

Accurate, Detailed, and Automatic Tree Modelling from Point Clouds

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1.1 Motivation

- Why do we want to model trees?
 - Trees are important to humans
 - 3D models of trees have many applications



Urban landscape design



Simulation



Entertainment

1.1 Motivation

- Why do we want to model trees?
- Why 'automatic' and 'accurate'?

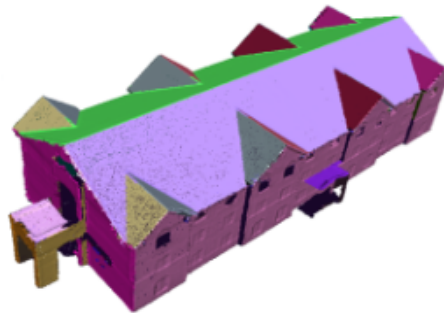
1.1 Motivation

- Why do we want to model trees?
- Why 'automatic' and 'accurate'?

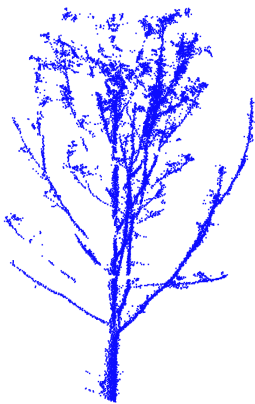


1.2 Challenges

- Trees are complex



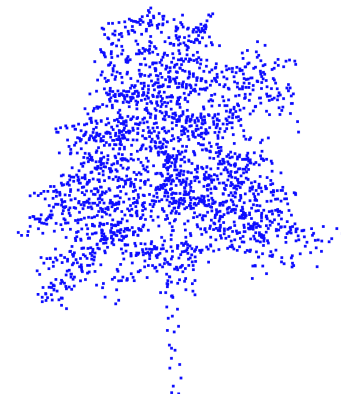
- Data is incomplete



Static scanner



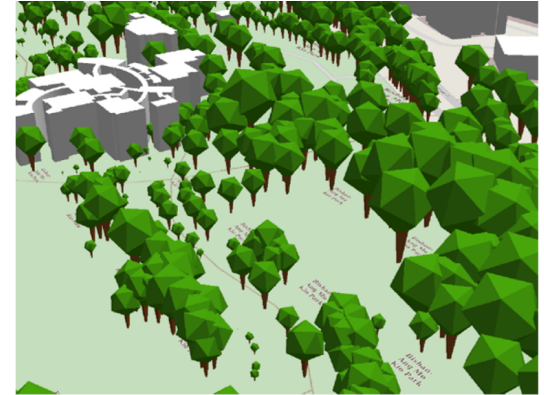
Mobile scanner



Airborne LiDar

2 Related work

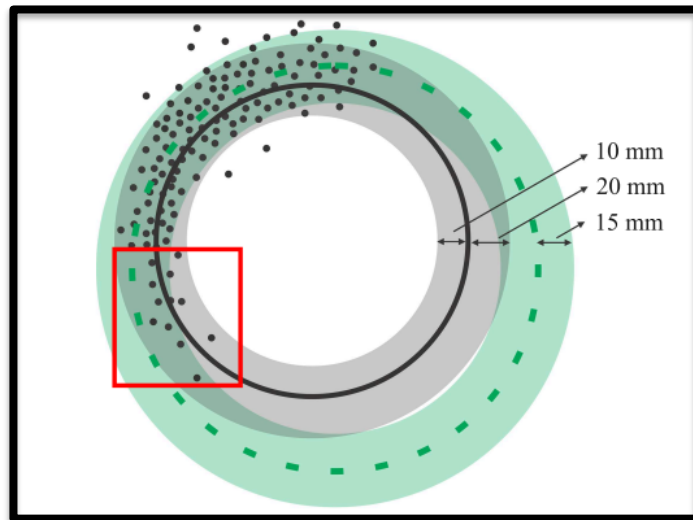
- Modelling 3D trees for CityGML Singapore
 - Tree model is not accurate or detailed



Soon et al. 2017

2 Related work

- Modelling 3D trees for CityGML Singapore (Soon et al. 2017)
- Automatic trunk reconstruction
 - Can only model the trunk only
 - Data needs to be reasonably clean and complete



Wang et al. 2016

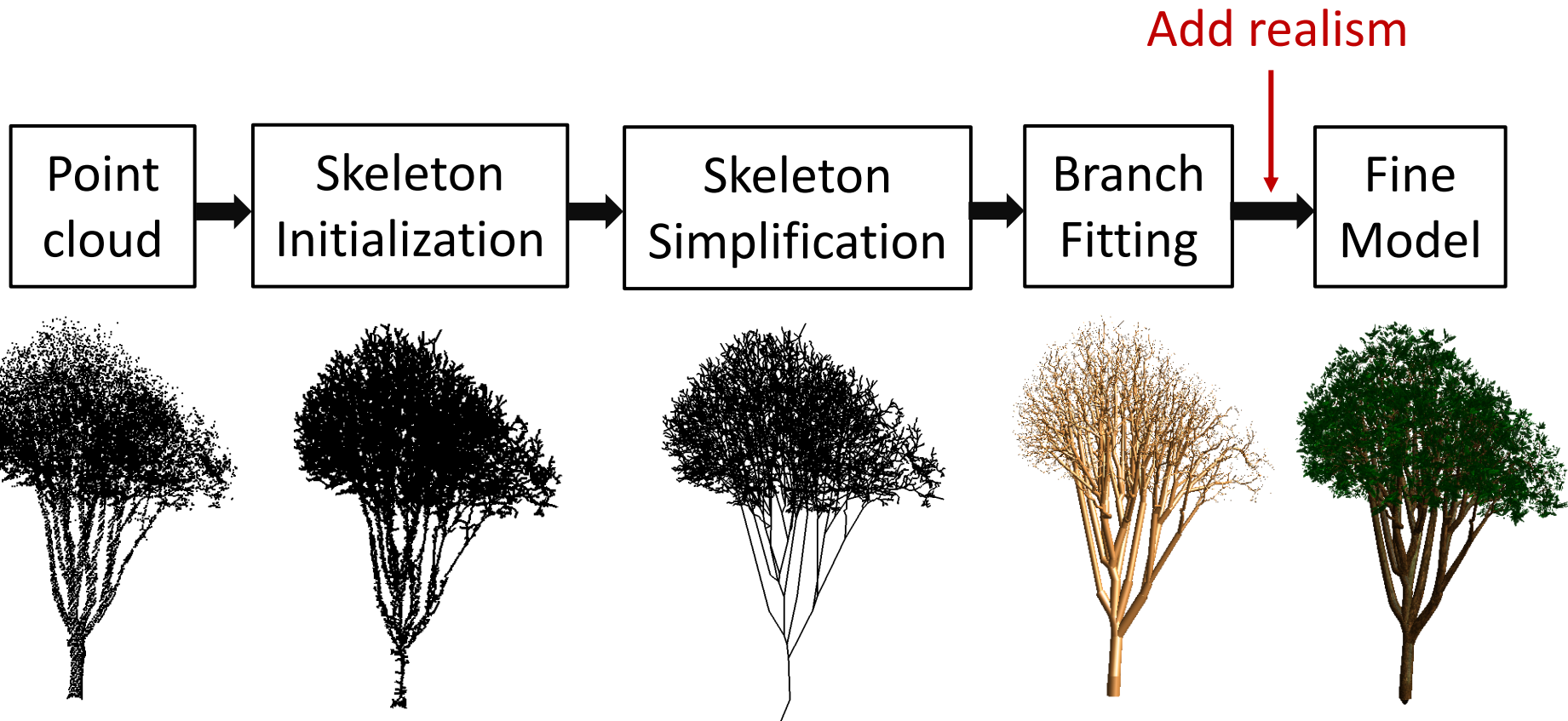
2 Related work

- Modelling 3D trees for CityGML Singapore (Soon et al. 2017)
- Automatic trunk reconstruction (Wang et al. 2016)
- Automatic reconstruction of tree skeleton
 - Can model the complex skeletal structure
 - Doesn't fit enough to the input points

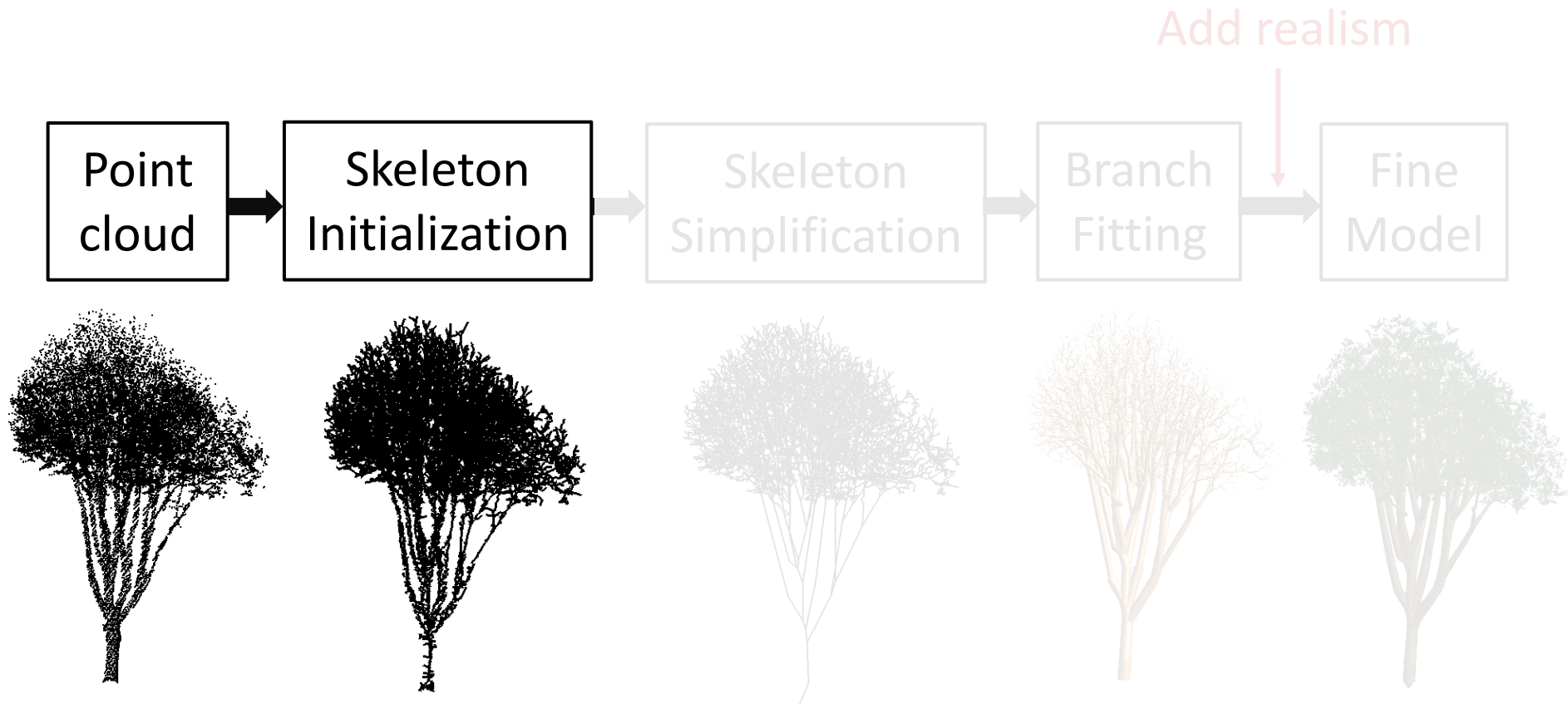


Livny et al. 2010

3. Methodology Overview

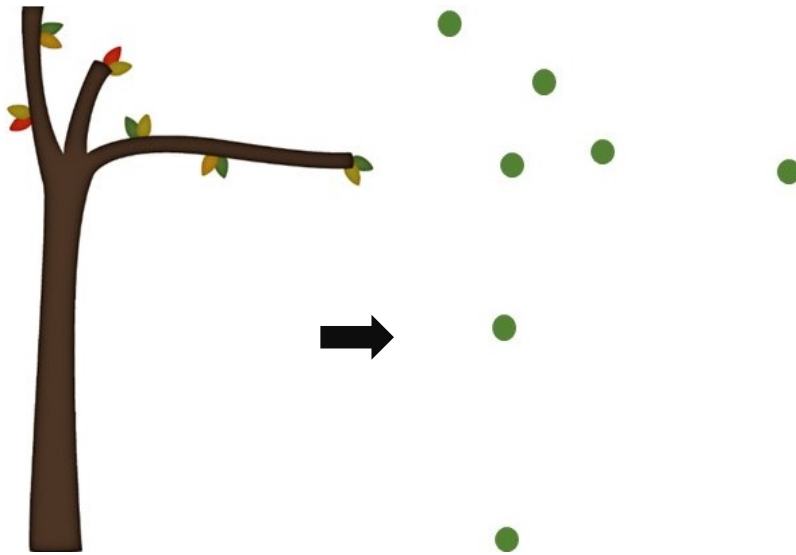


3. Methodology Overview



3.1 Skeleton Initialization

- We need a graph ('tree') representation

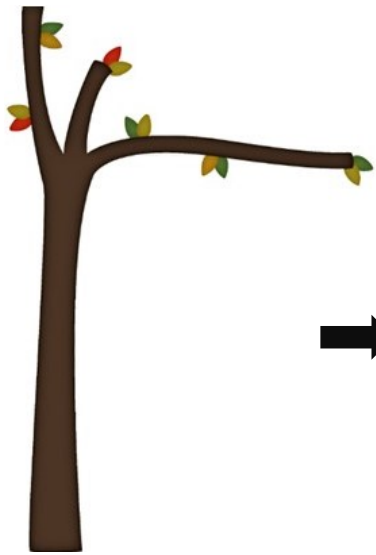


Real tree

Point cloud

3.1 Skeleton Initialization

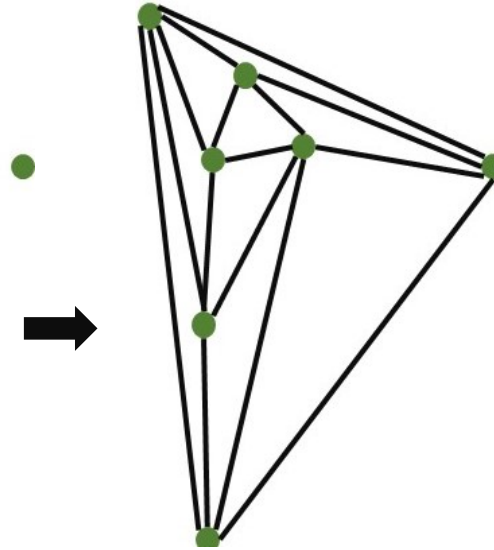
- We need a graph ('tree') representation
 - Delaunay triangulation
 - Initial graph; completes some missing parts



Real tree



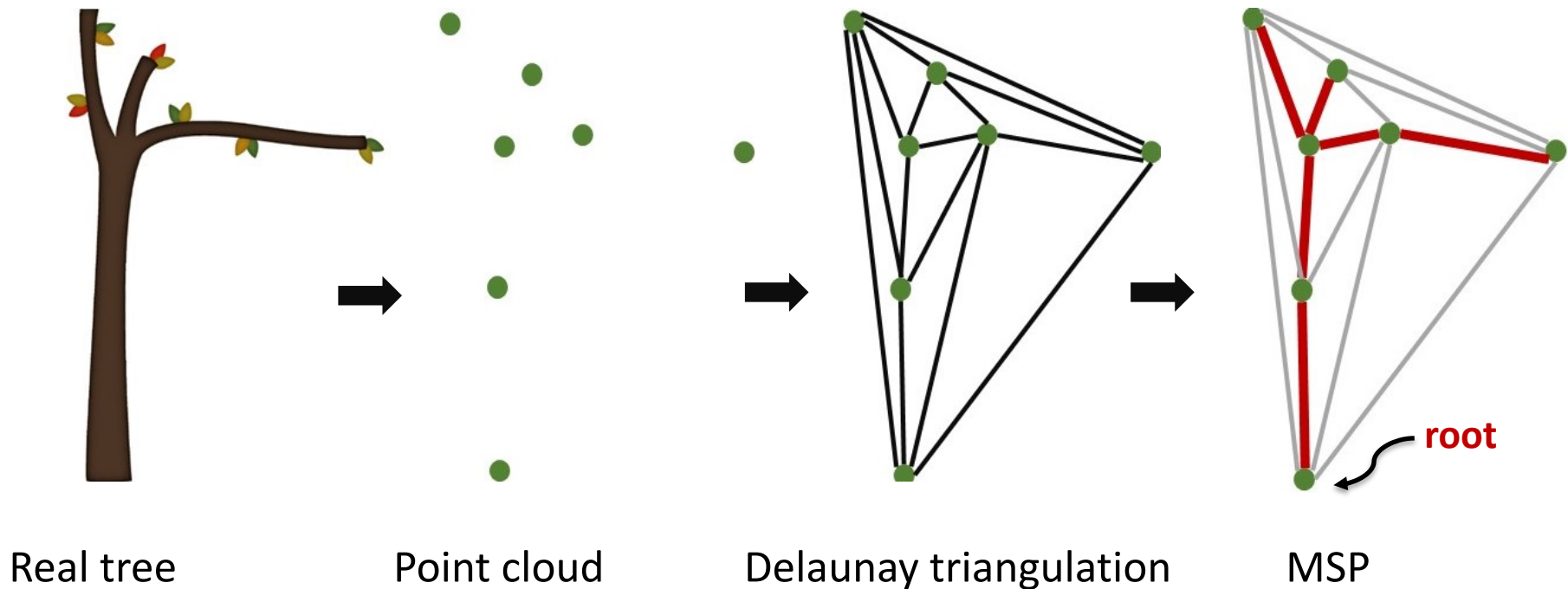
Point cloud



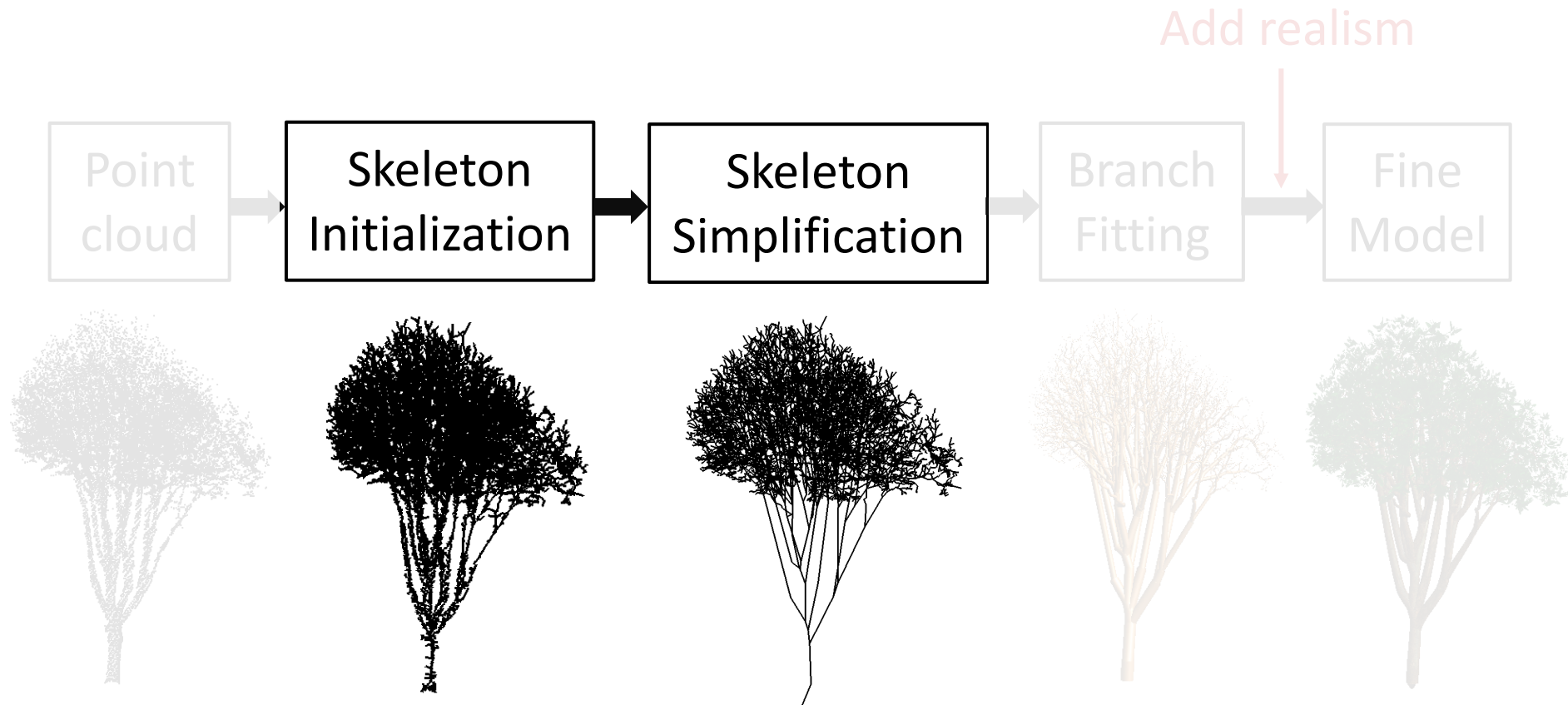
Delaunay triangulation

3.1 Skeleton Initialization

- We need a graph ('tree') representation
 - Delaunay triangulation
 - Minimum spanning tree

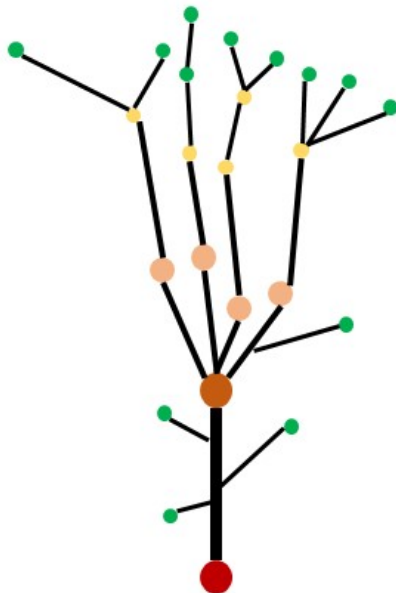


3. Methodology Overview



3.2 Skeleton Simplification

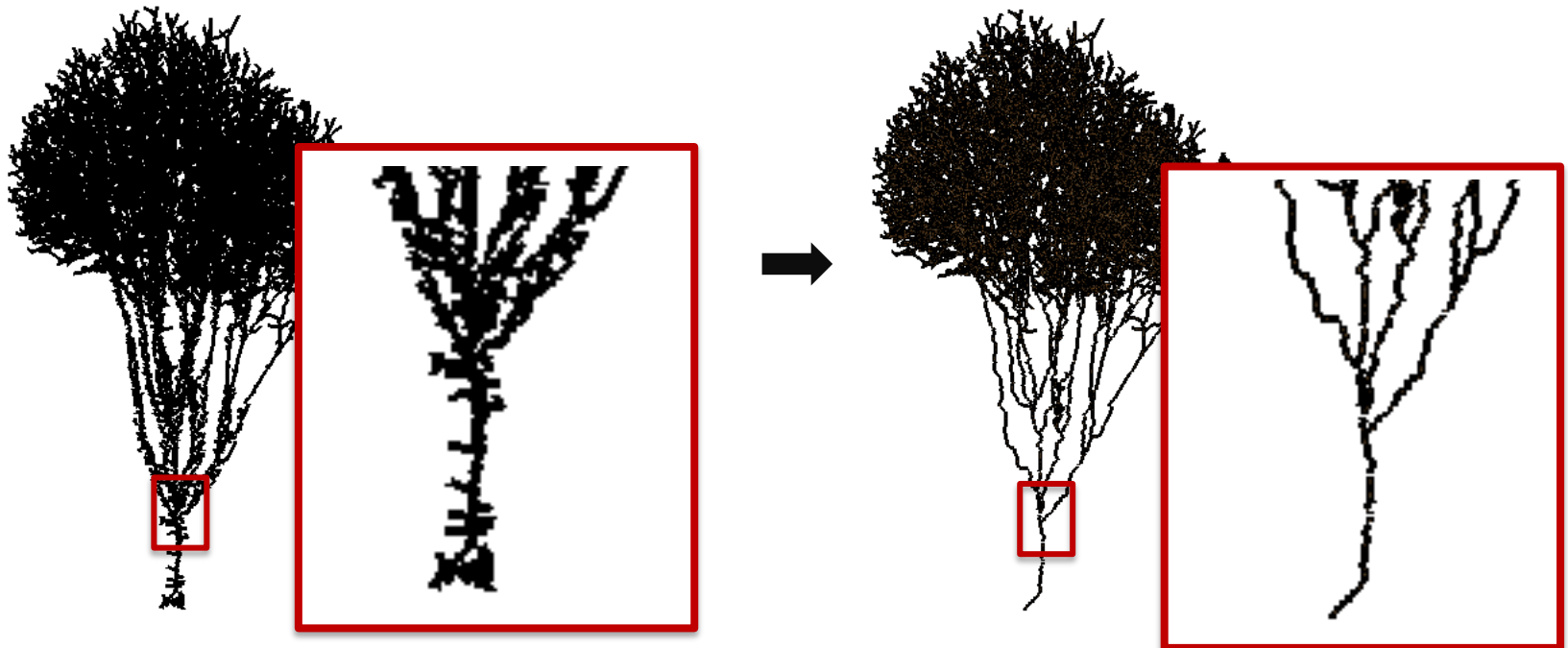
- Eliminate small noisy branches
 - Weight vertices and edges with subtree lengths
 - Less important branches first



- $\delta w = w_i / w_p$
- For the i^{th} vertex:
 - If $\delta w < \tau$:
 - Then remove i^{th} vertex and its subtree

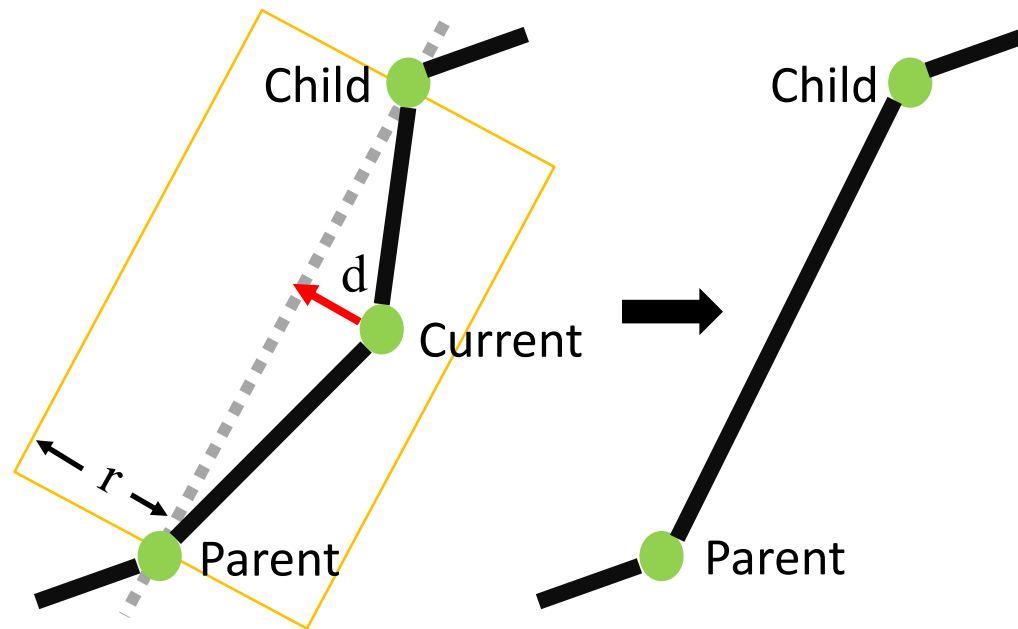
3.2 Skeleton Simplification

- Eliminate small noisy branches
 - Weight vertices and edges with subtree lengths
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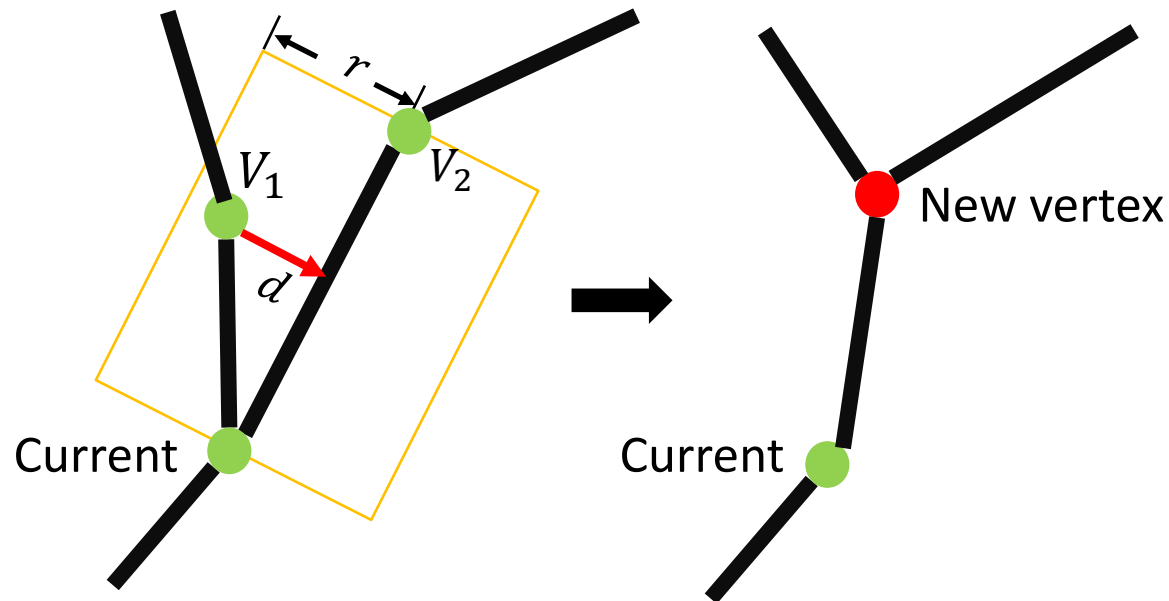
3.2 Skeleton Simplification

- Iterative simplification
 - Single-child vertex simplification



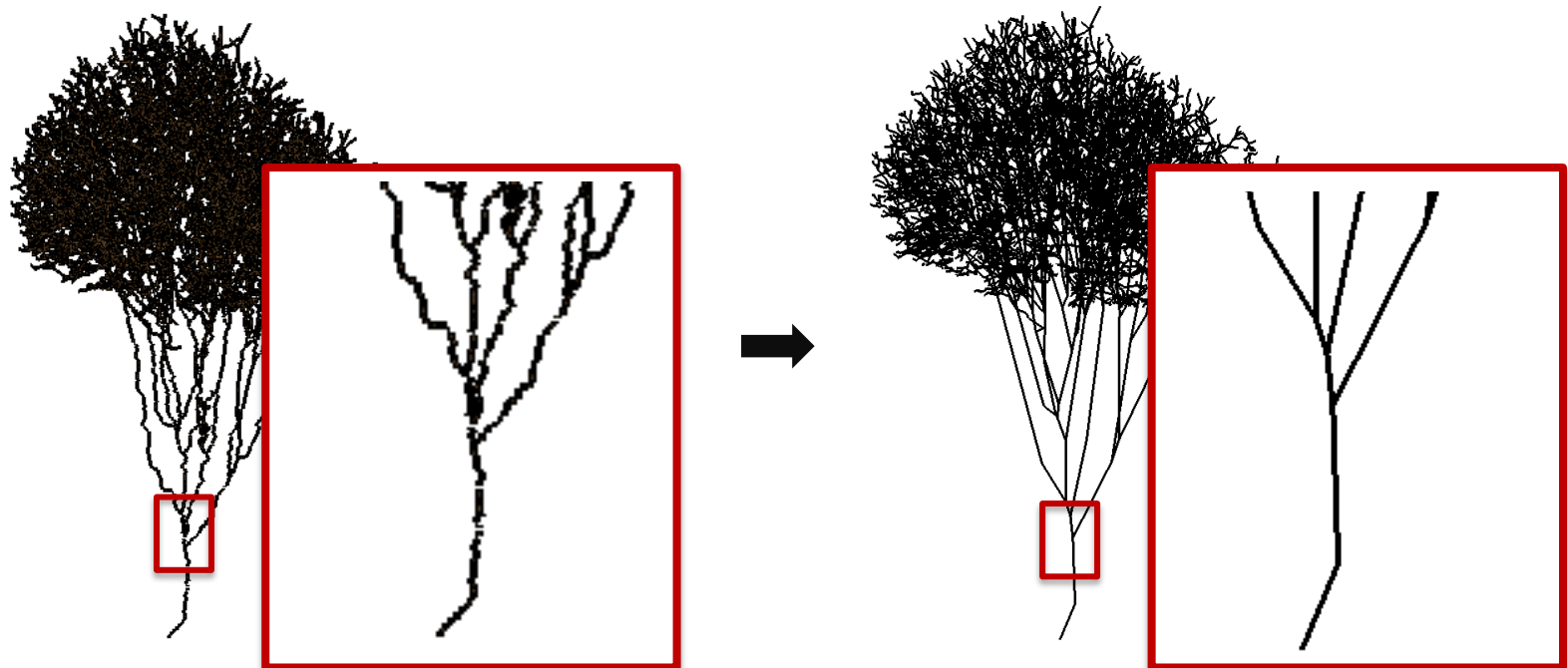
3.2 Skeleton Simplification

- Iterative simplification
 - Single-child vertex simplification
 - Multiple-children vertex simplification

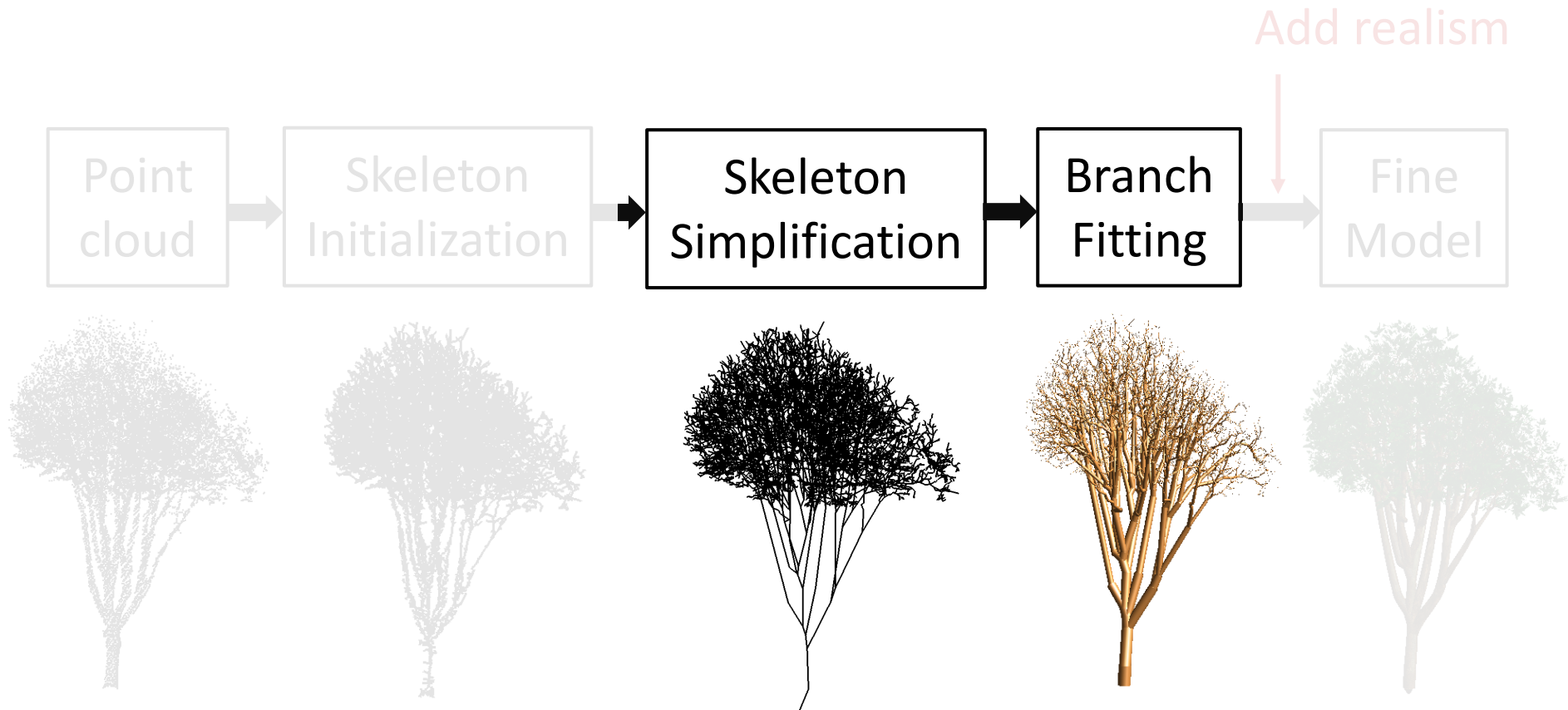


3.2 Skeleton Simplification

- Iterative simplification
 - Single-child vertex simplification
 - Multiple-children vertex simplification

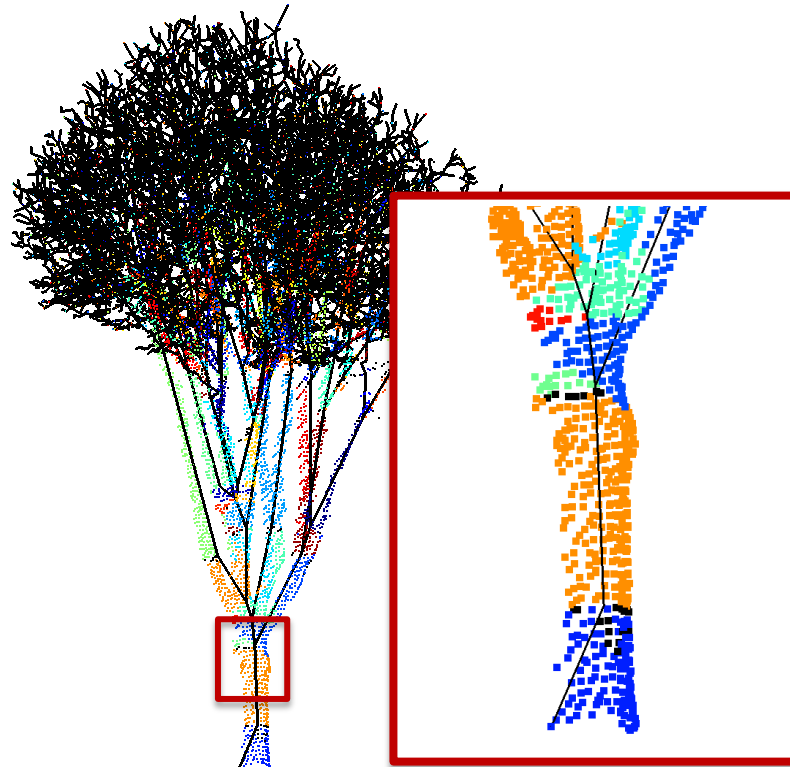


3. Methodology Overview



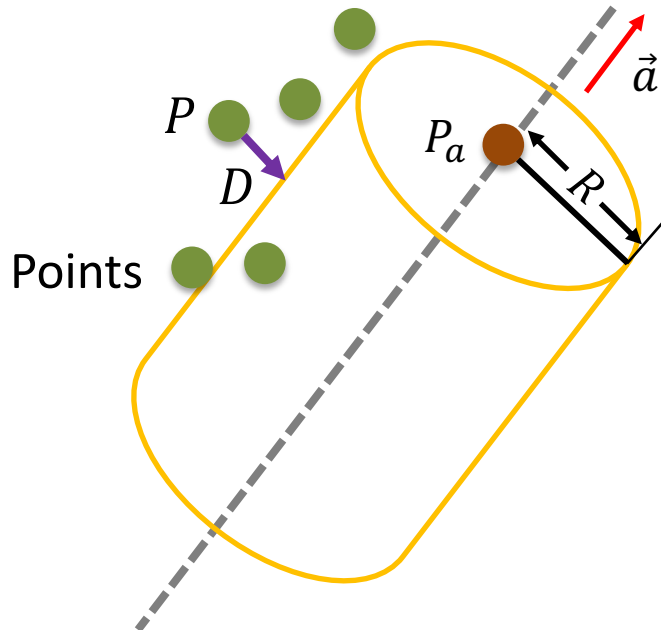
3.3 Branch fitting

- Fit cylinders to approximate the branch geometry
 - Assign each branch with corresponding points



3.3 Branch fitting

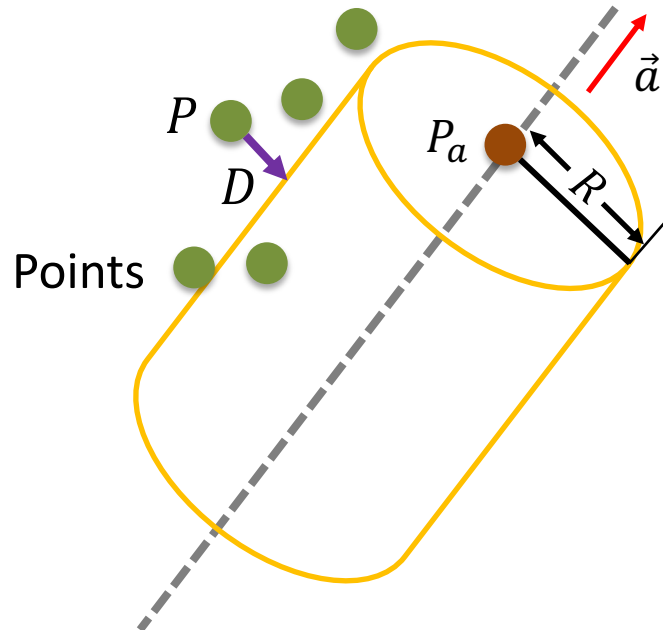
- Fit cylinders to approximate the branch geometry
 - Non-linear least squares problem



- **Parameters to solve:**
 - $P_a, R, \vec{a}$
- **Input data:**
 - Position of P
- **Objective function:**
 - $\min \sum D$

3.3 Branch fitting

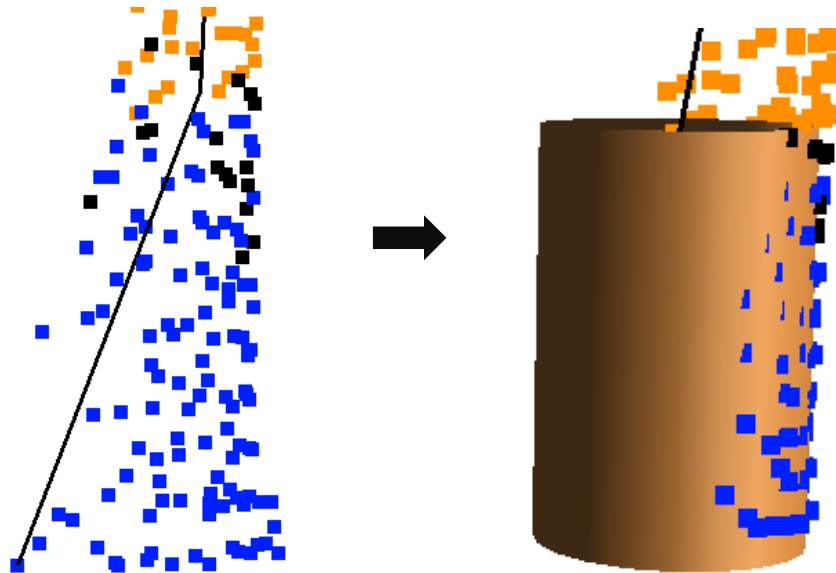
- Fit cylinders to approximate the branch geometry
 - 2nd iteration: Weighted non-linear least squares



- **Weight:**
 - $w_i = 1 - \frac{D_i}{D_{max}}$
- **Objective function:**
 - $\min \sum D_i w_i$

3.3 Branch fitting

- Fit cylinders to approximate the branch geometry
 - Fit a cylinder for the main trunk



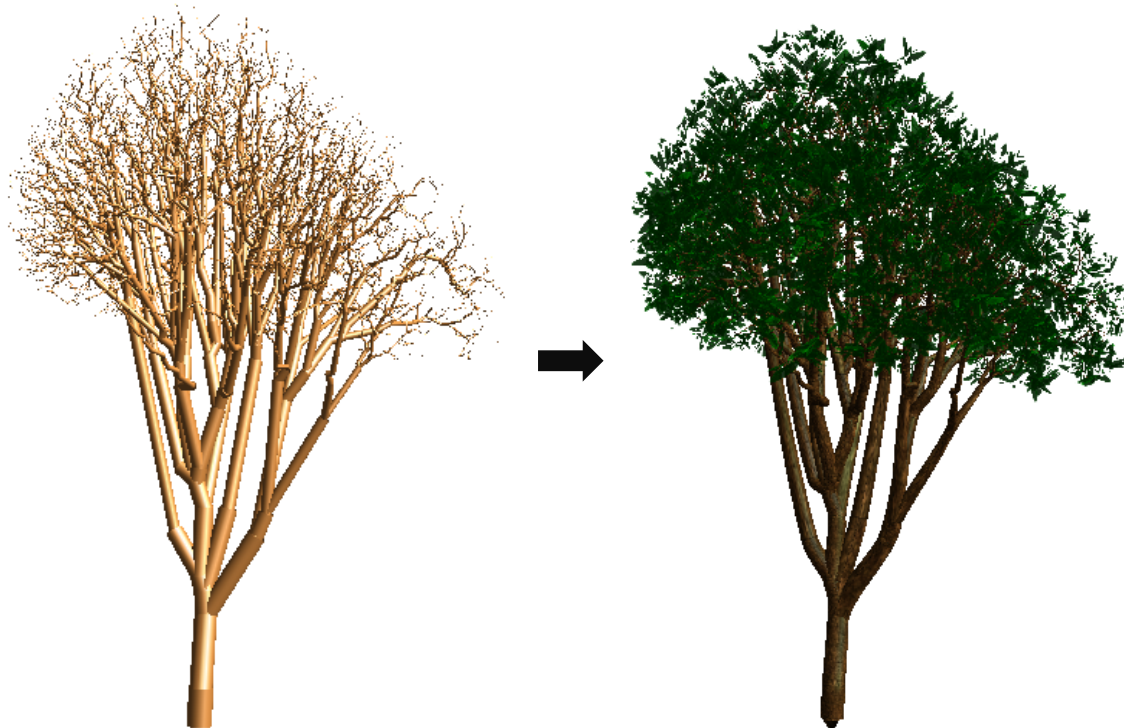
3.3 Branch fitting

- Fit cylinders to approximate the branch geometry
 - Fit a cylinder for the main trunk
 - Small branches
 - Don't have enough points
 - Radius is proportional to the length of its subtree

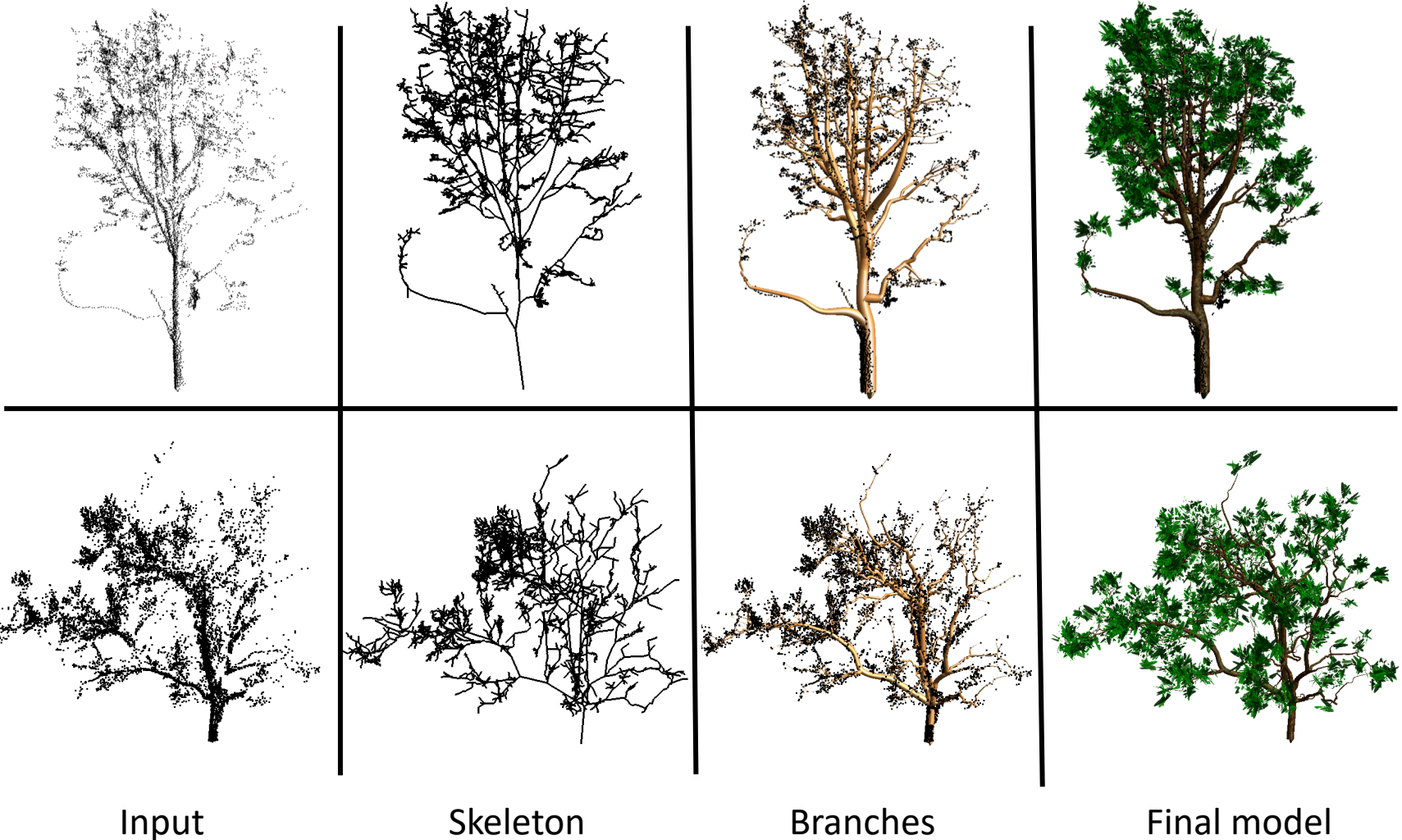


3.4 Adding realism

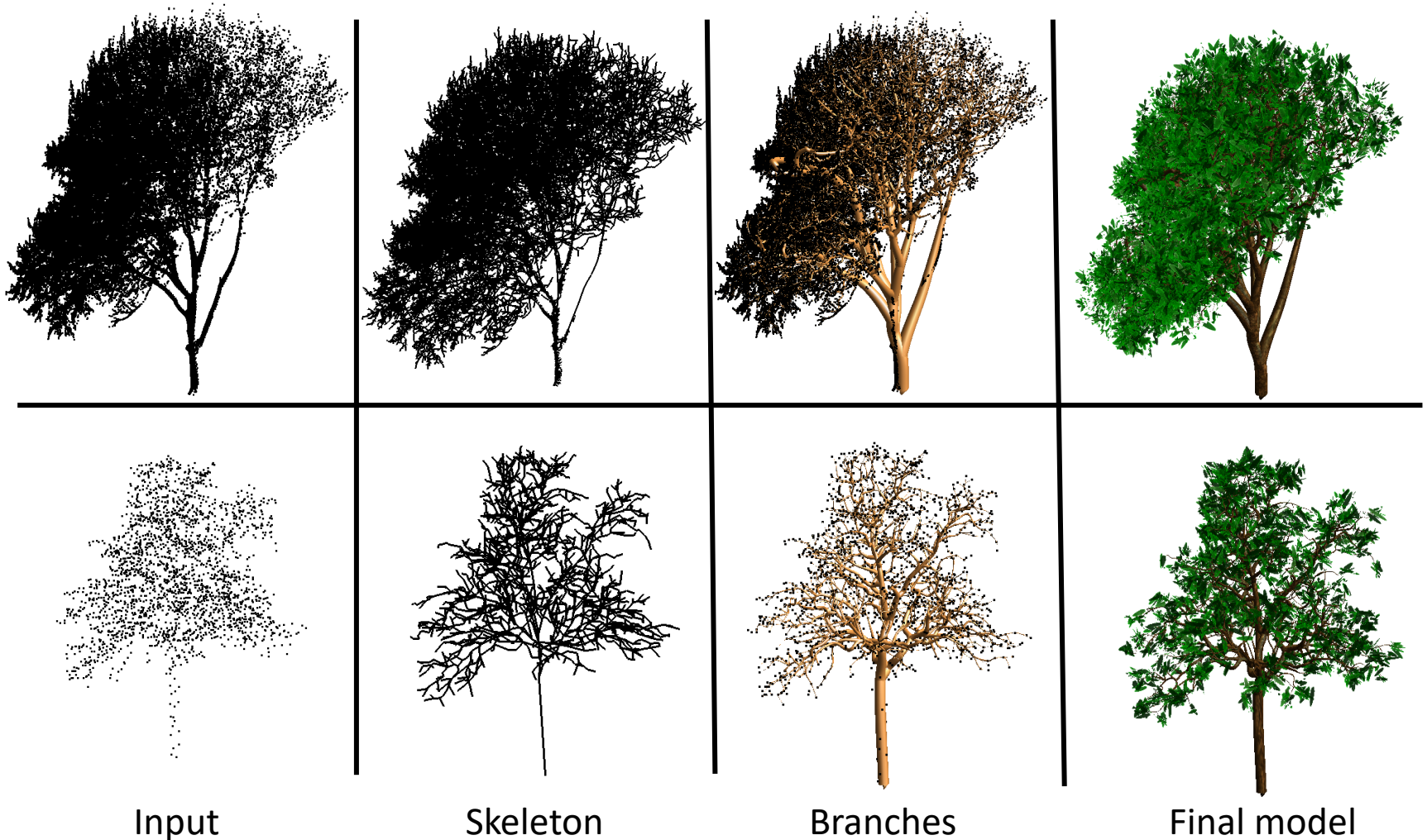
- Add leaves and texture to the tree model
 - Reconstructing leaves almost impossible
 - Randomly grow leaves on top of branches



4. Results: different tree types



4. Results: different data sources



5. Future Work

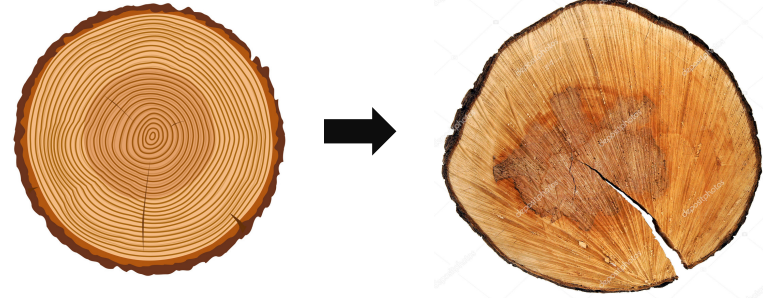
- Individual tree

👉 A set of trees



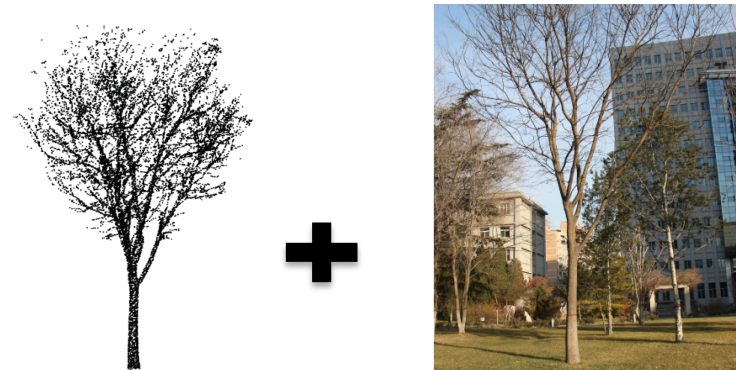
- Cylinder fitting

👉 Free form surface fitting



- Point cloud only

👉 Points with Images



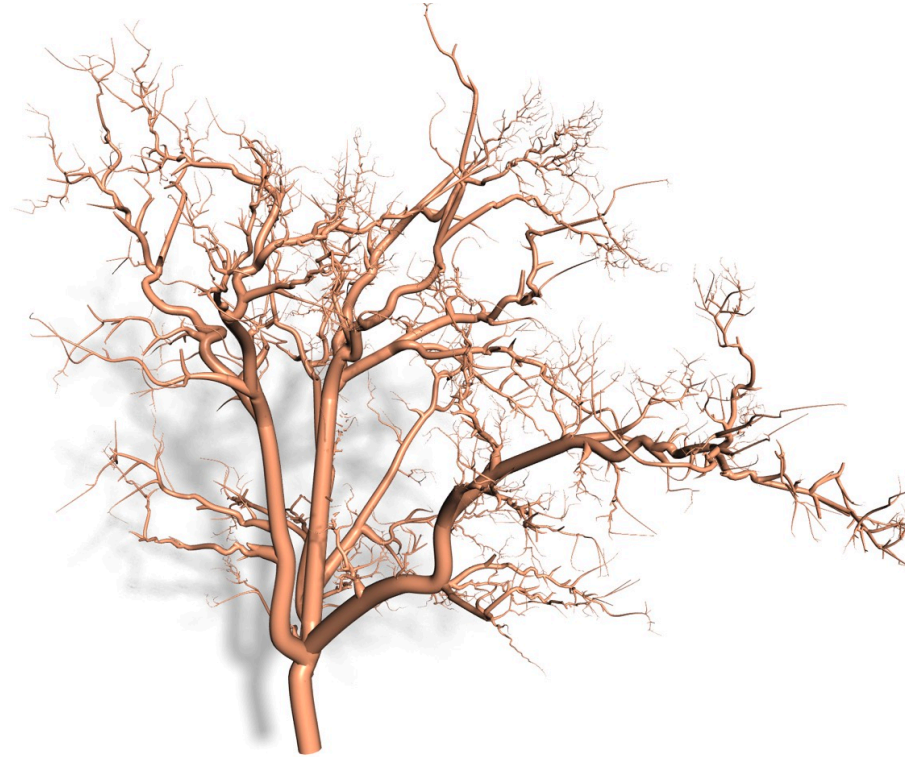
5. Future Work

- Application
 - Estimate wood volume, biomass..



6. Live demo

Thank you!



Source code:

<https://github.com/tudelft3d/adtree>

Technique paper:

https://3d.bk.tudelft.nl/liangliang/publications/2019/adtree/AdTree_RS-2019.pdf