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AI-Enhanced Low-Cost Mobile Mapping for Digital Earth: Integrating LiDAR and Vision-Based Depth Estimation

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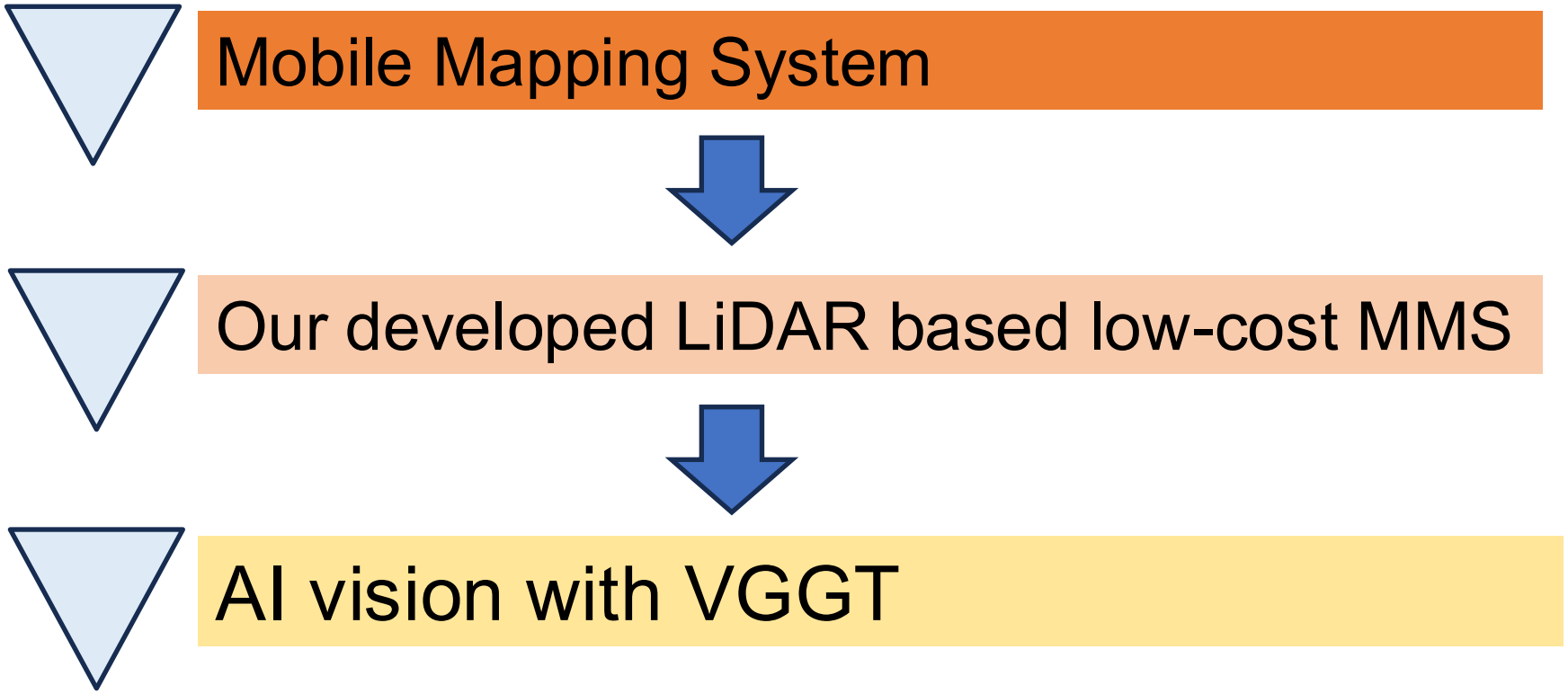
Talk Overview



Reality Capture: Connecting the Physical and Digital Worlds

From physical environments to intelligent 3D representations

AI / SLAM

REALITY CAPTURE

Accurate • Scalable • Up-to-date

Infrastructure

Digital Twins

Smart Cities

Environmental Monitoring

Source: Geo Week News, "The Growth and Future Challenges of Reality Capture" (Qiu et al., 2022)

Source:Chatgpt

Mobile mapping system (MMS)

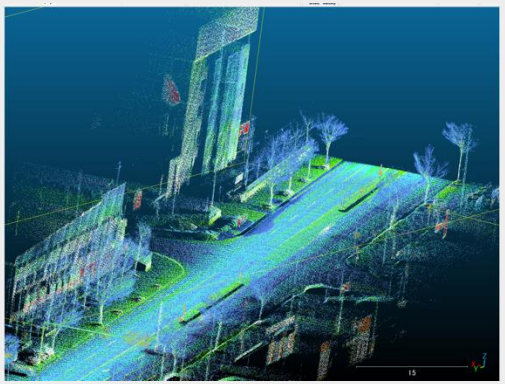
MMS is the abbreviation of Mobile Mapping System.

Mobile Mapping System collects georeferenced spatial data while the platform is moving.

Vehicle

Mapping System

3D map



Mobile Mapping Workflow

From multi-sensor measurements to georeferenced 3D data

1. Data Acquisition

Collect data while moving

LiDAR
Livox Mid-360
3D geometry

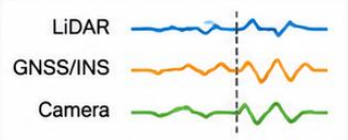
GNSS / INS
Bynav X1-5H
Position & orientation

Camera
Dashcam
RGB imagery

2. Synchronization & Calibration

Align multi-sensor data

Time synchronization



Sensor calibration

Estimate relative position and orientation between sensors

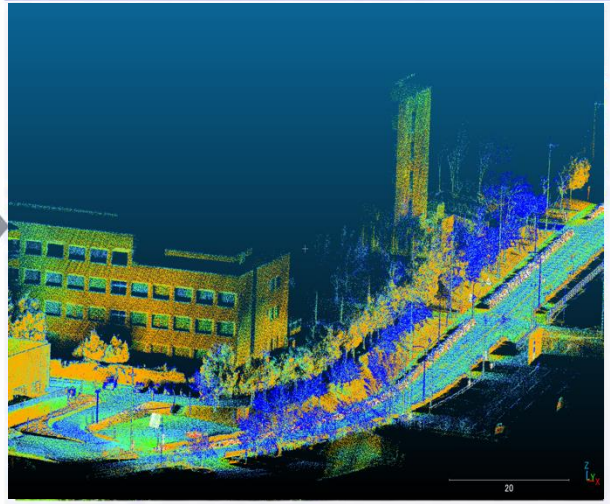
3. Vehicle Trajectory

Estimate position and attitude

Position + Orientation along the route

4. Georeferenced 3D Point Cloud

Integrate LiDAR with trajectory



3D point cloud (Toyama Prefectural University campus)

3D Geometry LiDAR
Shape of the environment

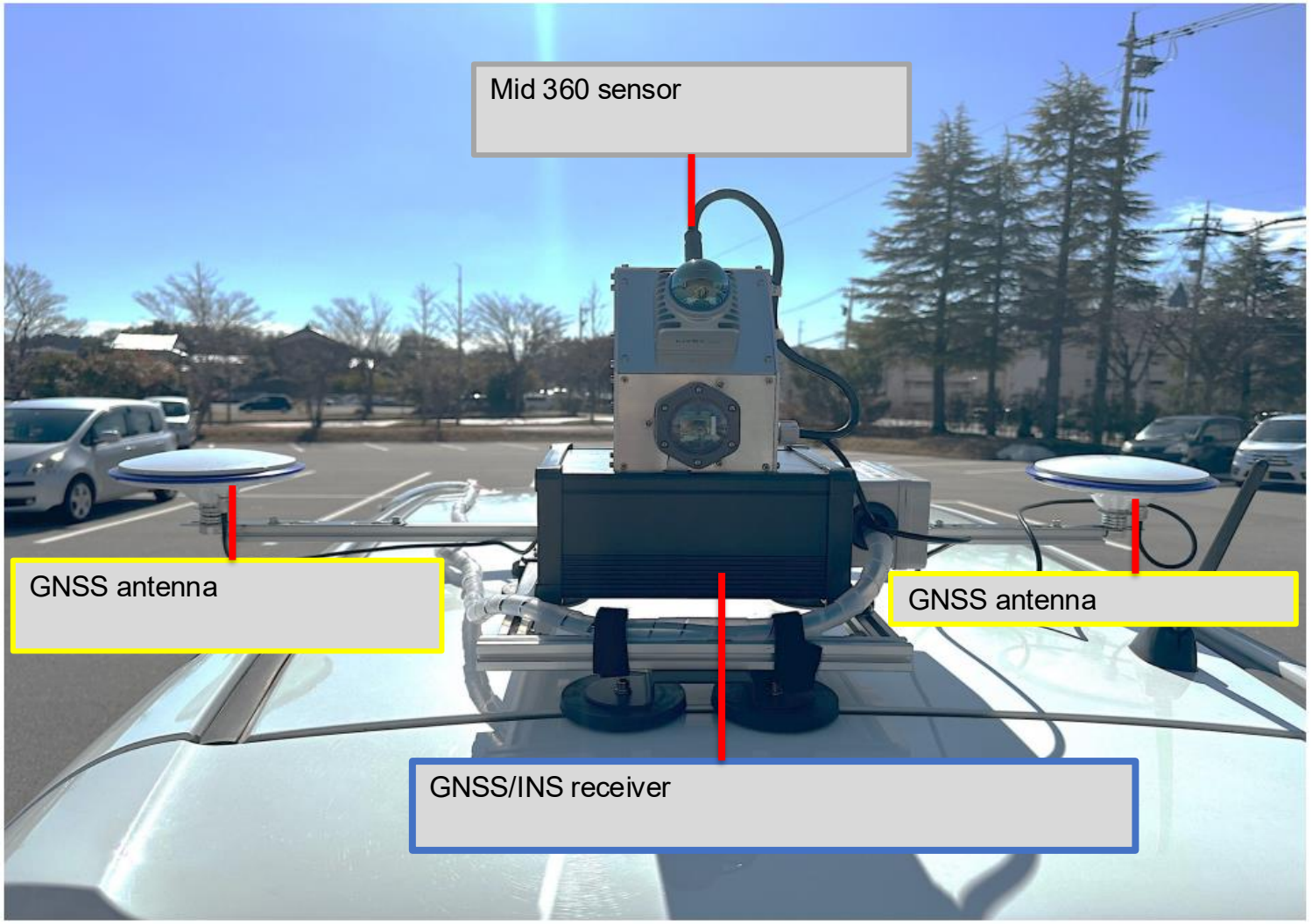
+

Position & Orientation (GNSS/INS)
Where was the vehicle?

→

Georeferenced 3D Map
3D information in a global coordinate system

Our Developed low-cost MMS



Commercial: Mobile Mapping System at ¥50-70 million
Our developed MMS: <¥1 million

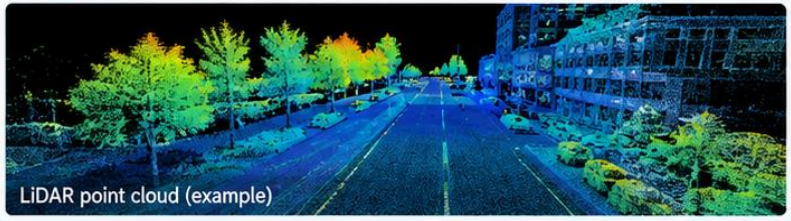
Why Combine LiDAR and AI Vision?

Complementary strengths for more accessible and scalable mobile mapping.

LiDAR
Direct and accurate 3D measurement


Livox Mid-360

- **Direct** range measurement
- **Metric 3D geometry** (high accuracy)
- Dense and reliable point clouds
- Works in **various lighting conditions**
- Specialized and relatively expensive sensor


LiDAR point cloud (example)

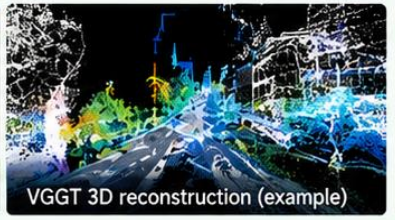
Complementary strengths

AI Vision / VGGT
3D geometry from ordinary images


Dashcam (RGB)

- Geometry from **RGB images**
- **Rich visual and semantic** information
- **Low-cost** and widely available cameras
- Recovers **3D structure** (depth, point maps, tracks)
- Sensitive to lighting and texture, typically **sparser** than LiDAR


Input image (dashcam)


VGGT 3D reconstruction (example)

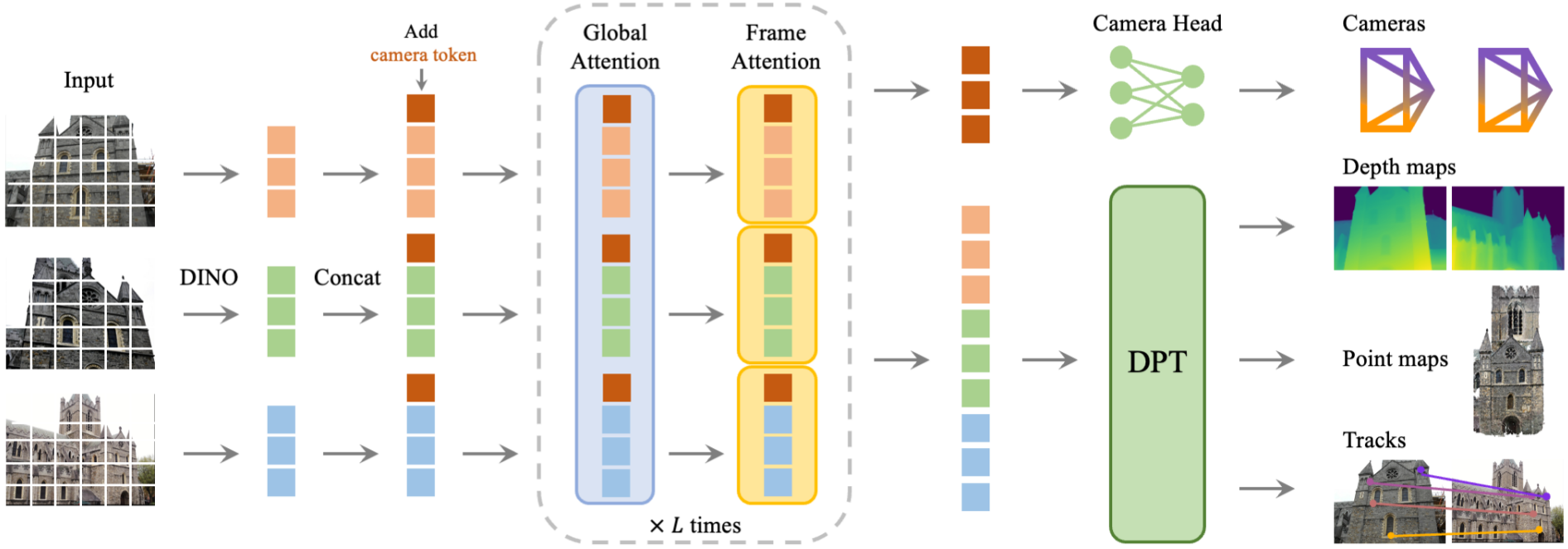
- ✓ Accurate geometry
- ✓ Stable and reliable
- ✓ Ideal for metric mapping

LiDAR + AI Vision
More accessible and scalable 3D mapping

- ✓ Rich visual information
- ✓ Low-cost and scalable
- ✓ Complementary to LiDAR

Toward a more complete, cost-effective, and scalable reality capture for Digital Earth.

Visual Geometry Grounded Transformer (VGGT)

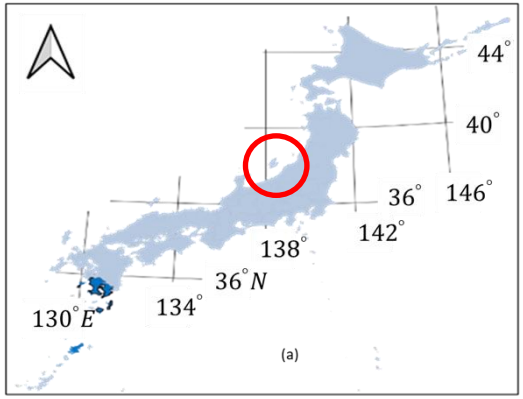


Source: Wang et al., “VGGT: Visual Geometry Grounded Transformer,” CVPR 2025

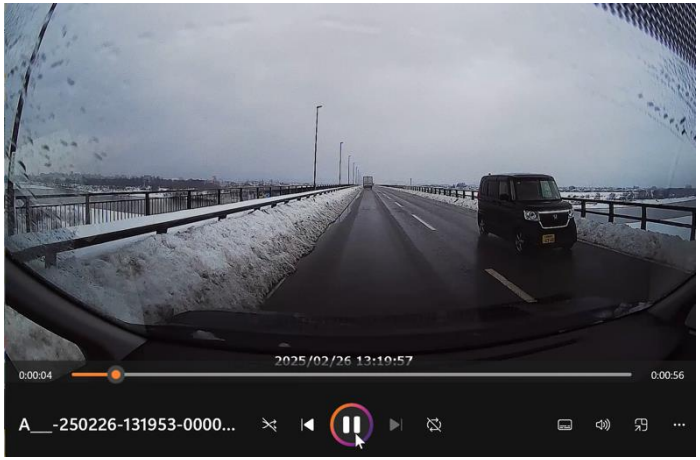
A single feed-forward model transforms multi-view images into multiple forms of 3D scene information.

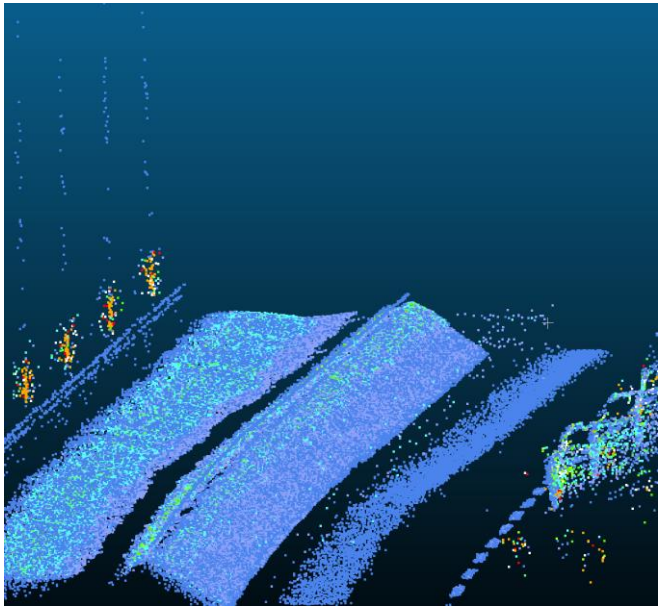
Experimental Setup

- **Dashcam data**
- **Reference data LiDAR MMS data**



Study area:
Nagaoka, Niigata, Japan





Experiment done: 2025/02/26

From RGB Images to VGGT 3D Reconstruction

RGB→ VGGT→ 3D

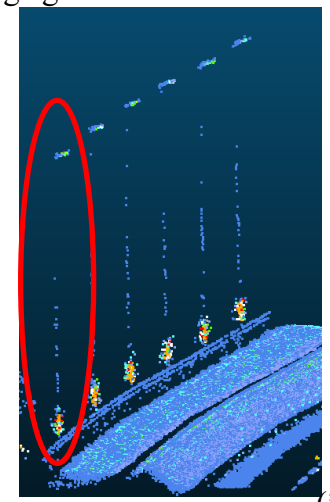
(*1) reference LiDAR data

(*2)Result of VGGT model generated point cloud data

LiDAR vs. VGGT

Resolution of image: 1920x1080
Bit Depth:24

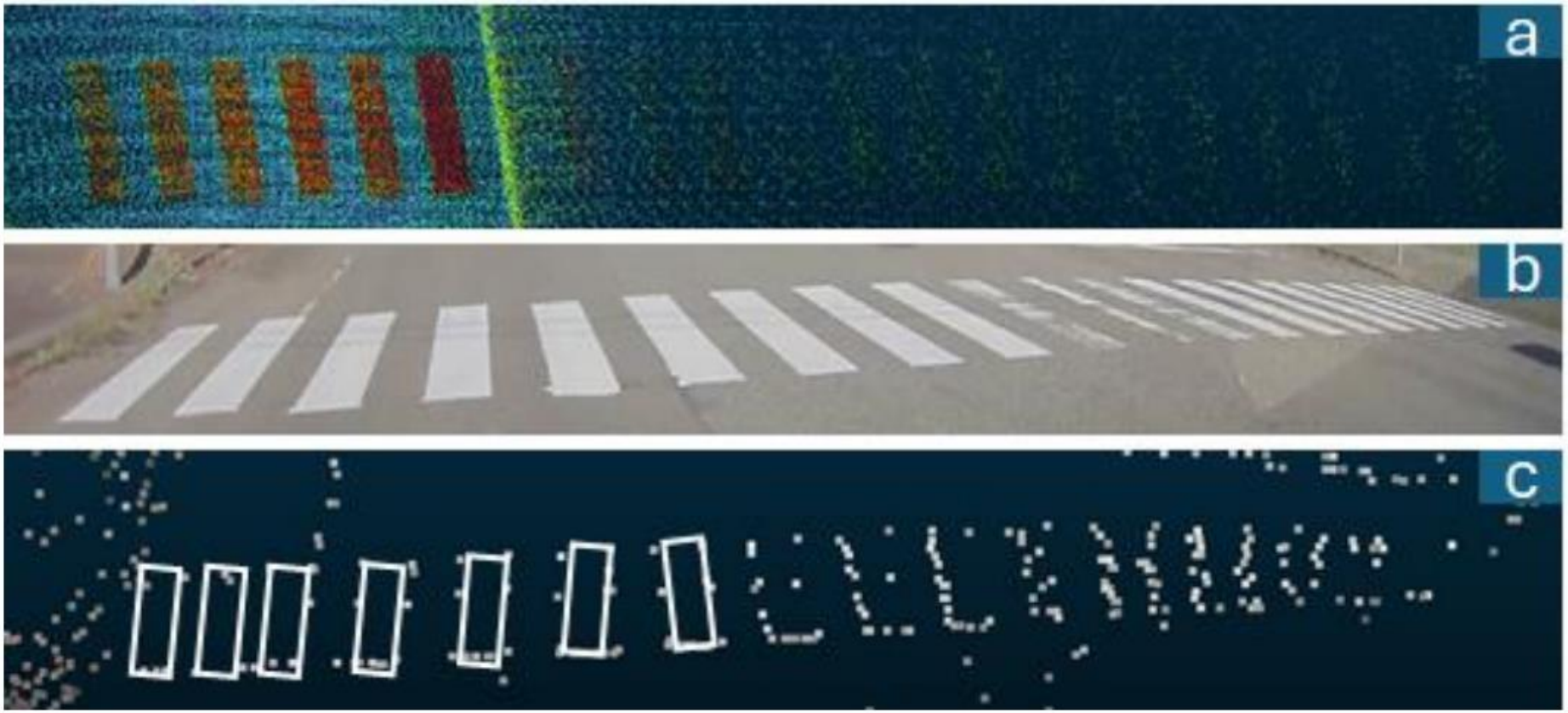
(*1) Image generated from dashcam video



(*3) reference LiDAR data

(*2)Result of VGGT model generated point cloud data

Can VGGT Recover Road Features?



Crosswalk geometry remains recognizable despite sparse reconstruction.

Take-home Messages

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1 Accessible 3D mapping

low-cost MMS lowers the barrier to 3D data acquisition.

2 AI-Derived Geometry

VGGT reconstructs meaningful road geometry from ordinary RGB images

3 Complementary Sensing

LiDAR and AI vision provide complementary information for scalable Digital Earth applications.

Thank you!

Questions and Discussion

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