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# Vision-Based Estimation of PM2.5 from Surveillance Images


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# About myself

- **Name:** Dipti Mitra
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- **Research Interests**
  - Computer Vision Technology
  - Image processing
  - Deep learning
  - Machine Learning

# AGENDA

- Introduction
- Literature Review
- Proposed Method
- Result and Discussion
- Conclusion and Future Work

# INTRODUCTION

- PM2.5, a fine particulate matter
  - Solid particles
  - Liquid droplets
- Size is 2.5 $\mu$m in diameter

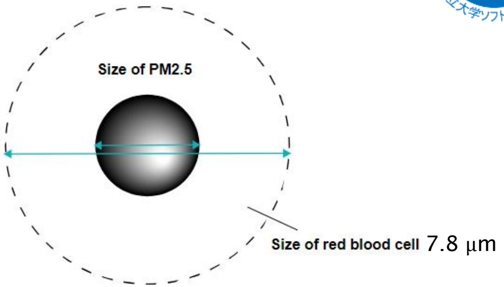


Figure 1 PM2.5

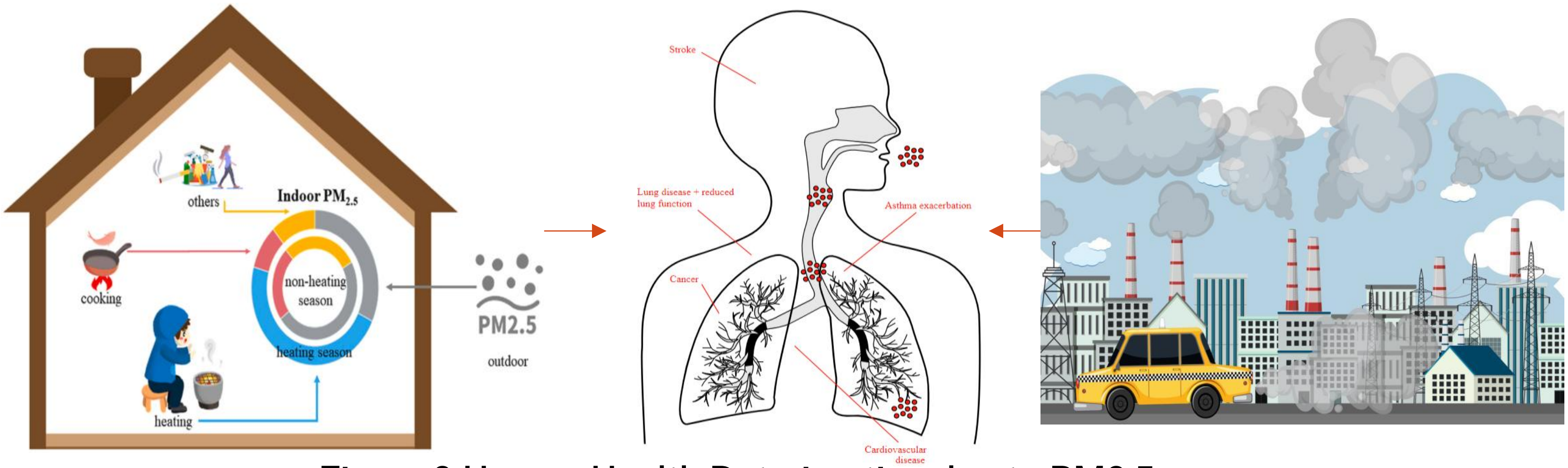


Figure 2 Human Health Deterioration due to PM2.5 sources

# INTRODUCTION (CONT.)


Air quality measurement station

Captures a large amount of particles

Provides precise data based on laser scattering

PM2.5 sensor

Does not cover wide areas

Influencing factors disrupt accuracy

Small sensitivity

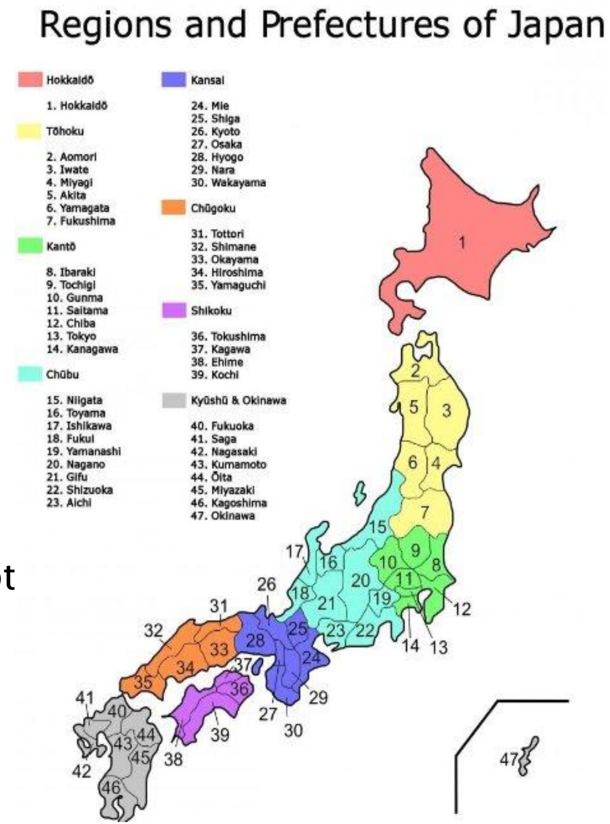


Figure 3 Research Problems

# Introduction (Cont.)

- **Objectives**
  - To identify particles, geographical images of Japan's various prefectures will be used
  - To measure PM2.5 accurately, especially in the presence of haze and scenes objects, an AI method will be utilized


Figure 4 Block Diagram of Proposed Goal

# LITERATURE REVIEW

- S. Laohakiat, S. Klerkkidakan, and N. Wiwatwattana proposed a method that uses images for estimating and forecasting PM2.5 concentrations using deep learning technologies
  - Convolutional Neural Network (CNN) as a base model
  - Long Short-Term Memory (LSTM) as an output layer

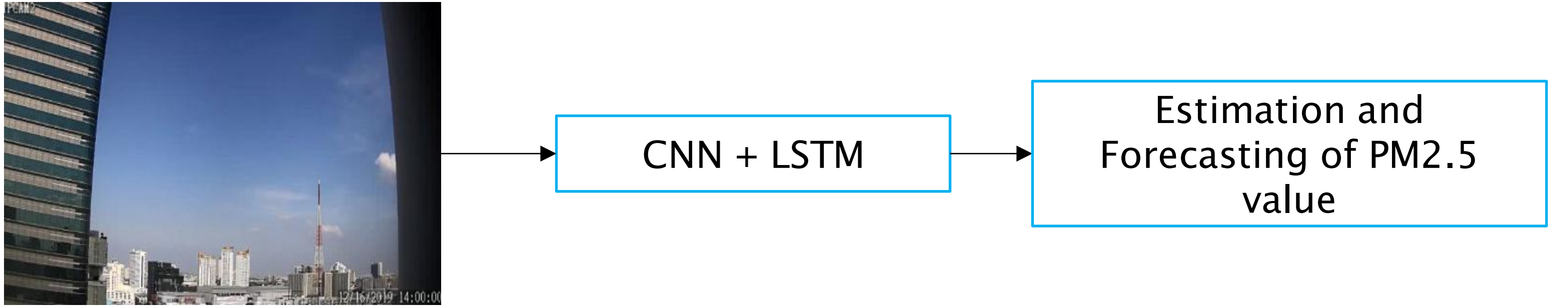


**Figure 5** Visually Estimating and Forecasting PM2.5 Levels Using Hybrid Architecture Deep Neural Network

# Literature Review (Cont.)

- Z. Fan et al. proposed computer vision technology and regression model
  - to extract the real-time traffic volume and street-view information from the traffic images, and
  - to predict the road concentration of PM2.5

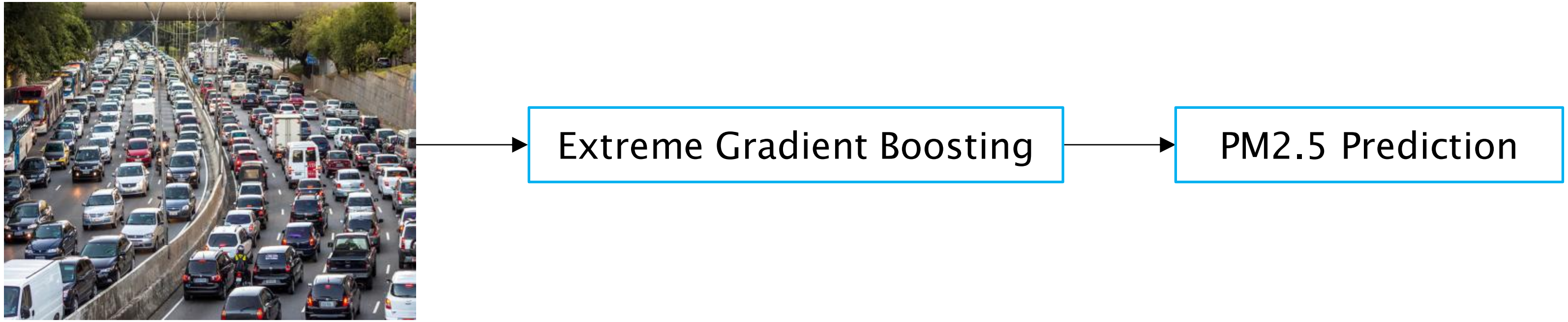


**Figure 6** Enhancing Urban Real-Time PM2.5 Monitoring in Street Canyons by Machine Learning and Computer Vision Technology

# Literature review (Cont.)

- Most prior work relies on raw image data to capture visual information related to atmospheric conditions such as
  - haze and visibility degradation,
  - meteorological conditions,
  - particulate matter-related predictors, and
  - development of deep learning technologies
- These limitations motivate the need for using the combination of dehazed images and object segmentation

# PROPOSED METHOD

- **Data Collection Method**
  - Webscraping

City Surveillance Camera

Afternoon

Noon

Morning

Scraped Morioka City Image

Morioka City AQI Monitor Website → 7, 7, 8

Scraped PM2.5 Values

**Figure 7 Collecting Data using Webscraping technique**

# Proposed method (Cont.)

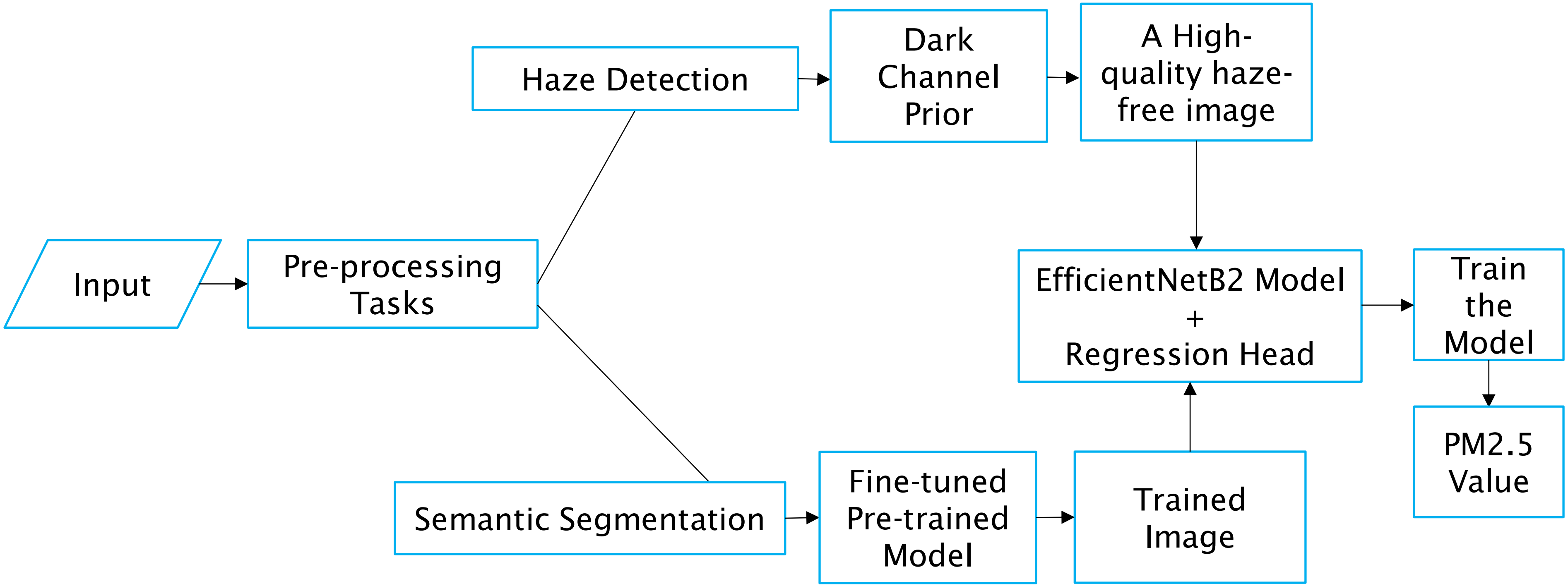


Figure 8 Flow chart of Proposed Work

# PROPOSED METHOD (CONT.)

- **Image Dehazing using Dark Channel Prior Algorithm**

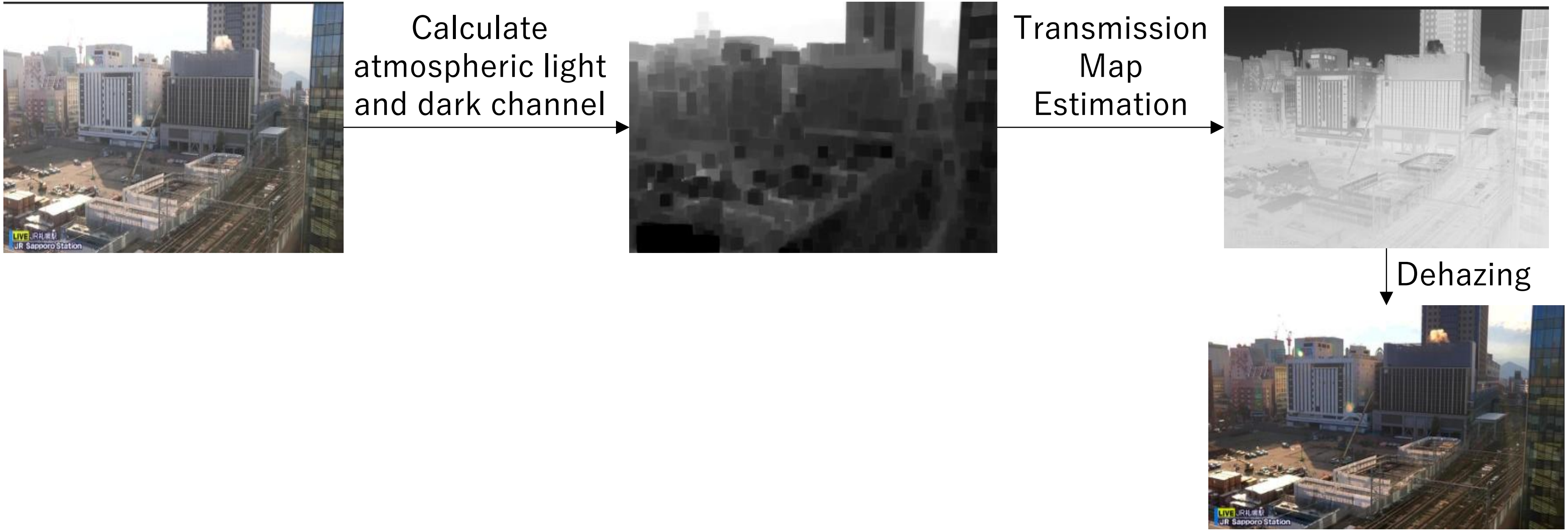


**Figure 9 Process of Dehazing the Sapporo City Image**

# PROPOSED METHOD (CONT.)

- **Semantic Segmentation for Sapporo city**
  - Assigned the class indices ‘background:0’, ‘sky:1’, ‘building:2’
  - Adapted from 150 classes of ADE20K environmental dataset to 3 classes
  - Detected Classes : [0, 1, 2]
  - Class Percentage of 3 classes background: 45.15% sky: 9.16%, building: 45.69%

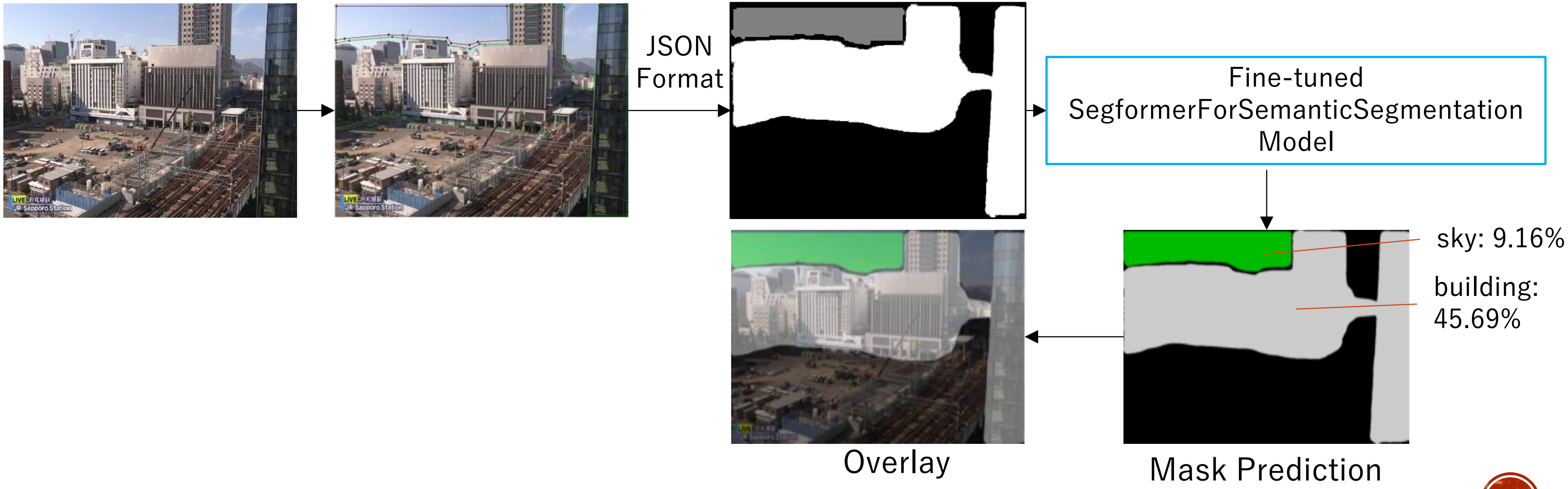


**Figure 10 Model Fine-tuning and object coverage percentage estimation**

# PROPOSED METHOD (CONT.)

- The performance of the segmentation model has been evaluated as shown in Table 1

Table 1 Performance Evaluation of Semantic Segmentation across cities

| Dataset | Pixel Accuracy | Mean Intersection over Union (mIoU) | F1-Score | Recall |
|---|---|---|---|---|
| Sapporo | 0.99 | 0.97 | 0.99 | 0.99 |
| Aomori | 0.98 | 0.93 | 0.96 | 0.96 |
| Kagoshima | 0.98 | 0.93 | 0.97 | 0.96 |
| Chofugaoka | 0.99 | 0.99 | 0.99 | 0.99 |

# Results and Discussion

- **Experimental results**
  - The prediction results for each city are presented in Table 2 using five input configurations

Table 2 Experimental results using five input configurations

| Dataset | Model A (Original Images) | | | Model B (Dehazed Images) | | | Model C (Segmentation Masks) | | | Model D (Dehazed + Semantic Segmentation) | | | Model E (Original + Dehazed + Semantic Segmentation) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $R^2$ | MSE | MAE | $R^2$ | MSE | MAE | $R^2$ | MSE | MAE | $R^2$ | MSE | MAE | $R^2$ | MSE | MAE |
| Sapporo | 0.16 | 1.95 | 1.72 | **0.29** | 6.21 | 1.92 | 0.01 | 6.70 | 1.81 | 0.22 | 2.37 | 1.81 | 0.18 | 4.93 | 1.70 |
| Kagoshima | 0.14 | 5.28 | 1.99 | **0.20** | 6.73 | 2.09 | 0.08 | 7.23 | 2.20 | **0.27** | 3.82 | 1.58 | 0.24 | 5.29 | 1.79 |
| Aomori | 0.19 | 8.69 | 2.49 | **0.26** | 7.82 | 2.32 | 0.04 | 7.47 | 2.16 | **0.43** | 7.39 | 2.40 | 0.31 | 8.34 | 2.32 |
| Chofugaoka | -0.21 | 13.06 | 3.02 | **0.18** | 14.91 | 3.00 | 0.04 | 5.33 | 1.94 | 0.15 | 13.35 | 2.95 | 0.11 | 8.56 | 2.03 |

# Results and Discussion (Cont.)

- **Discussion**
  - The experimental results show that employing dehazed images and semantic segmentation masks usually enhance PM2.5 prediction performance across most cities

Table 3 Implications of dataset characteristics on quantitative results

| Dataset | Performance level (Model D) | Sample size | Segmented predictors | Weather conditions | Camera resolution | Camera-to-station distance |
|---|---|---|---|---|---|---|
| Sapporo | Consistent | 72 | Sky and building | Sunny | 960 x 540 | 3.4 kilometers |
| Kagoshima | Consistent | 79 | Sky and mountain | Sunny and cloudy | 638 x 359 | 4.5 kilometers |
| Aomori | Consistent | 96 | Sky and building | Sunny and snowy | 960 x 540 | 3.5 kilometers |
| Chofugaoka | Consistent | 93 | Sky and water | Sunny and cloudy | 960 x 540 | 2 kilometers |

# Conclusion and Future Work

- This research presents a visual estimation of PM2.5 concentration in the air
- Various Japan's geographical images and their associated PM2.5 values are used to construct datasets
- Haze detection and semantic segmentation are determined to estimate the PM2.5 values precisely
- Two inputs the dehazed images and their corresponding segmented masks are put into the regression model to predict PM2.5 concentration
- The results provide consistent PM2.5 prediction when applying the integrated dehazed images and segmentation masks
- In future work, the proposed approach will be utilized to the other existing PM2.5 datasets to evaluate its performance

# Thank You..