Drone-Based Multi-spectral Pipeline for Detecting Abnormal Potato Strains in the Field

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01 Introduction

1. Introduction

Frequent manual visual inspections for detecting infected and abnormal plants are often necessary to decrease their impact on potato yields.

Objectives

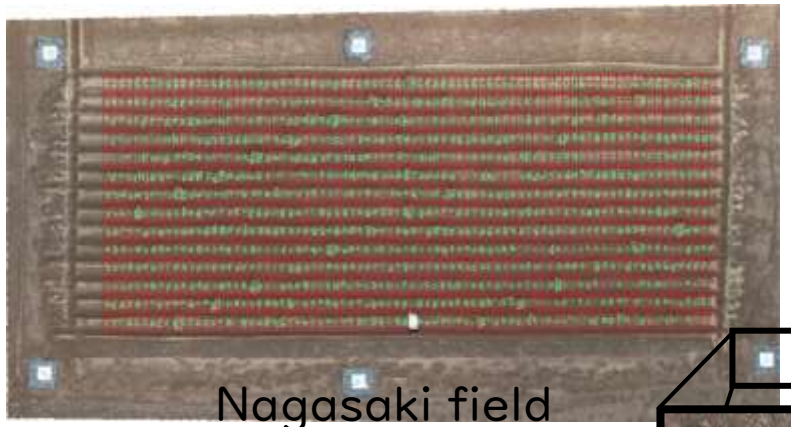
Develop a UAV-based pipeline for obtaining abnormal positions and guide the field investigation

02 Methods and Materials

2. Methods & Results

1) Experimental fields

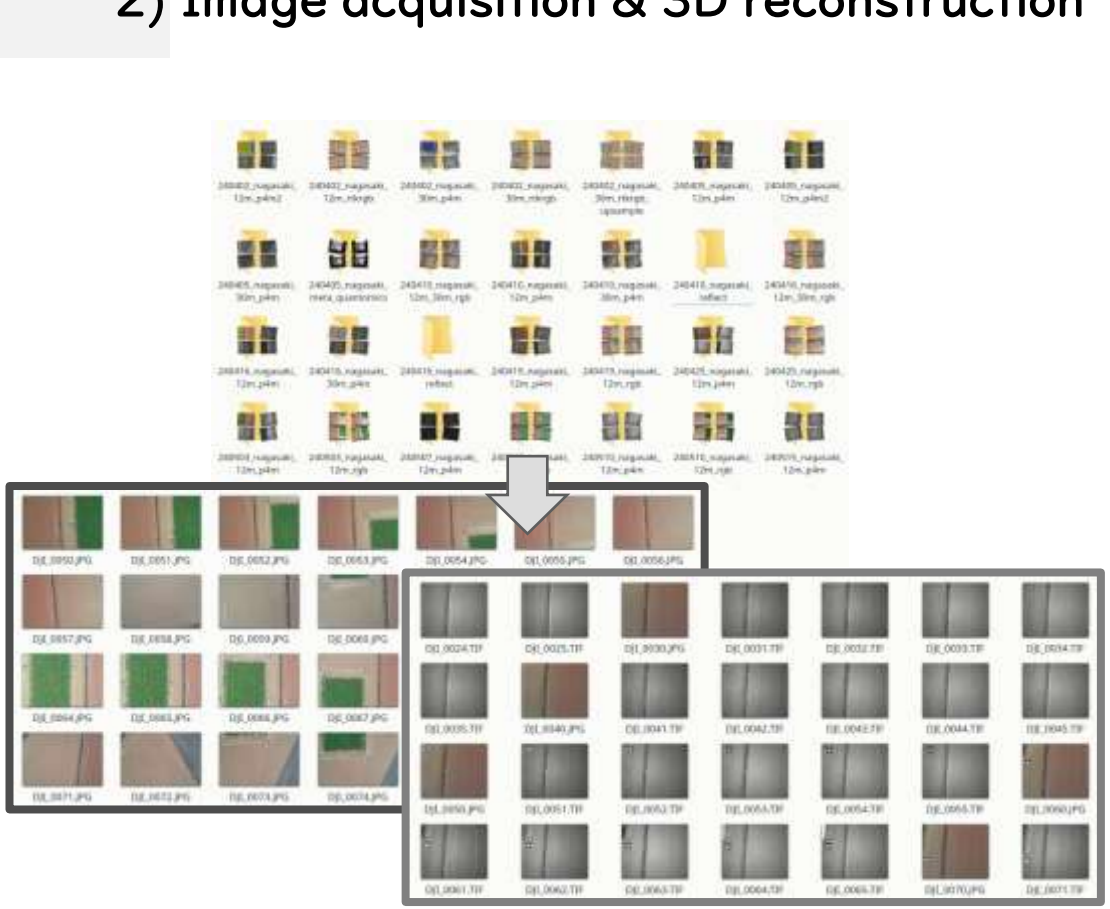
Canopy-level grids



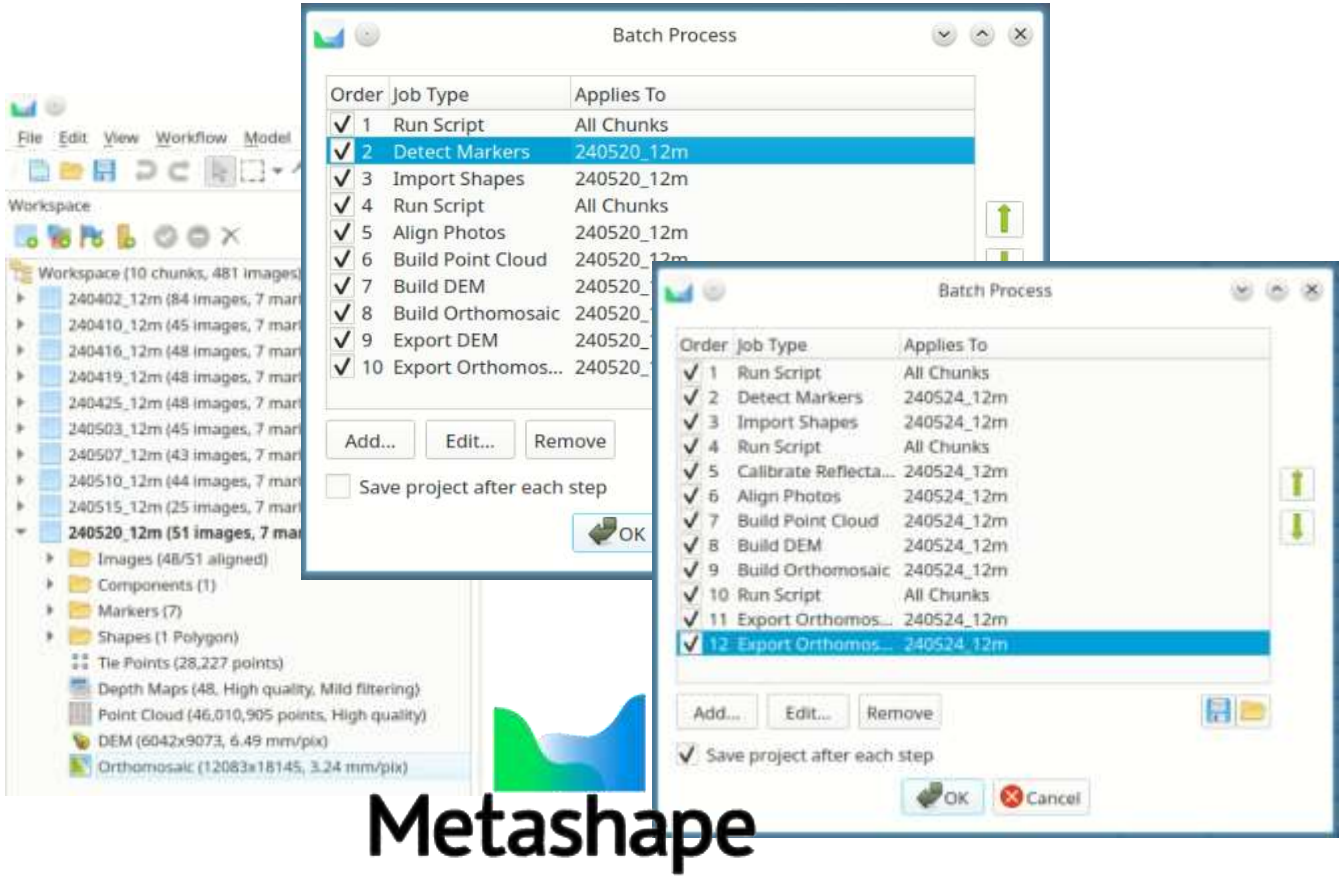
Individual-level grids

2. Methods & Results

2) Image acquisition & 3D reconstruction



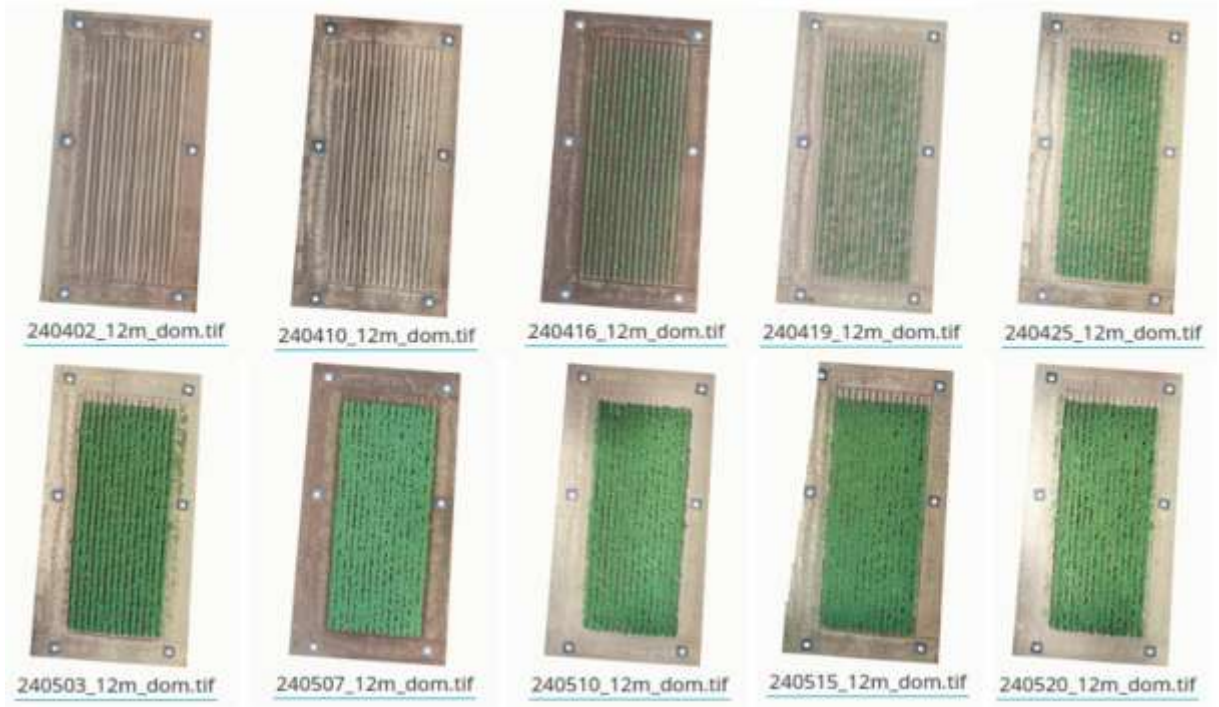
Collect time-series RGB and multi-spectral images by DJI P4 UAV at 12m



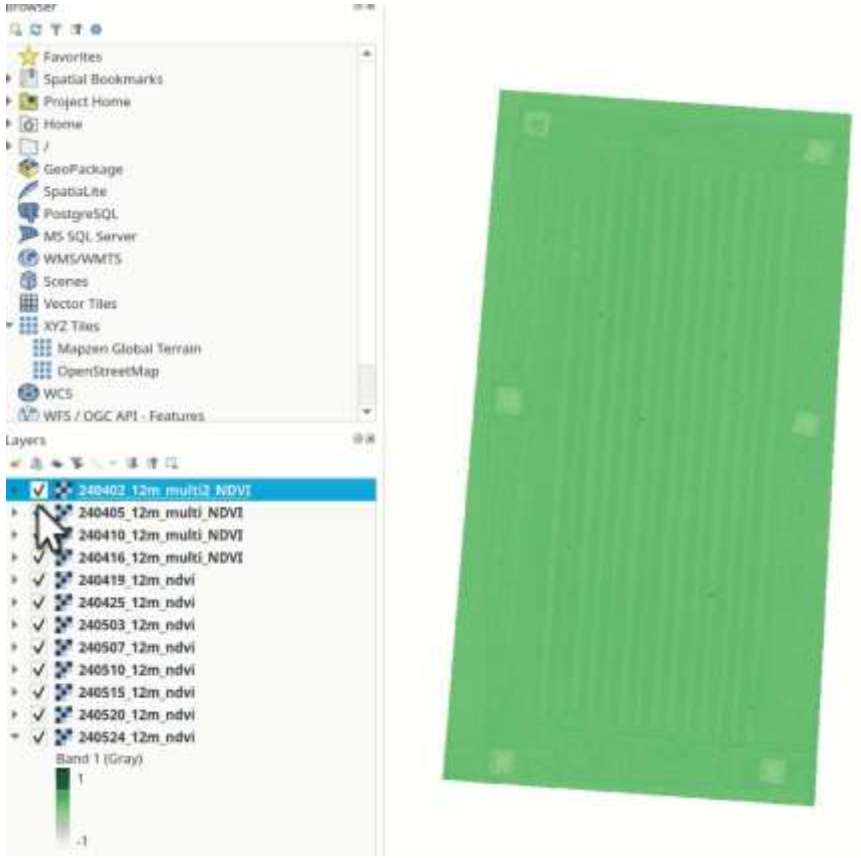
Implement batch processing scripts for automatic time-series reconstruction

2. Methods & Results

2) Image acquisition & 3D reconstruction



Time-series RGB ortho-maps
(Nagasaki field)



Time-series NDVI maps
(Nagasaki field)

2. Methods & Results

3) Traits calculation

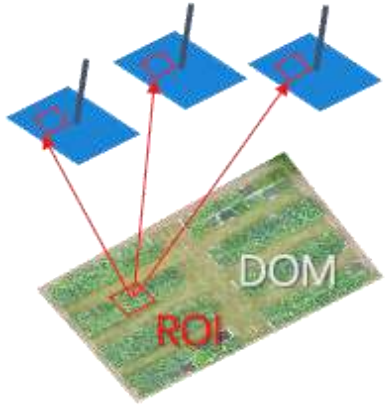
Fraction of Coverage

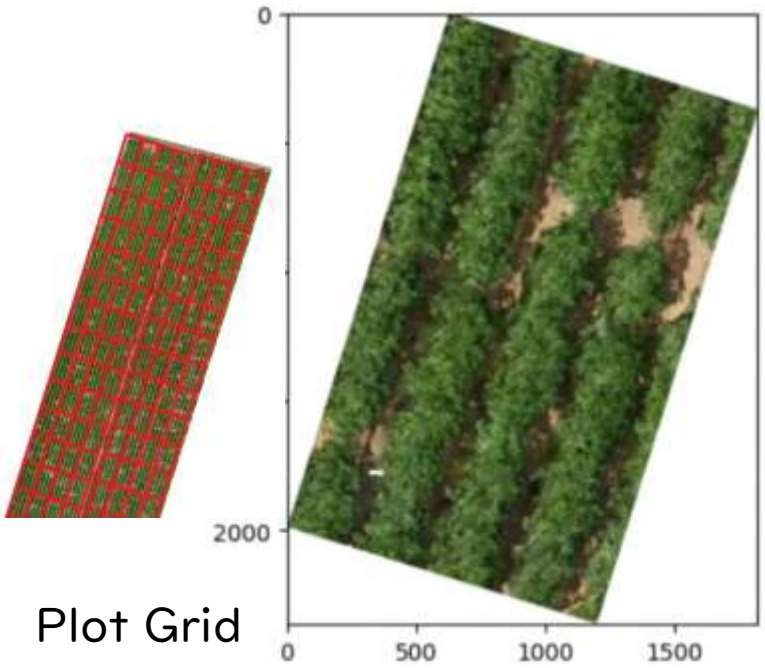
Canopy Height

Canopy NDVI

2. Methods & Results

3) Traits calculation – Coverage





Plot Grid

Ortho-maps often has low quality

Use EasyIDP.v2 to obtain corresponding place on raw UAV image

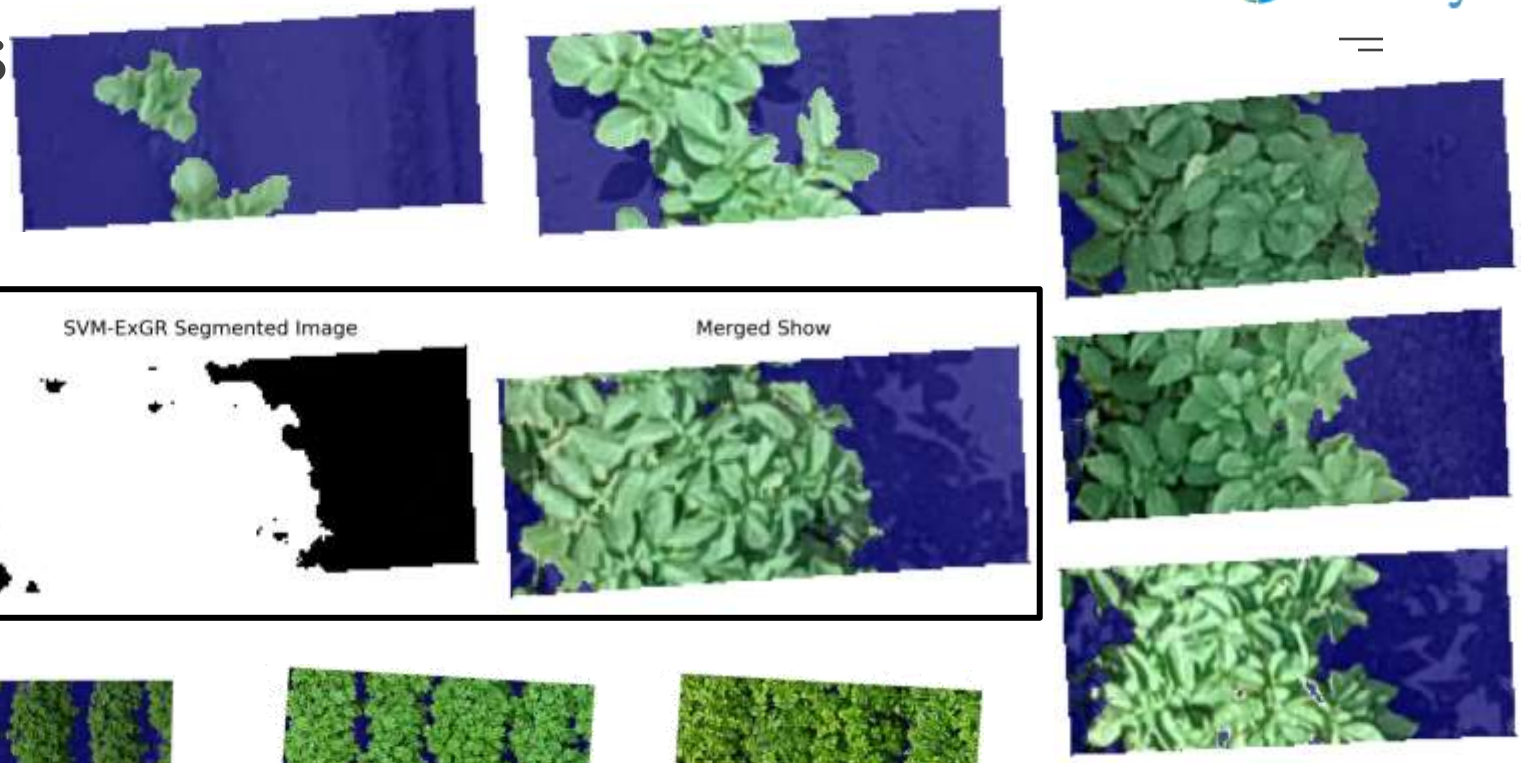
Label a few bbox training data by LabelMe

Train EasyPCC.v3

SVM-based segmentation machine learning model
(input features: ExG | ExR | HSV | Lab)

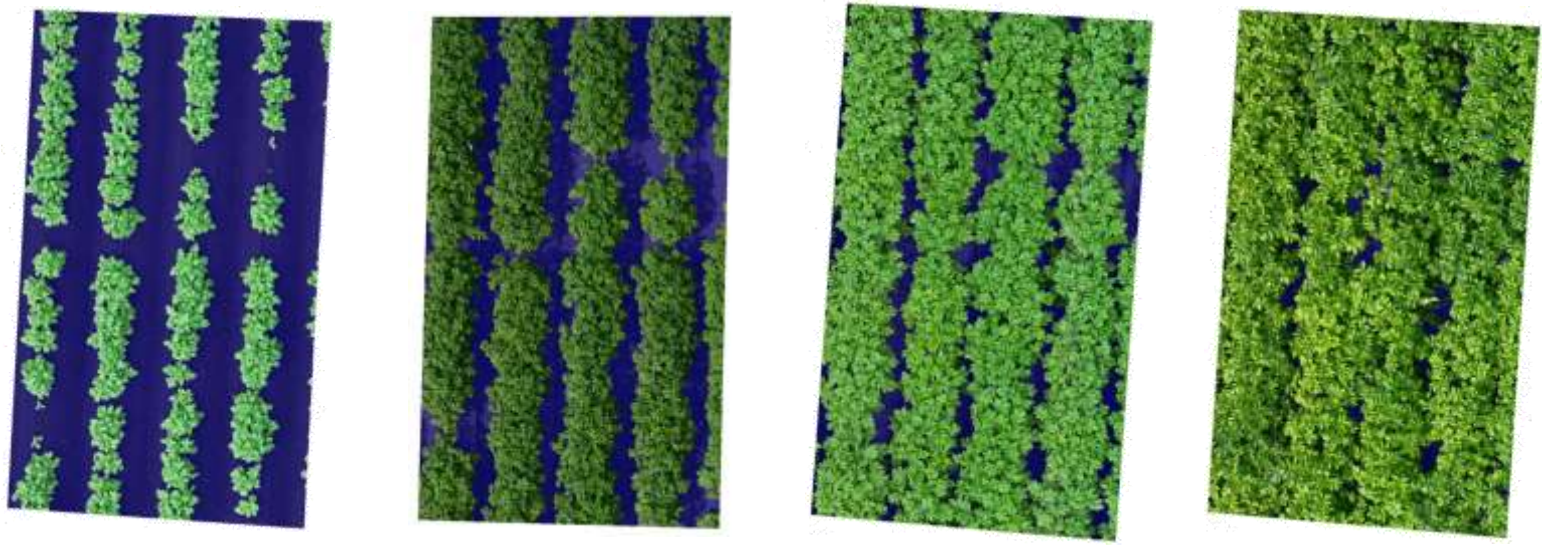
2. Methods & Results

3) Traits calculation – Coverage



Nagasaki field

Hokkaido JA field



Processing speed: 2s per plot

Fraction of Coverage

2. Methods & Results

3) Traits calculation

Fraction of Coverage

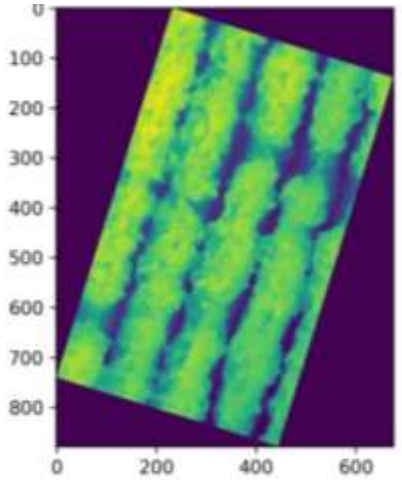
Canopy Height

Canopy NDVI

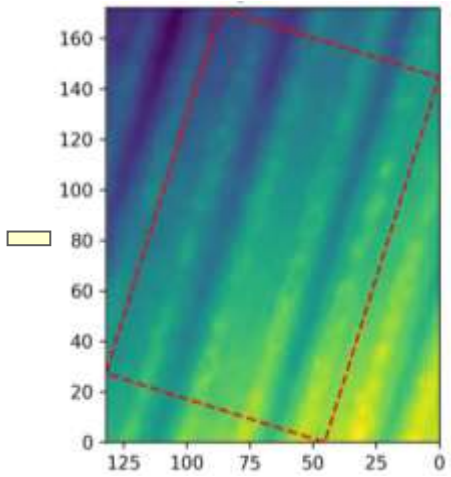
2. Methods & Results

3) Traits calculation – Height

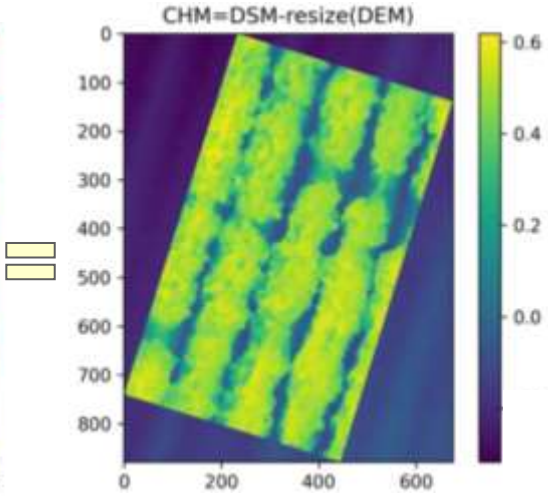
EasyIDP plot region extraction



Surface model of specific date (DSM_i^{plot})



Bare soil surface model at early stage (DSM_0^{plot})



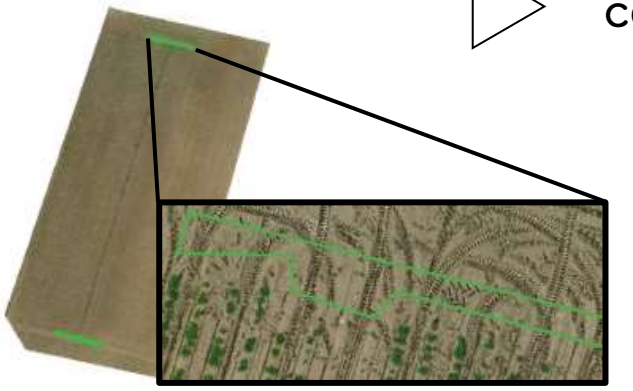
Canopy surface model

Nagasaki plot is stabilized by GCPs

95p meanHt

Means of over 95 percentile of CHM

Hokkaido JA plot without GCPs



Height offset calibration by bare region

$$= \overline{DSM_i^{cali}} - \overline{DSM_0^{cali}}$$

2. Methods & Results

3) Traits calculation

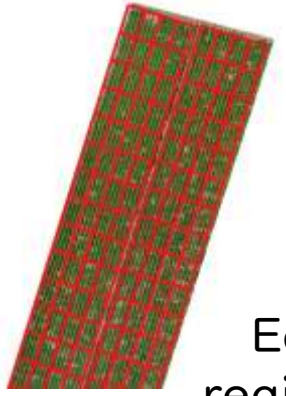
Fraction of Coverage

Canopy Height

Canopy NDVI

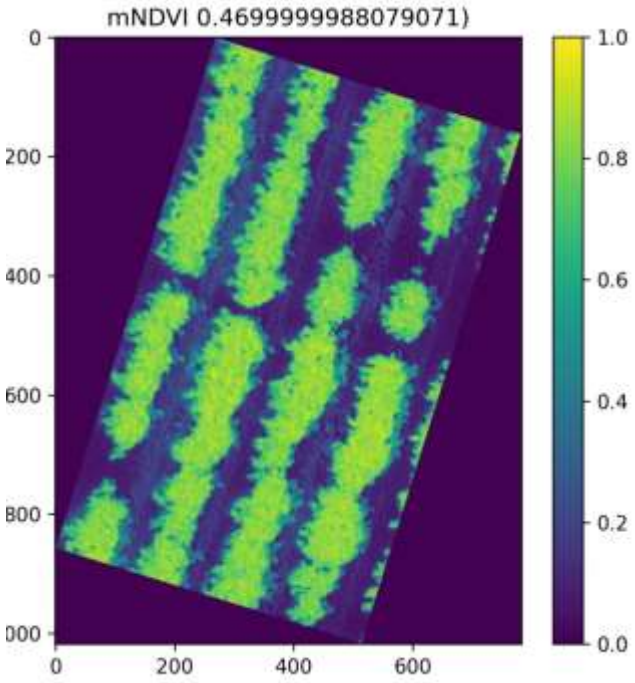
2. Methods & Results

3) Traits calculation – NDVI

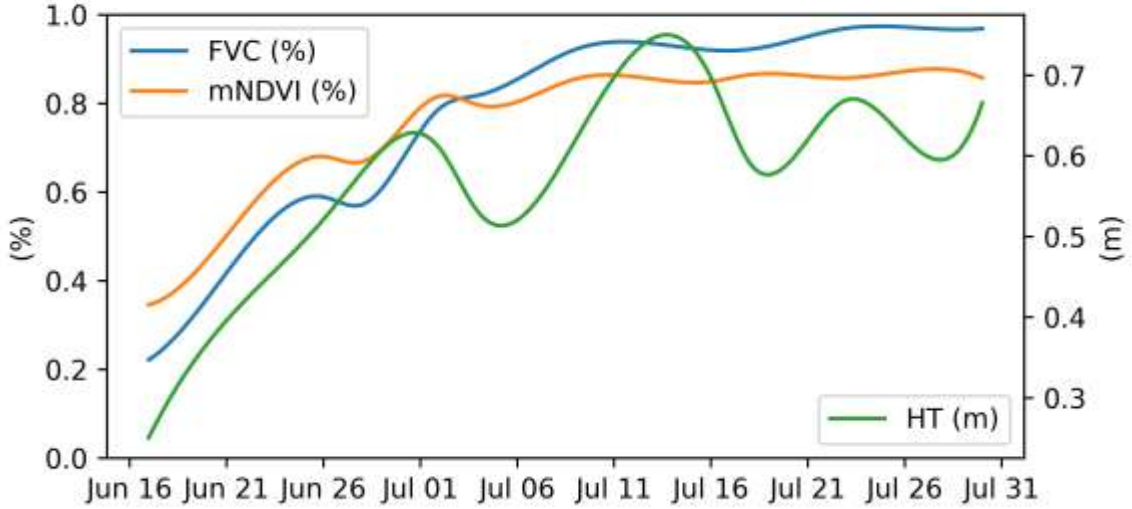


EasyIDP plot region extraction

meanNDVI



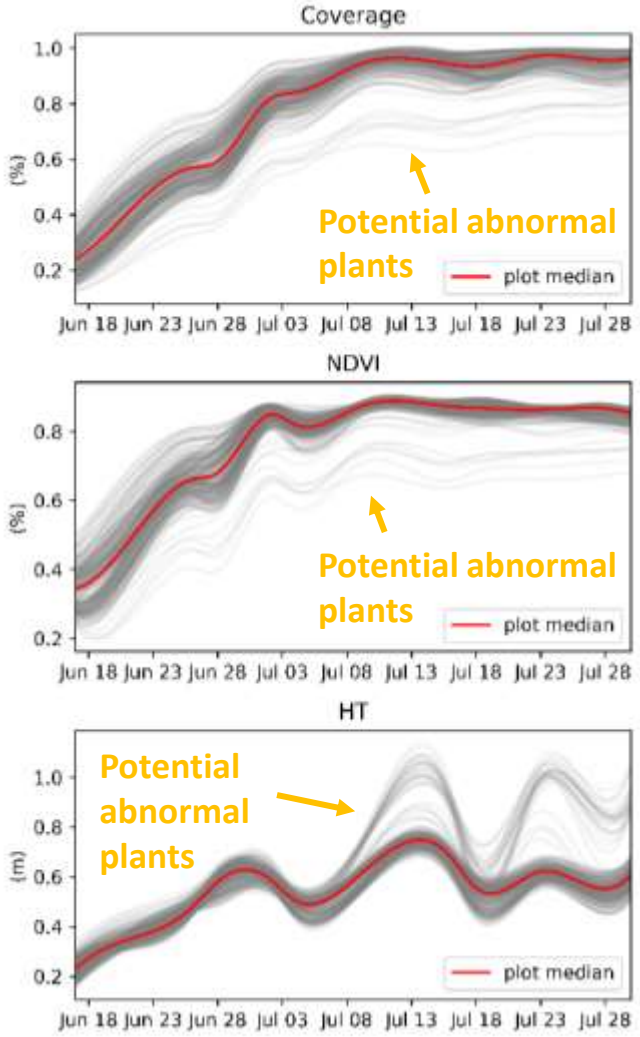
NDVI map of each plot



Plotting traits changes during growth

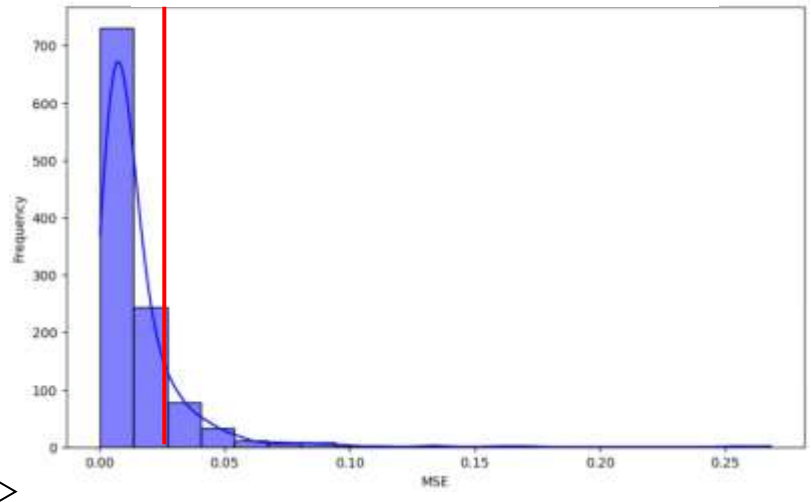
2. Methods & Results

4) Abnormal plot acquisition



Growth dynamic of full plot

Distribution of coverage MSE

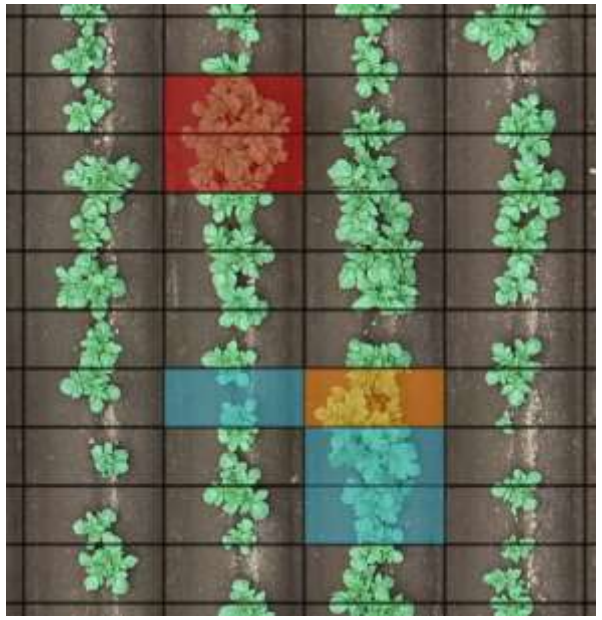


Estimate MSE of each plot to median

IQR outlier thresholding

$= 75\ percentile\ - 25\ percentile$

Counting outlier frequency of each trait



Appear

1 time	Slight Abnormal
2 times	Mid Abnormal
3 times	Abnormal

2. Methods & Results

5) Guide field operation by Google Earth App

Export result to KML file
for Google Earth App

```
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```

Slight Abnormal
Mid Abnormal
Abnormal

Field check
and remove

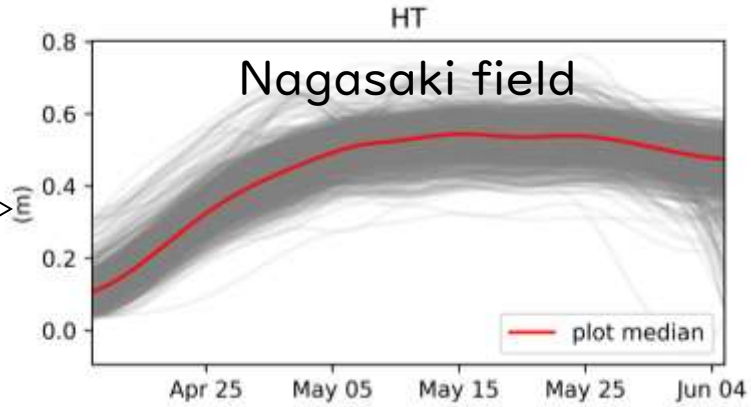
03 Results and Discussion

3. Results & Discussion

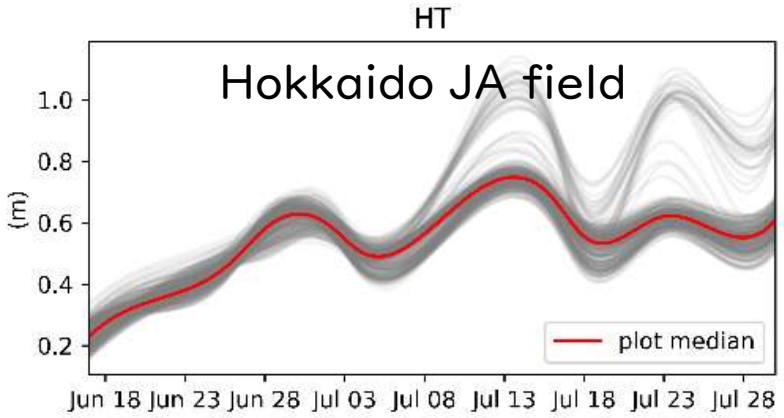
1) The effects of setting ground control points (GCP)

In pre-experiment, Nagasaki field sometimes involves large shifting

Hokkaido JA field has better RTK devices, acceptable on X-Y plane

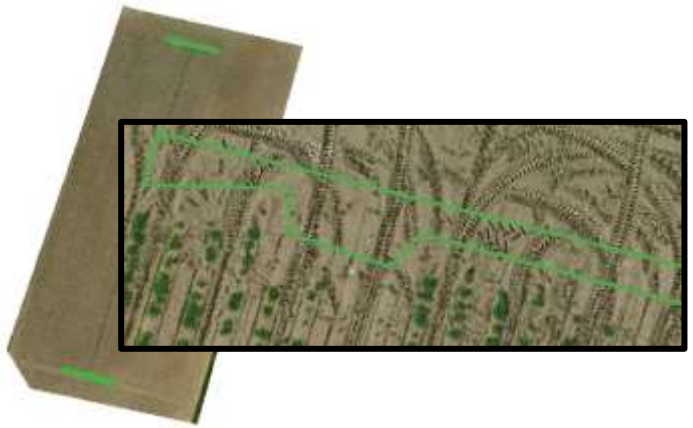


Setting GCP to stabilize both X-Y plane and Z-axis shifting



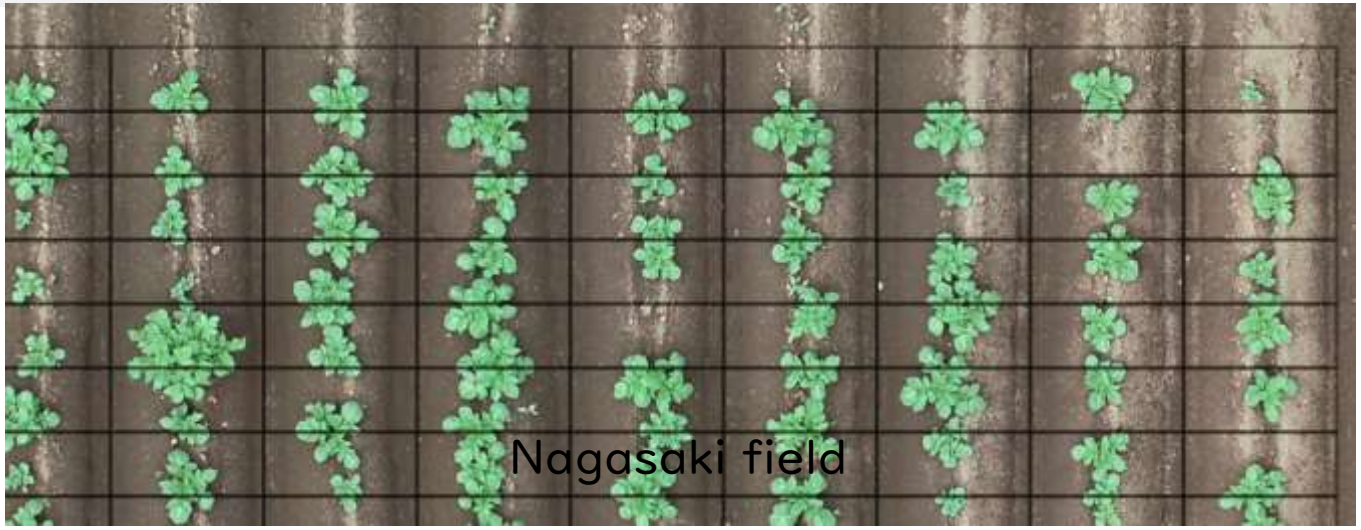
Without GCP to has large Z-axis shifting

Without GCP produces variable plant height even with calibration by bare area



3. Results & Discussion

2) The necessarily of root position detection



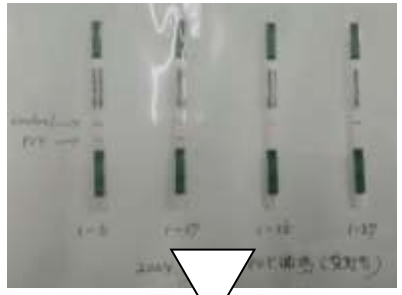
For quickly testing the feasibility of full pipeline, we simply generated grids not perfectly covering individuals and groups.

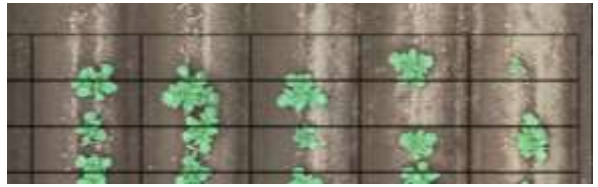
▽

Need developing individual root position / group boundary extraction method for better analyzing results

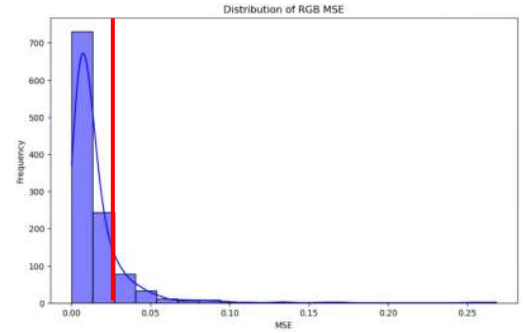
3. Results & Discussion

3) Abnormal miss detection for diseases



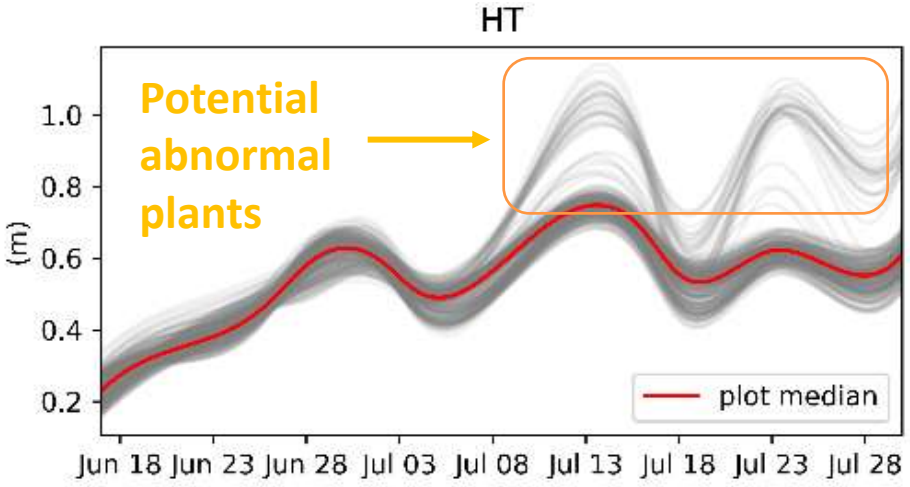


- Grid boundary not perfectly cover each plants

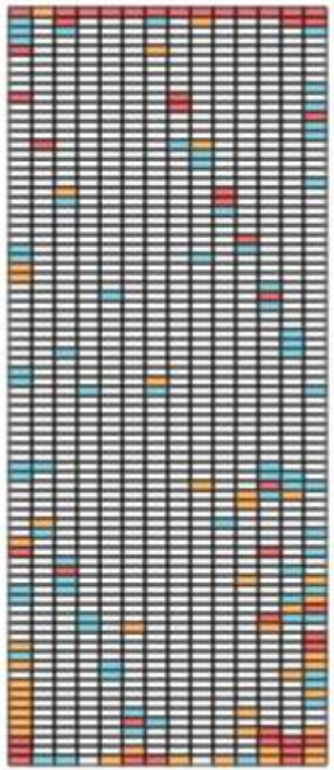


- Non-perfect outlier thresholding selection
- Only using HT, coverage, NDVI may not enough to reflect disease abnormal

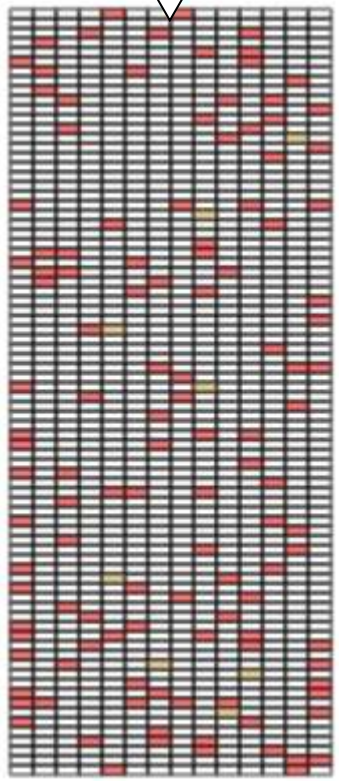
Current abnormal detection is statistical based “outliers”



The outlier abnormal results not catch with ground disease investigation well



Pipeline outliers abnormal



Ground disease investigation

Fusing RGB+Multi (3+4 layers) & Train time-series supervised machine learning classification models

04 Conclusions

4. Conclusions

Tested pipeline for detecting abnormal potato strains, including:

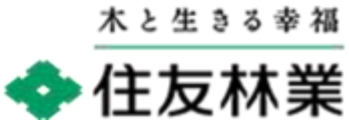
- Time-series UAV photogrammetry and batch processing workflow
- Coverage, NDVI and HT extraction by EasyIDP.v2 and EasyPCC.v3
- Abnormal detection based on statistical outliers
- Mobile app support for in-field operation

Future works

- Better root position & group boundary detection
- Train image-based supervised machine learning models for abnormal detection
- Integrate full pipeline to GUI-based software

UTokyo

Acknowledgement



Thank You !

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