Estimation of volume and products that can be obtained from individual stems using consumer grade cameras

Bogdan Strimbu

Oregon State University

Stem Measurements

Ground estimation issues

- Time consuming
- Inaccurate (at the best first log)
  - Form factor (usually Girard)
  - Rarely measured in daily practice - guestimation
- Lack precision (half log)

Tree Volume in Board Feet (International ¼)
Number of useable 16-foot logs

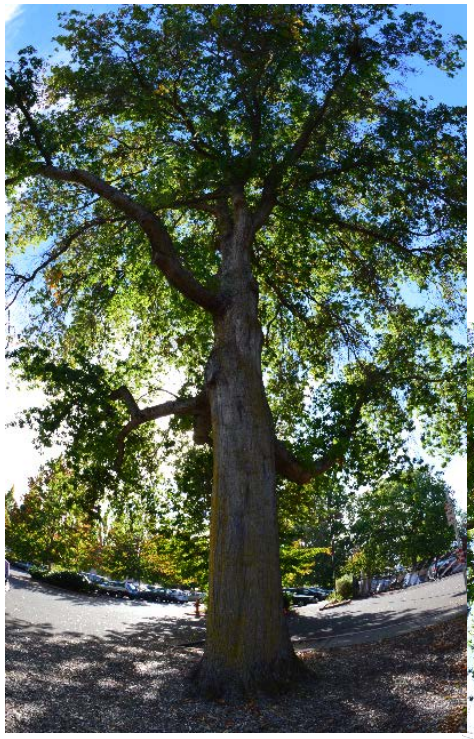
Tree Diameter	1	1.5	2	2.5	3	3.5	4	4.5	5
10	36	48	59	66	73				
11	46	61	76	86	96				
12	56	74	92	106	120	128	137		
13	67	90	112	130	147	158	168		
14	78	105	132	153	174	187	200		
15	92	124	156	182	208	225	242		
16	106	143	180	210	241	263	285		
17	121	164	206	242	278	304	330		

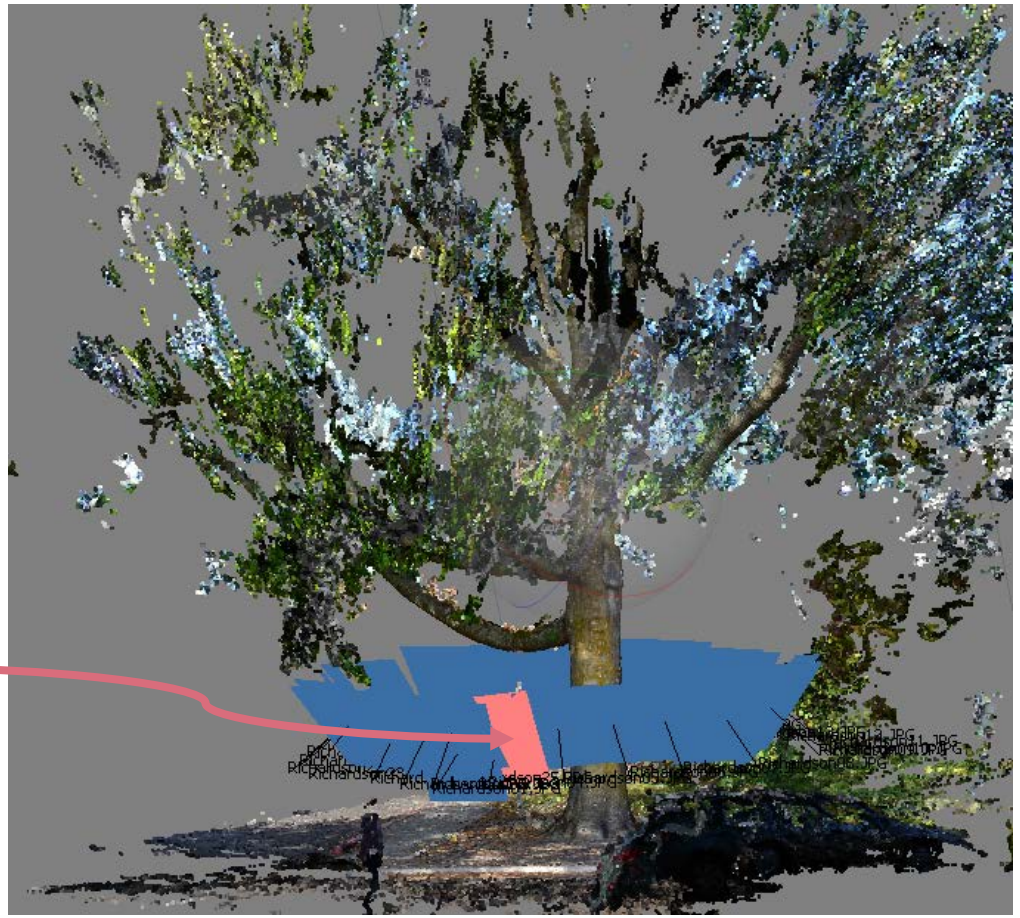
Objective

- **Main**: Develop a procedure that estimate tree products that is fast, accurate, precise, and inexpensive.
  - Focus on fast and accurate
- **Secondary**: prove that computer vision techniques provide fast and accurate estimates of stem attributes → dbh

Structure from Motion

- Range imaging technique for estimating 3D objects from multiple 2D images





Procedure

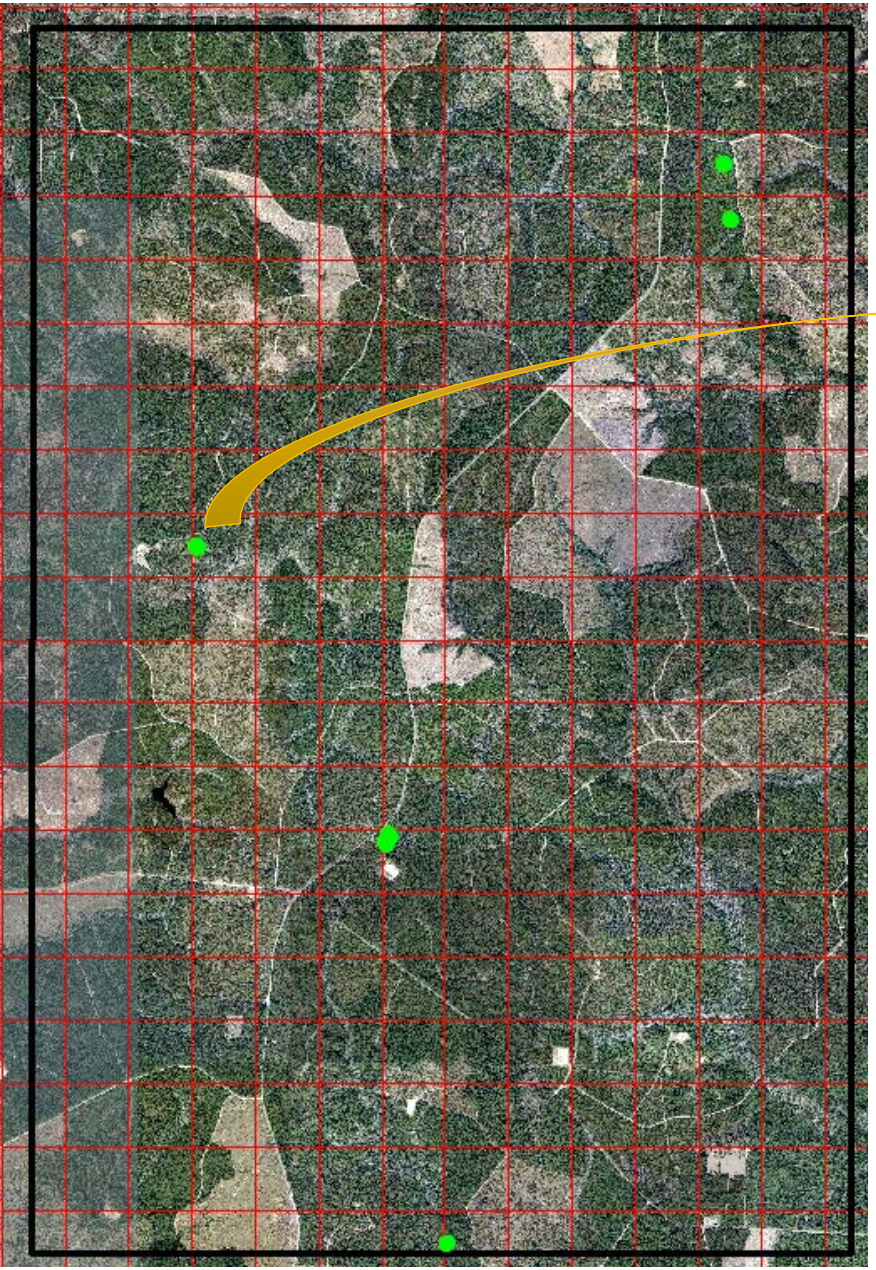
1. Record images
2. Create point cloud
3. Calibrate point cloud
4. Execute measurements
5. Corrections

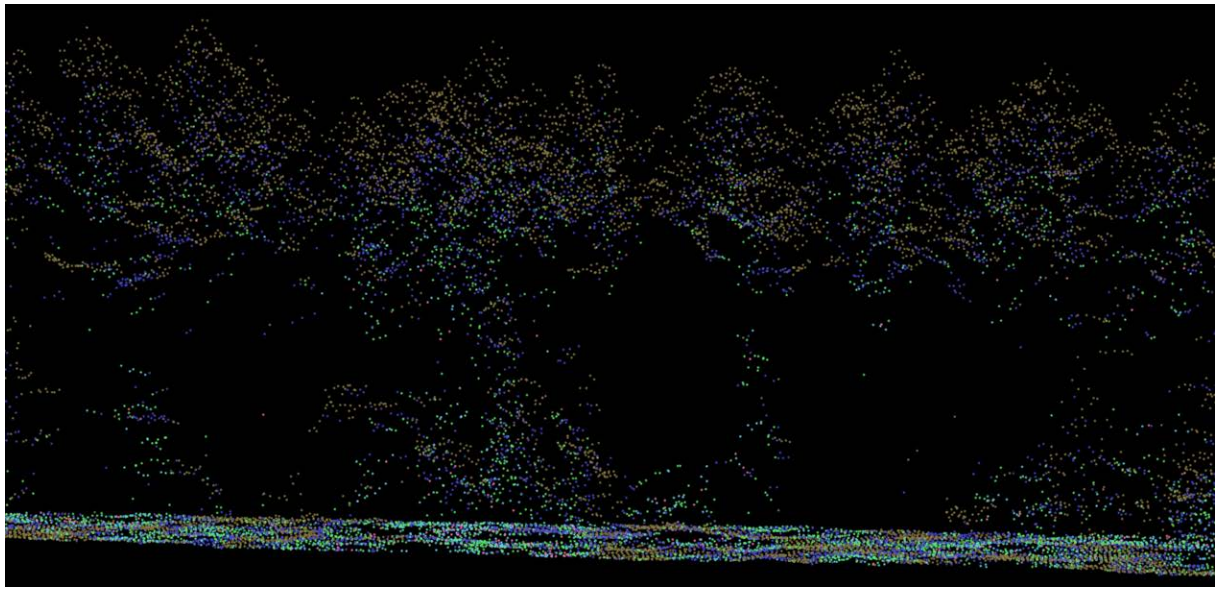
Species & Location

- Loblolly pine

- From first thinning to rotation age

Location

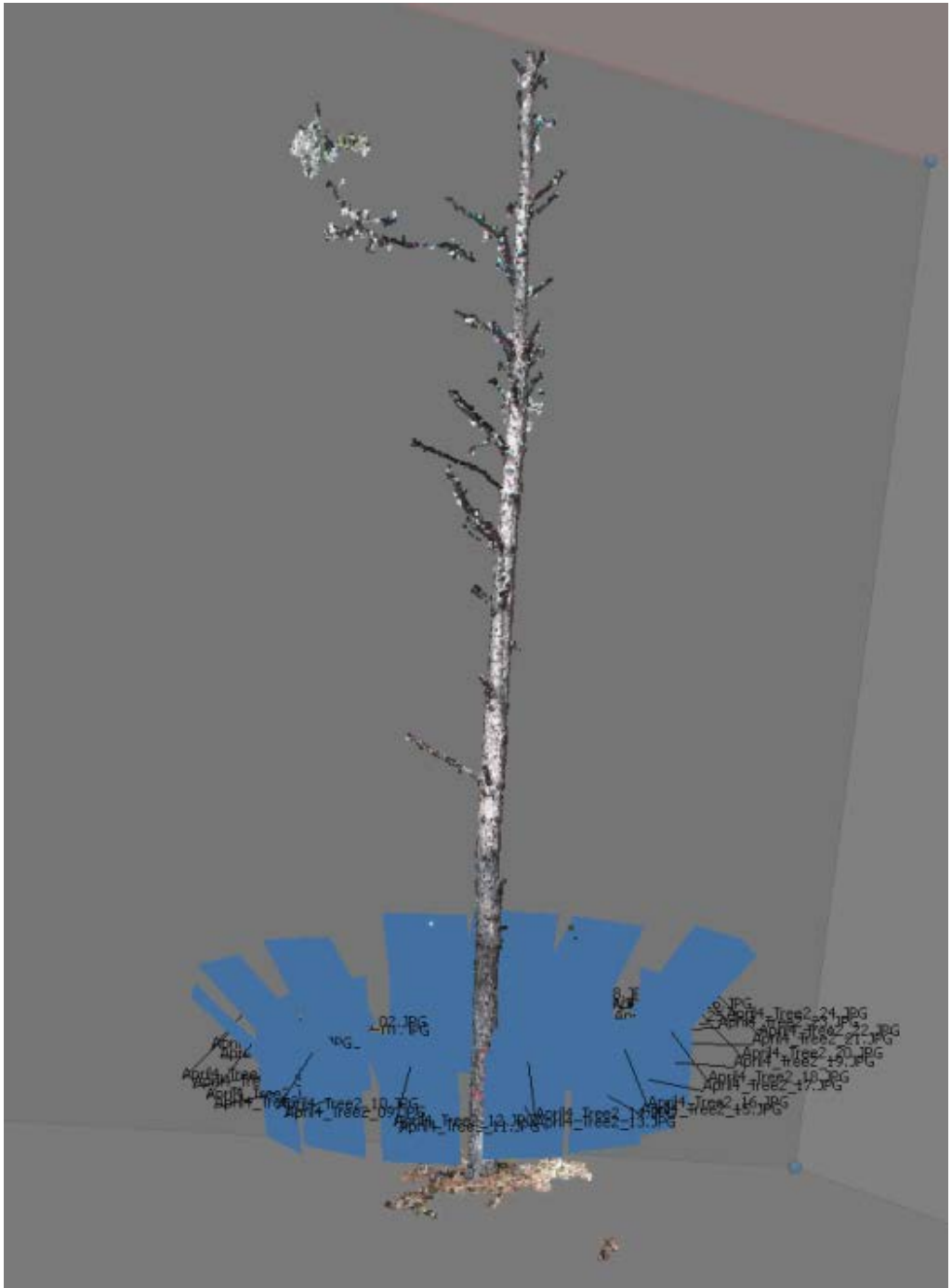




Input

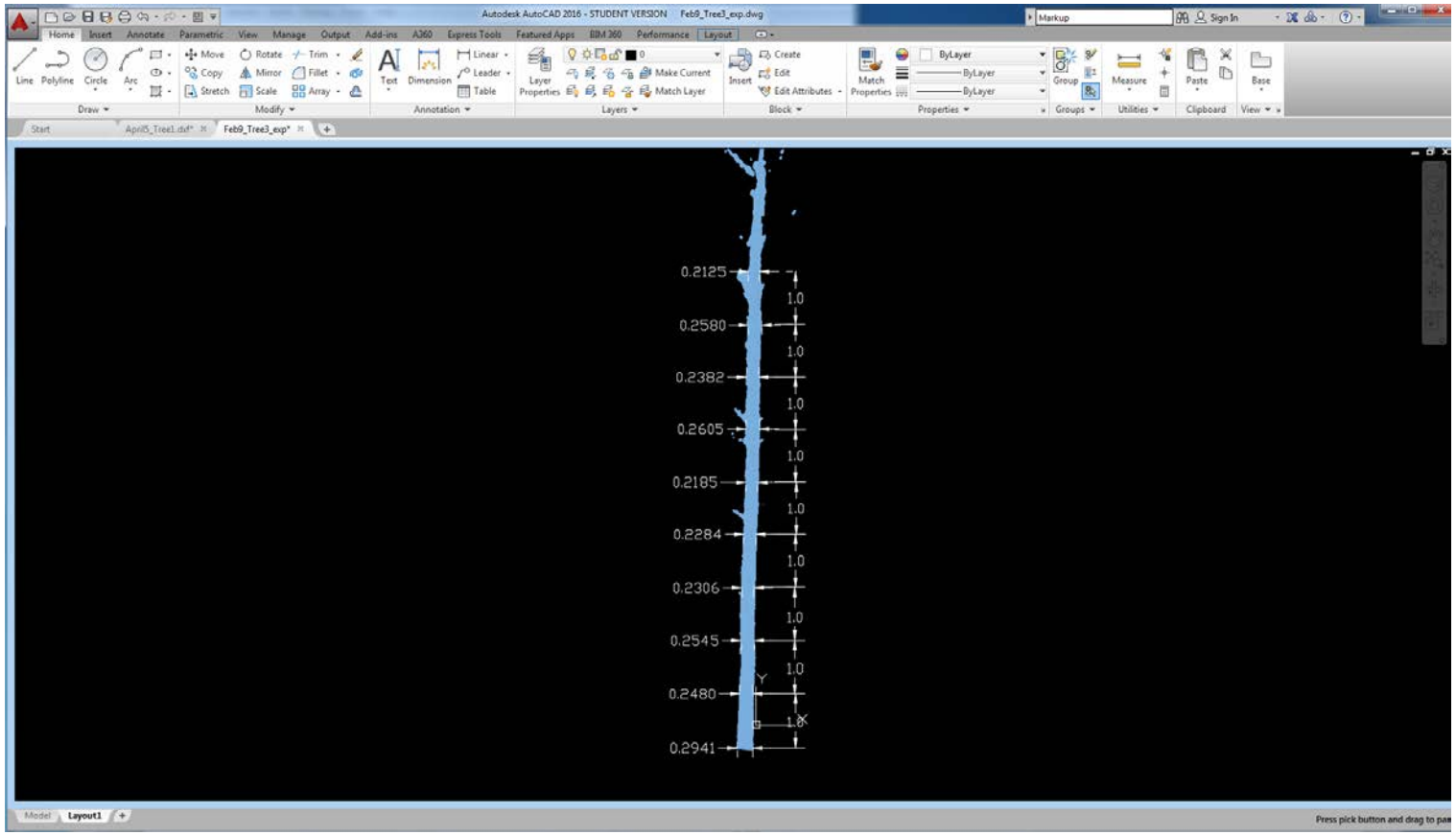
- Nikon 3200- 24.2 Mpixels - $700

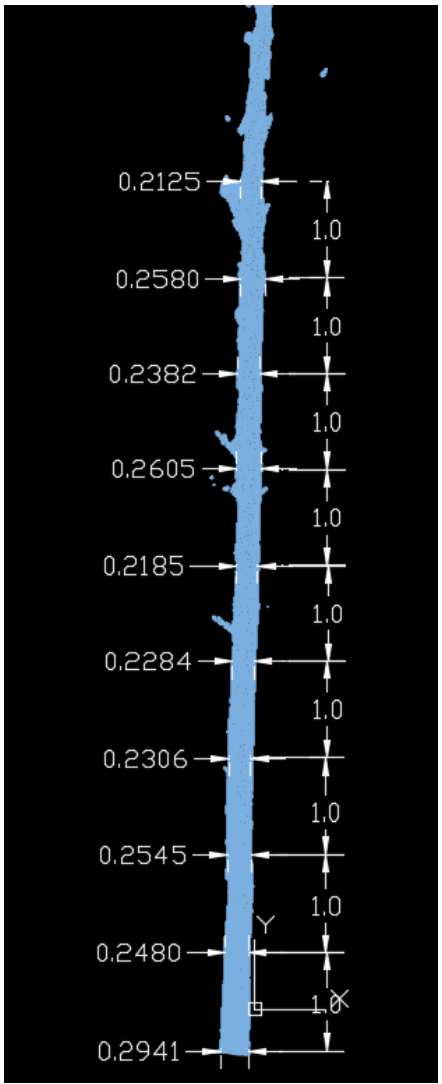
Photogrammetric Point Cloud



PPC calibration

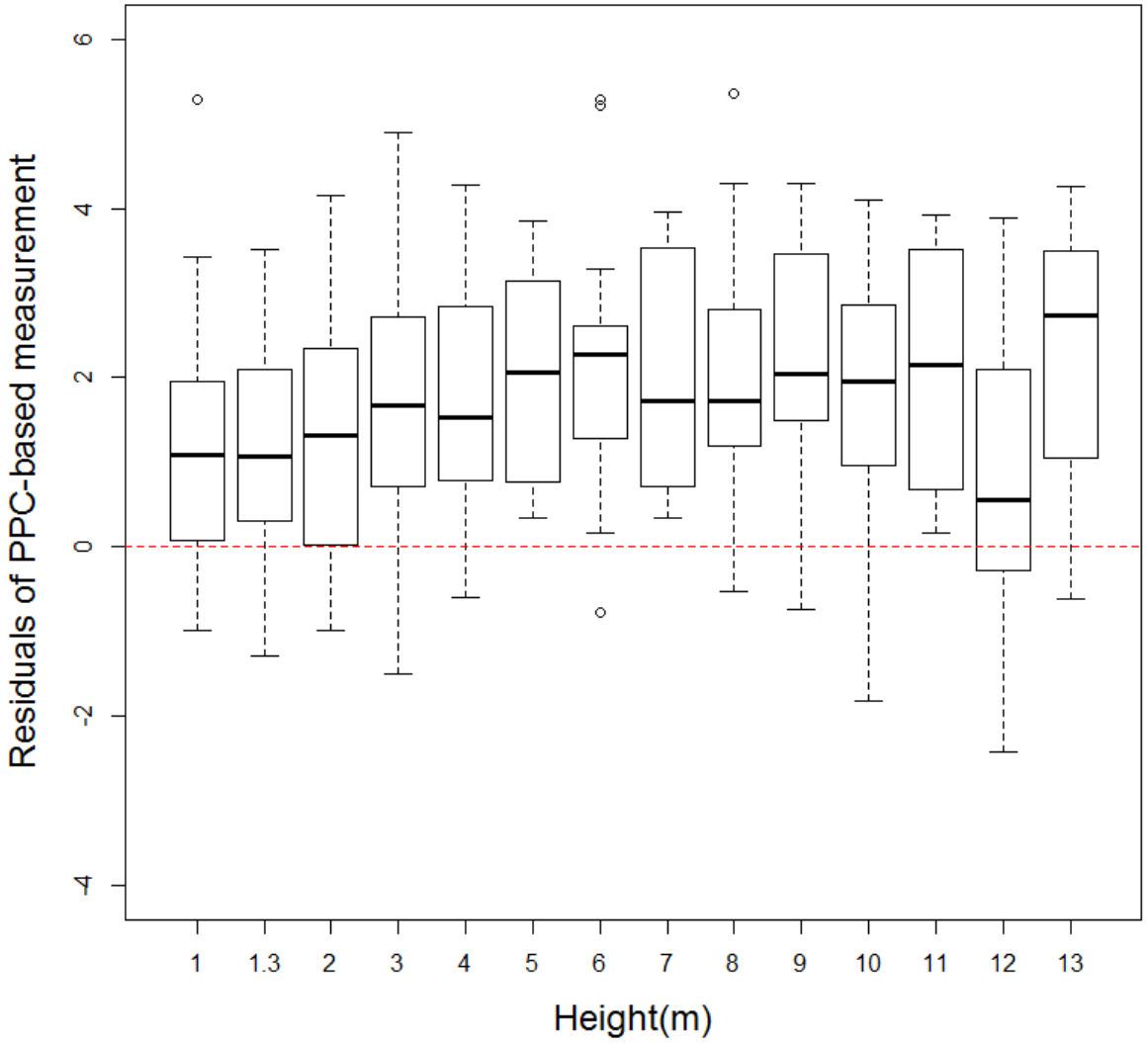
PPC Measurements





Bias

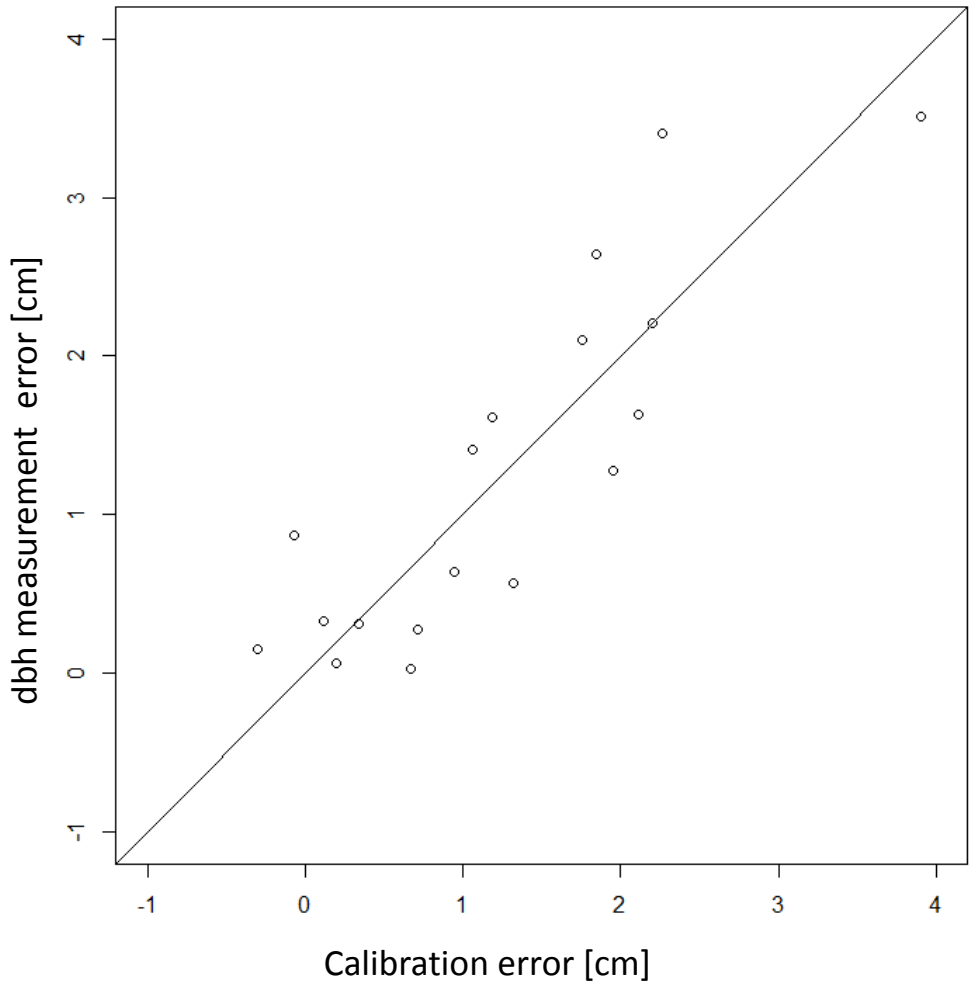
Bias=1.72 cm



$$Bias\,@\,height\ \ h = d_{ppc} - d_{ground}$$

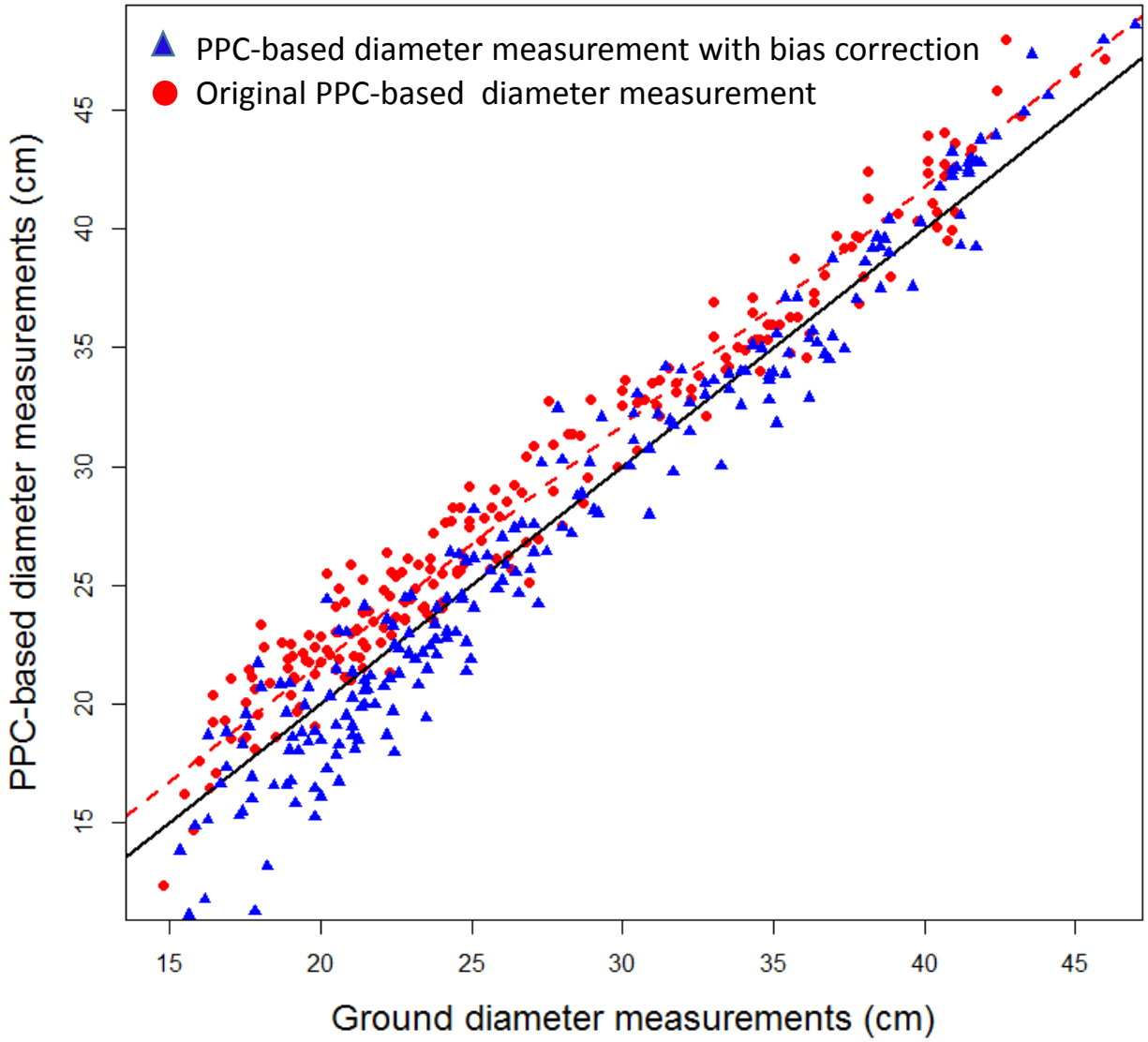
Bias reduction

$$bias_{correction} = error@dbh + Calibration_{error} \times Relative\ Height$$



Calibration error is close to bias

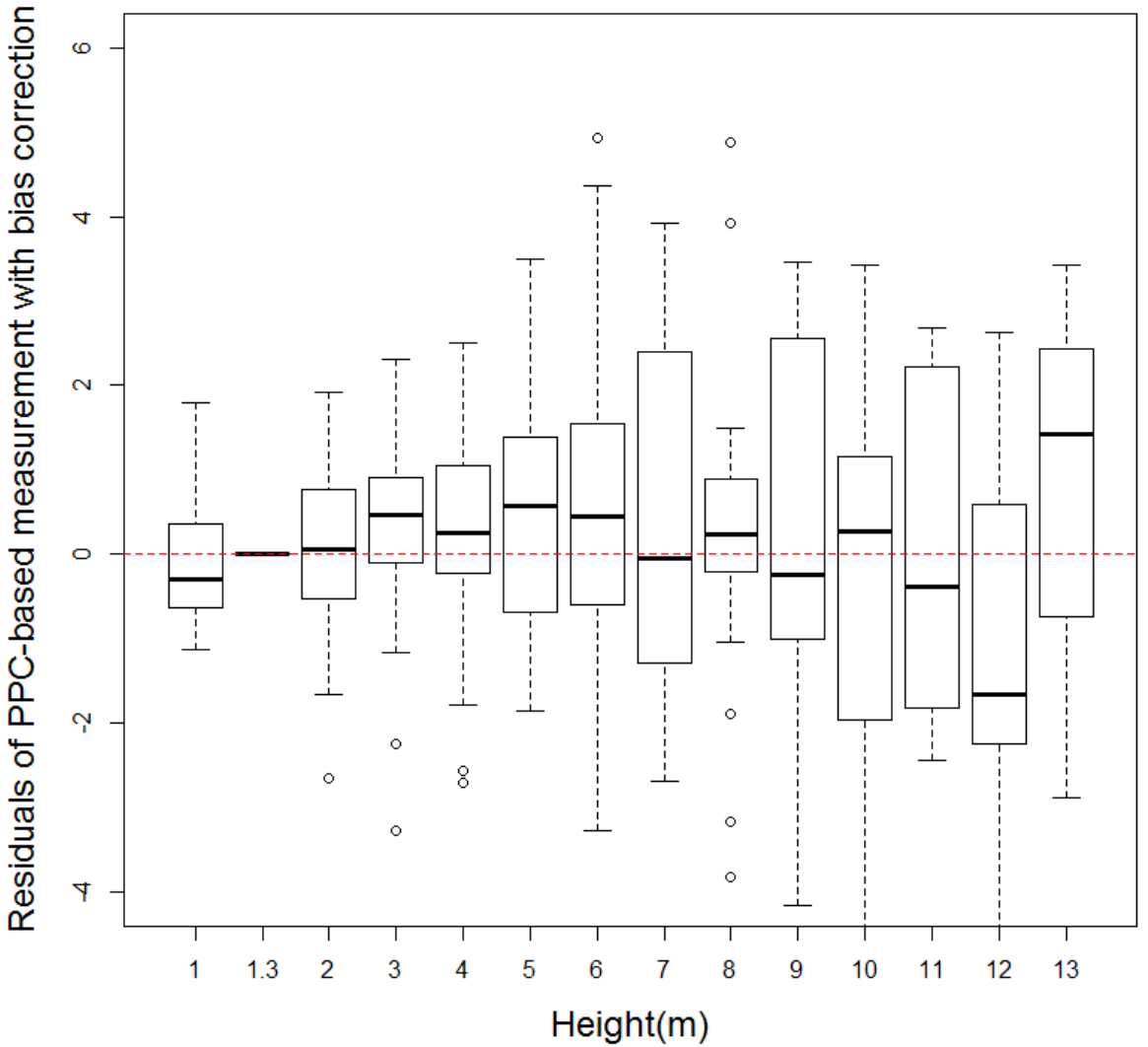
Diameters


PPC-based diameter measurement with bias correction
Original PPC-based diameter measurement
PPC-based diameter measurements (cm)
Ground diameter measurements (cm)
15
20
25
30
35
40
45

Bias reduction (2)

- After reduction: accuracy 1.5 mm

$$\overline{Height\ at\ which\ difference < 10\%\ is \geq 10\ m}$$



Problems

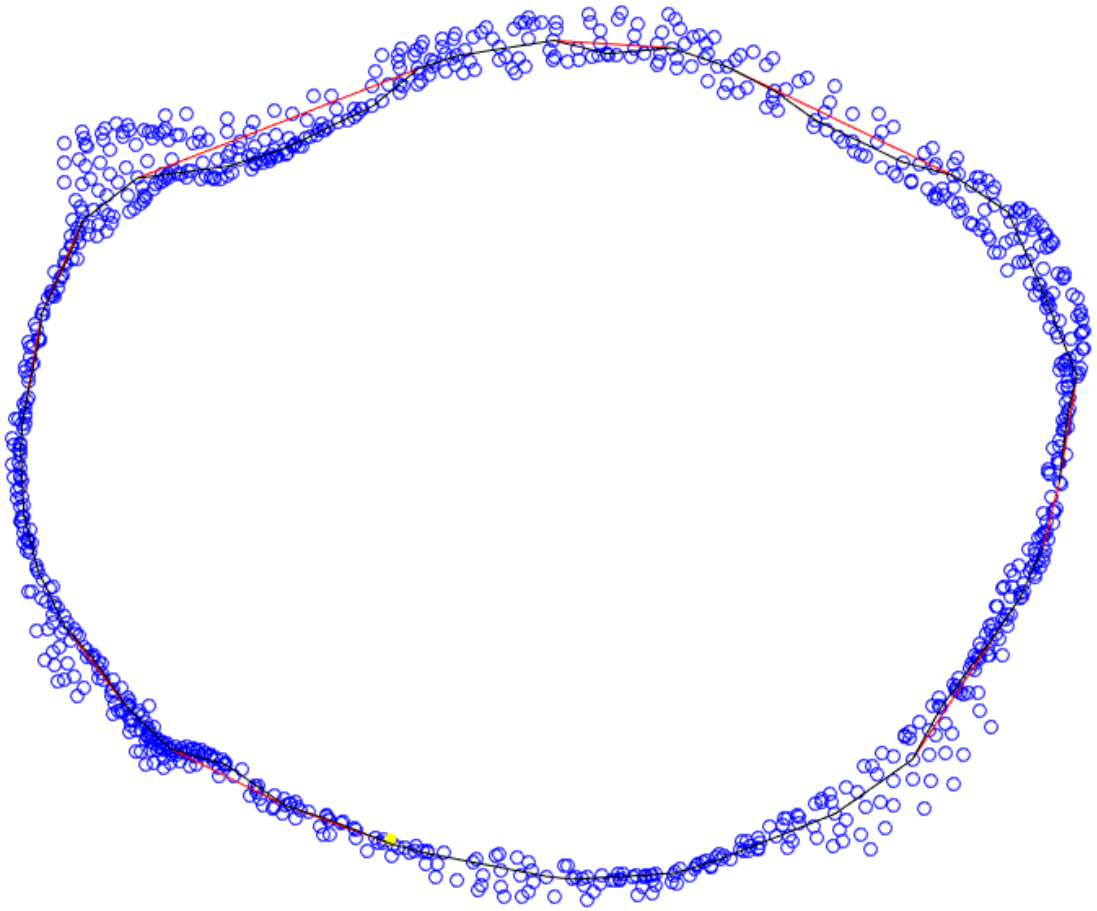
1. Slow

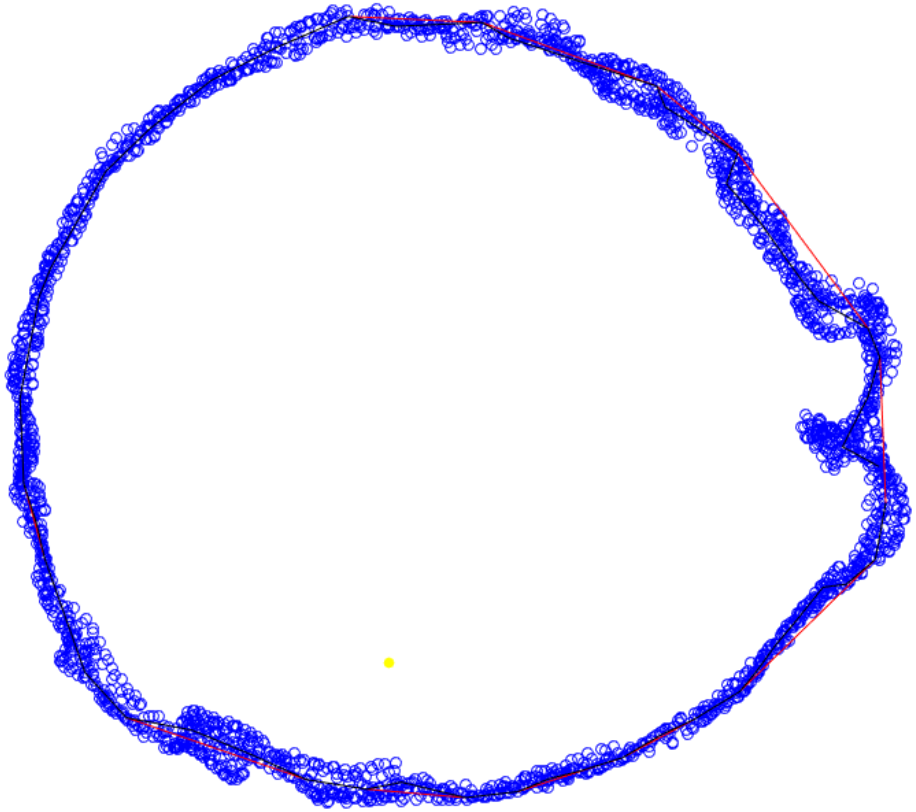
2. Needs bias corrections for outside diameter

Automatic measurements

- Complex combination of algorithms
  - Existing
  - Newly developed
- Compute INSIDE BARK diameter at any height
- Matlab

Automation Results





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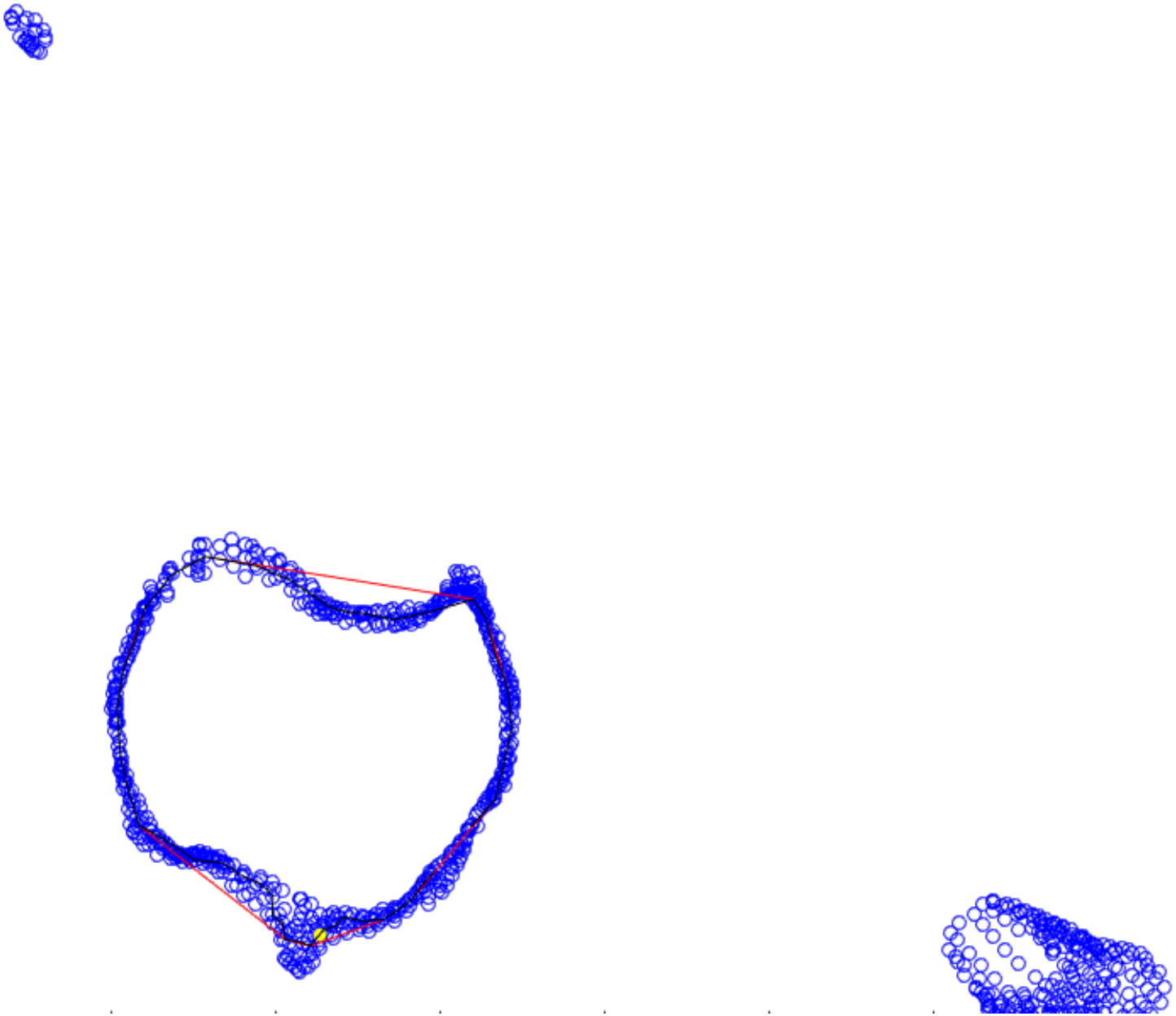

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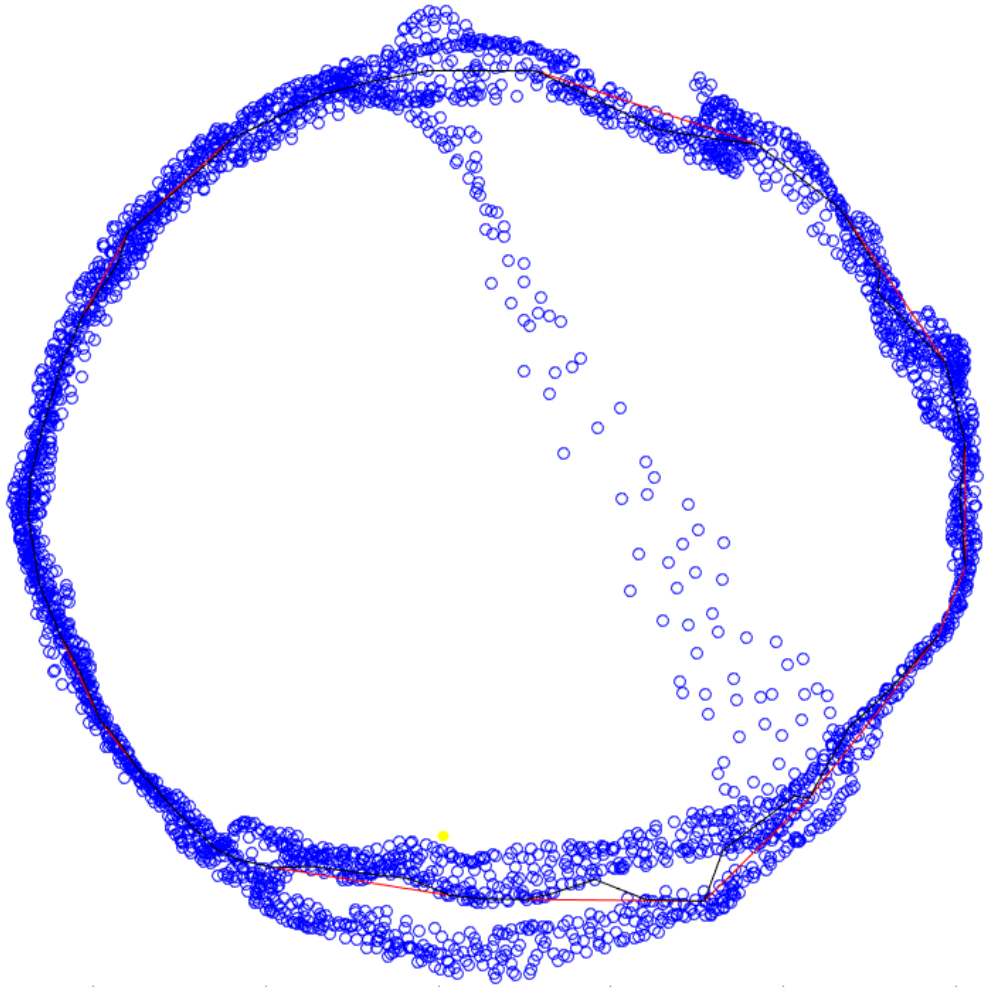
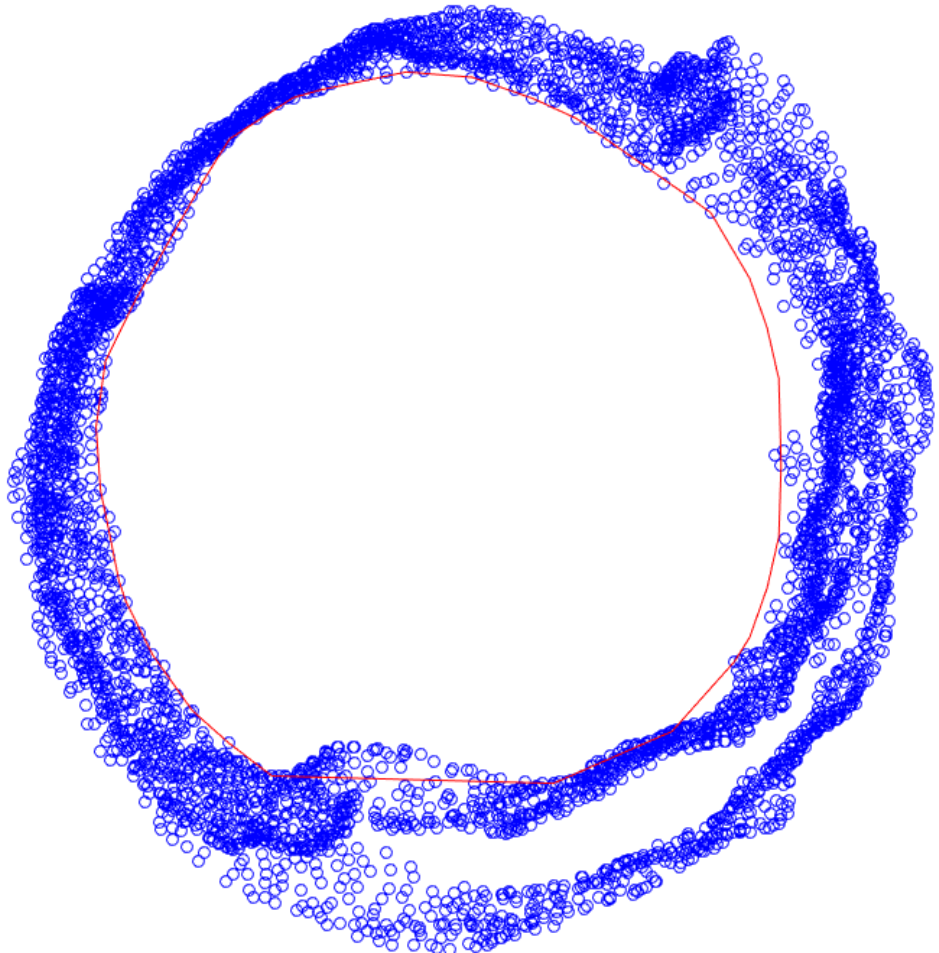
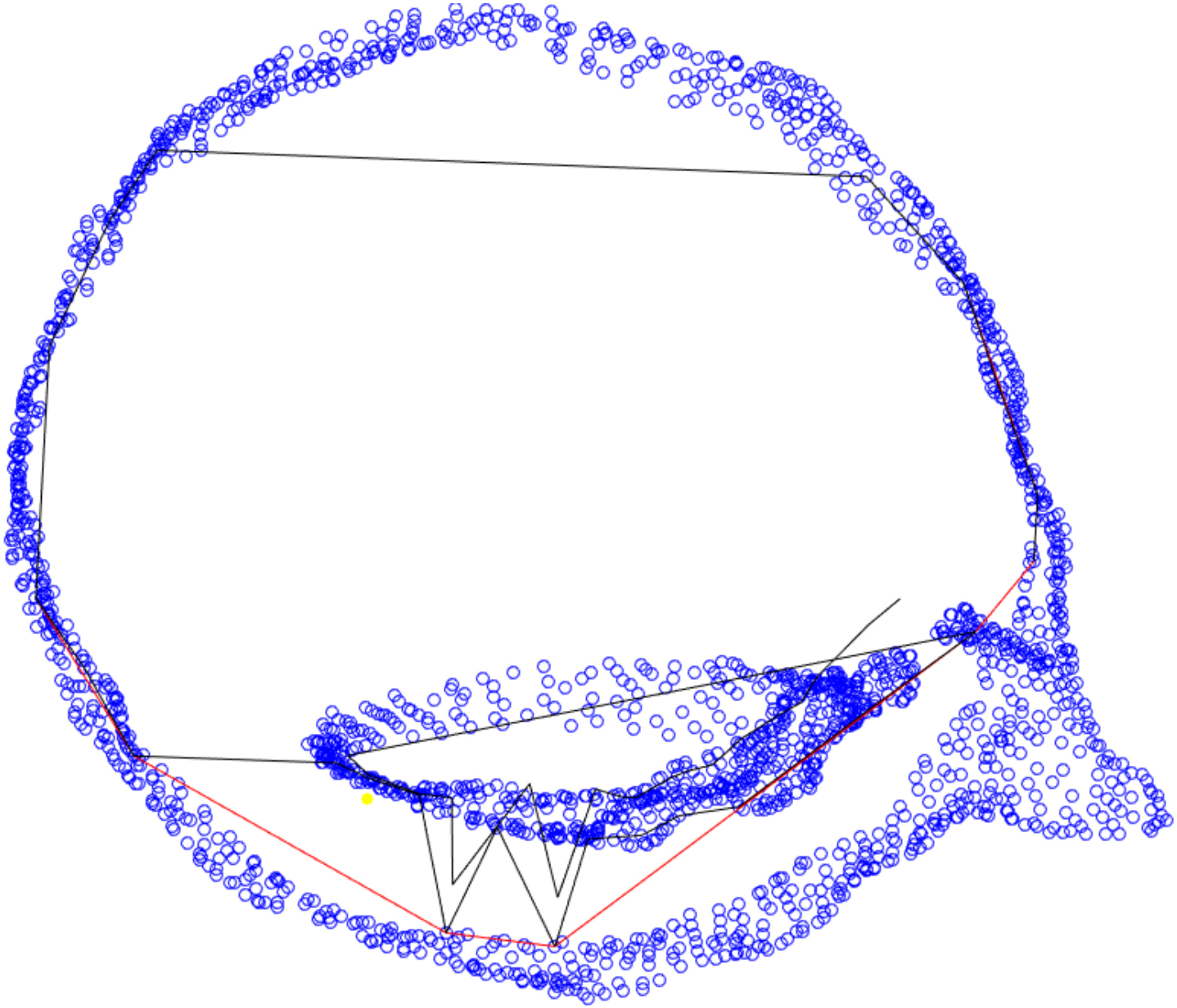




Issues



Results

- Computation time: aprox. 250 sec
- Measurements every 4 inch
- Inside bark diameter
- Accuracy: more than 95%
- Depends on rendering process