Third ITU/WMO/UNEP Workshop on Artificial Intelligence for Natural Disaster Management

Using UAV and Deep Learning to Identify Pest Infested Trees in Natural Forests

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Insect Disturbed Forest

- 75 countries
- 85.5 million hectares
- 82% in temperate regions
- 3% = 2807 million hectares (van Lierop et al.,2015)
- 26% of 33.4 billion tons of forest biomass loss from 1979-2018 (Forzieri et al., 2021)

Purpose

- Quantify forest vulnerability to disturbances in order to develop mitigation and adaptation strategies.
- Require precise information at forest unit level, which is a single tree.
- Combine UAV and Deep Learning to automatically detect and classify tree health due to pest infestation.

Zao Mountain, Yamagata, Japan

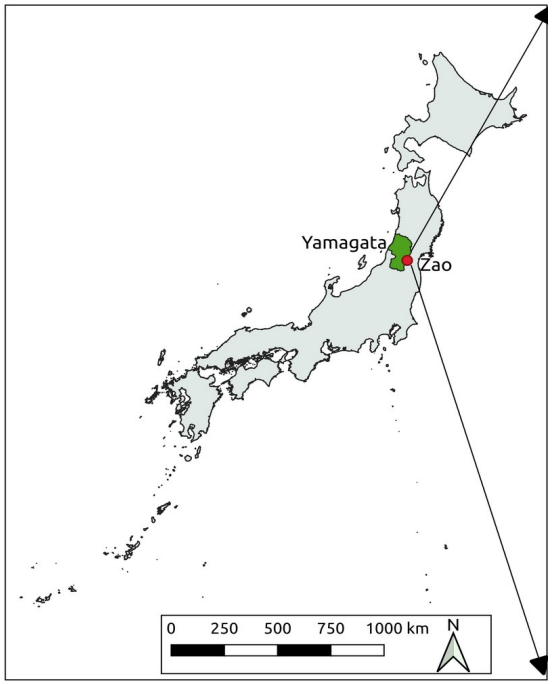


Image source: http://powerhounds.com

Zao Mountain – Pest infestation

Figure: dead trees in Zao Mountain

Totrix moth
2013 – 2016
Weakened the trees

Polygraphus proximus beetles
2016 – present
Kill the trees

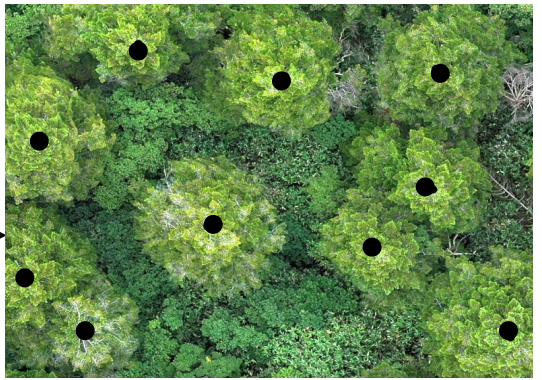
Image source: https://www.discoverlife.org/
http://nordicforestresearch.org/

Objectives

Drone images

OpenCV python™

Individual tree detection

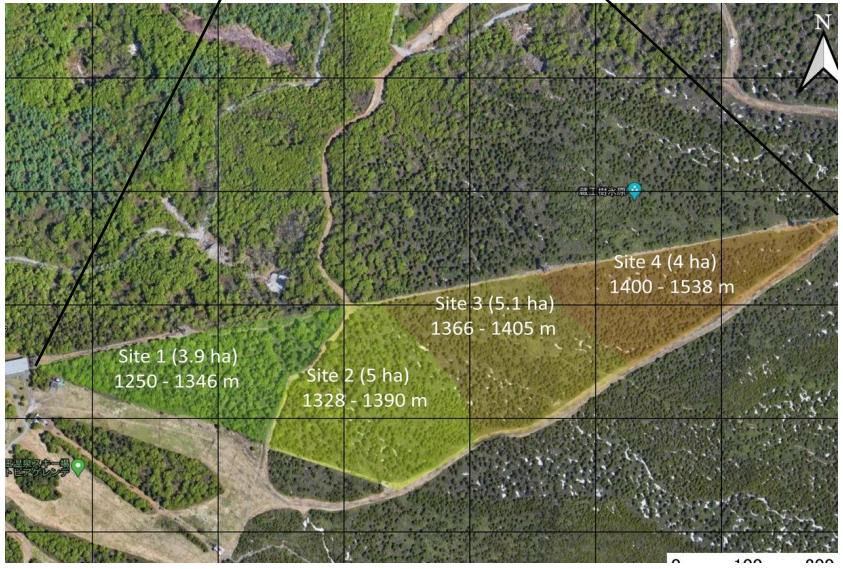


Deep Learning

Tree health classification

Healthy fir Sick fir

UAV Image Acquisition



- DJI Mavic 2 pro and DJI Phantom 4
- 18 hectares
- 4 sites
- 90% side and forward overlap
- Flying altitude 60-70m
- Ground sampling distance: 1.23cm – 2.54cm/pixel

Problem Definition

Healthy fir

Healthy fir

Sick fir

Sick fir

Healthy: no leafless branches were observed

Sick: leafless branches were observed

Individual Tree Detection

Drone images

Metashape,

Fusion, Global mapper

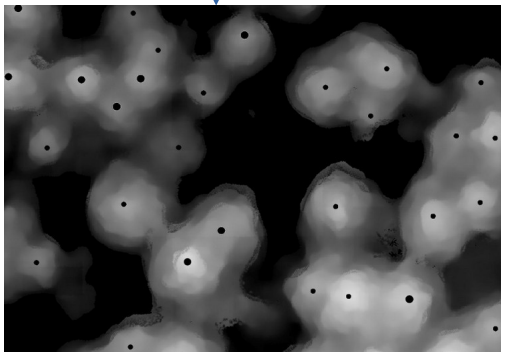
Canopy height model (CHM)

CHM (meters)

0

23

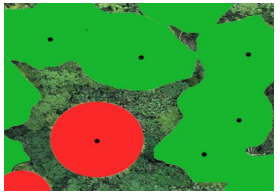
Using a sliding window to find the highest value



Deep Learning – Individual Tree Classification

(GT/detected) Treetops

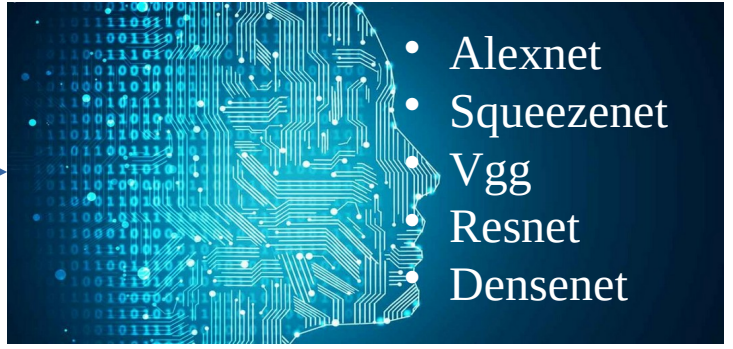
Annotated tree types



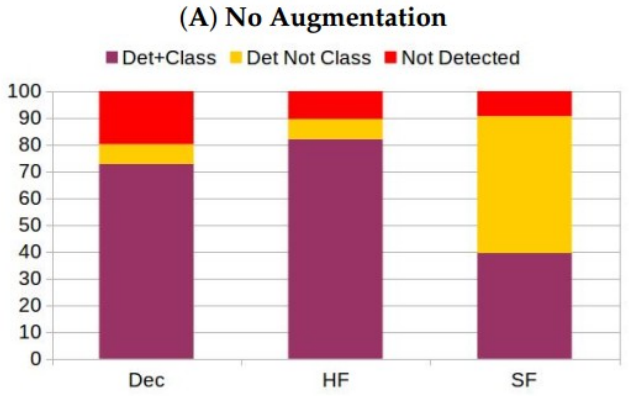
Healthy fir

Sick fir

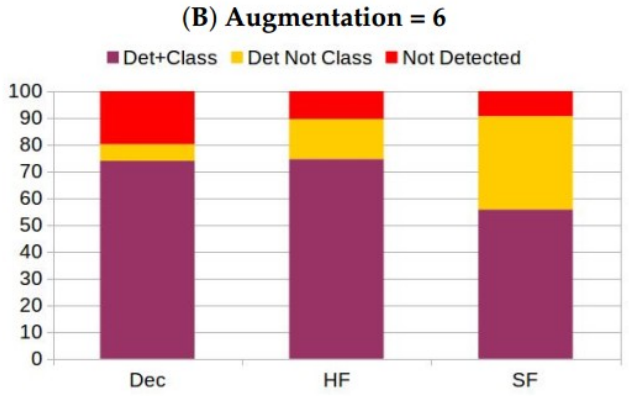
Deep learning



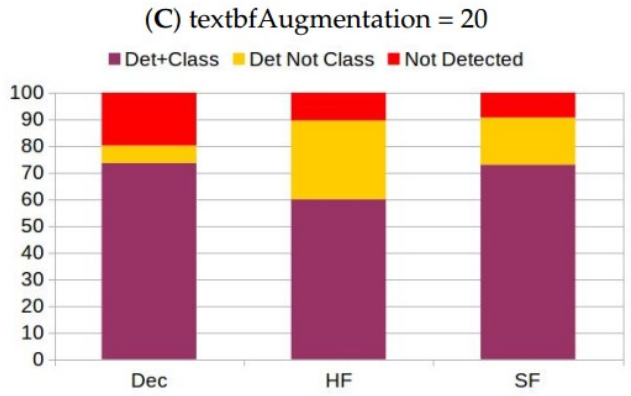
Result and Discussion – Classification of Detected treetops



DM% All Classes = 78.59%
Sick Fir (DM%, FPR) = (39.64, 0.26)



DM% All Classes = 73.47%
Sick Fir (DM%, FPR) = (55.82, 2.13)

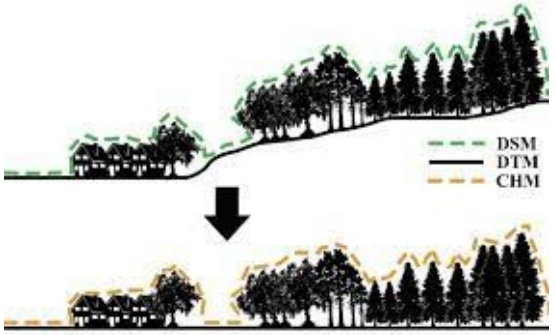


DM% All Classes = 63.57%
Sick Fir (DM%, FPR) = (73.01, 5.24)

SF: sick fir (169 trees)
HF: healthy fir (3788 trees)
Dec: deciduous (1407 trees)

- Detection + classification
- Detection not classification
- Not detected

Results and Discussion



- The constructed CHM made the treetops shift
- Trees close to each other were usually identified as one tree
- Small fir trees (< 4 m) were not visible on CHM
- The dead trees hardly appear on CHM, limiting the ability to identify dead trees

Conclusions

- Treetop detection was found to be a key part in the process of automatic classification of fir tree's health using DL. However it has not been studied in enough detail so far.
- We have shown how computer vision and DL networks when used to process UAV-acquired images, already provide a valuable tool for the automatic detection and monitoring of sick fir trees with tangible benefits in terms of study time, human resources needed and extent of land area required for study.

Conclusions

- The implementation of UAV acquired RGB images, computer vision and DL techniques prove a high potential to evaluate the impact of insect outbreaks in forest.
- Regarding future research directions, quantifying different degrees of damage will provide a valuable tool for early warning and the design of insect damage control strategies.
- Collecting datasets with a larger number of sick tree examples would reduce the need to use data augmentation and with it, the number of false positive detections.

Reference

- Nguyen, H. T., Lopez Caceres, M. L., Moritake, K., Kentsch, S., Shu, H., & Diez, Y. (2021). Individual Sick Fir Tree (Abies mariesii) Identification in Insect Infested Forests by Means of UAV Images and Deep Learning. Remote Sensing, 13(2), 260.
- van Lierop, P., Lindquist, E., Sathyapala, S., & Franceschini, G. (2015). Global forest area disturbance from fire, insect pests, diseases and severe weather events. Forest Ecology and Management, 352, 78-88.
- Forzieri, G., Girardello, M., Ceccherini, G., Spinoni, J., Feyen, L., Hartmann, H., ... & Cescatti, A. (2021). Emergent vulnerability to climate-driven disturbances in European forests. Nature communications, 12(1), 1-12.


THANK YOU