AI4Good 2022: Team 3A

ReforesTree: A Dataset for Estimating Tropical Forest Carbon Stock with Deep Learning and Aerial Imagery

Presentation 4

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Agenda

- Reminder: Problem and Context
- Overview of Advances and Insights
  - Reproducing the Paper’s Results
  - Tree Crowns Detection & Bounding Boxes Matching
- Tree Crown Detection with DeepForest
- Out-of-site Filtering
- Field Data Matching
- Work Plan Overview
- Questions

Reminder: Problem and Context

Data Quality

- Relevant data are trees location, DBH, AGB. Height also useful for imputation.
- Around 95% of the height values are missing. 230 trees have a height value.
- Around 44% of the diameter values are missing. 2631 trees have a diameter value.
- AGB has inconsistent values.
- Note: pointless to predict the DBH without knowing the group of all trees

Location noise + plantation area hard to delimit accurately (even using the shapefile!)
→ poor one-to-one mapping between detected trees and the field data samples

We do not have the true matching of an image of a tree and its group
→ we can at best differentiate manually banana vs. non-banana

Reminder: Problem and Context

Recall the ultimate goal:
→ Predict the carbon stock of a tropical agroforestry site based on RGB drone images.

This is what we aim for, or at least want to contribute to!

The paper's data are not good enough to be able to evaluate the feasibility and performances of such a procedure.

For a model to be able to be used, evaluated and improved, we need appropriate data.

How to Evaluate Meaningfully Our Results ?

- Paper's data (and hence results) are not meaningful... but the general procedure may be.
- We can (try to) reproduce their results... and consider:
  - Our model on their data
  - Their proposed model and ours on our new data

But... creating new data and baseline justifiably better (--> qualitative analysis) seems more relevant!

- To obtain a more quantitative comparison to the paper's model, we need to reproduce very closely its experiment setting as the RMSE was used as sole evaluation metric

Reproducing the Paper's Results

- From what we explained previously, we naturally focus on improving the data, but...
- It is still useful to obtain similar results as that of the paper, because it allows us to compare our model to theirs in addition to comparing them to the improved data.
  → can help with the qualitative analysis of the data and performances.
- We focused on two models: a simple CNN and a pre-trained ResNet18 to be fine-tuned on the data.
- We modified the models so that they can handle different types of inputs:
  - images (tree crowns) OR
  - images + categorical feature (i.e., tree group label)
    → appropriate (considering that we can add a binary group classification ability to the DeepForest model) and useful (considering that the AGB of a tree is related to the tree group)
- We used a similar sampling procedure, the same batch size of 64, epoch number of 30, learning rate of 1e-3, with a MSE loss and Adam optimizer, to estimate single trees AGB.

> With a dataset of matched bounding boxes and tree labels, we fine-tuned a basic pre-trained CNN, ResNet18 (He et al. 2015) with a mean-square-error loss to estimate individual tree AGB. The results were satisfying despite the simple

- We did not manage to obtain a RMSE as low (i.e., 0.1) as that of the paper. → The experiment setting needs to be exactly similar to be able to compare

Tree Crowns Detection and Bbox Matching

Tree Crowns Detection

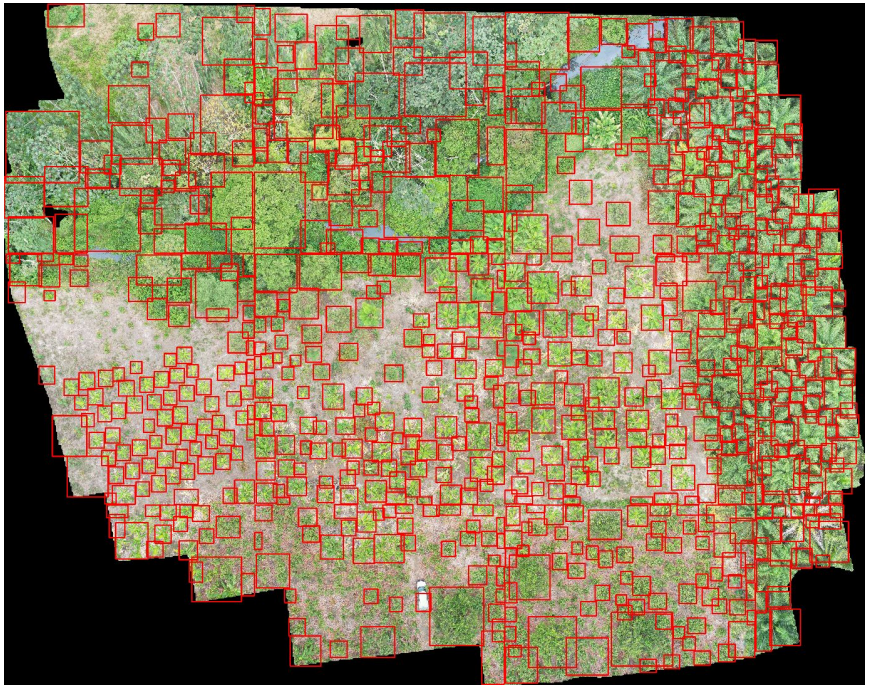
- Same trees are detected multiple times
- Trees outside of the area to be considered are detected
  → we can use the shapefile to delimit the relevant area within the agroforestry

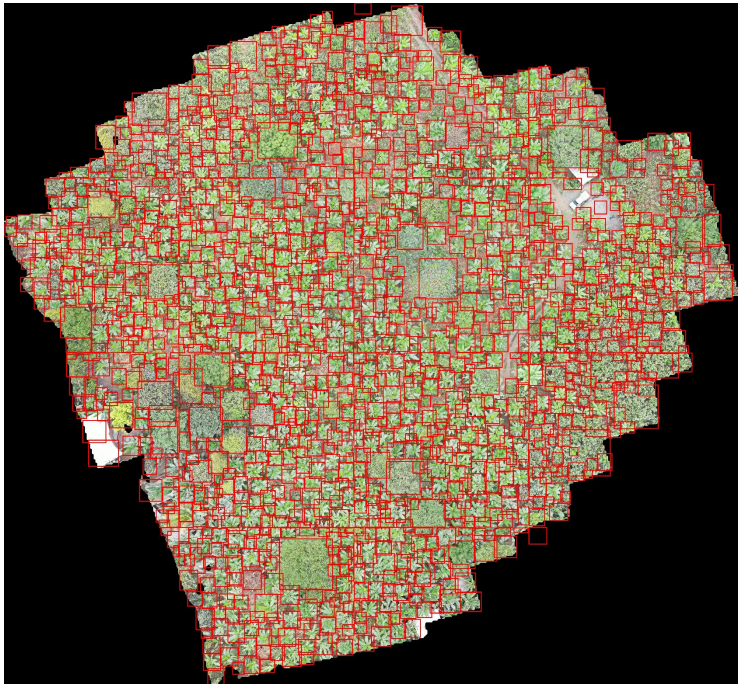
- We annotated manually more than 2000 trees (almost half of the field data although there are more trees than in the field data)
- We use the reliable annotations to fine-tune the DeepForest model
  → improves the tree crown detection
  → reliable way to make the model learn to differentiate between the group banana and non-banana (which can certainly improve the results)

Bounding Boxes Matching

- Without a good matching, the regressor cannot learn a meaningful distribution
- Paper's matching is very poor, hence yielding unreliable data measurements per tree
- We want a (direct) 1-to-1 matching... but we have noise + hard to detect exactly all trees
- In the paper, they use a simple greedy algorithm based on Euclidian distance
  → possibilities of improvement!
- Despite the obvious improvements when using the shapefile, there still seems to have a noise issue...

Tree Crown Detection

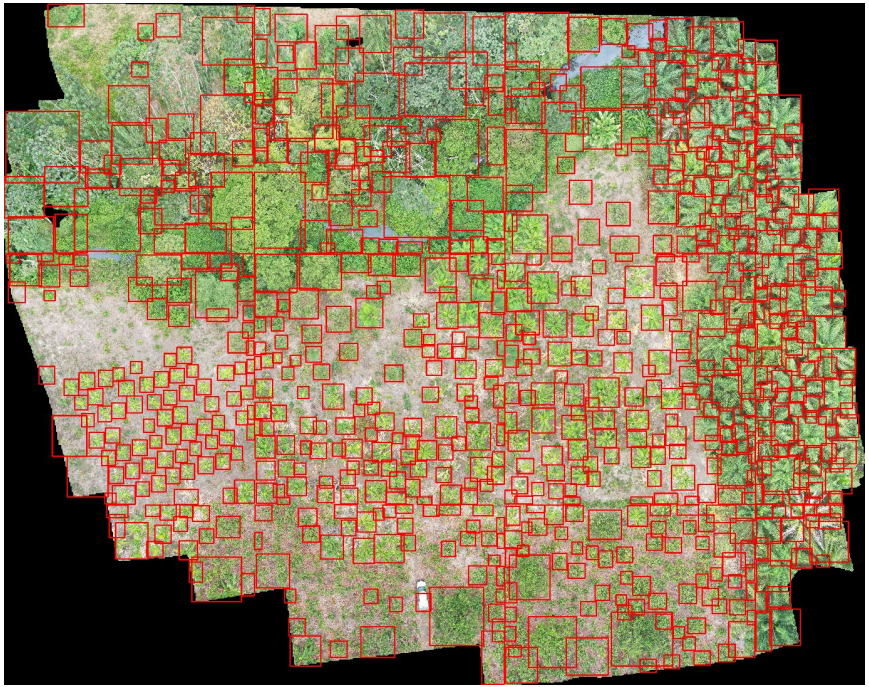


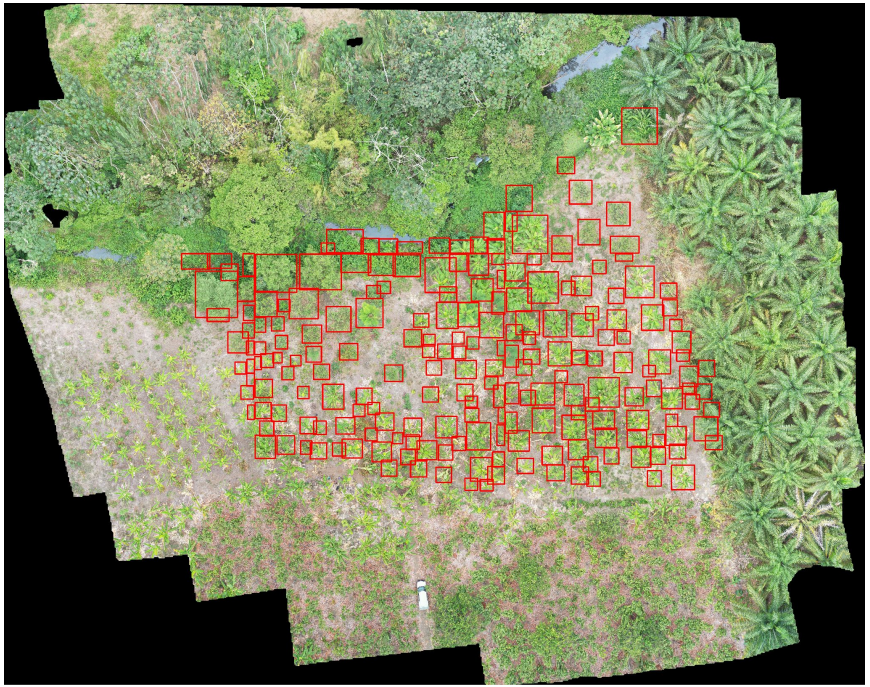


Tree Crown Detection

- The current deepforest model only predicts bounding boxes of trees
- The score (probability) is also an output of the model
  - The score is used for matching with optimal transport
- It is possible to use probability that a detection belongs to each tree group to improve matching
- Moving forward: train detection model that distinguished bananas and non-bananas

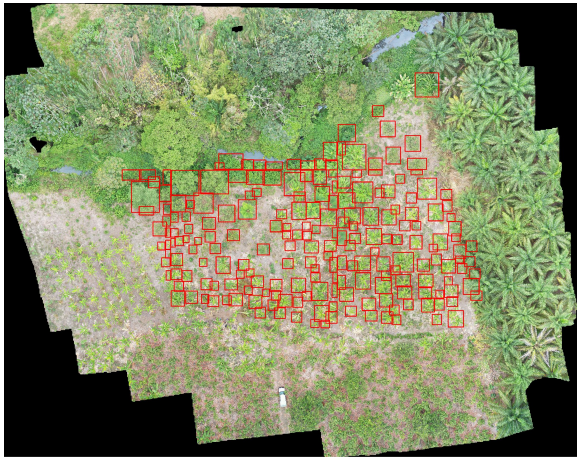
Out-of-site filtering





Out-of-site filtering

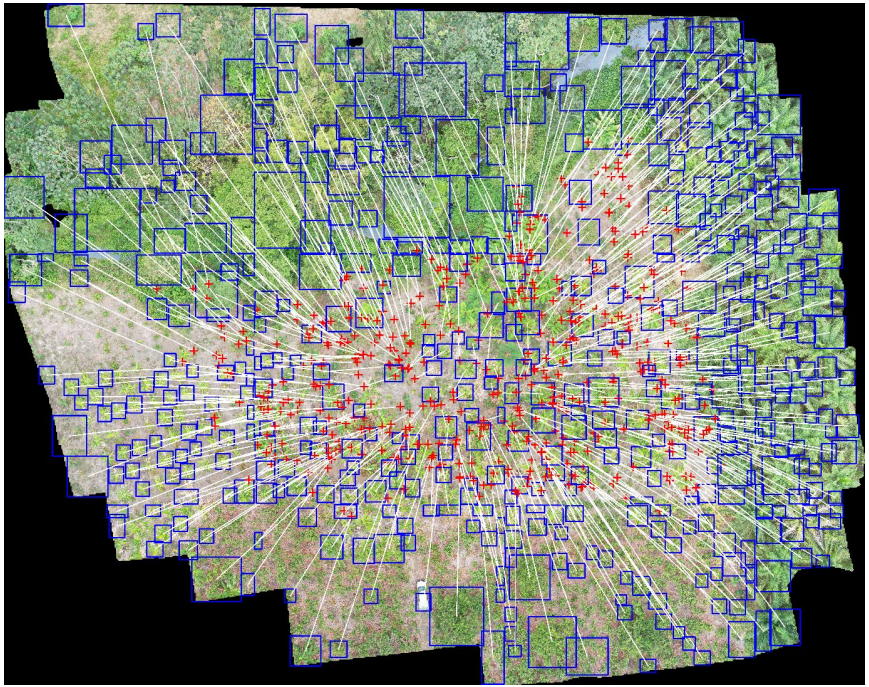
- Boundary of site is given in the dataset
  - List of GPS coordinates to form a polygon
- A detected tree is in the site, if the center of the bounding box is within the boundaries
- How were the boundaries of each sites obtained?



Field Data Matching with Optimal Transport

- OT algorithm: earth mover’s distance
- Distance measure:
  - Euclidean distance
  - Cross entropy
- Merging strategy:
  - Greedy (linear sum assignment)
  - Naive matching

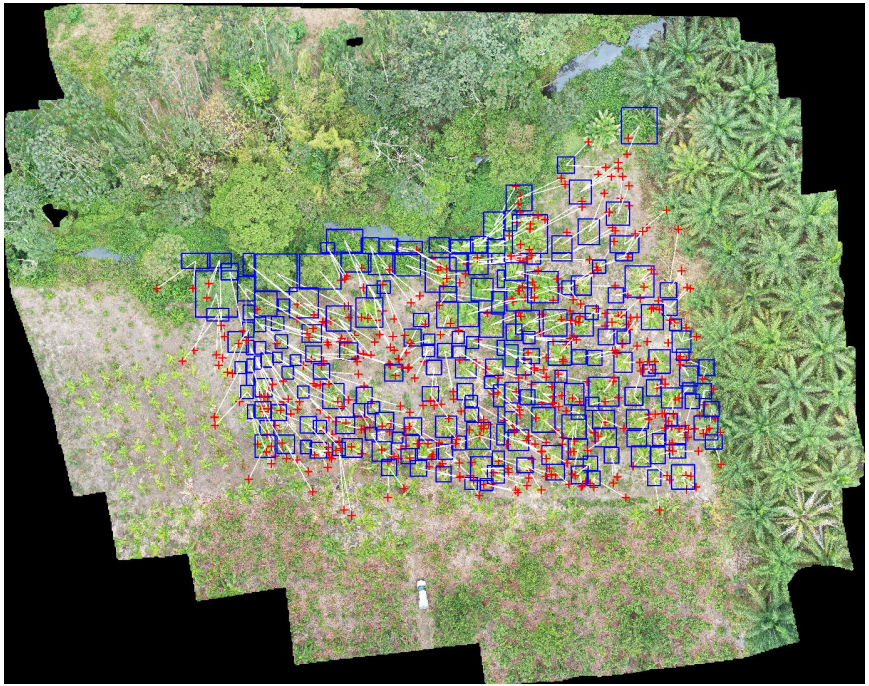
OT - Euclidean distance



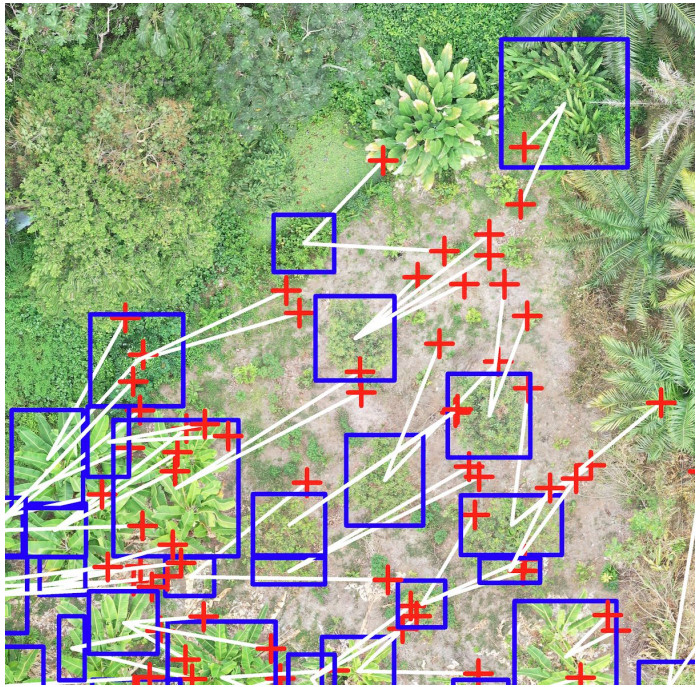
Naive merging

Site name	Number of detections	Number of field measurements	Number of unique matches
Nestor Macias	1218	872	872
Leonor Aspiazu	1017	789	789
Carlos Vega Arteaga	817	743	739
Flora Pluas	1400	846	846
Carlos Verga Guevara	932	929	929
Manuel Macias	788	484	484

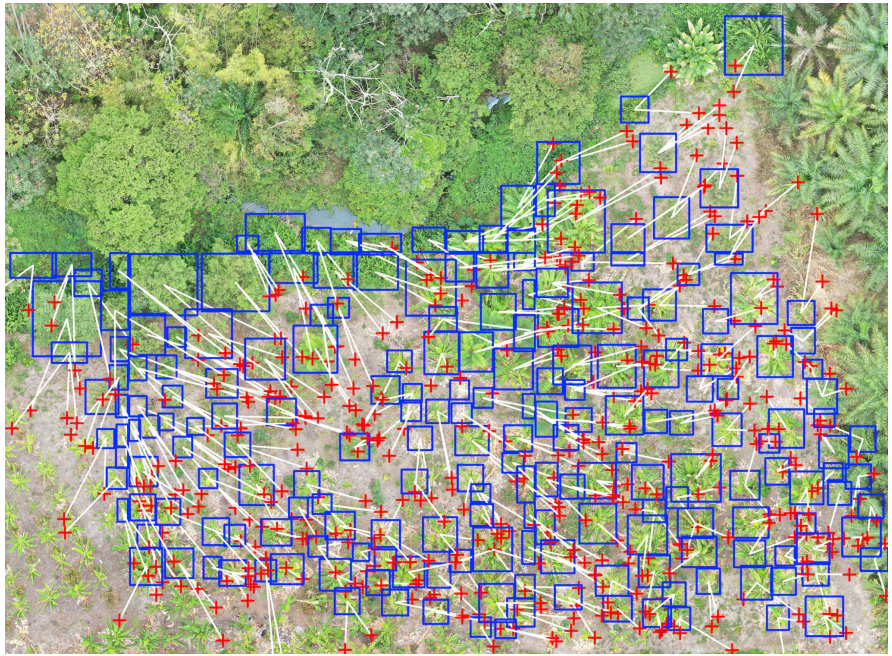
Matching with out-of-site filter



Matching with out-of-site filter



Matching with out-of-site filter



- Number of detections: 209
- Number of field measurements: 484

Matching with out-of-site filter

Site name	Number of detections	Number of field measurements	Number of unique matches
Nestor Macias	394	872	394
Leonor Aspiazu	322	789	322
Carlos Vega Arteaga	250	743	250
Flora Pluas	375	846	375
Carlos Verga Guevara	378	929	378
Manuel Macias	209	484	209

Work Plan Overview

Until now

- Manual data labelling
- Reproduction of the paper's results
- Study and improvement of the tree detection procedure
- Study and improvement of the matching algorithm
- Creation and experimentation of our own model
- Evaluated different data augmentation techniques, multi-modal inputs, etc.

From now (see final presentation!)

- Apply the carefully chosen imputer
- Fine-tuned our DeepForest model on manually labeled data
- Build an enhanced version of DeepForest capable of more accurate and reliable detections as well as binary group (i.e., banana/non-banana) classification ability
- Finalize and validate our improved matching algorithm
- Hyper-parameter search for our modified multi-inputs ResNet CNN
- Set and document the evaluation procedure to obtain low RMSE and high R2 score with our own model on our new data
- Continue to write the project report!

Questions ?

Contributions

- All group members contributed equally to the following
  - Went through the repo of the master thesis and OneForest
  - Manually labeled a considerable part of the dataset (bboxes + binary group)
  - Worked on the reproduction of the paper's results
    - Tree crown detection with deepforest
    - Optimal transport matching algorithm with OneForest
  - Creation and experimentation of our own tree crown detection model
  - Studied and improved the tree crown detection model
  - Extended matching algorithm with site constraint
  - Investigated the noise issues and relevant plantation area within the sites from shapefile