

TRUEBRANCH

METRIC LEARNING-BASED VERIFICATION OF FOREST CONSERVATION PROJECTS

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Motivation

- Deforestation and forest degradation accounts for ~15% of all global greenhouse gas emissions ^[1]
- International stakeholders are paying landowners for forest conservation, if they can verify it ^[2]



www.reforestationworld.org

[1] IPCC. 2019: Summary for policymakers, WWF

[2] UN-REDD Programme, www.goldstandard.org

Monitoring, reporting and verification process

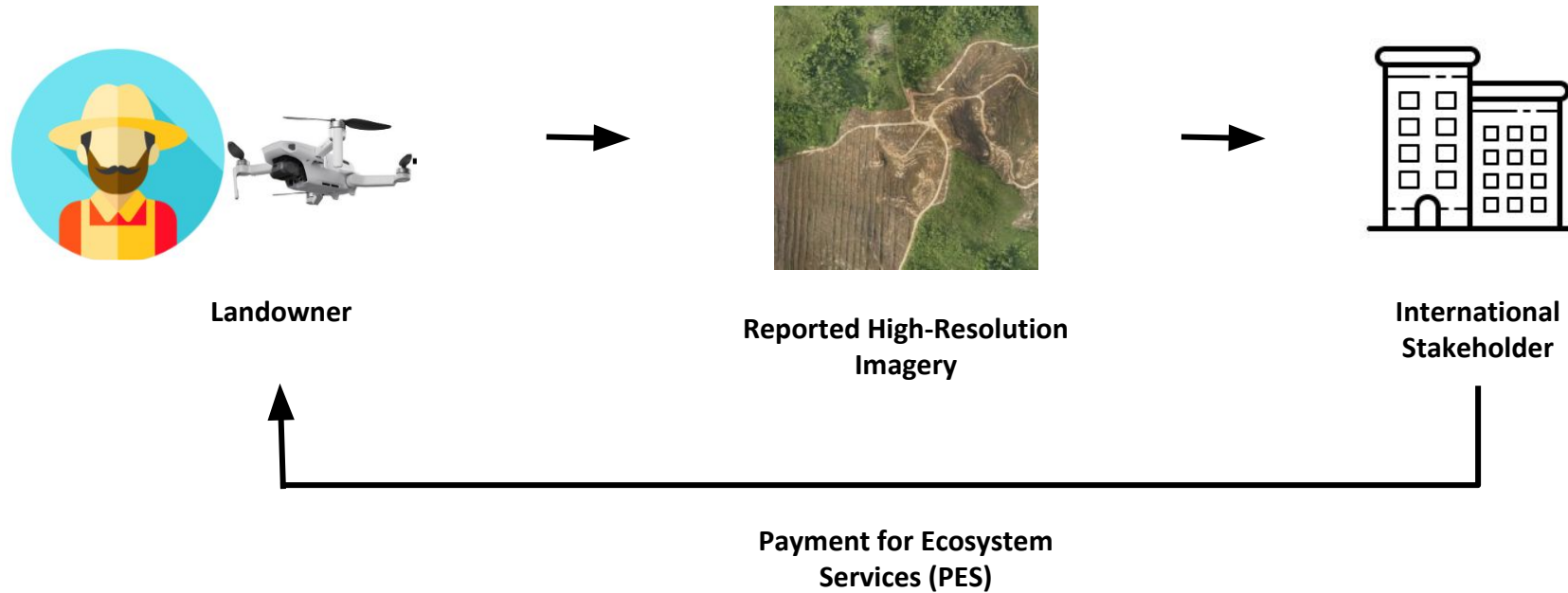
- On-ground inspection is expensive (300 USD/ha^[3]), biased, hard to scale, and corruptible
- Carbon estimates by satellites can have high uncertainties and long lead times



[3] Interviews with Ministry of Agriculture Peru

Verification with Drones

- Low-cost monitoring via drones



Challenge

- Opens up possibility of untruthfully reported imagery
- Attack vectors

*Reported
Land-Use*



true time
true location

*Detected
Forest Cover*

medium



wrong time
true location

high



true time
wrong location

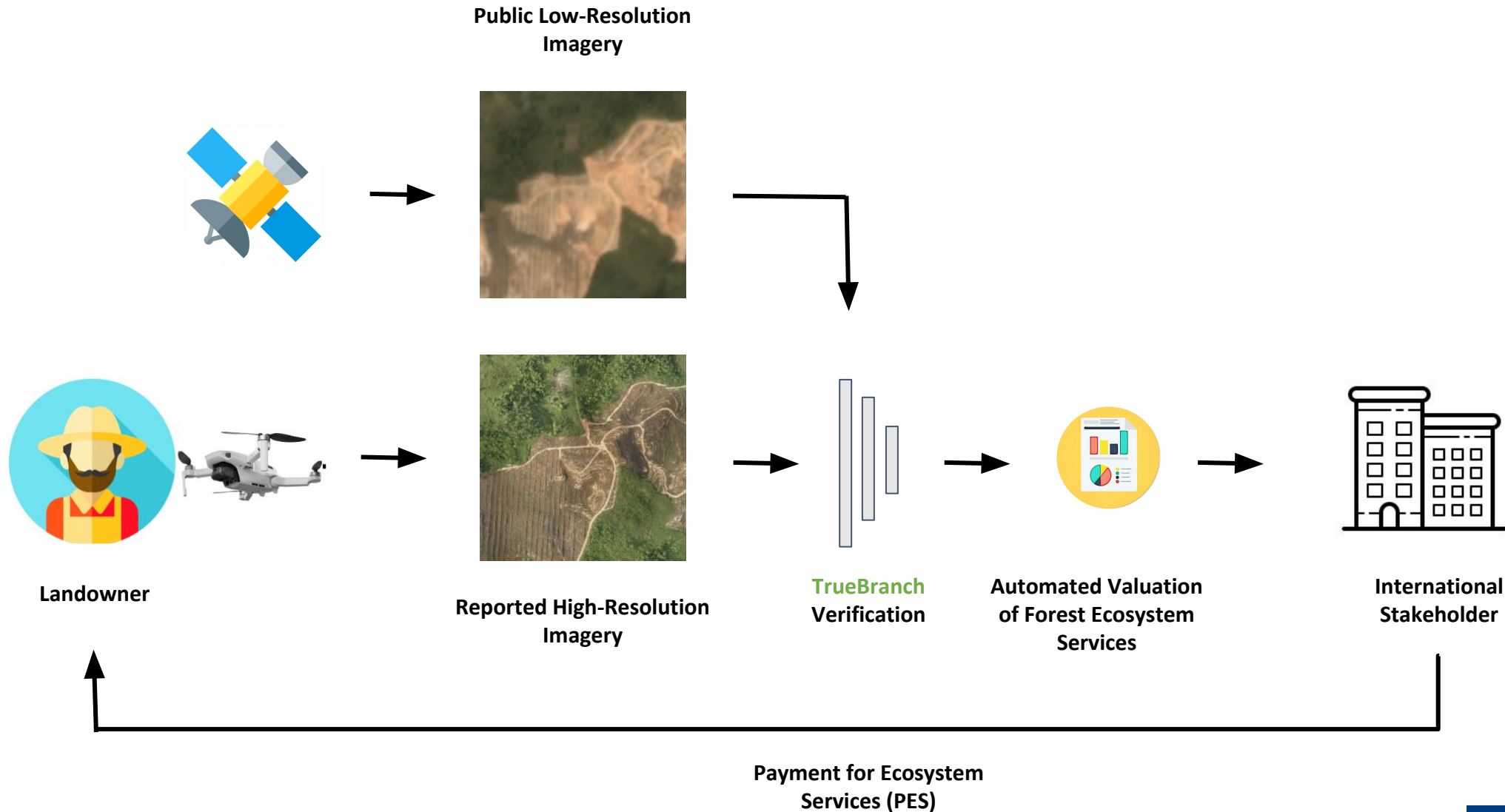
high



modified image

high

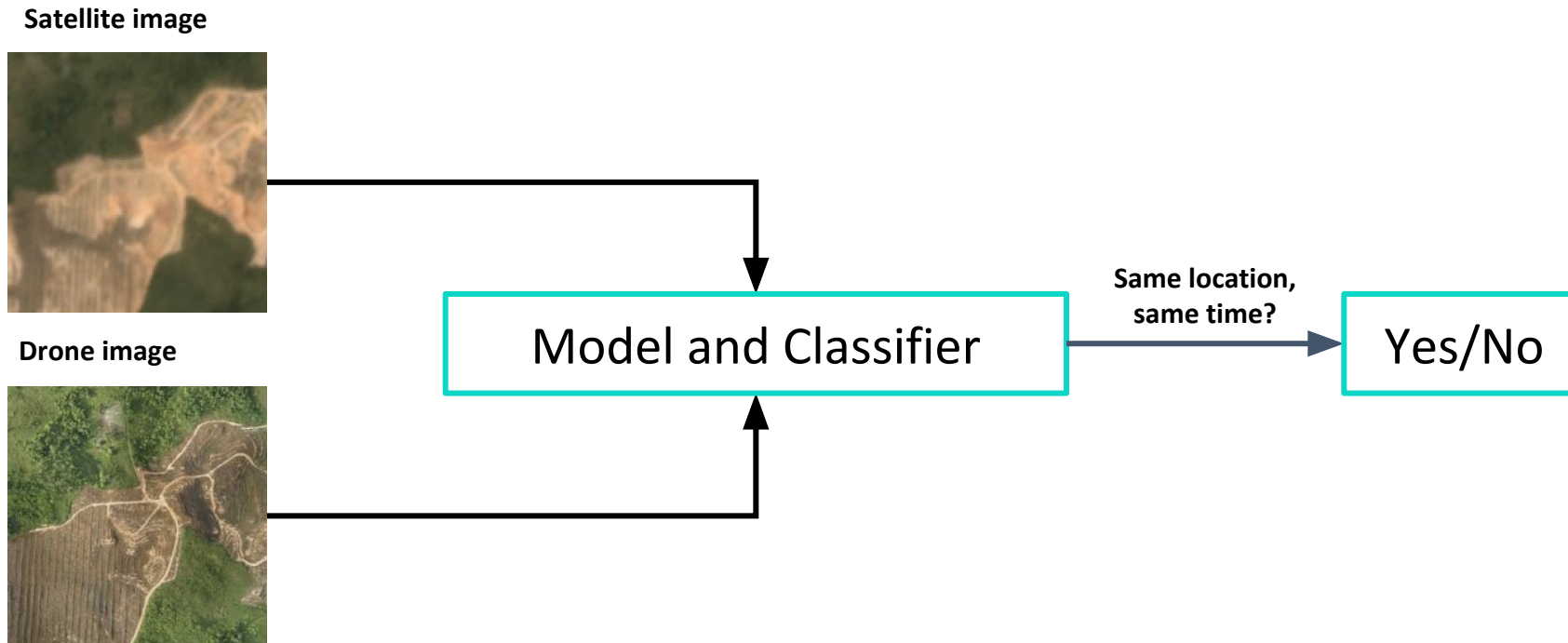
Approach - True Branch Verification System



Forest validation algorithm

How to distinguish truthful imagery from untruthful imagery?

- Image Registration: Matching Drone images with Satellite images



Nominal Metrics not able to detect attacks

- Nominal distance metrics of MSE in pixels space

Satellite image

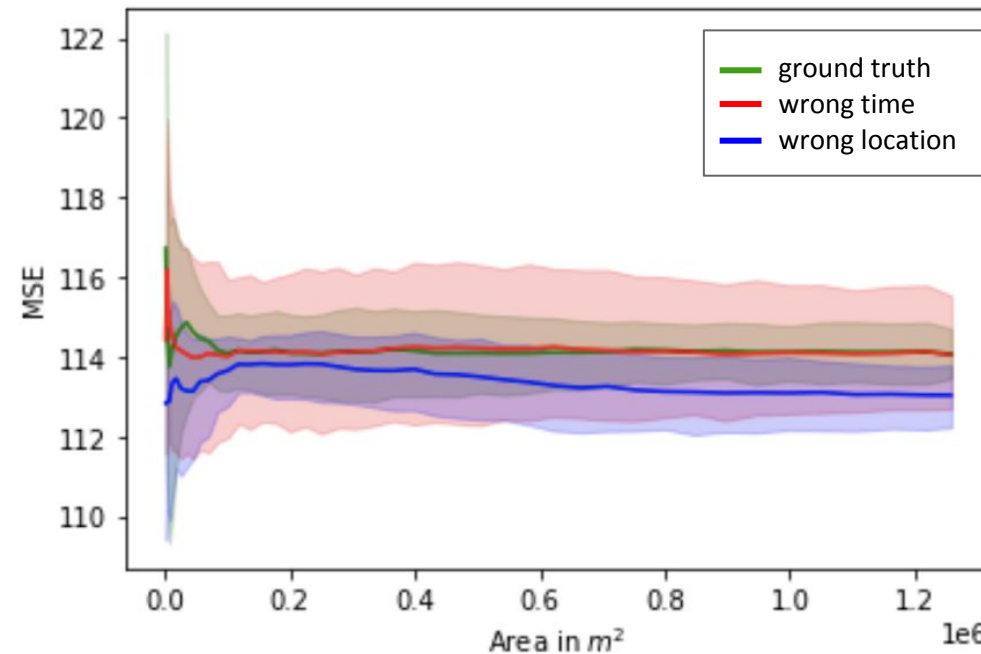


Drone image



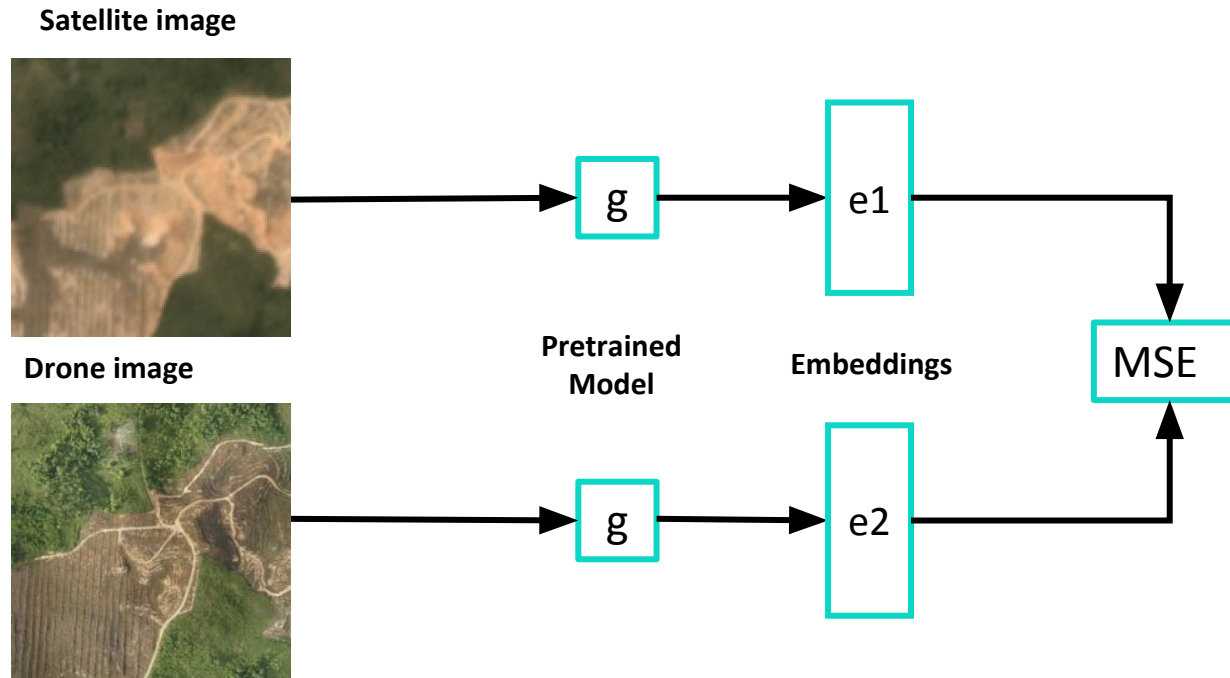
MSE

- MSE in pixel space

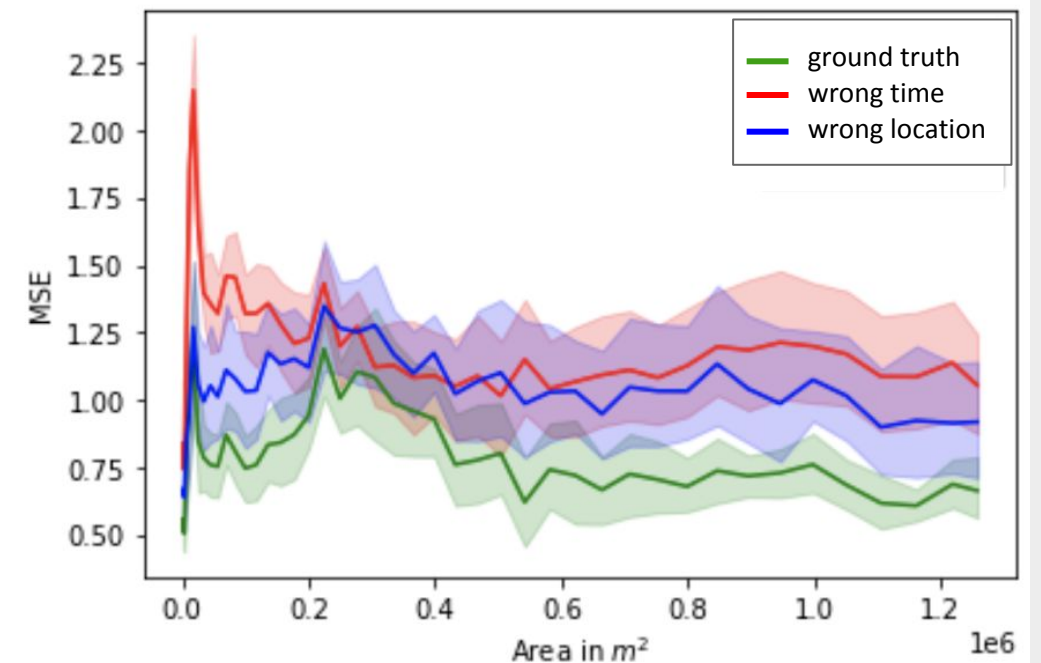


Nominal Metrics

- Nominal distance metrics of MSE in feature space

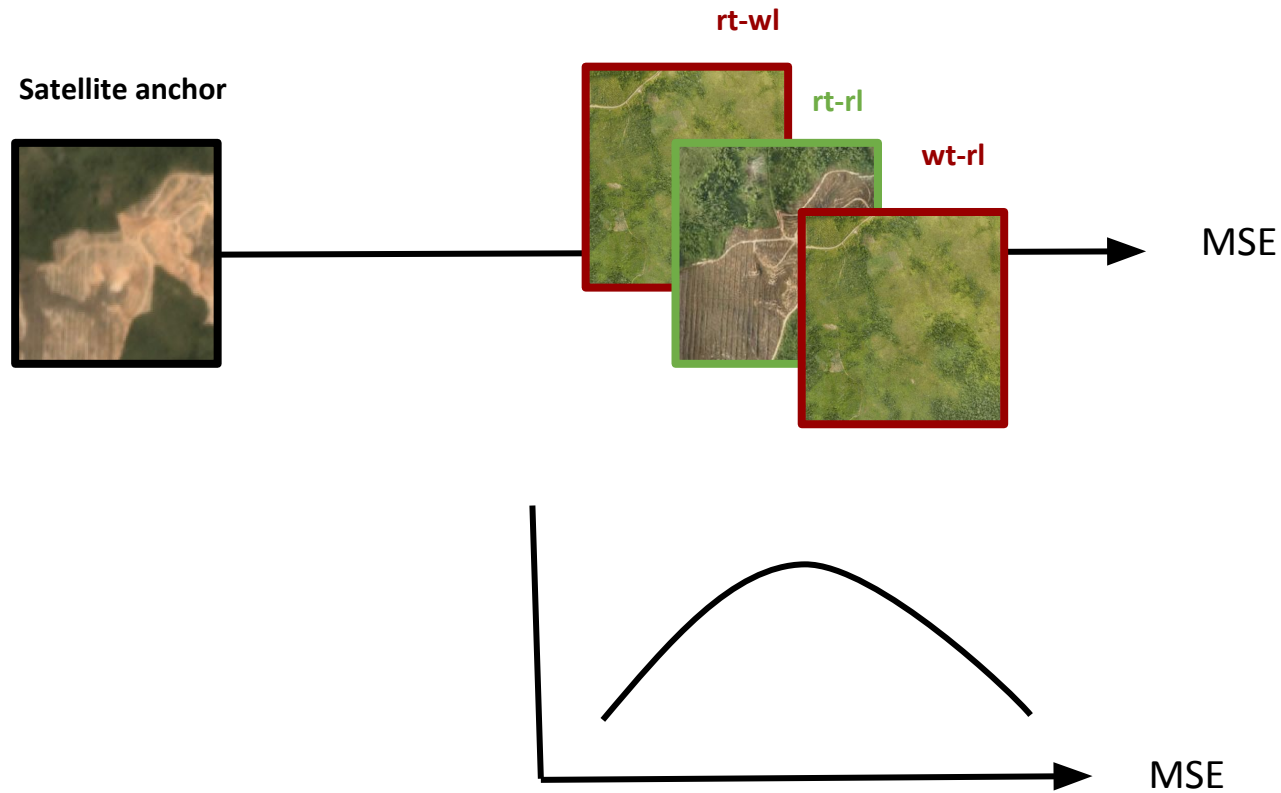


- MSE in feature space



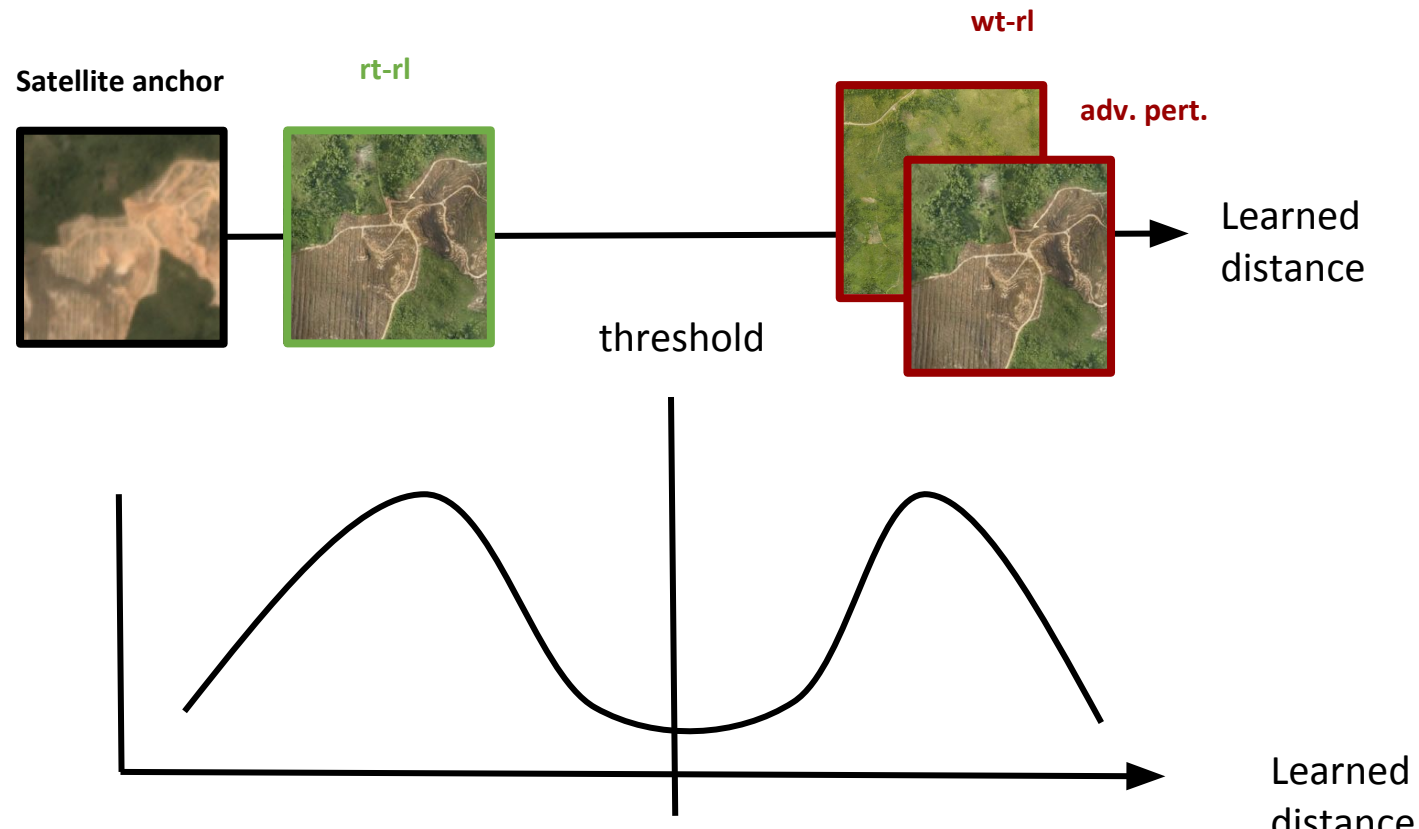
Learned Metrics

- MSE in pixel space and RESISC-45 feature space not sufficient

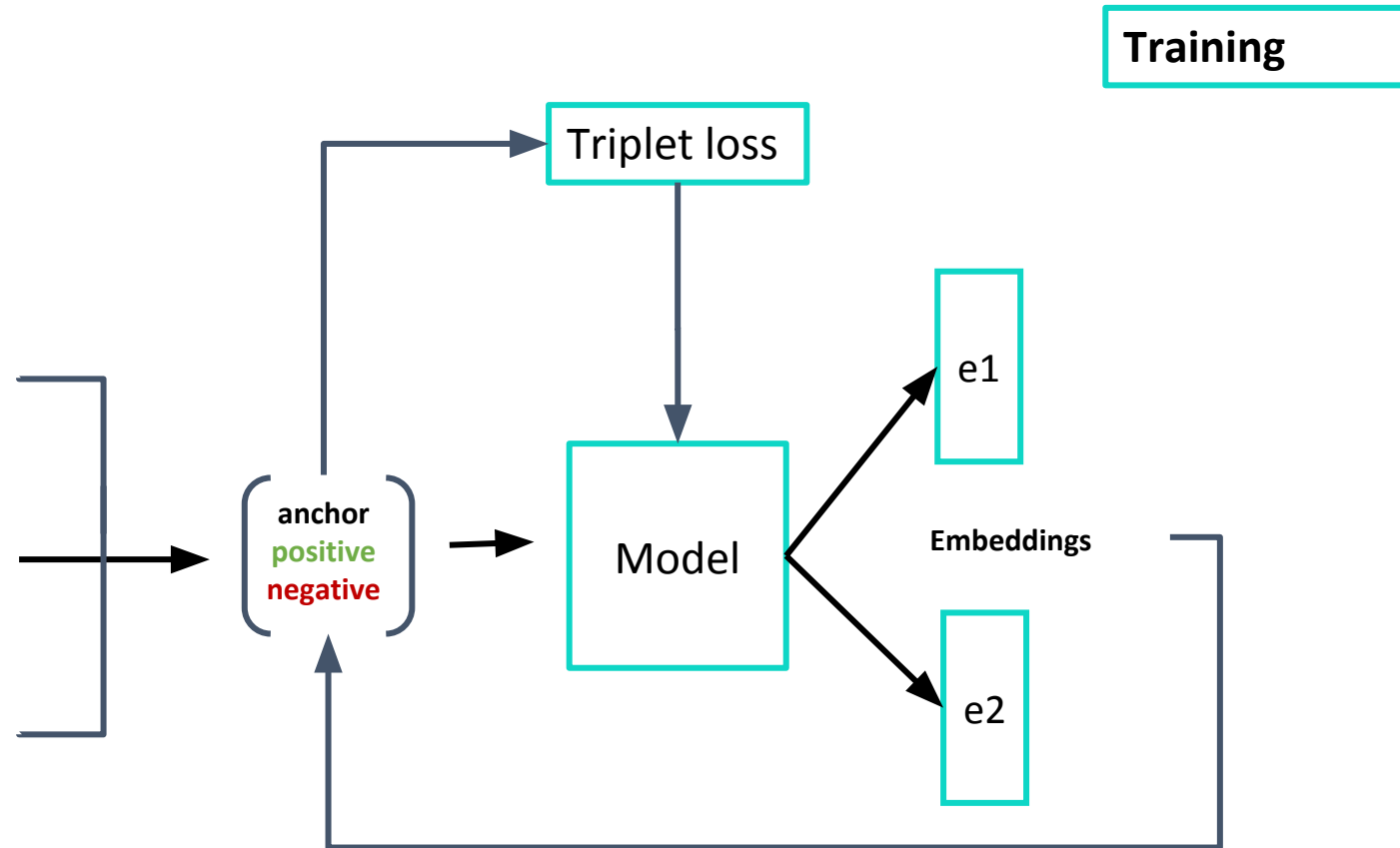
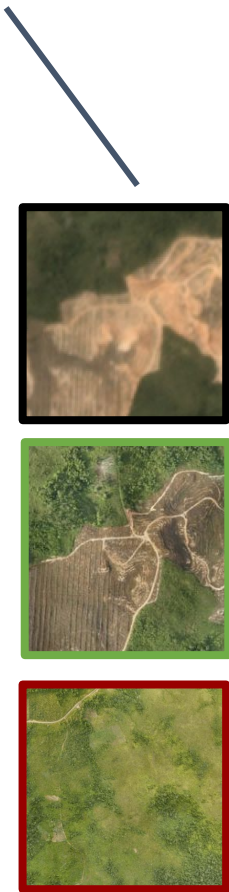


Learned Metrics

- MSE in pixel space and RESISC-45 feature space not sufficient
- Metric learning with triplet loss function

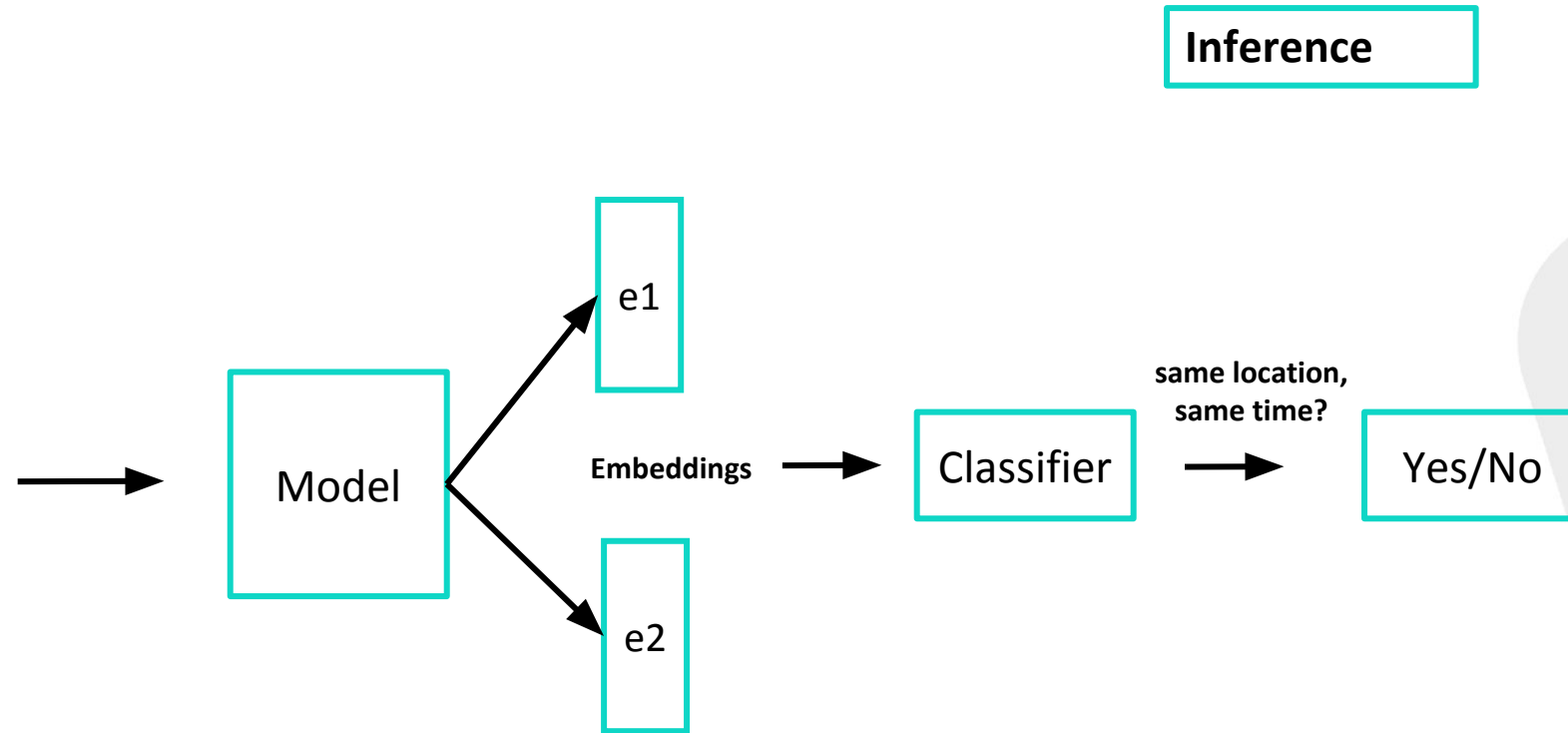
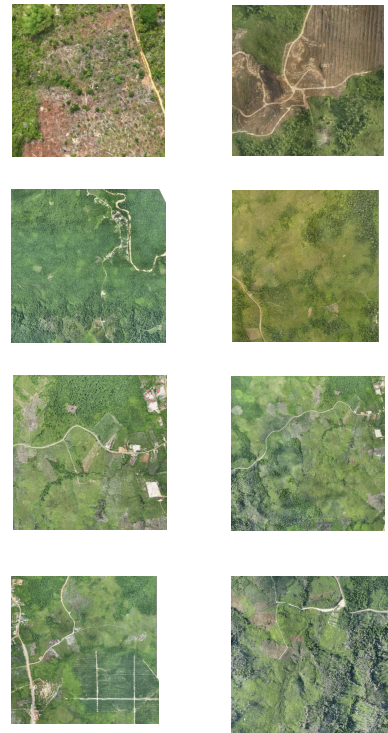


Metric Learning with Triplet loss



$$L(\underline{a}, \underline{p}, \underline{n}) = \max(|f(\underline{a}) - f(\underline{p})|^2 - |f(\underline{a}) - f(\underline{n})|^2 + \alpha, 0)$$

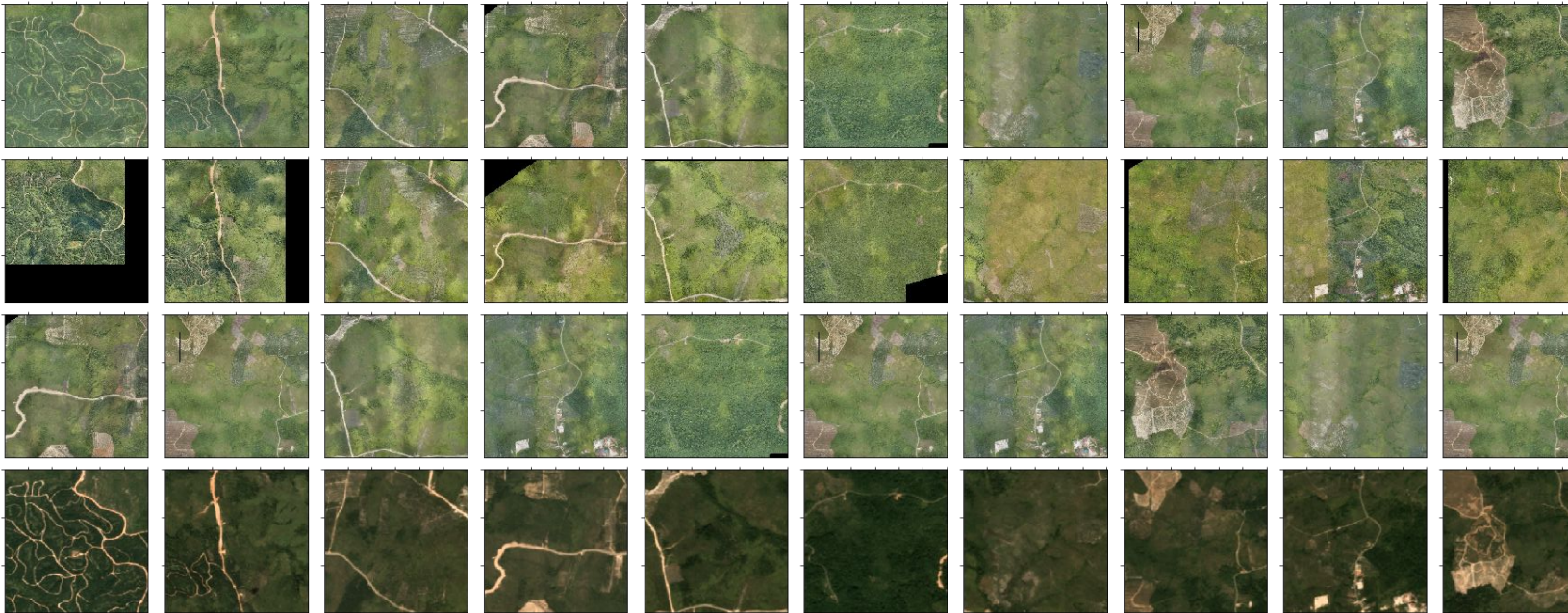
Metric Learning with Triplet loss



First Results on Dataset in Indonesia

- Dataset:

10 different locations, 3 different years



First Results on Indonesian Dataset



- Difference between satellite image and drone images

Satellite anchor



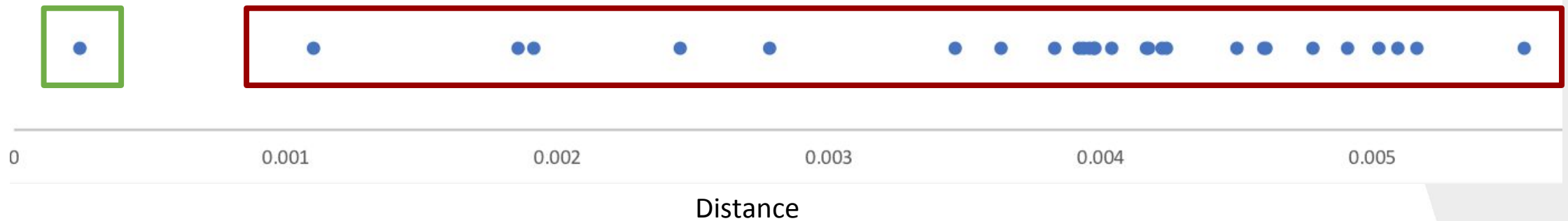
rt-rl



wt/wl



Location



Conclusion and Further Work



- Model with metric learning is able to distinguish truthfully reported imagery from untruthfully reported imagery
- Model evaluation on more training and testing data to ensure high reliability
- Protecting model from Adversarial perturbation
- Metric learning with images from different sources with different resolutions

Thank you very much for your attention

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