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Proposal for a System to Estimate the Best Time to See Yellow Leaves Using IoT Devices for Tourists

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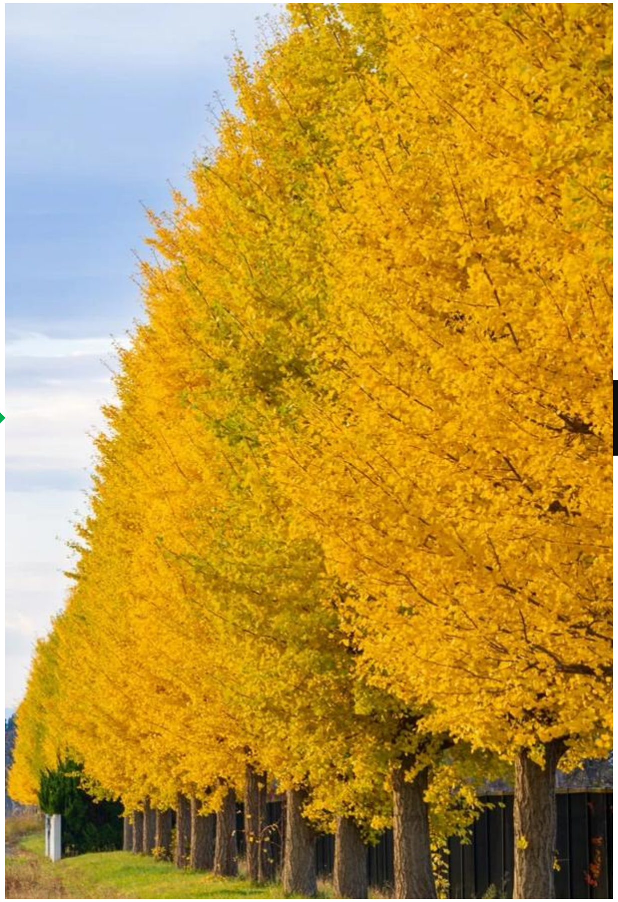
Introduction

About 1 week

Before
Green leaves
not bad
but
not very beautiful



After
Defoliation

Sad
Lonely

Research Background

- Phenology※ Observation
  - **Visual** observation by observers of cherry blossoms blooming, ginkgo leaves turning yellow and falling

- Cherry blossoms have bloomed, ginkgo leaves have turned yellow viewing time forecast
  - attracting tourists

※Phenology:
Seasonal changes in organisms

Problems

- High human costs
  - Difficulty in continuing observations

Solutions

- Automating observations
- Predicting the timing of biological season

Problems and Purpose of this study

- Problems with determining yellow leaves
  - Yellow leaf threshold setting is fixed
  - Influence of light such as glare
- Purpose
  - A method to predict the degree of yellowing of leaves in detail
    - Detecting the degree of yellowing and falling leaves using deep learning
    - Regression analysis of degree of yellowing and falling leaves

Measurement method using IoT devices

Observation period:
November 1, 2024 to January 10, 2025

- Fixed-point photography of specimen tree
  - Specimen tree: ginkgo tree on campus
  - Taking one photo per minute (6am 6pm)
- Measuring meteorological data
  - 1 set obtained per minute

Table1 Measurement target

Measurement	reasons for selection
Temperature	Effective in promoting yellowing of leaves
CO_2	Affects photosynthesis
Illuminance	Affects image color, weather, and photosynthesis

Fig.1 Specimen Trees

IoT device configuration diagram

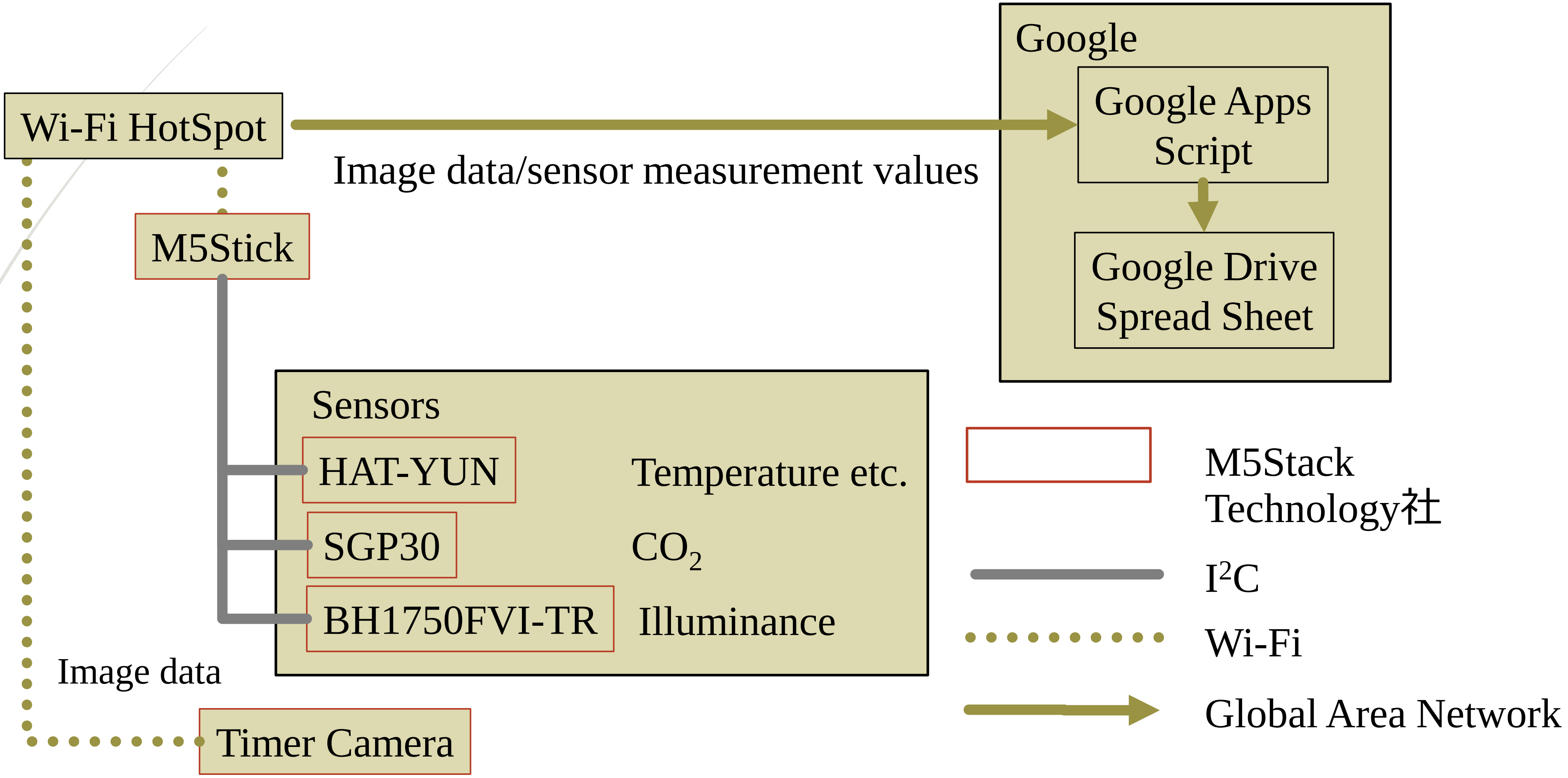
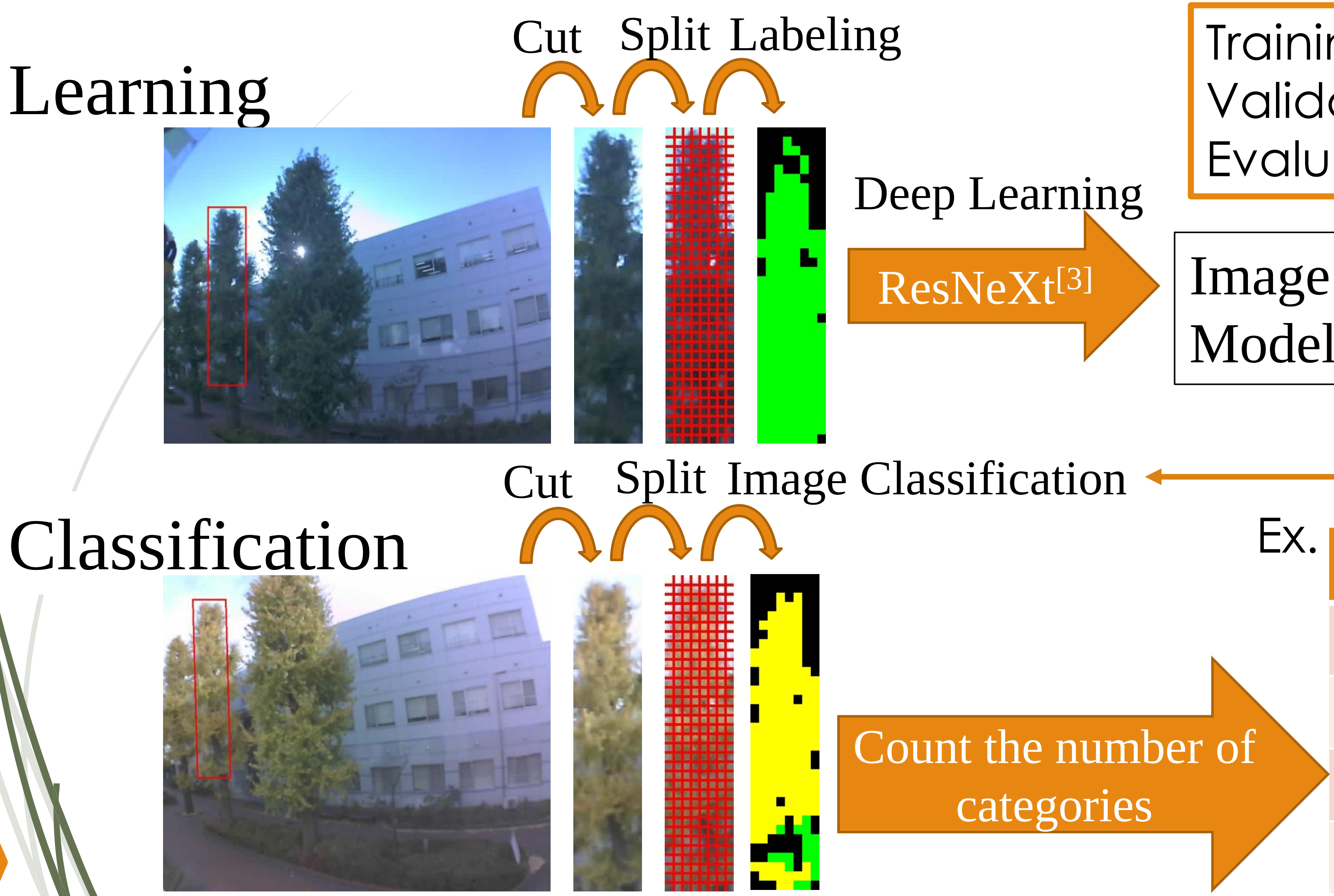


Fig.2 IoT device configuration

Image Classification Method Using Deep Learning

Training data:95,569
Validation data:23,893
Evaluation data:29,866



Ex.

Class	Number
Green(g)	18
Yellow(y)	163
Others	91
Total	272

Fig.3 Learning and Classification Flow

The rate of yellowing and falling leaves

- Yellow Classification

  Count : y

- Green Classification

  Count : g

$$\text{Yellow leaf rate} = \frac{y}{g+y} \times 100\ [\%]$$

$$\text{Defoliation rate} = \left(1 - \frac{g+y}{max(g+y)※}\right) \times 100\ [\%]$$

※$max(g+y)$: maximum value of $g+y$

Table 2　Definition by Meteorological Agency

Name	Definition
Yellow leaf day	First day when most of the leaves turn yellow
Defoliation day	First day is when approximately 80% of the leaves have fallen

Table 3　Our Definition

Name	Definition
Yellow leaf day	First day when the yellowing rate exceeded 80%
Defoliation day	First day when the leaf fall rate exceeded 80%

Image classification results

- The three-class image classification evaluation for "green", "yellow", and "other"

  over 89%

Table 4　Evaluating classification results

Classes	Precision	Recall	F-value
Green	0.892	0.928	0.909
Yellow	0.945	0.927	0.935
Others	0.921	0.928	0.924

Multivariate regression analysis

Analysis period : 2024.11.1～2025.1.10
Prediction : Yellowing and defoliation rates after 3 days
Learning Model : LightGBM
Evaluation Indicator : RMSE(Root Mean Squared Error)

Explanatory variables
Average yellow leaf rate over 3 days
Average defoliation rate over 3 days
Illuminance
Average CO_2 over 3 days
Total daily illumination

Object variable
Yellow leaf rate
Learning ▶ Yellow leaf regression model

Object variable
Defoliation rate
Learning ▶ Defoliation regression model

Fig.4 regression model

※Temperature, humidity and air pressure data are recorded at constant values due to sensor malfunction.

Multivariate regression results for yellowing

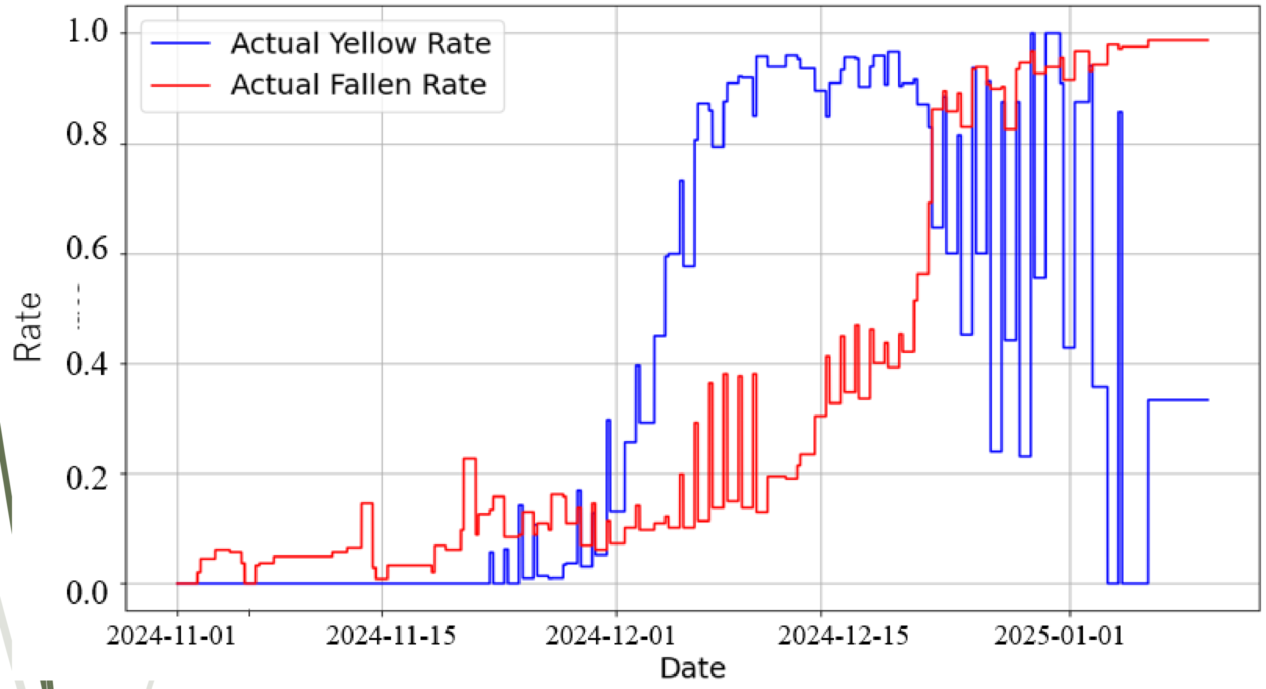


Fig.5　Actual values

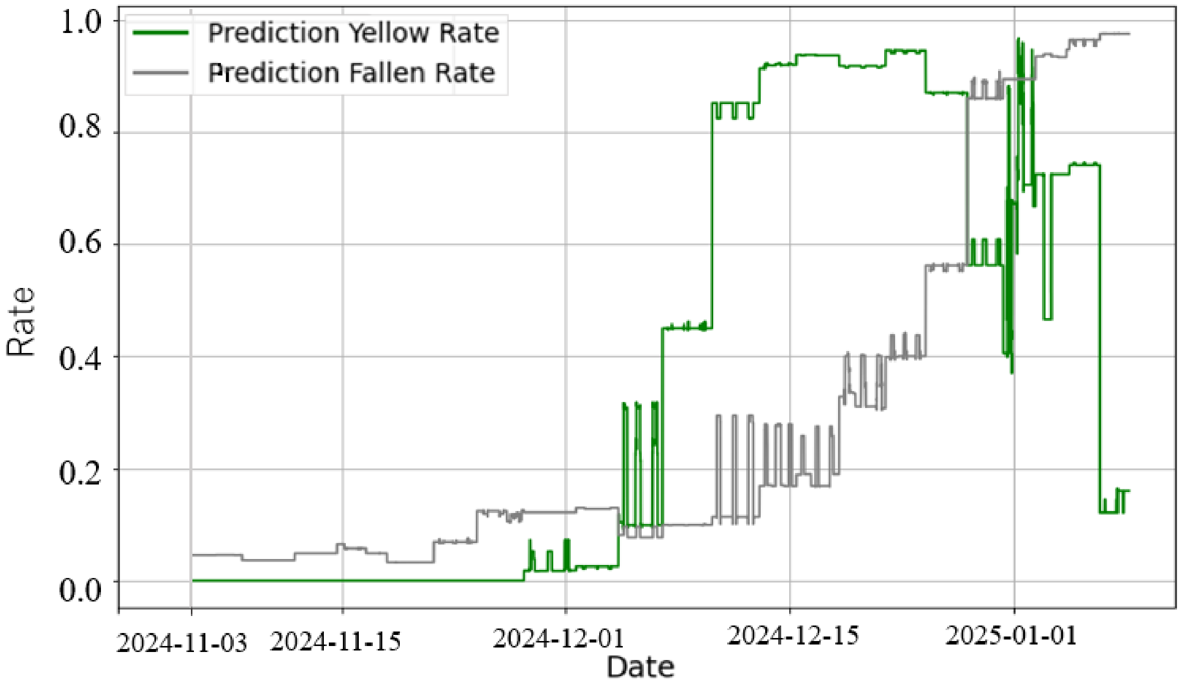


Fig.6　Predicted values

Table 5　Each RMSE value

Model name	Root Mean Squared Error
Yellow leaf regression model	0.164
Defoliation regression model	0.083

Conclusion

- Uses image classification using deep learning(ResNeXt)

  Detects the rate of yellowing and falling leaves from ginkgo images
- From image data and sensor data

  Regression analysis of yellow leaf rate and defoliation rate

Future works

- Sensor anomaly detection and multiplexing
- Targeting multiple trees at multiple locations

Thank you for your attention.