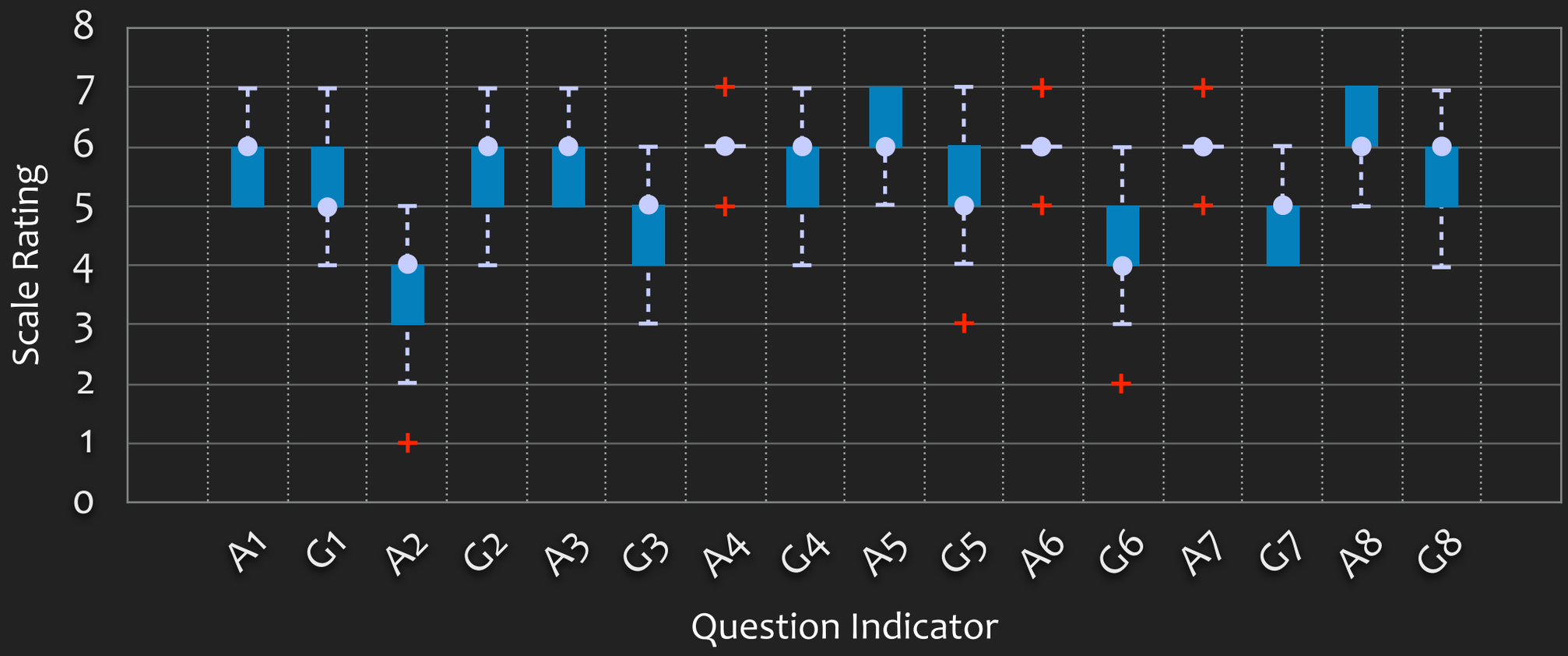
No.	Rating Question Statement
Q1	It was easy to navigate using this navigation service.
Q2	I need to pay extra attention on this navigation service when driving.
Q3	This navigation service provided user-friendly guidance .
Q4	This navigation service was useful in helping me navigate properly.
Q5	It was easy for me to learn how to use this navigation service.
Q6	I paid most of my attention on driving using this navigation service.
Q7	The guidance was user-friendly to interact with.
Q8	This navigation service provided me with effective guidance.

Likert scale rating questions

- ✦ Ease of use (Q1 & Q5)
- ✦ Perceived distraction (Q2 & Q6)
- ✦ Navigational experience (Q4 & Q8)
- ✦ User-friendliness (Q3 & Q7)

AR-based Navigation Service

❖ Evaluation



No.	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
p-value	0.0016	<0.0001	<0.0001	0.0003	<0.0001	<0.0001	<0.0001	<0.0001

- With-in subject user study
- Wilcoxon Signed Rank Tests

- Easier to use
- Less distracted
- More user-friendly

AR-based Navigation Service

- **Evaluation — details of routes**

Route	A	B	C	D	E
Length (km)	12.7	17.4	36.8	12.5	16.8
Length of Expressway (km)	8.73	15.35	36	4.46	14.28
Length of Highway (km)	3.97	2.05	0.8	8.04	2.52
Number of Traffic Lights	15	19	5	18	17
Average Velocity (km/h)	49.7	51.2	56.1	45.4	53.7

AR-based Navigation Service

- **Evaluation — details of drivers**

Property	Description of Group A	Description of Group B
Age (year)	32 - 61 (mean: 40.3)	31 - 57 (mean: 42.8)
Driving Experience (year)	2 - 27 (mean: 15.8)	1 - 30 (mean: 17.6)
Gender	21 Male (84%), 4 Female (16%)	19 Male (76%), 6 Female (24%)