



NAGOYA UNIVERSITY

# Research experiences

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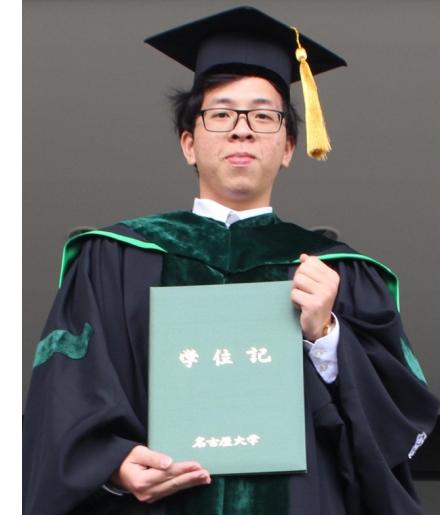
**Quang Nhat Nguyen**

Department of Electrical Engineering  
Graduate School of Engineering, Nagoya University

# Biography

## Quang Nhat Nguyen

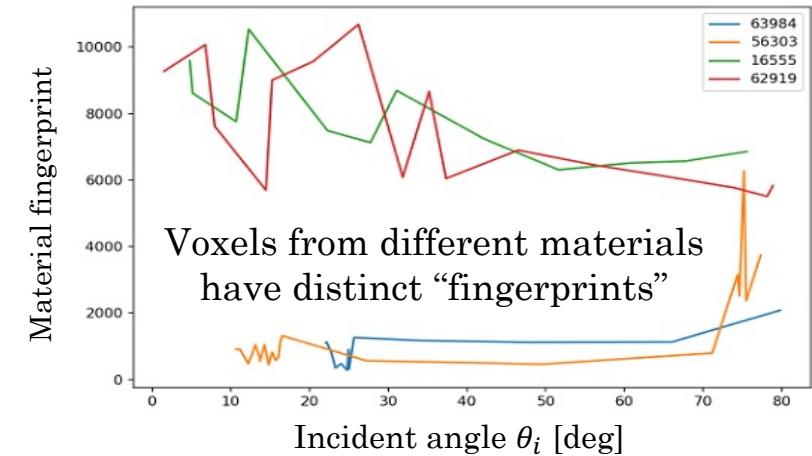
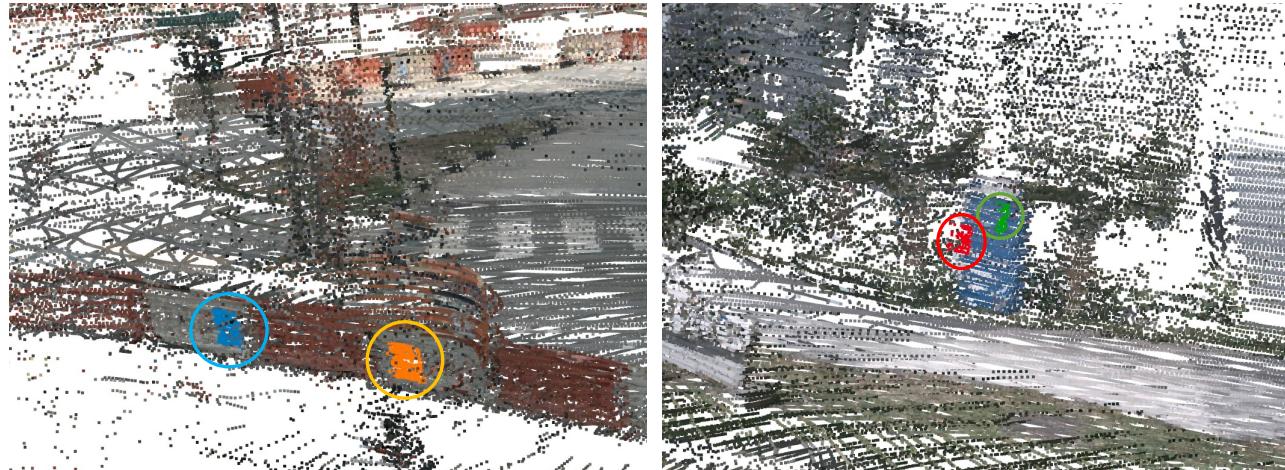
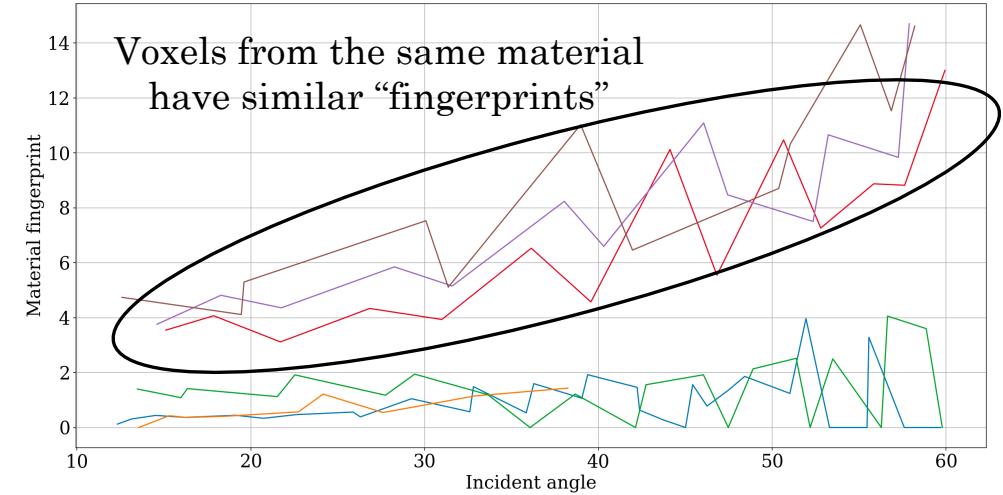
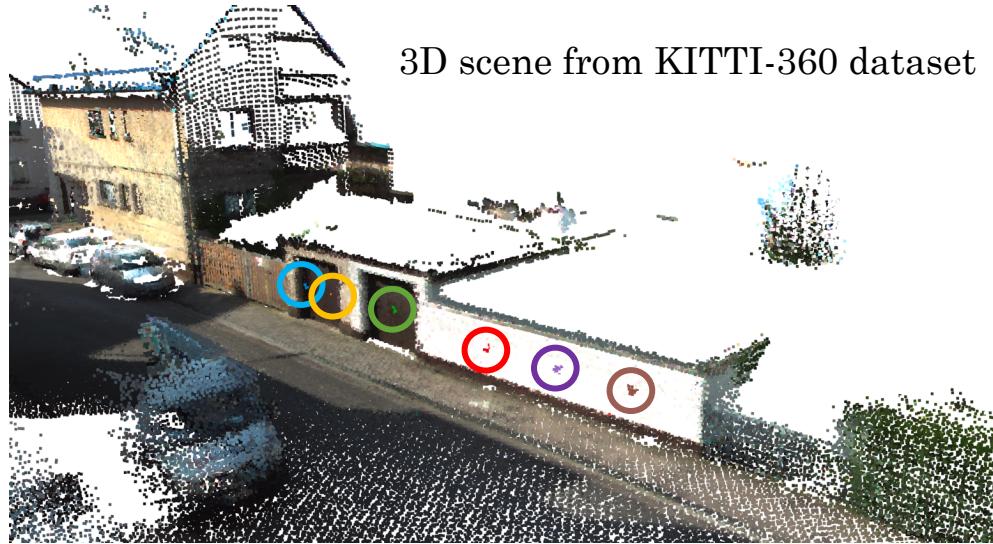
- Date of birth: 27 November 1999 (23 years old)
- Department of Electrical Engineering  
Graduate School of Engineering, Nagoya University
- [nguyen@g.sp.m.is.nagoya-u.ac.jp](mailto:nguyen@g.sp.m.is.nagoya-u.ac.jp)



## 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”



# “Material fingerprint” theoretical basis

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

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

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

$$L_s = \rho_m(\theta_i) \cos \theta_i L_i(\omega_i)$$

- 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:

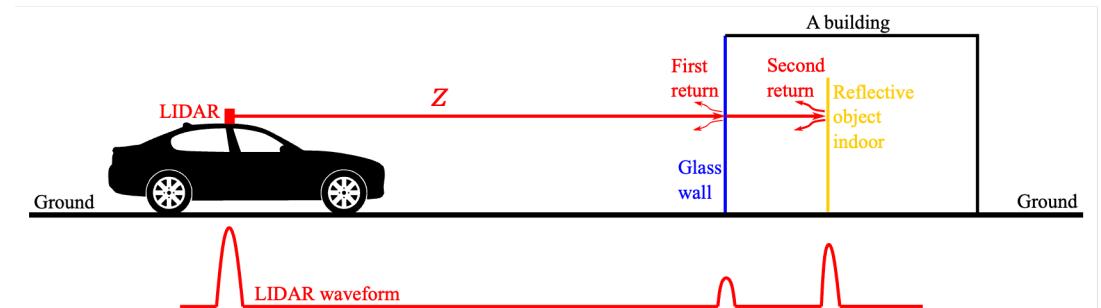
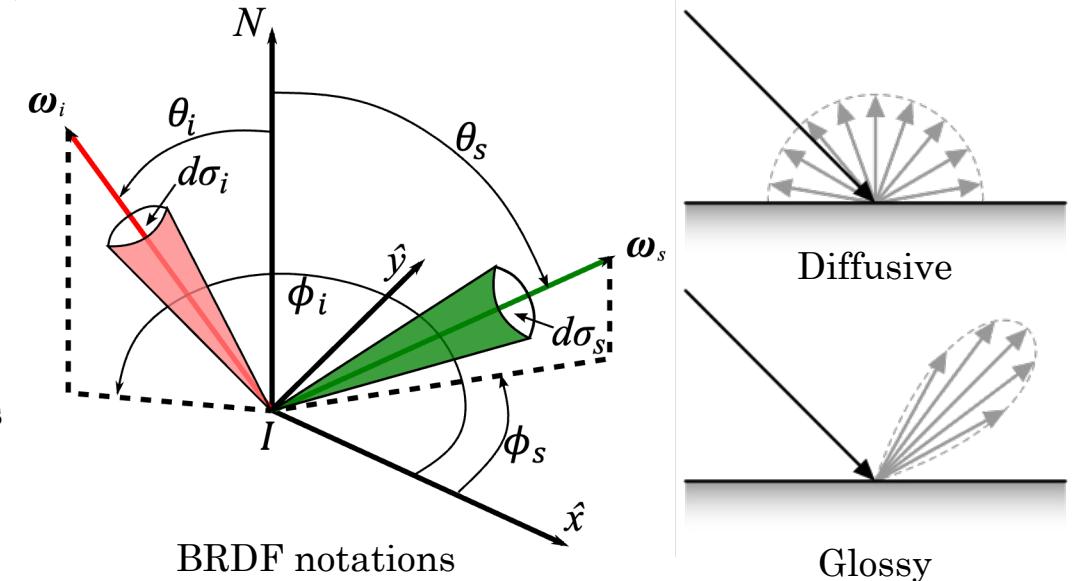
$$I_r(m, z, \theta_i) = C_{const} \times \frac{\rho_m(\theta_i) \cos \theta_i}{z^2}$$

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

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

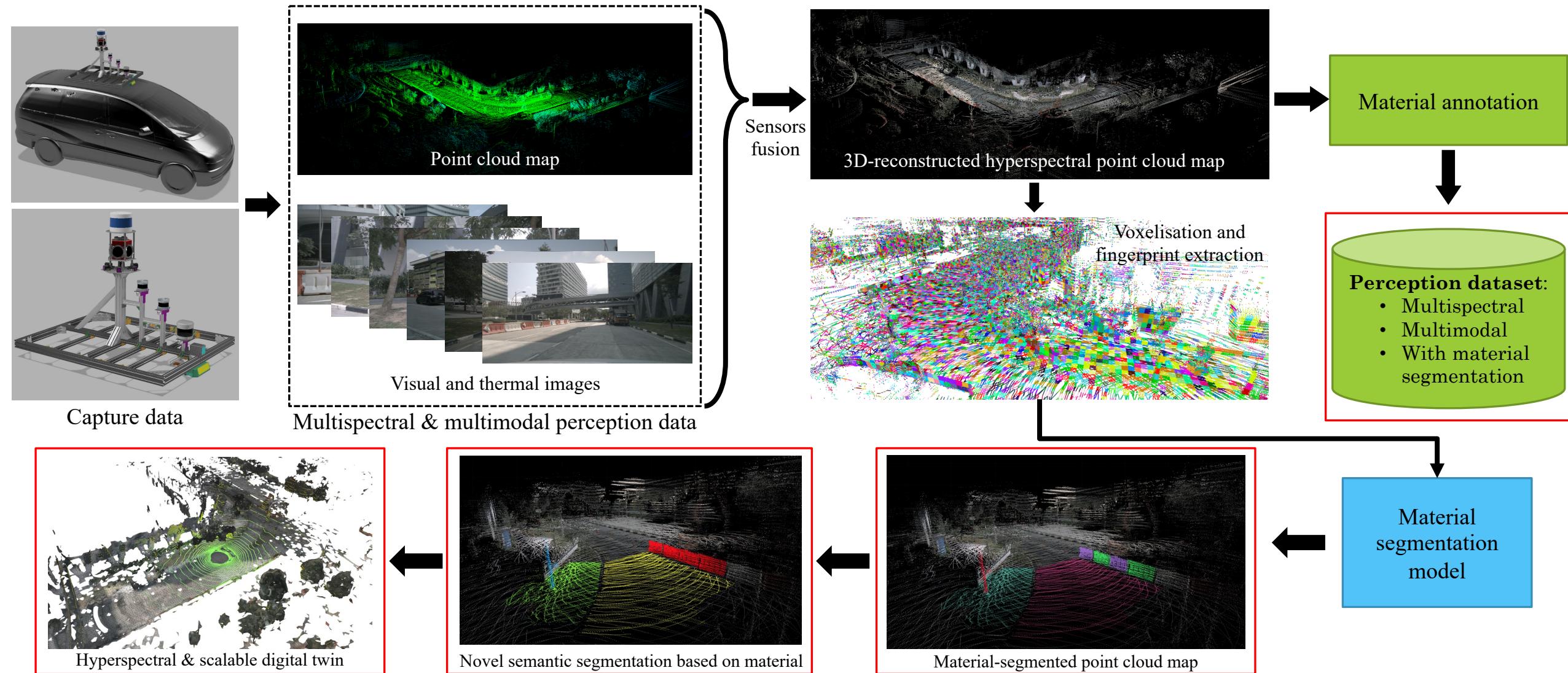
- It is obtained by decoupling LiDAR’s intensity from distance  $z$  as:

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

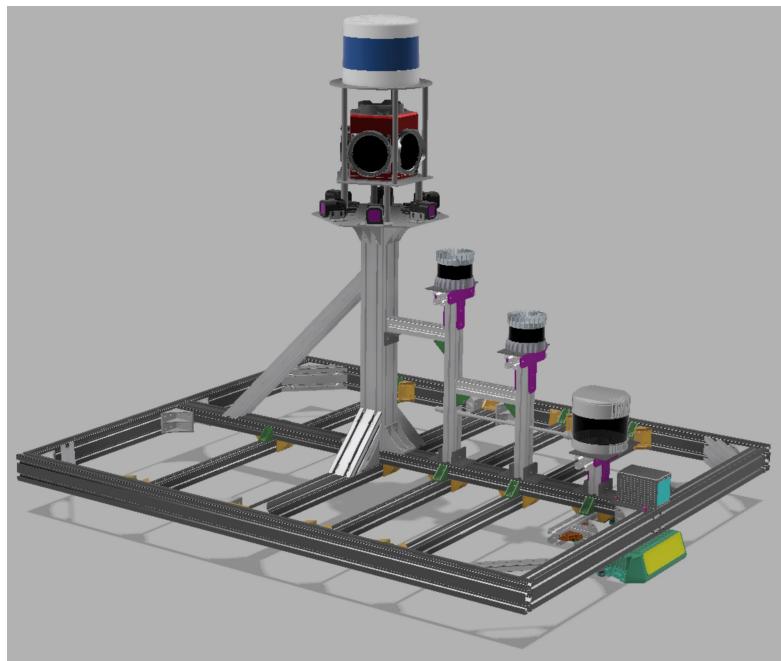
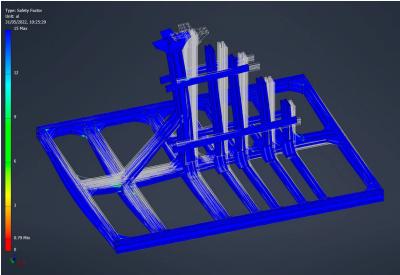


Transmission and remission of a LiDAR’s laser beam

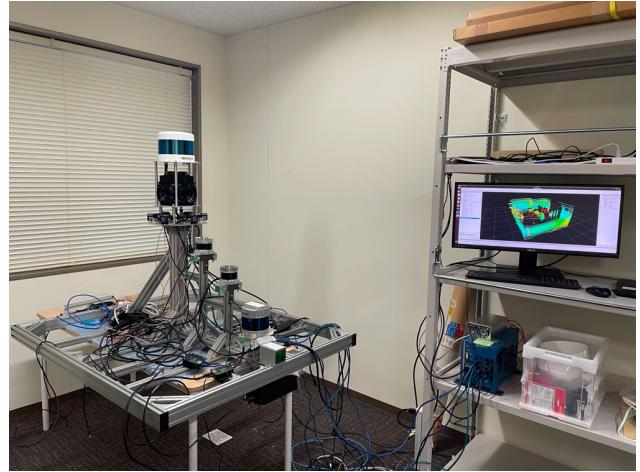
# Four objectives of my current research



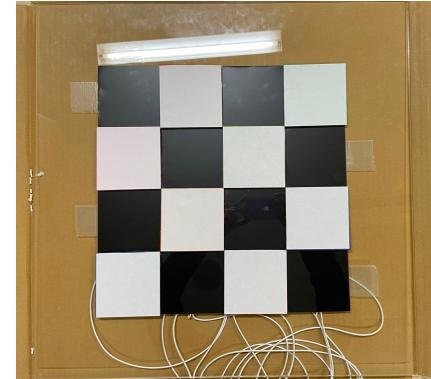
# Engineering a multispectral & multimodal sensors system



3D CAD and structural analysis



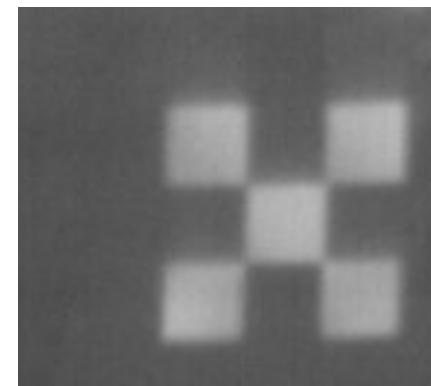
Assembly, ROS implementation, synchronisation



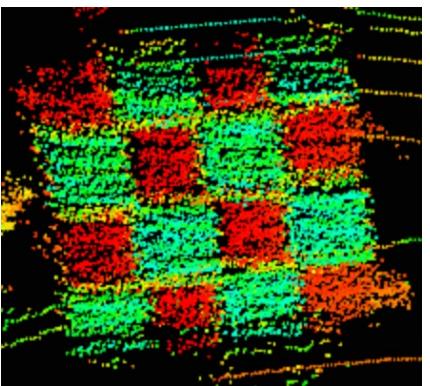
Calibration prototype's front view



Calibration prototype's heating setup



Calibration prototype's thermal image



Calibration prototype's LiDAR intensity

Calibration

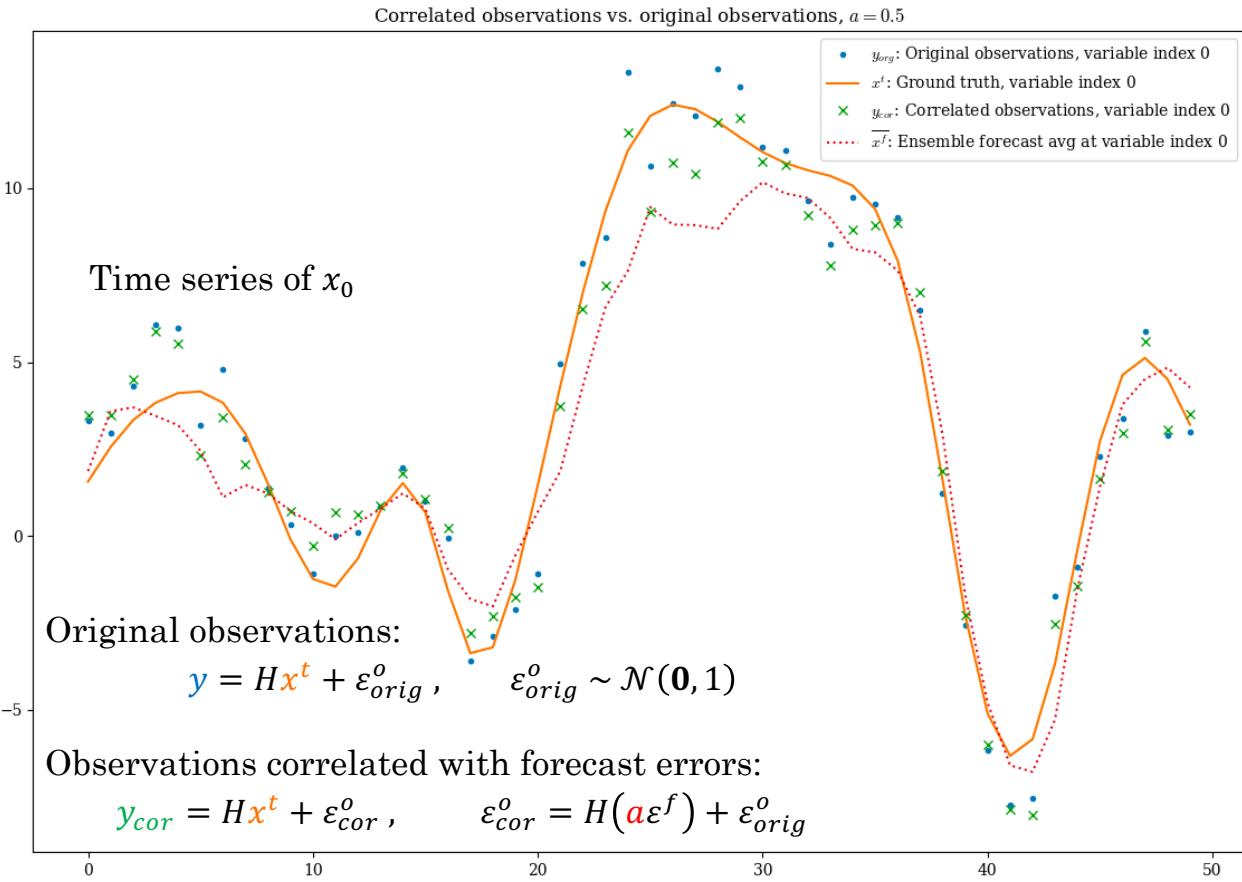
# Data assimilation research at RIKEN CCS

- I derived the following equations for LETKFCC:

$$x^{a(i)} = \bar{x^f} + X_{orig}^f \left\{ (1-a) \tilde{P}_a \left( Y_{orig}^f \right)^T (R_{orig})^{-1} (\mathbf{y}_{cor} - H\bar{x^f}) + W^{(i)} \right\}$$

$$\tilde{P}_a = \left\{ \frac{(N-1)}{\rho} I + (1-a)^2 \left( Y_{orig}^f \right)^T (R_{orig})^{-1} Y_{orig}^f \right\}^{-1}$$

$$W = [(N-1)\tilde{P}_a]^{1/2}$$



- 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.

