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Extracting DBH measurements from RGB photo images

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- 2  **Methods**
Site, instruments, and algorithms
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Effectiveness, pros and cons
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A large, irregular teal-colored shape resembling a watercolor splash or a circular stamp. It contains several white line-art floral motifs, including daisy-like flowers and winding vines with leaves.

Why?

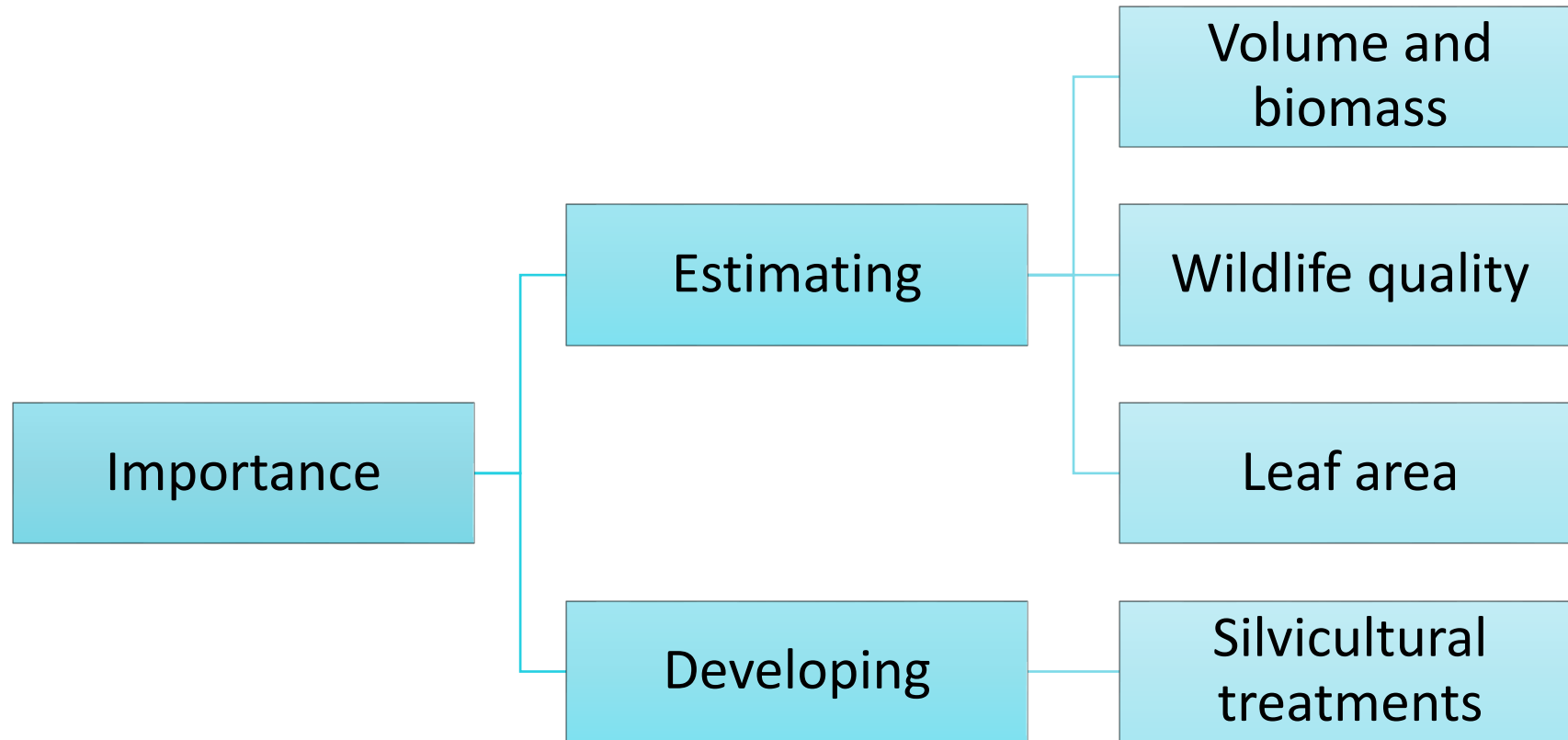
A small, irregular red-colored shape, similar in style to the teal one, containing a white number 1.

1



1 Introduction

Why



A large, irregular teal-colored circle with a rough, hand-painted edge. Inside the circle, there are several white line-art floral patterns, including small daisies and a larger, more complex vine-like flower on the right side.

How?

A small, irregular red-colored circle with a rough, hand-painted edge. Inside the circle is a white number '1'.

1



1 Introduction

How



Measurements

Direct
measurements

Diameter tapes

Calipers

Biltmore stick

Regression model

Indirect
measurements

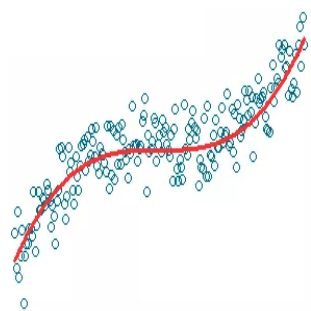
Laser technology

Photos with
computer vision



1 Introduction

Indirect measurements



Indirect Measurements

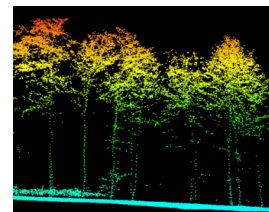
Regression model

Laser technology



Photos with computer vision

Direct measuring



LiDAR (3D)

2D laser scanner

Structure from motion (SfM)

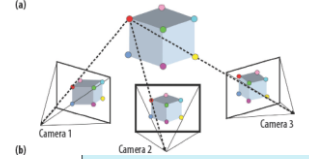
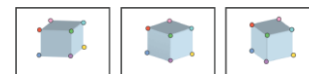
Vanishing point horizon

Laser dendrometers

Hand-held laser survey instrument

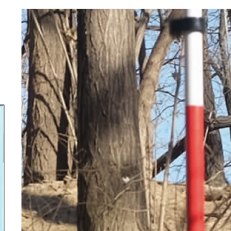
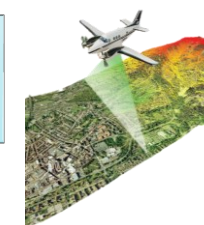
Ground-based

Airborne laser scanner







Benchmark assist

Laser point assist



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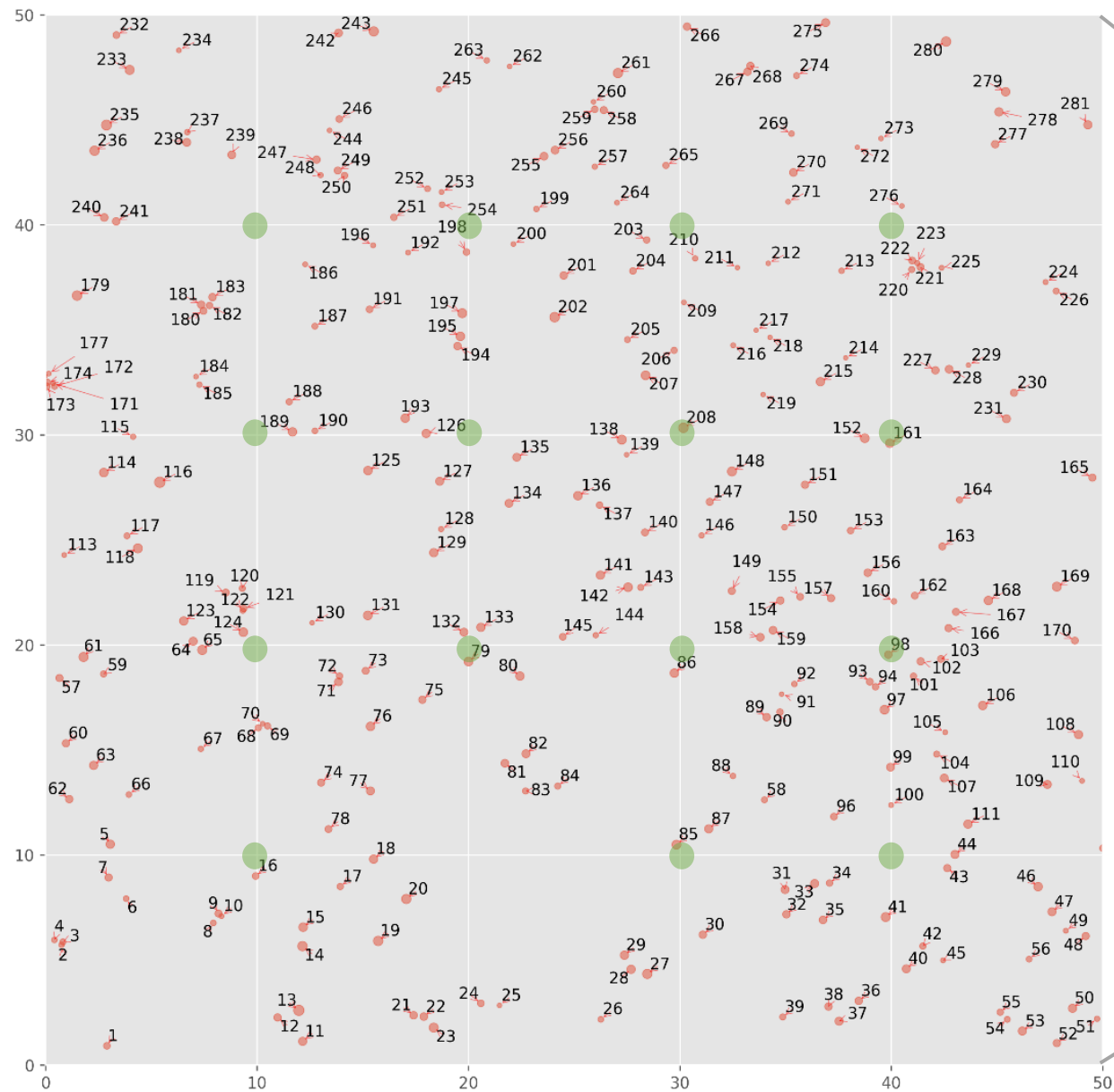
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2





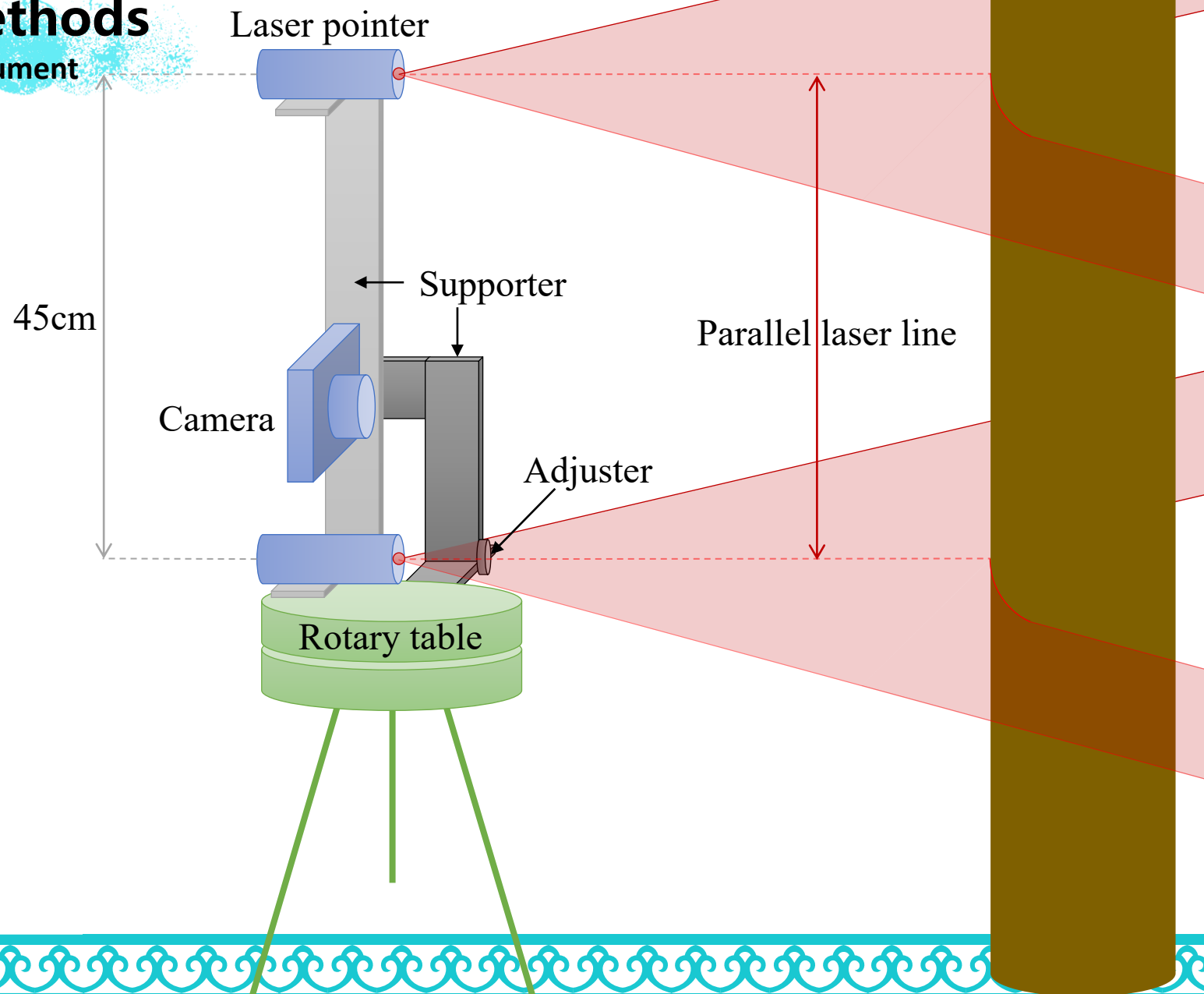
Instrument

2



2 Methods

Instrument



Algorithm

2



2 Methods Algorithms

$$D_L \times r = LX \times OO'$$

$$r = \frac{LX \times OO'}{D_L} = \frac{\frac{1}{2}LR \times (r + D_C)}{D_L}$$

$$r = \frac{\frac{1}{2}LR \cdot D_C}{D_L - \frac{1}{2}LR}$$

$$D_L \text{ \& } D_C \triangle O D_C U_C \sim \triangle O' D_C' U_C'$$

$$\begin{cases} \frac{O'C}{f} = \frac{D_C U_C}{D_C' U_C'} \\ \frac{D_C' U_C'}{D' U' (F_y)} = \frac{n}{N} \end{cases} \gg \begin{cases} O'C = \frac{45 \text{ cm}}{D_C' U_C'} f \\ D_C' U_C' = \frac{n}{N} F_y \end{cases}$$

$$O'C (D_C) = \frac{45 \cdot f \cdot N}{F_y \cdot n}$$

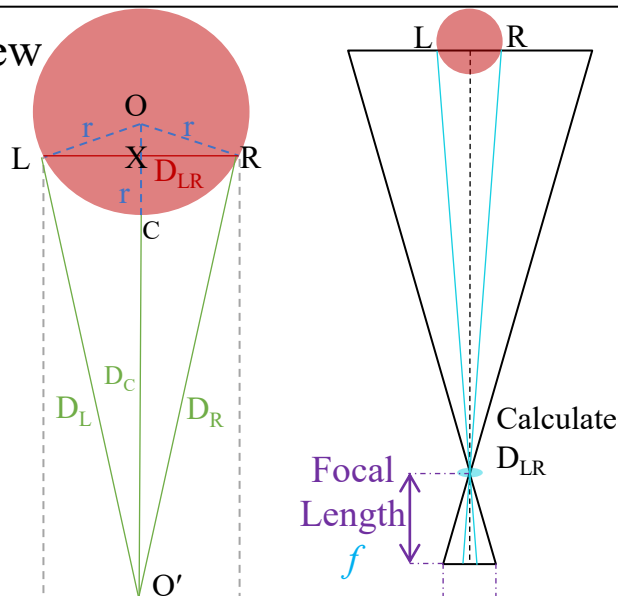
LR:

$$LR = \frac{D_C \cdot m \cdot F_x}{f \cdot M}$$

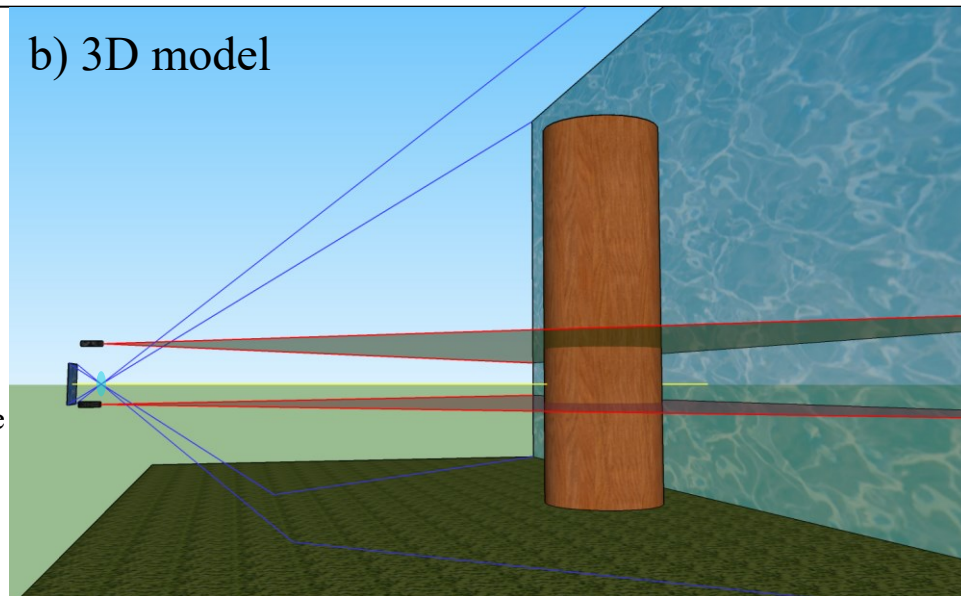
DBH:

$$DBH = 2 * r = \frac{LR \cdot D_C}{D_L - \frac{1}{2}LR}$$

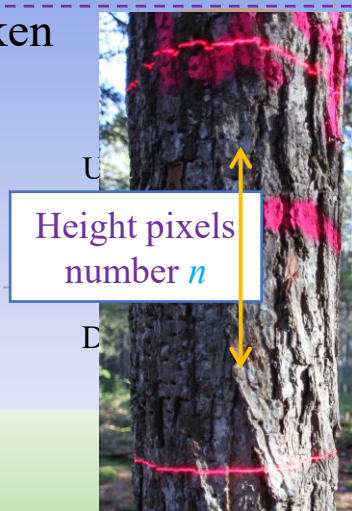
a) Horizontal view
(calculate DBH)



b) 3D model



c) Photo taken

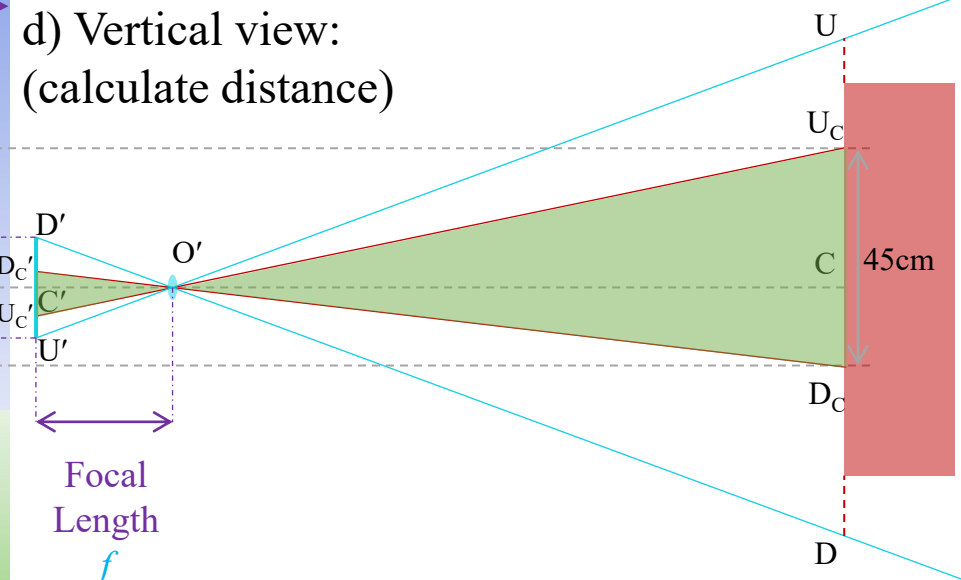


Focal X
Width F_x

Focal Y
Height F_y

Height pixels
number N

d) Vertical view:
(calculate distance)



A large, irregular teal-colored shape with a rough, hand-painted edge. Inside this shape, there are several white line-art illustrations of flowers and vines. One vine starts from the bottom right and winds upwards towards the top right. Another vine is on the left side, and there are some smaller floral motifs scattered within the teal area.

Software

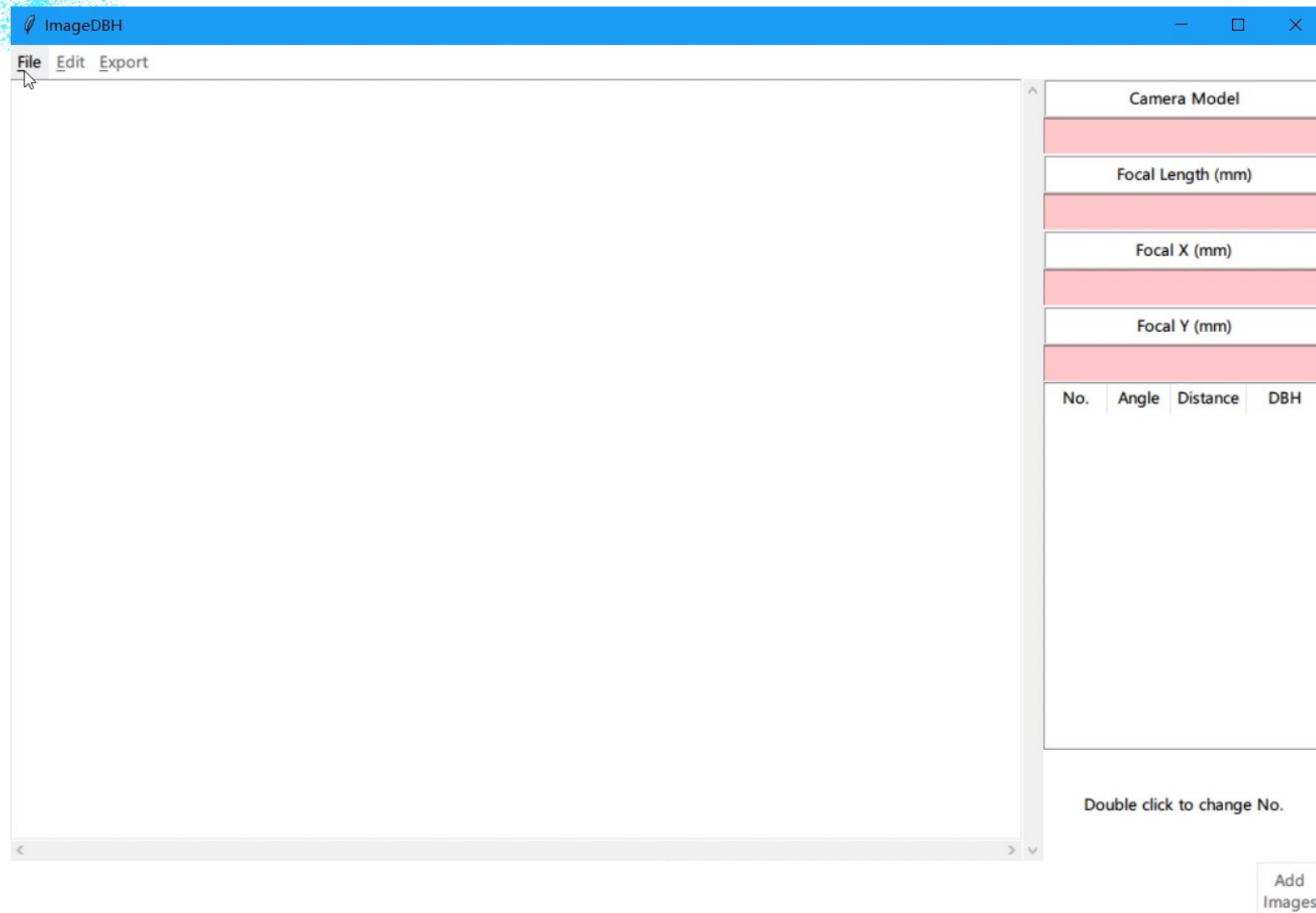
A small, irregular red-colored shape with a rough, hand-painted edge. Inside this shape is a white number '2'.

2







2 Methods

Software



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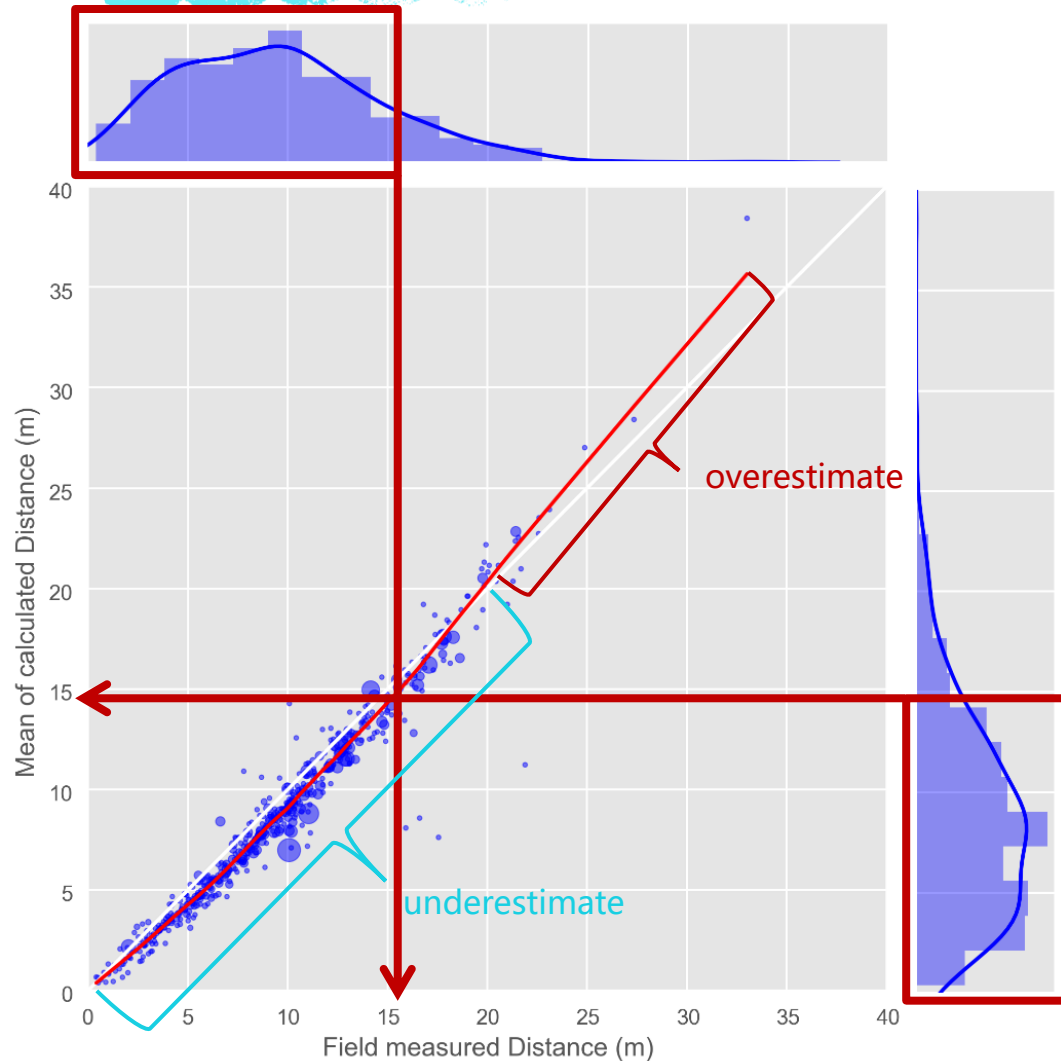
Comparison

3



3 Results and Discussion

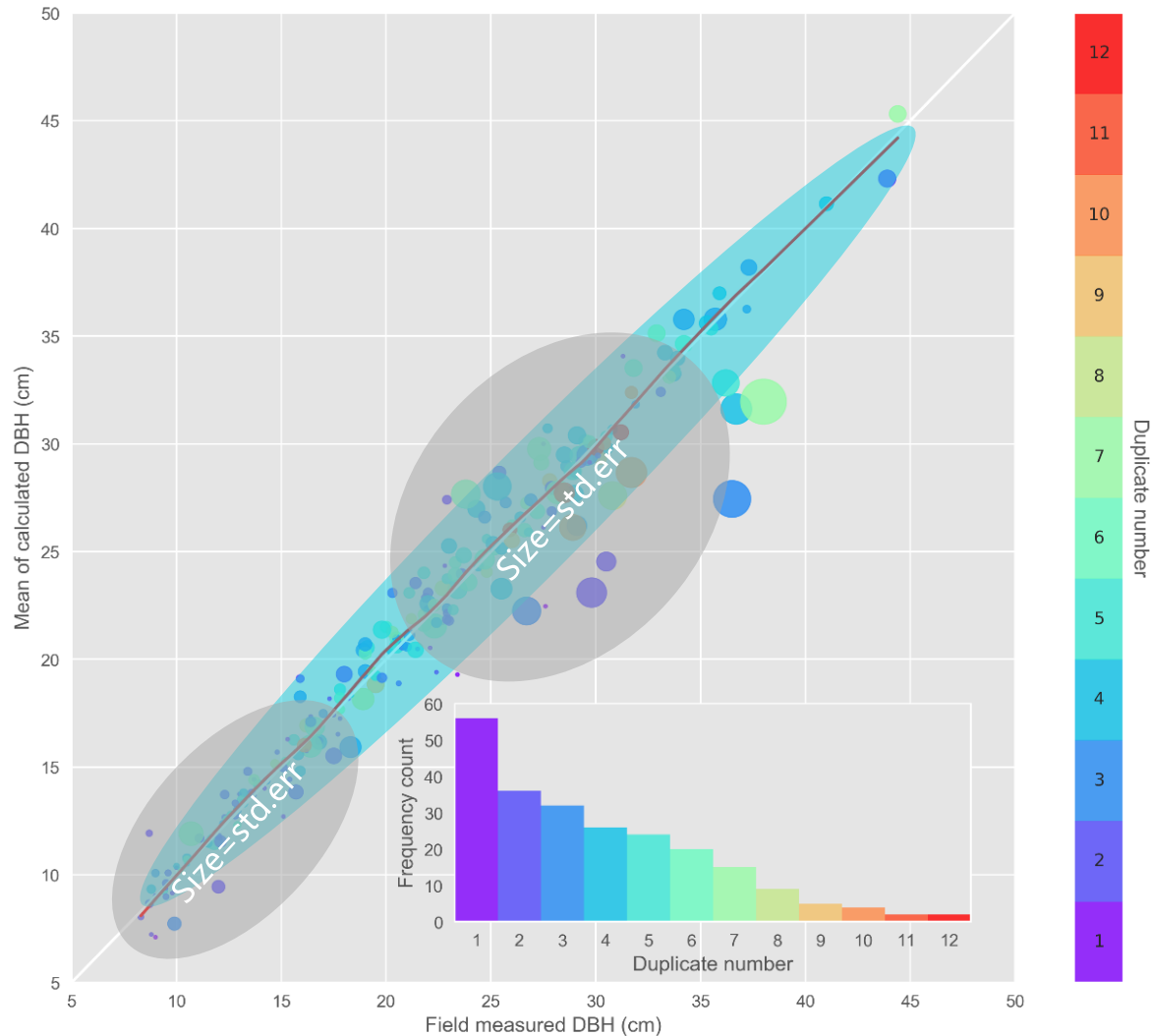
Distance results comparison



1. Most of calculated distance distributed below 15m
2. Underestimate: hard to guarantee the tape no curving
3. Overestimate: distance too far, the trunks in photo are too small (only a few pixels), causes variance

3 Results and Discussion

DBH results comparison



1. Equivalence test: region of similarity = 32% at $\alpha = 0.05$
2. Standard errors associated with multiple DBH measurements increased with increasing distance from the camera



Error reasons

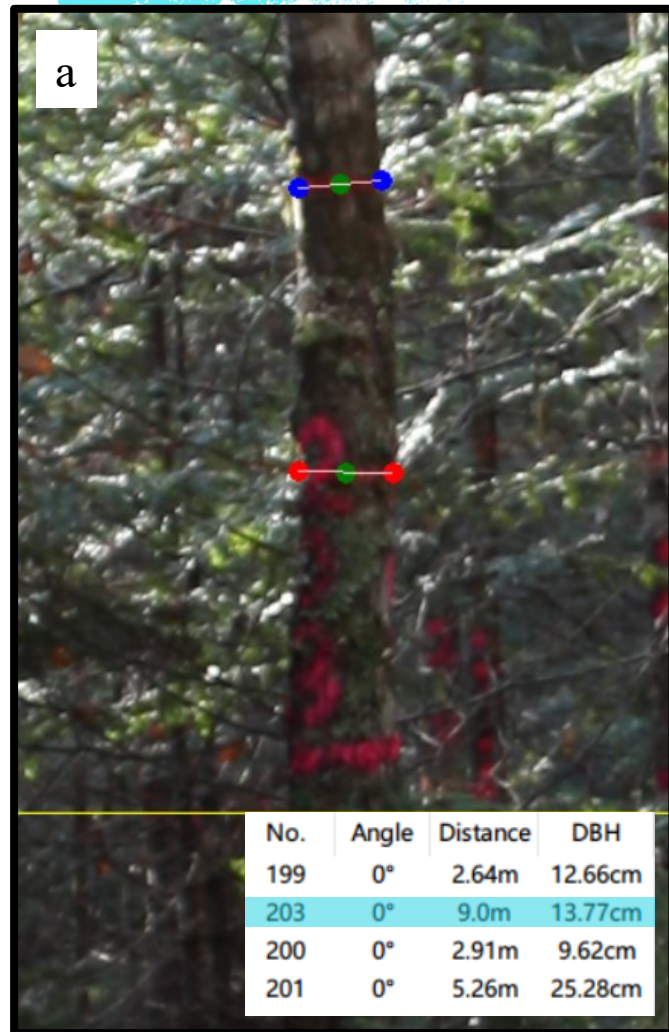


3



3 Results and Discussion

Reasons that cause error

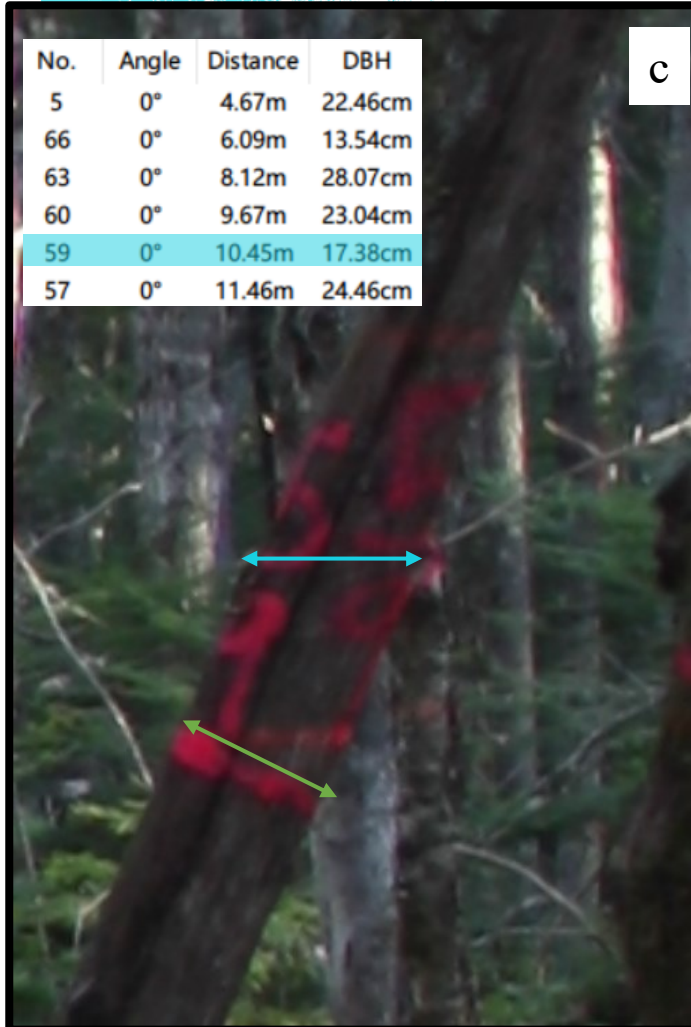


1. Different photo angles may capture shorter or longer axes of the stem cross-section

Field measured: No.203 = 17.5cm

3 Results and Discussion

Reasons that cause error



2. Tree lean is another factor that contributes to large deviations in DBH measurement

Field measured: No.59 = 16.4cm

3 Results and Discussion

Reasons that cause error



3. the photo measured diameter position was consistently higher than that of field survey

4. Key points are marked manually which may cause error

Improvements

3



3 Results and Discussion

Improvements

1

2

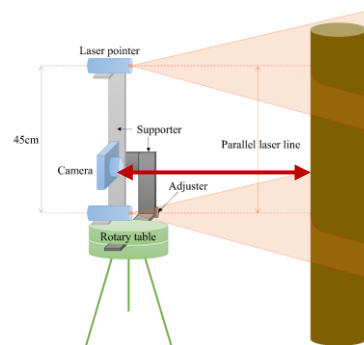
3

4



Make the photo calculated and field measured places on trunk closed to each other

The best distance between trees and camera is around 10-20m







Just take photos for single trees rather than multiple trees

Automate laser line detection through **artificial intelligence (AI)** to **minimize** human-induced errors associated with **manual selection**



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4 Conclusion

The **procedure and algorithms** to **extract the DBH** of trees from digital images with laser line have been illustrated.

The calculated results have also been **validated** by the field survey data. It is **applicable** to obtain DBH from photos

In the future, this new technology could

1. be applied for estimating the **upper-stem diameter**
2. optimize **image identification algorithm** and reduce people participation

Under the circumstance of **tree shield**, the survey ratio is up to **82.2%** which has high correlation with field survey data

Due to the **limitation of picture resolution** which could make trees not recognizable, **the best distance** is **<15 m.**

An **open source software** developed in **Python 3.5** also makes great contribution for **simplify the calculation procedure** and making it convenience for other researchers' usage

Acknowledgement

1. Funding for this project

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2. Advisor and supervisor for this thesis

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- Zhijie HOU

5. Support and encouragement

- Yaquan CHANG



Questions?

