NAGOYA UNIVERSITY

Research experiences

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Biography

NAGOYA UNIVERSITY

Quang Nhat Nguyen

- Date of birth: 27 November 1999 (23)
- Department of Electrical Engineering
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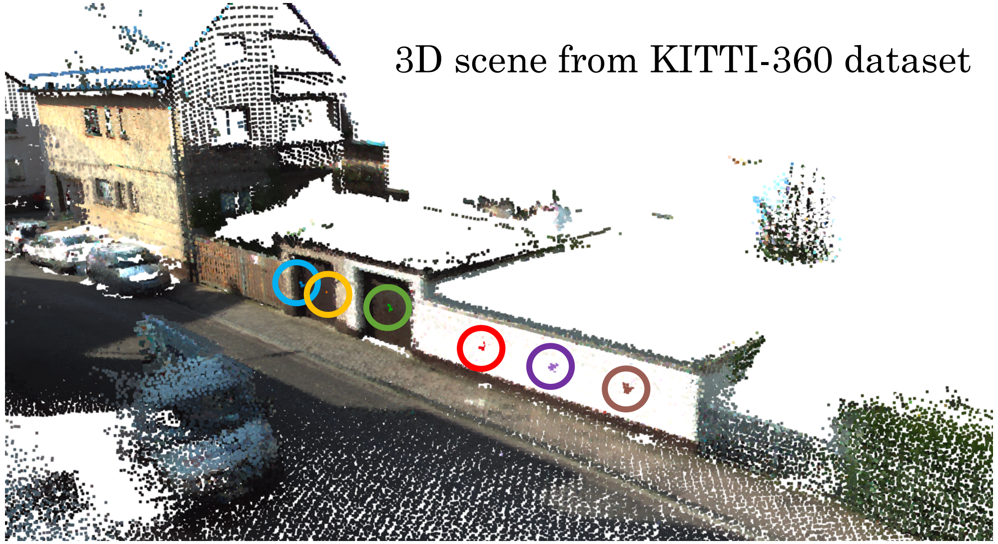
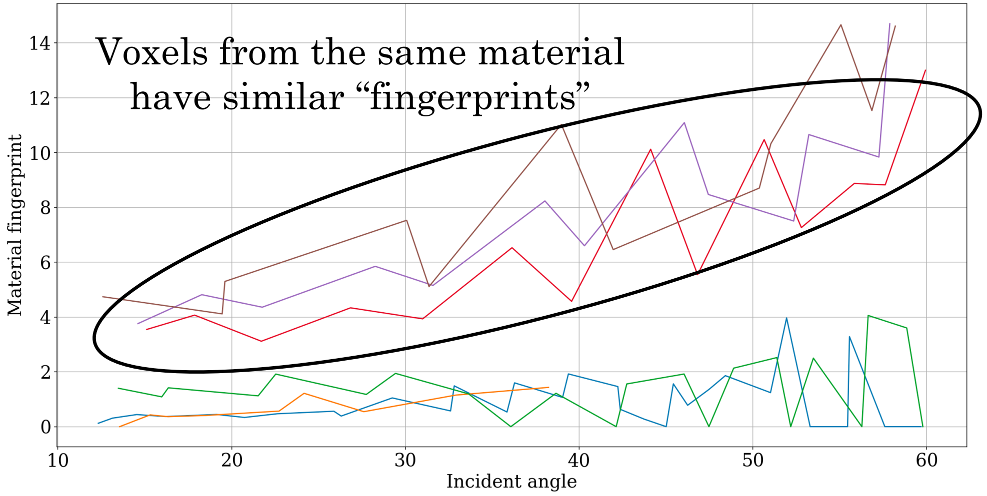
Research experiences

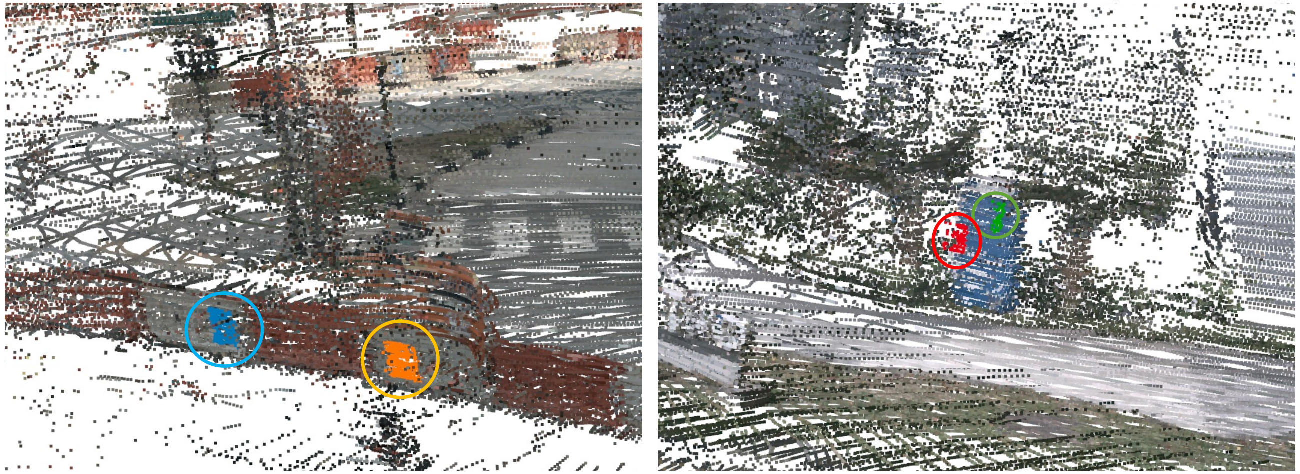
- 10.2018 – 3.2020: **Graduate School of Mathematics**, Nagoya University
  Research on spectral theory and functional analysis. Journal article published in *Adv. Oper. Theory* (2020).
- 4.2020 – 9.2021: **Takeda Lab**, Dept. of Intelligent Systems, Nagoya University
  Research on Physics-based LiDAR waveform simulation. First-author paper published in *FAST-zero* (2021).
- 10.2021 – Present: **Takeda Lab**, Dept. of Intelligent Systems, Nagoya University
  Research on material classification from multispectral and multimodal perception data.
- 11.2021 – 3.2022: **JARI** (Japan Automobile Research Institute)
  Research on Unreal Engine's LiDAR simulation module based on Physics.
- 4.2022 – Present: **NEDO** (New Energy and Industrial Technology Development Organisation)
  Research on designing, calibrating, and synchronising a multimodal and multispectral data capturing system.
- 9.2022: **RIKEN Centre for Computational Science, Data Assimilation research group**
  Research on the LETKFCC (Local Ensemble Transform Kalman Filter with Cross Correlation).

Material classification using “material fingerprint”

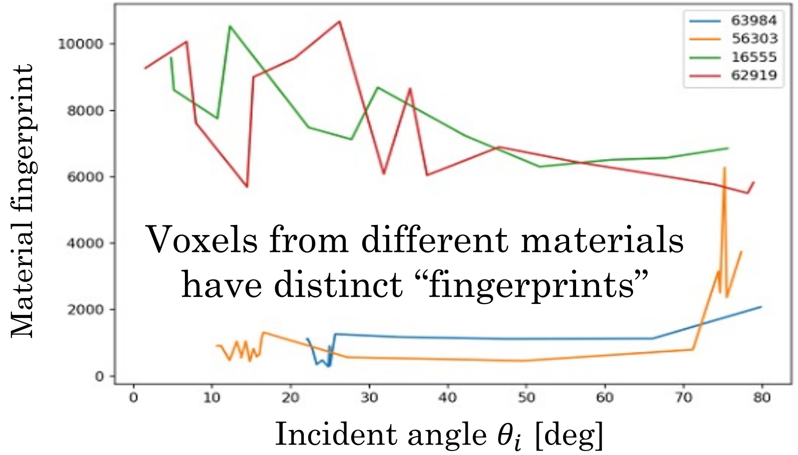


3D scene from KITTI-360 dataset





3D scene from nuScenes dataset



“Material fingerprint” theoretical basis

- **BRDF** (Bi-directional Reflectance Distribution Function) quantifies the **optical scattering characteristic** of each material:

$$f_r(\boldsymbol{\omega_i}, \boldsymbol{\omega_s}) = \frac{dL_s(\boldsymbol{\omega_s})}{dL_i(\boldsymbol{\omega_i})} = \frac{dL_s(\boldsymbol{\omega_s})}{L_i(\boldsymbol{\omega_i}) \cos\theta_i \, d\boldsymbol{\omega_i}}$$

- In case of a LiDAR sensor, the above eq. simplifies to:

$$L_s = \rho_m(\theta_i) \cos\theta_i \, L_i(\boldsymbol{\omega_i})$$

- The backscattering function $\rho_m(\theta_i)$ appears again in the LiDAR’s intensity equation:

$$I_r(m, z, \theta_i) = E_l \frac{c\rho_m(\theta_i) \cos\theta_i \, A_r}{2z^2} \tau_T \tau_R \exp\left(-2 \int_0^z \alpha(z')dz'\right)$$

- In clear weather condition, it simplifies to:

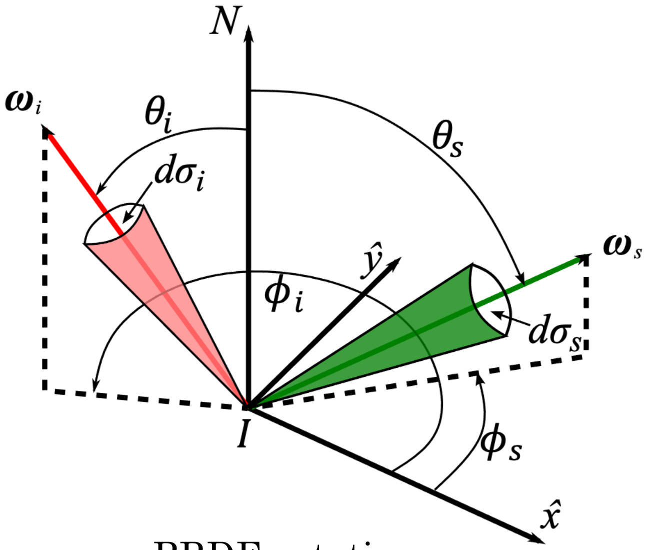
$$I_r(m, z, \theta_i) = C_{const} \times \frac{\rho_m(\theta_i) \cos\theta_i}{z^2}$$

- The dependency on incident angle θ_i characterises the optical property of the material hit by LiDAR’s laser beam. We call it “material fingerprint”:

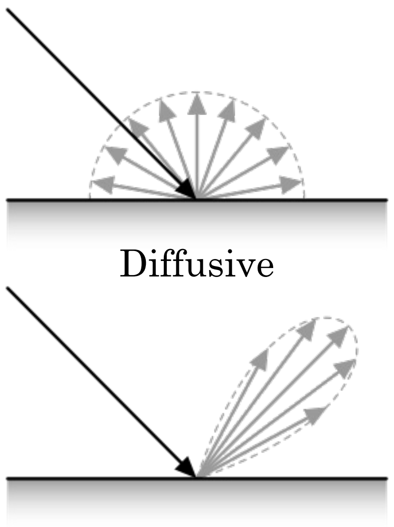
$$\mathcal{F}_m(\theta_i) = C_{const}\rho_m(\theta_i) \cos\theta_i$$

- It is obtained by decoupling LiDAR’s intensity from distance z as:

$$\mathcal{F}_m(\theta_i) = I(m, z, \theta_i) \, z^2$$

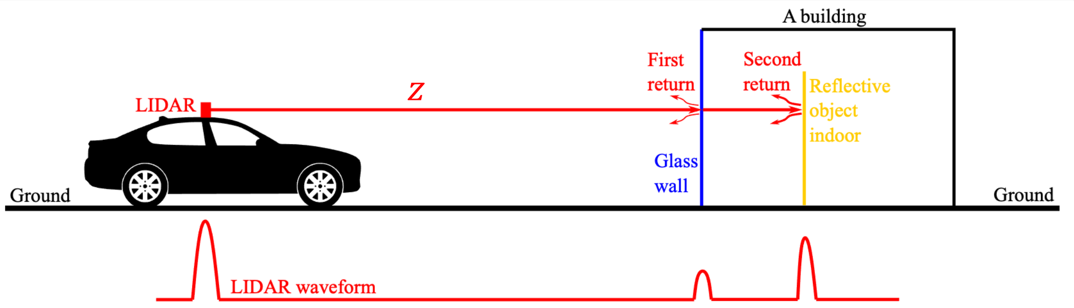


BRDF notations



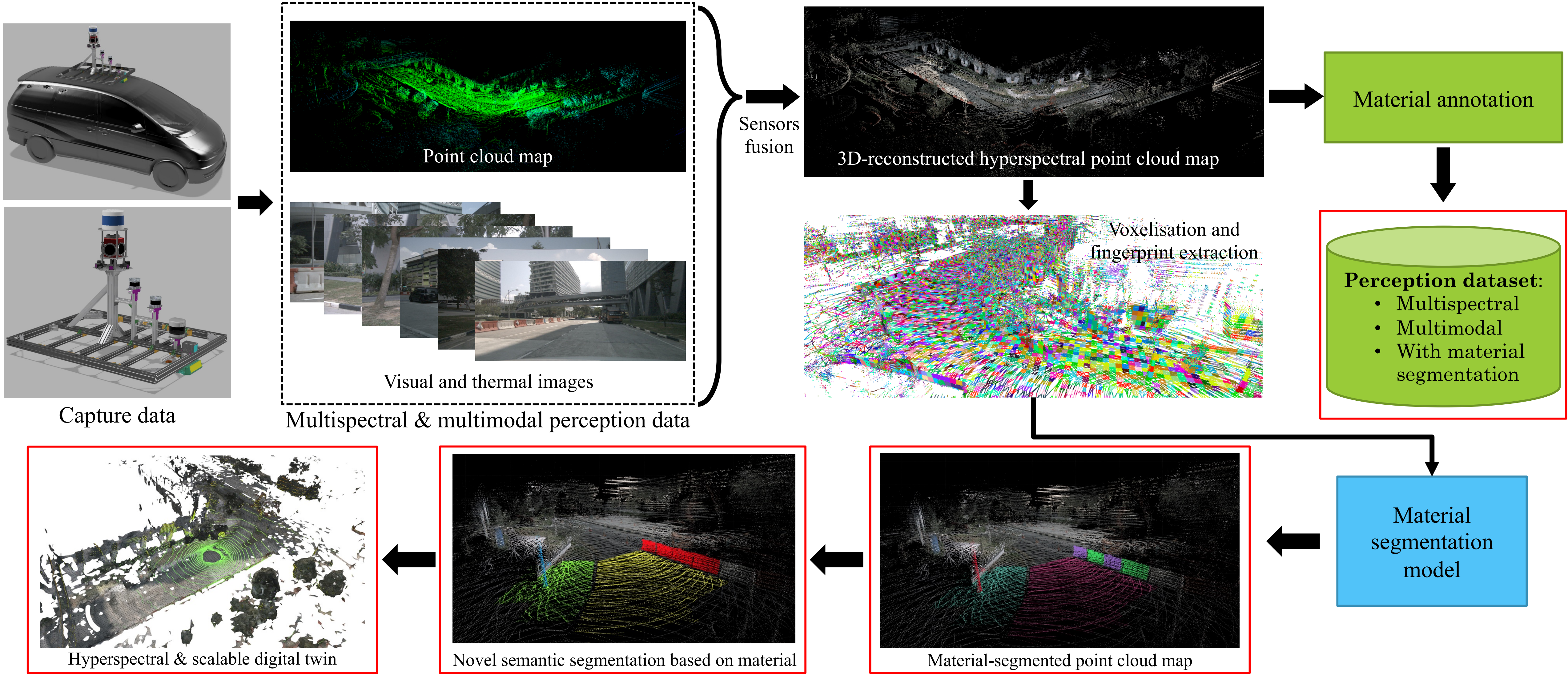
Diffusive

Glossy



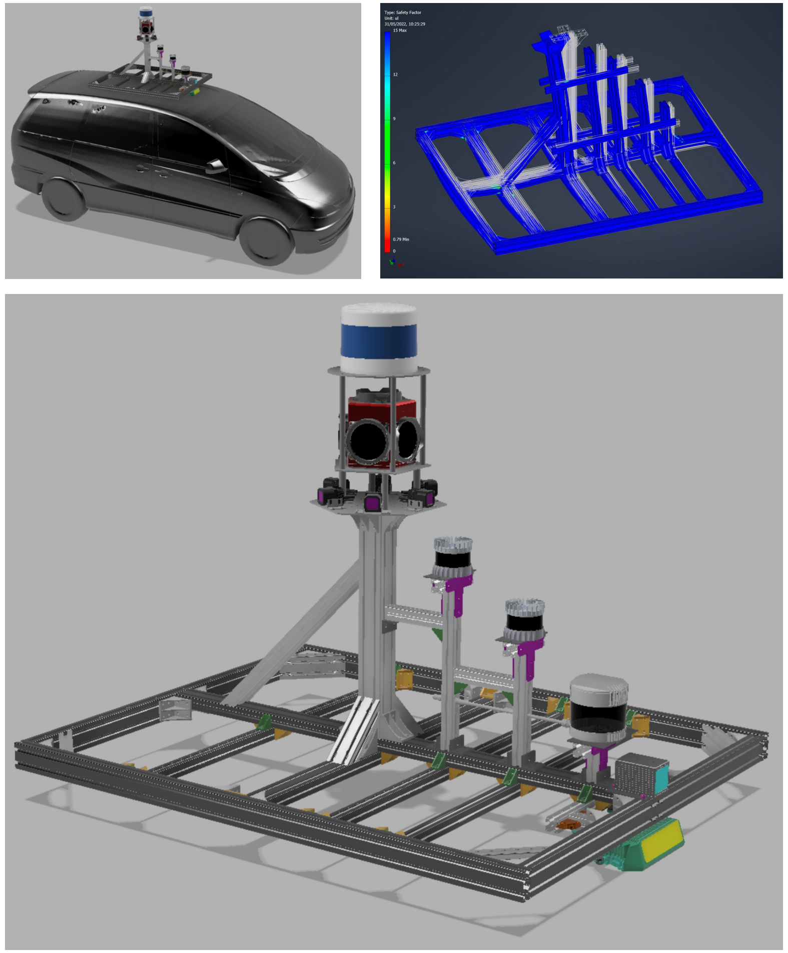
Transmission and remission of a LiDAR’s laser beam

Four objectives of my current research

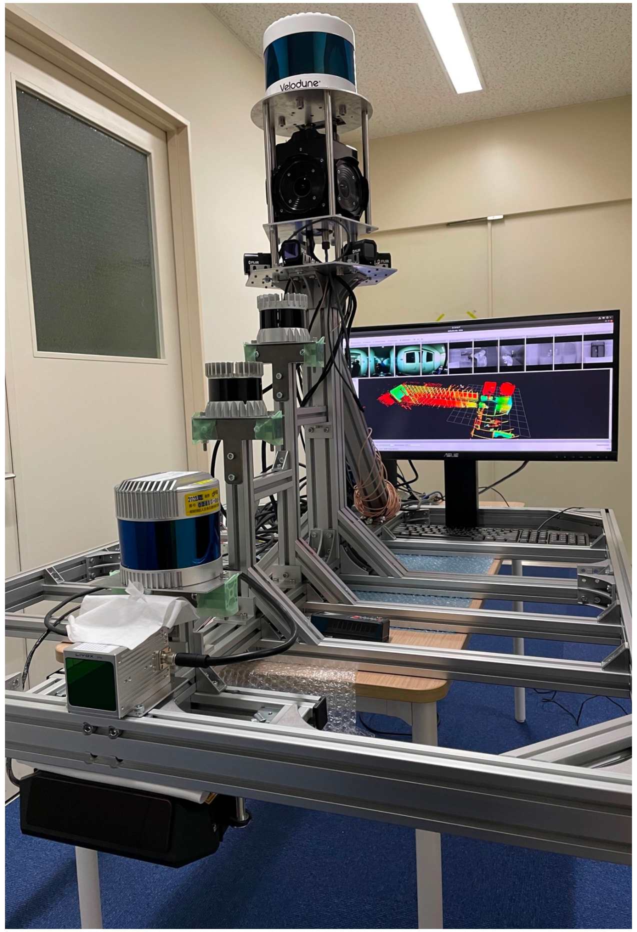


Work in progress, will be submitted for publication in ITSC 2023

Engineering a multispectral & multimodal sensors system



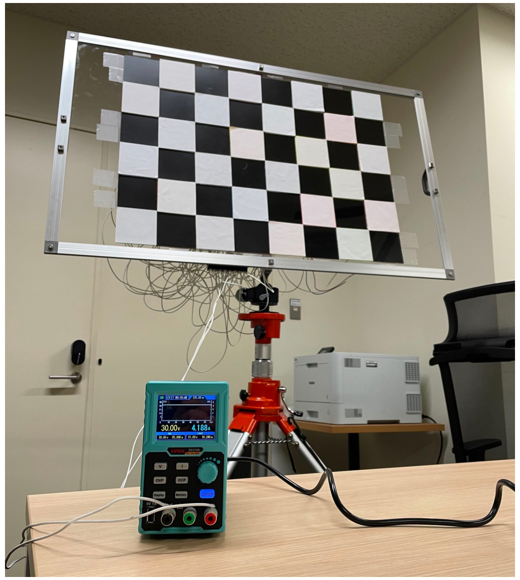
3D CAD and structural analysis



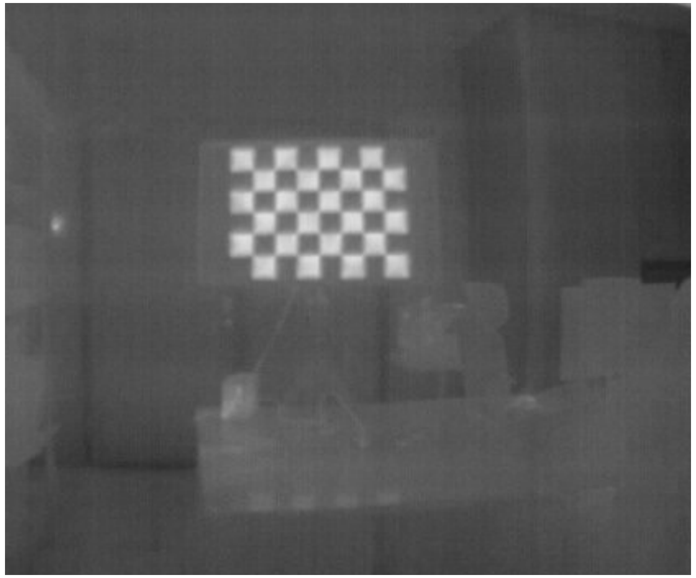
Assembly, ROS implementation, synchronisation

Calibration

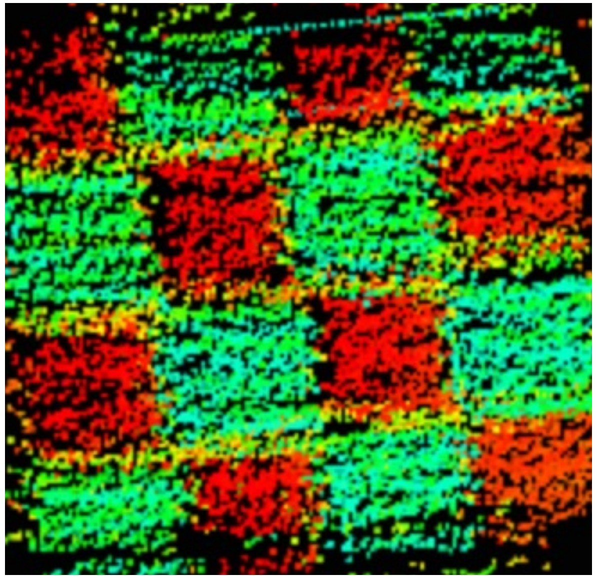
Joint calibration target for multiple sensor modalities



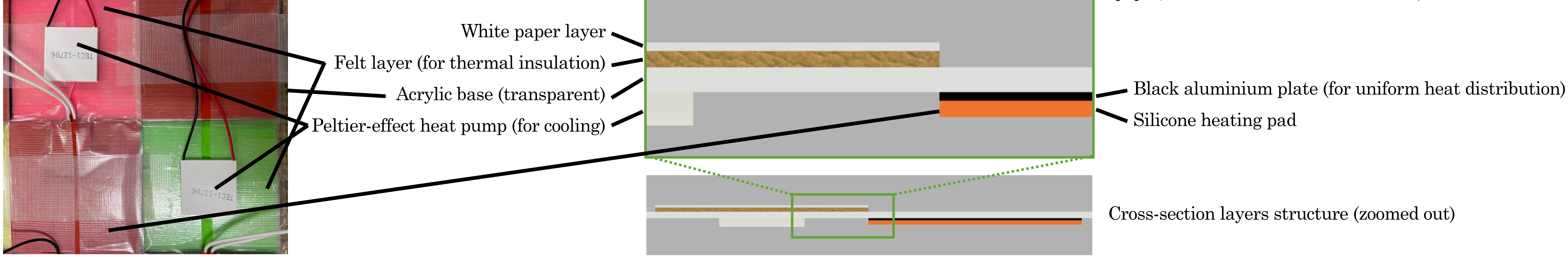
Heating setup



Thermal image from FLIR ADK camera (cropped)



Point cloud from Velodyne VLS-128 AlphaPrime
(Black and white squares are made of aluminium and paper, which have distinct reflectivities)



Work in progress, will be submitted for publication in ITSC 2023

Data assimilation research at RIKEN CCS

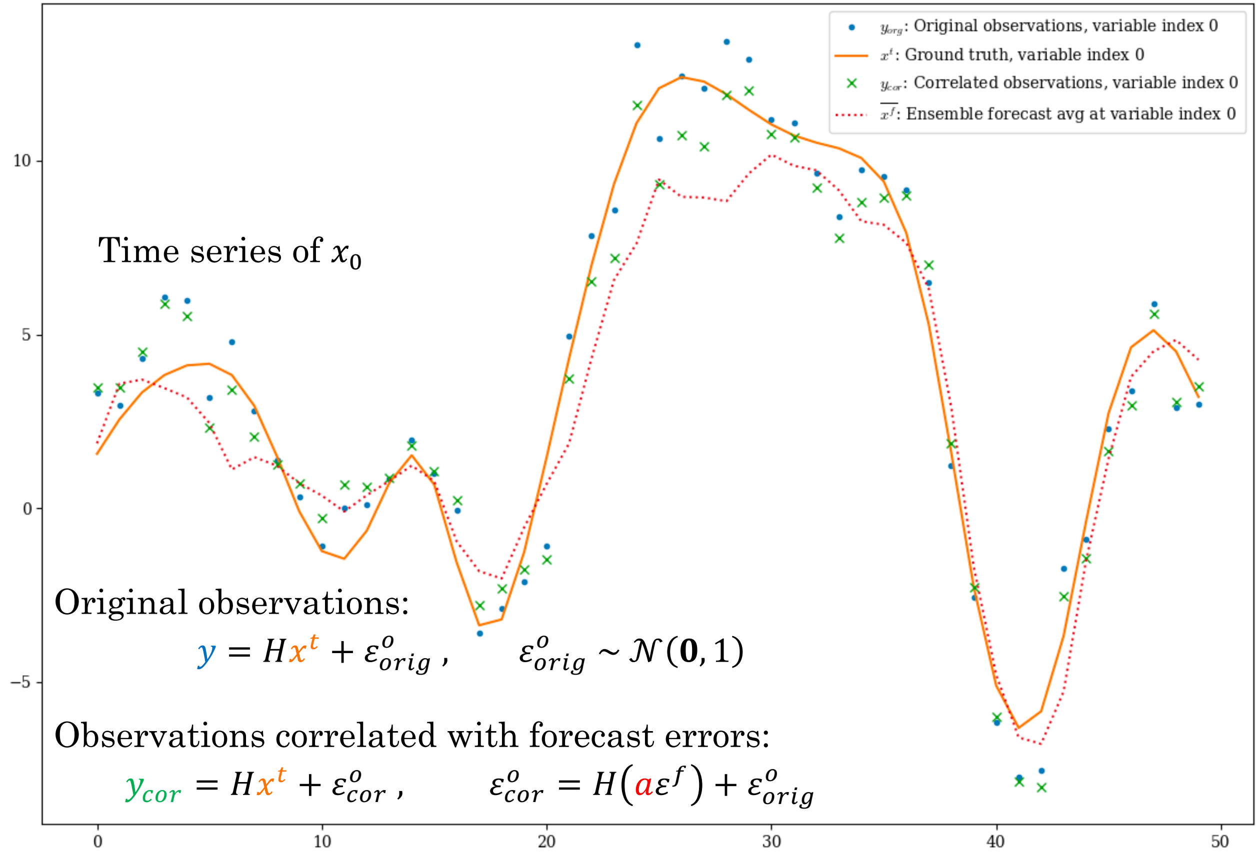
- I derived the following equations for the LETKFCC (Local Ensemble Transform Kalman Filter with Cross Correlation):

$$x^{a(i)} = \overline{x^f} + X^f_{orig}\left\{(1-a)\widetilde{P_a}\left(Y^f_{orig}\right)^T\left(R_{orig}\right)^{-1}\left(y_{cor} - H\overline{x^f}\right) + W^{(i)}\right\}$$

$$\widetilde{P_a} = \left\{\frac{(N-1)}{\rho}I + (1-a)^2\left(Y^f_{orig}\right)^T\left(R_{orig}\right)^{-1}Y^f_{orig}\right\}^{-1}$$

$$W = \left[(N-1)\widetilde{P_a}\right]^{1/2}$$

Correlated observations vs. original observations, $a = 0.5$



- I implemented parallel computation of many large-scale data assimilation experiments on the Fugaku supercomputer.

- Through the experiments, I investigated the impacts of the cross-correlated observations on the accuracy of the LETKF and LETKFCC.