Artificial intelligence (AI) powered framework for plantation volume estimation: a case study in teak (*Tectona grandis*)

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October 22, 2025

Vision

Transforming tropical forestry management through Artificial Intelligence

— maintaining accuracy, enabling transparency, and sustainability from standing trees to market-ready logs.

Photos from https://www.greentnmission.com/

Motivation

- Field inventory in a plantation is an essential element in management and decision making
  - Important to assess growth, harvestable timber volume, plan on transportation logistics of harvested timber, and facilitate ‘standing auction’
- Estimation of volume using images from the field
  - Application in a smartphone
  - Real-time, compact, intuitive, and cost-effective
- Estimation of volume of harvested logs
  - End-to-end traceability and real-time inventory assessment across timber yards, felling sites, depots,…
- Feasibility
  - Proof of Concept (POC) developed
    - Python scripts to be integrated into a user interface

Methods – case study in Kerala

- Existing method
  - 20 × 20 m^2 sample plot per 2 ha of plantation
  - Measure the girth at breast height (GBH) for the trees
  - Volume calculation using volume table

- Developing method
  - 20 × 20 m^2 sample plot per 2 ha of plantation
  - Take images
  - Use convolutional neural network (CNN) model
    - Tree identification
    - Diameter detection and GBH calculation
  - Volume calculation using volume table

CNN Model and transfer learning

- General framework of convolution

$$G[m,n] = (f * h)[m,n] = \sum_j \sum_k h[j,k] f[m-j, n-k]$$

Where G is the feature image; f and h are the input image and the kernel; m and n are the row and column indices of feature image; j and k are the indices of kernel

Tree Identification – Darknet framework

- Compatible framework
  - Fewer manageable configuration
- Work in low-computational devices
  - Eg., Mobile phones

Diameter detection – Deterministic framework

- Deterministic
  - Bounding box & edge detection
  - Pre-processing shades of color
  - Geometric analysis
- Lightweight framework
  - Compatible to a mobile phone


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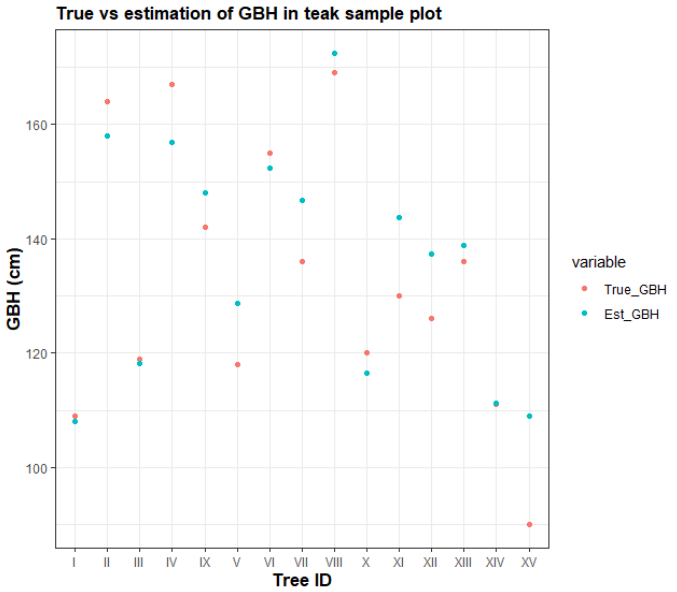
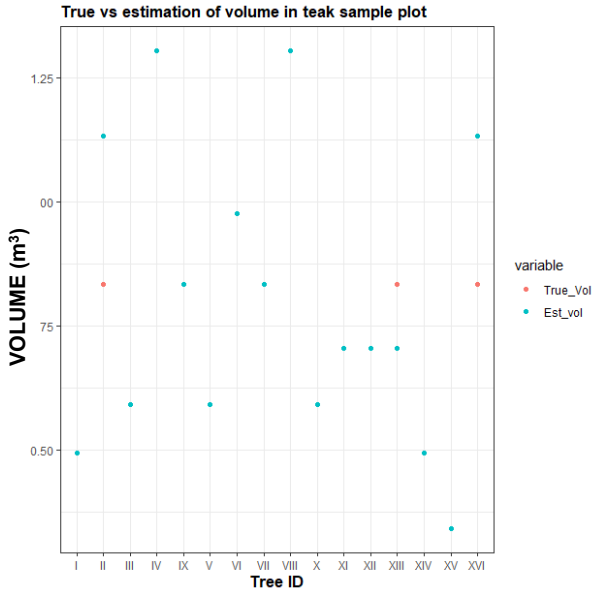
AI method is significantly faster and independent of the number of trees present in the plot



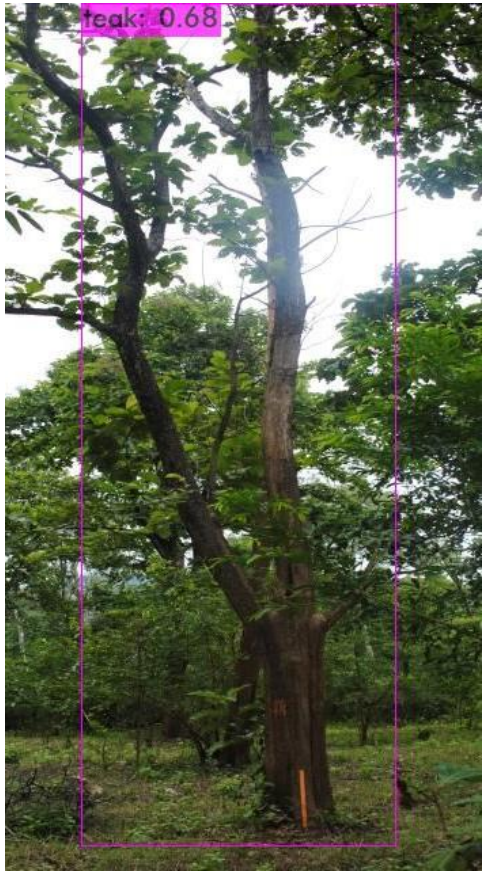


Underestimation of 3.5 cm on an average in GBH estimation.

Existing method (Time α number of trees)	AI method (Time ⊥ number of trees)
30s per tree for measuring GBH and volume each 3 to 7.5 minutes per plot (6 to 15 trees per plot) for GBH 3 to 7.5 minutes for volume estimation **6 to 15 minutes in total**	3s for imaging; 28s for tree detection; 1 minute for GBH estimation 1 s for volume estimation **Less than 2 minutes in total**

Work in progress

- Increase the accuracy of GBH estimation
  - In noisy environment
- Develop a mobile application
  - Real-time measurement from the field
- Expansion of use of the application
  - Apply on other species with available volume tables
  - Determine the volume of harvested logs



A game changer for forest departments, plantation owners, and timber traders

- Automated inventory of standing and harvested timber
  - A mobile application that can be used in the plantations
  - Rapid, scalable, consistent, and repeatable volume assessment across large areas
- Reduces reliance on intensive ground surveys
- Centralized geo-tagged repository for long-term tracking and carbon stock assessment
- Data-driven insights for resource optimization and planning
- Elimination of intermediaries, enabling fair pricing for farmers
- Transparent, efficient, and sustainable digital forestry management system

Integration with existing framework

- Unified digital ecosystem for the entire forestry supply chain
  - ITTO's Forest Information Systems (FIS)
- Continuity from plantation to end user

Thank you

- Kerala Forest Department
- ICFRE – IFGTB
- HelixOmics Analytics

- Ms. Anusiya (JRF)

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