



Real-time Dynamic Map Lab.

Enhancing Autonomous Vehicles' Spatial-temporal Situational Awareness with Dynamic Maps

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Outline

1 Background

2 Dynamic Map (DM)

3 Prediction Functionality of DM

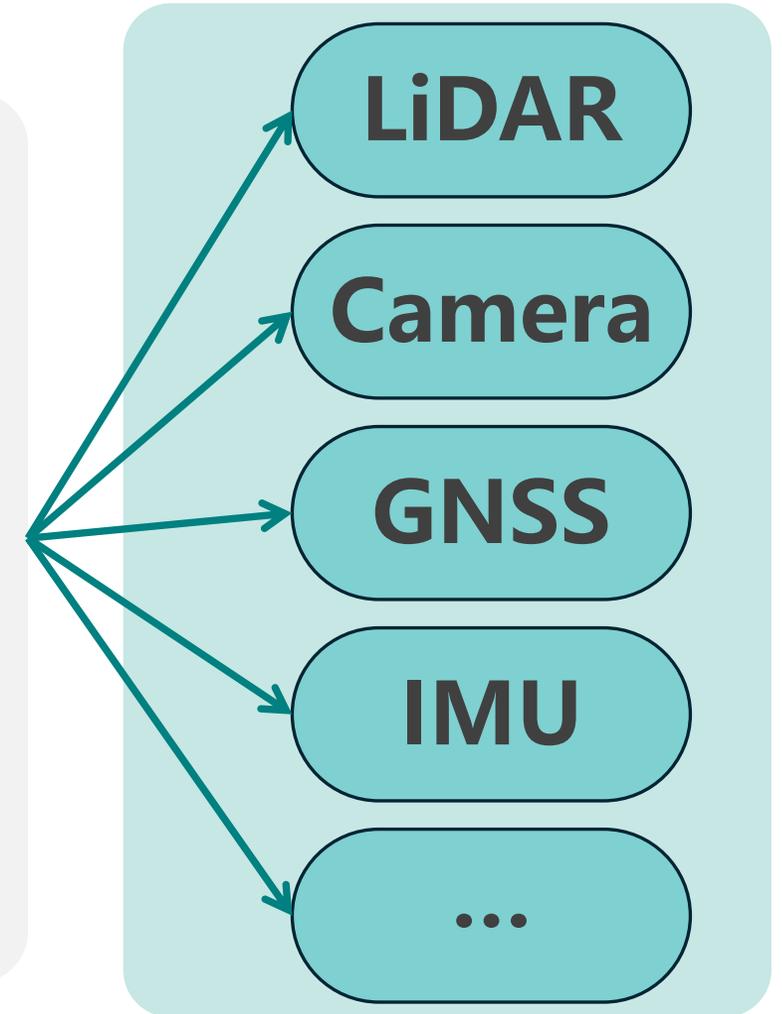
4 VRC Integration with DM

5 Spatial-temporal Enhancements via DM



Background

- Autonomous vehicles (AVs) utilize multiple sensors to perceive the physical world.





Background

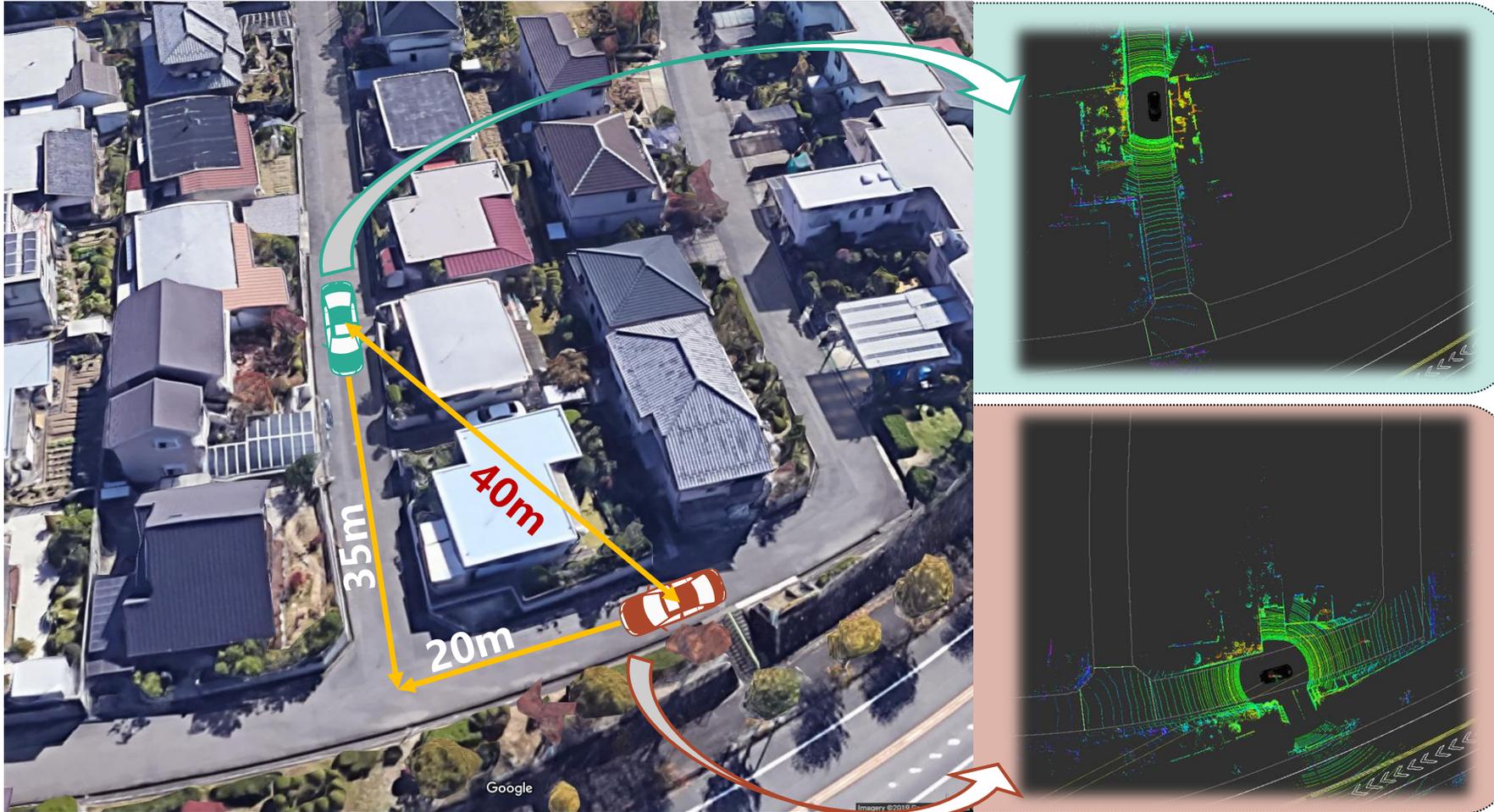
- Sensor's perception range is bounded.

Sensor	Range	FoV	Precision
 LiDAR	100-400m	H: 120-360deg V: 10-40deg	2cm
 Radar	20-250m	H: \pm 30-60deg	0.1-0.5m
 GNSS	--	--	0.1-10m
 Camera	20-200m	H: 60-120deg	sub-meter



Background

- Physical obstacles are unavoidable.



**Blind spots
are widely
distributed.**

**A single AV
cannot
perceive its
surroundings
completely.**





Background

- V2X communications are employed to exchange perception data among vehicles, a technology known as cooperative perception.

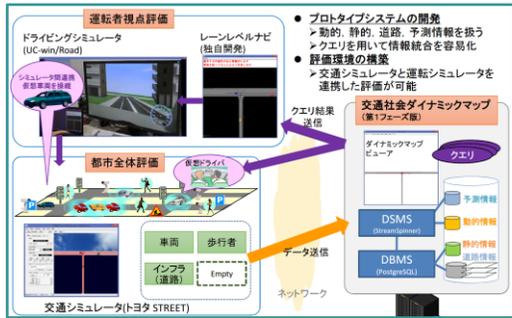
The image is a composite of three parts:

- Architecture Diagram (Left):** Shows a 'Dedicated Server' containing a 'Collision Risk Assessor', 'Bounding Box Generator', 'CRA Server', and 'Trajectory Predictor', all connected to a 'Communication System'. This server communicates with two vehicles, 'Vehicle 1' and 'Vehicle 2', which each have their own 'Communication System', 'CRA Client', 'Autaware' (with LiDAR, IMU, GPS), and 'State Estimator'. The entire system runs on the 'DynamicMap2.0 Platform'.
- Cloud Server Terminal (Top Right):** Displays two terminal windows. The left one is titled 'Cloud server: our CRA service' and the right one is 'Cloud server: the referred CRA service'. Both show a stream of 'receive vehicle: v1's request' and 'receive vehicle: v2's request' messages with associated timestamps.
- Vehicle Dashboards (Bottom Right):** Two side-by-side dashboards showing real-time perception data. The left dashboard is for 'vehicle1 on major roadway' and the right is for 'vehicle2 on minor roadway'. Both show various estimates (Velocity, Heading, Angular velocity, Acceleration) and a large '0.00' for 'Our method' and 'Referred method'. A 'distance between vehicles' of 58.01 is shown at the bottom.

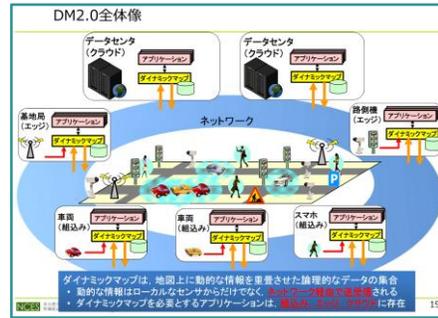


Background

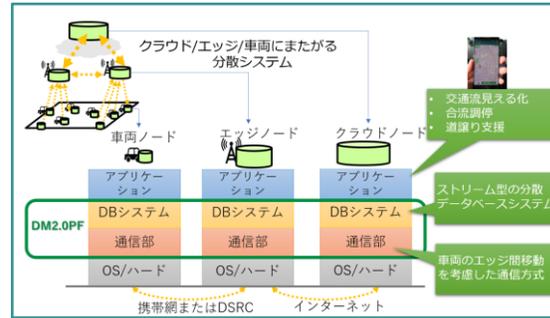
- Dynamic map (DM) is a logical dataset that enables the overlay of multisource sensor data onto an HD map, and was first proposed by Hiroaki Takada and Kenya Sato in Japan.



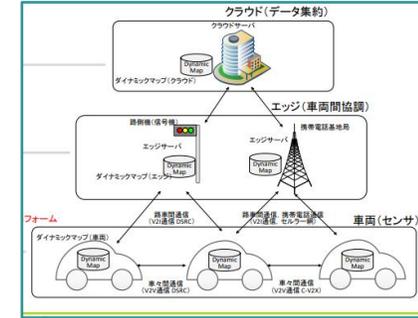
COI-TIG
(2014-2016)



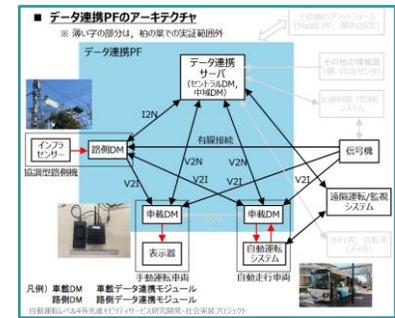
DM 2.0
(2016-2020)



DDM 2.0
(2020-2023)



AdMobi-DM 2.0
(2023-2025)



Cool4
(2022-2025)

The Dynamic Map R&D has consisted of a series of research projects

Prediction functionality of DM

- Why DM needs to predict?



**V2X communications
introduce latency inevitably.**

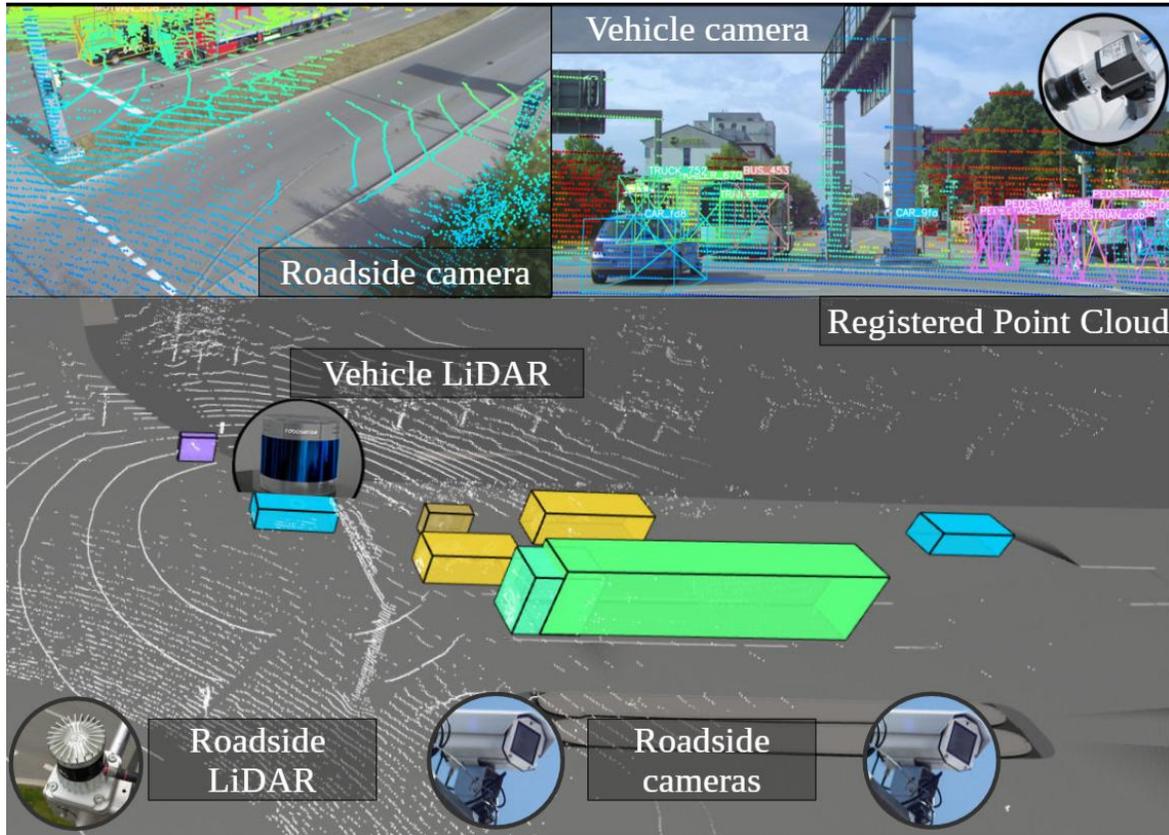


**Prediction data can be used
to compensate for the
delay.**



Prediction functionality of DM

- Why DM needs to predict?



Cooperative perception only extends an AV's spatial situational awareness at the current moment.

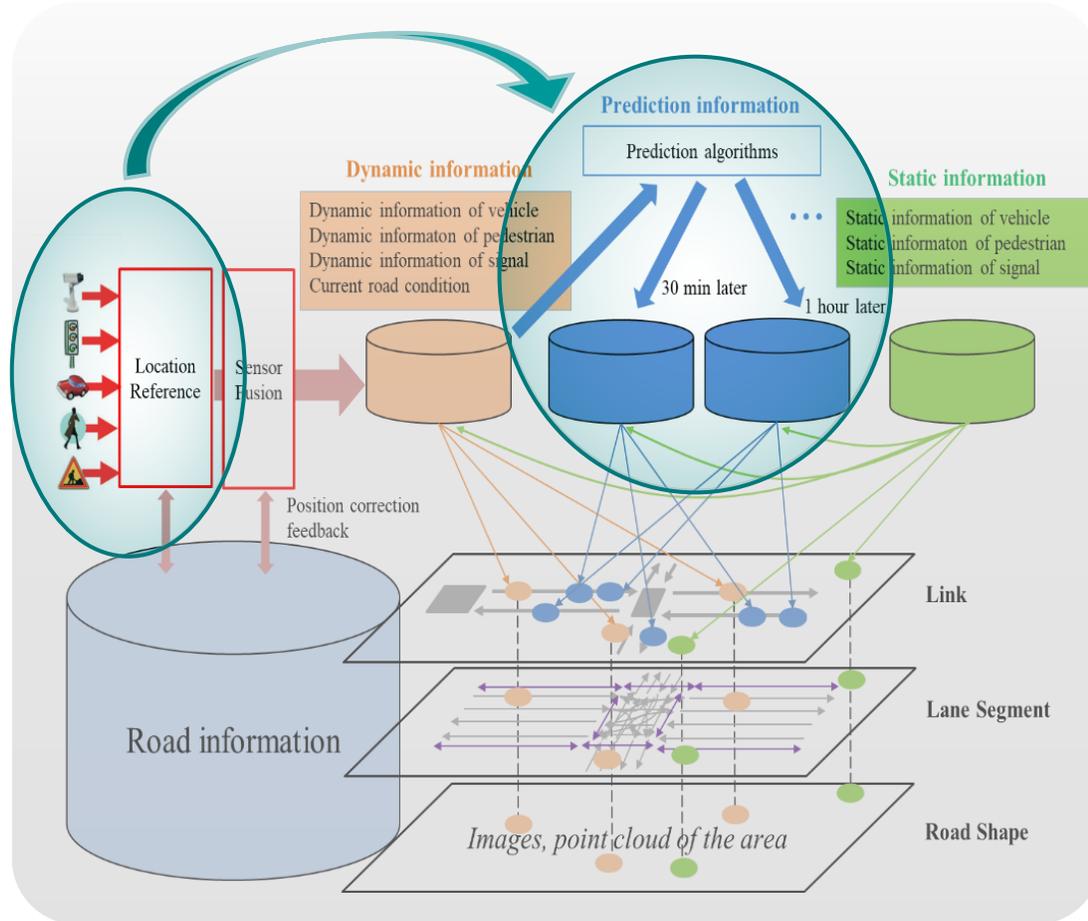


Prediction data can be used to enhance the AV's temporal situational awareness over a future time horizon.



Prediction functionality of DM

- Why DM needs to predict?

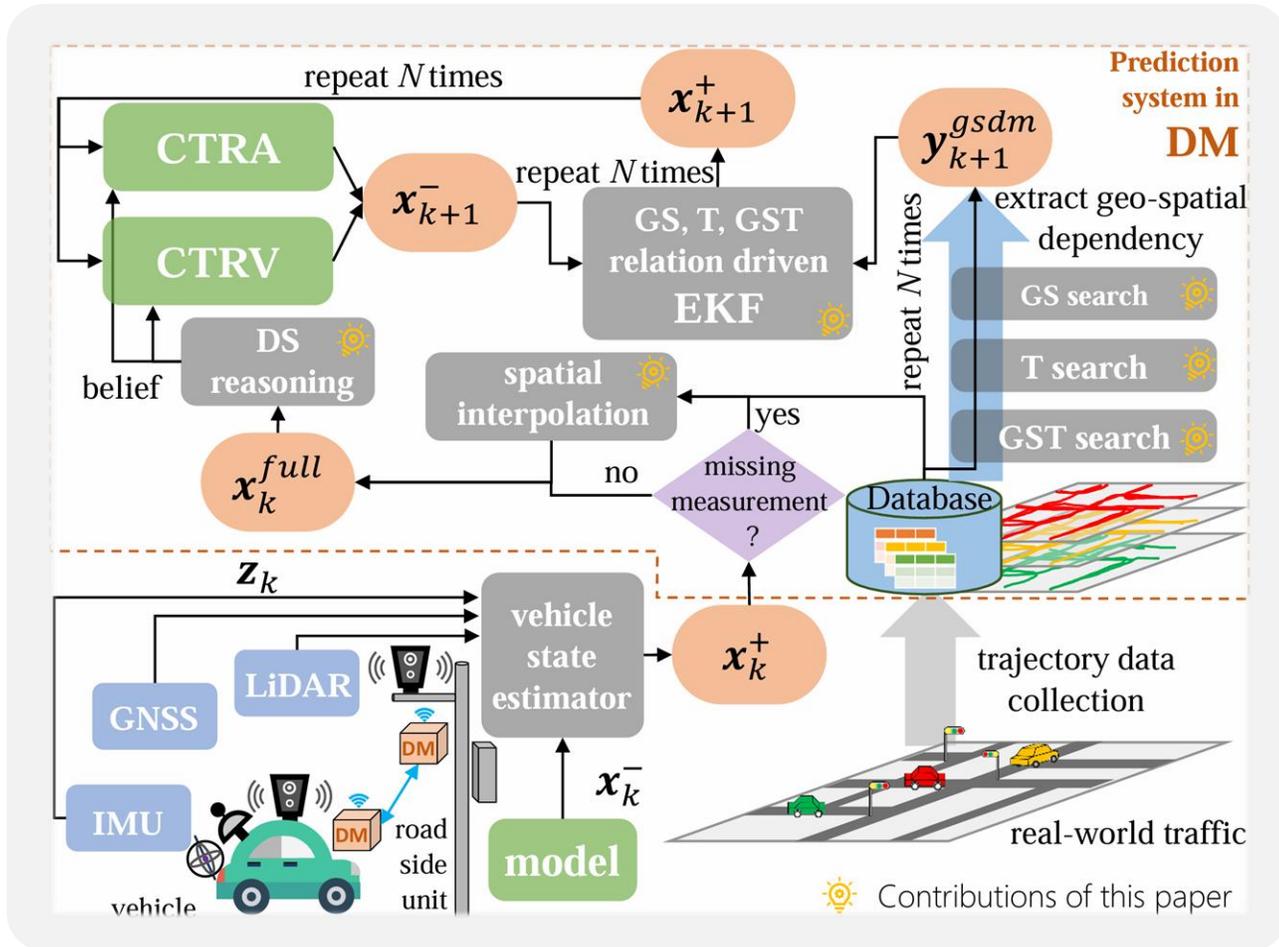


Prediction information is a core data type in DM.

It must be generated internally from DM, independent of outside inputs.

Prediction functionality of DM

- Geo-spatial and temporal relation driven vehicle motion prediction



Prediction Function of DM

GST method

GS method

T method



Spatial-temporal Enhancements via DM

- Over-the-horizon and beyond-the-time-horizon situational awareness

Cloud

vehicle

```

dm2@ubuntu: ~
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,-9728.440325,-9728.340172,-9728.245718,-9728.152475,-9728.057546,-9727.959227,-9727.857640,-9727.
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76.332663,-78977.363756,-78978.415193,-78979.473271,-78980.493876,-78981.553324,-78982.577852,-78
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```

Clip 3

Cloud

image: Google





The end

Thanks for your attention.



*Real-time Dynamic Map
Laboratory*