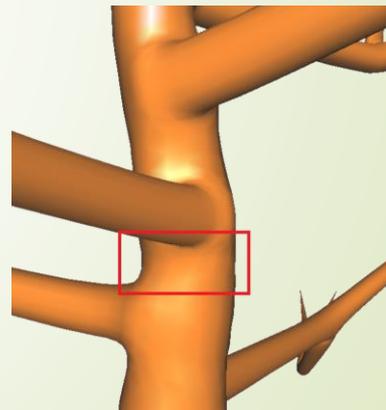# Realistic Modeling of Tree Ramifications from an Optimal Manifold Control Mesh

Zhengyu Huang, Zhiyi Zhang, Nan Geng, Long Yang, Dongjian He, Shaojun Hu
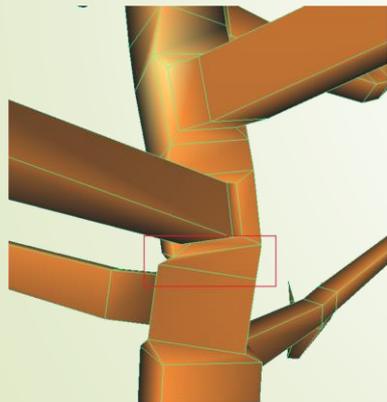
Northwest A&F University, China

August 24, 2019

http://icig2019.csig.org.cn/?page_id=730

Most tree modeling focus on a **global** impression

[Tan et al. 2007] [Xu et al. 2007] [Livny et al. 2011] [Hu et al. 2017]

Image-based Tree Modeling [Tan et al. 2007]

Texture-Lobes for Tree Modeling [Livny et al. 2011]

How to model realistic trees with **continuous** ramifications ?

Approaches for surfaces generation of trees
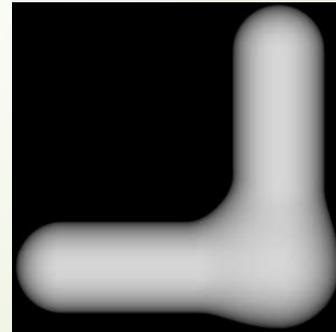
- **Parametric surfaces**

→ **Discontinuous between branches**

- **Implicit surfaces**

→ **Well continuity but difficult to control**

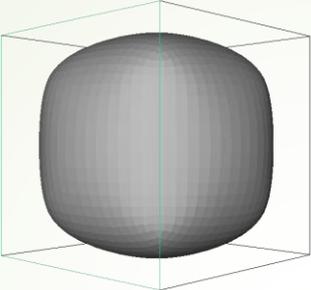

Generalized cylinder (Bloomenthal and Wyvill 1990)
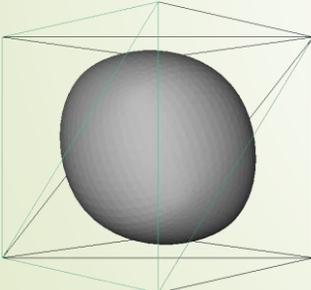

Bulge when blending two line segments

Motivation: Subdivision surface + Parametric surface
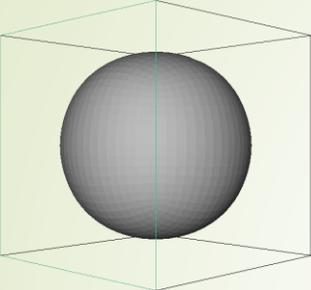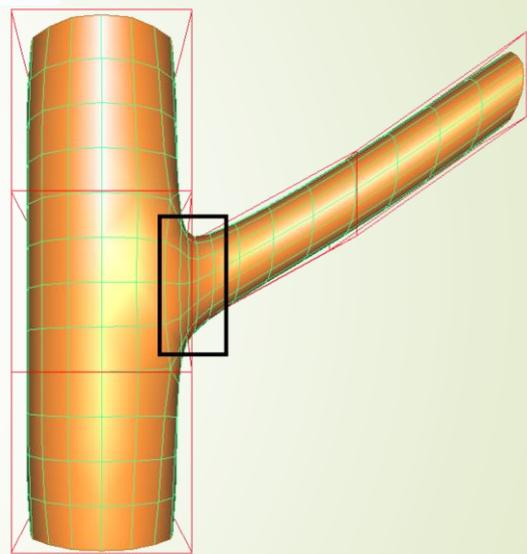
Catmull-Clark

Doo-Sabin

Loop
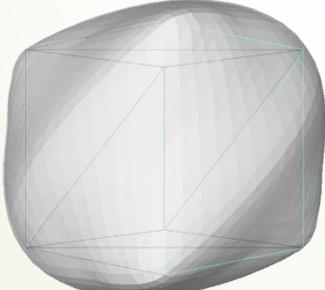
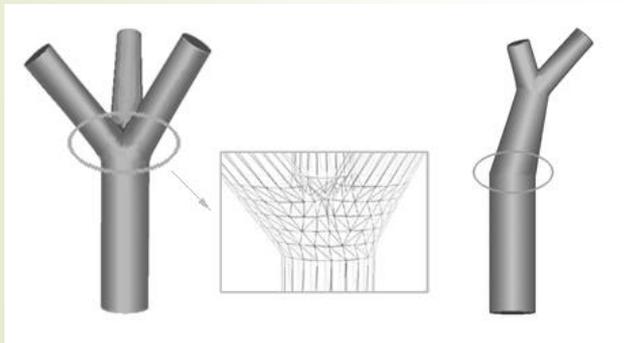**Butterfly**

Catmull-Clark

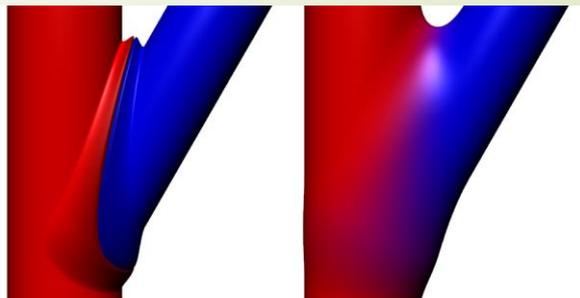# Related work

- **Implicit surfaces**

[Galbraith et al. 2004] [Tai et al. 2004] [Xiaoqiang et al. 2015]
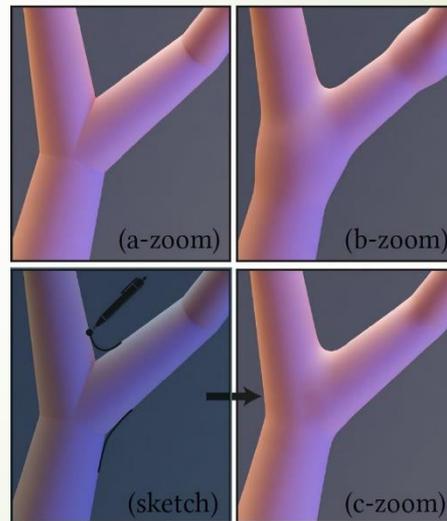[Angles et al. 2017]

- **Construction method**

[Lluch et al. 2001] [Tobler et al. 2002] [Xunlei et al. 2011]

[Galbraith et al. 2004]

(a-zoom) (b-zoom)

(sketch) (c-zoom)

[Angles et al. 2017]

[Lluch et al. 2001]

Input: User-defined Skeletons of tree

Real tree

[Hu et al. 2017]

Skeletons

Overview

Step 1: Create basic units

Step 2: Connection optimization

Step 3: Cut-paste scheme

2nd subdivision

1st subdivision
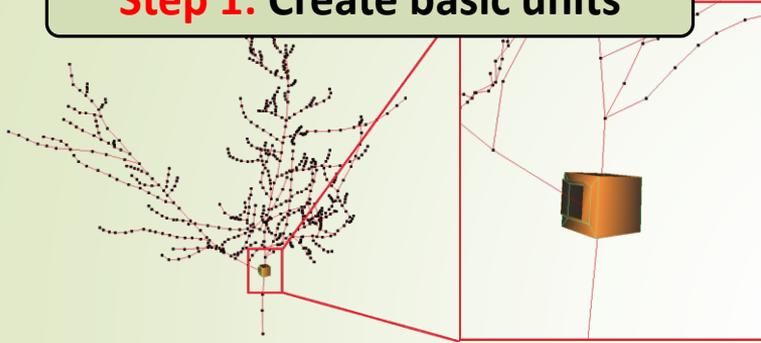
Overview

Step 1: Create basic units

Set *RU = 0*

$$f(Rems) = \sum_{i=1}^{N} RU(Rems_i) + \sum RC(Rem_{i,j}) + \sum CP(Rem_{i,k})$$

Step 2: Connection optimization

Step 3: Cut-paste scheme

1. Basic units creation

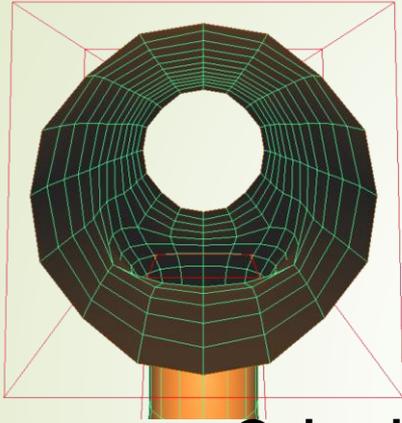Step 1: Create basic units

1st subdivision

2nd subdivision

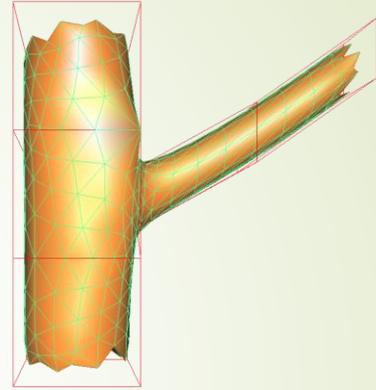# Basic unit creation

➢ The red sub-branches are additional branches
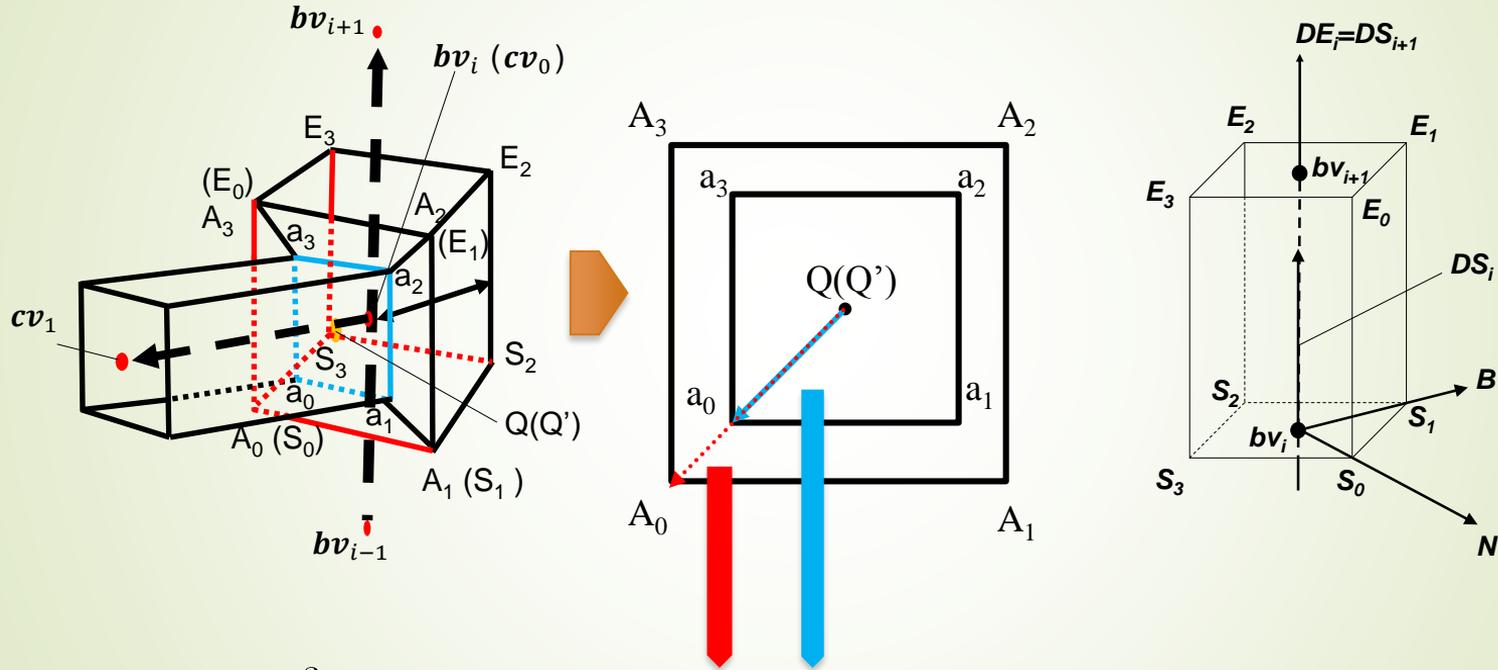
$$\text{Set} \quad RU(Rems_i) = \sum_{k=0}^{3} CosDistance(\vec{QA_k}, \vec{Q'a_k}) = 0$$
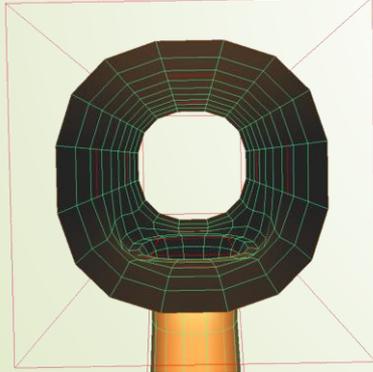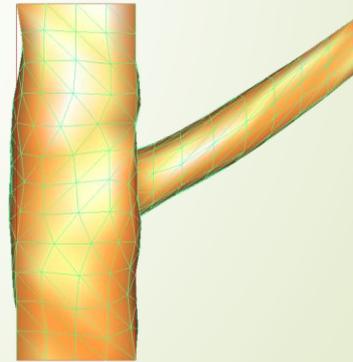
Subdivision results for a single ramification

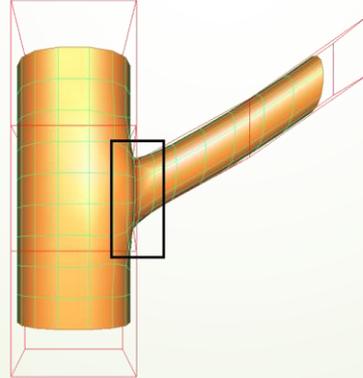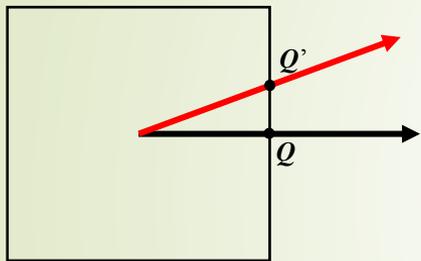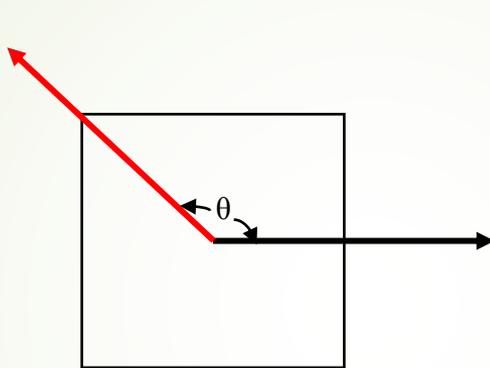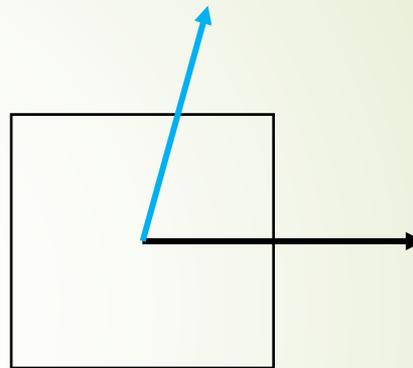
Catmull-Clark
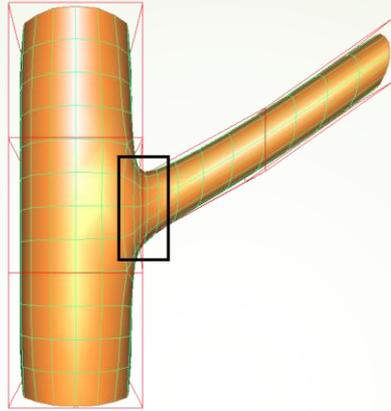
Loop

Doo-Sabin

Butterfly

Additional branch

➤ The red subbranches are additional branches

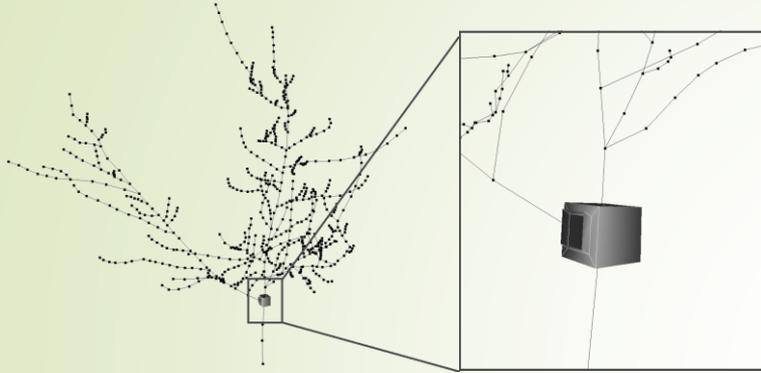**Q** and **Q'** are in the same face $|(\theta)mod(45°)| < 10°$ Connectable ramification

2. Connection optimization

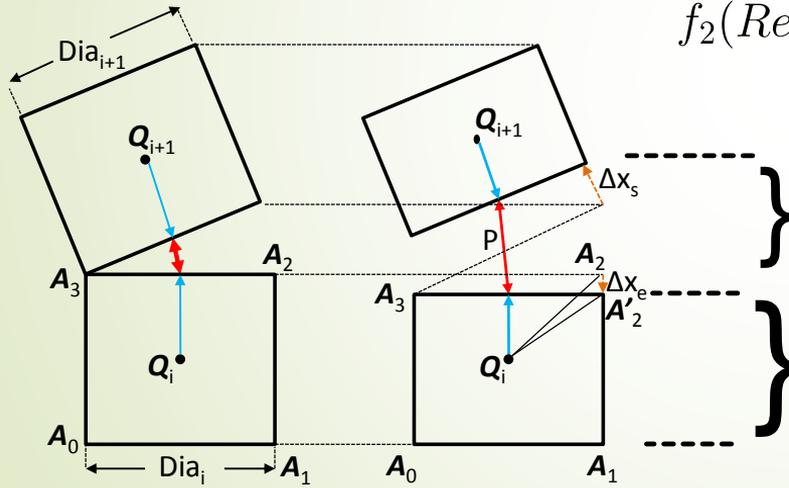**Step 2:** Connection optimization

2nd subdivision

1st subdivision

Additional branch
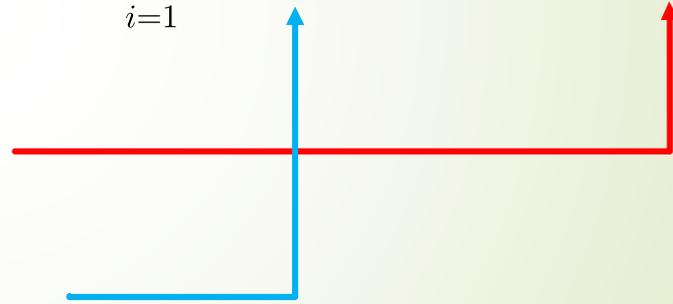
➤ Radial optimization

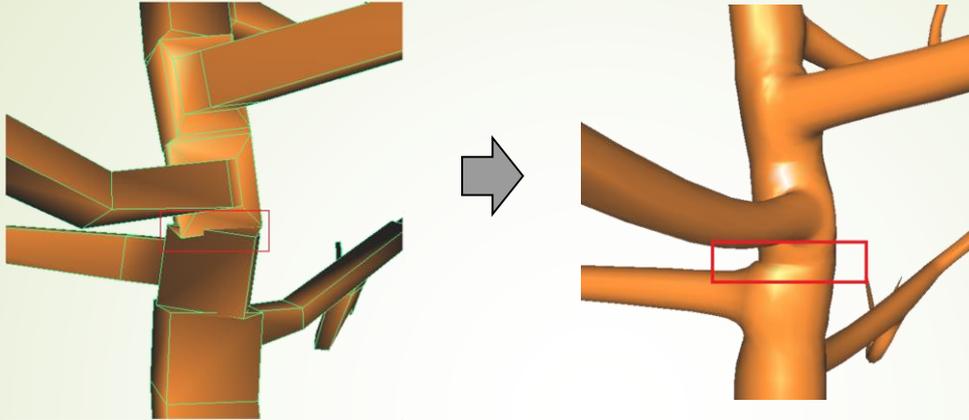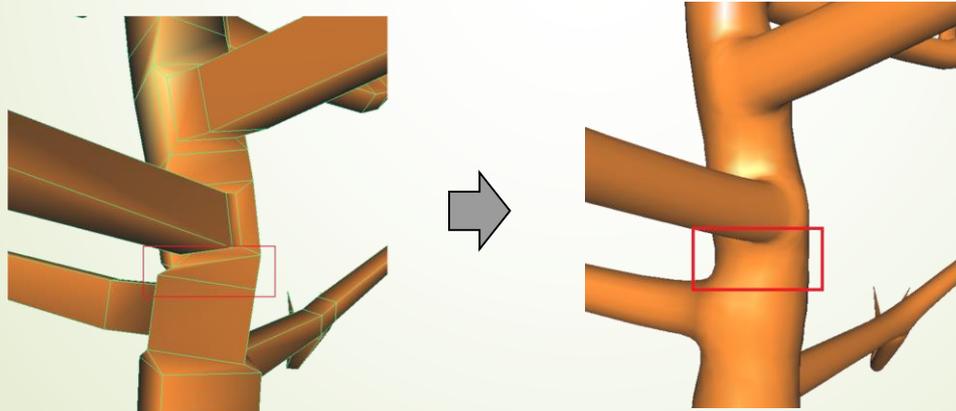connect the start and boundaries with minimal cosine distance.

➤ Axial optimization

$$f_2(Rems) = \sum_{i=1}^{N} RU(Rems_i) + \sum RC(Rem_{i,j})$$
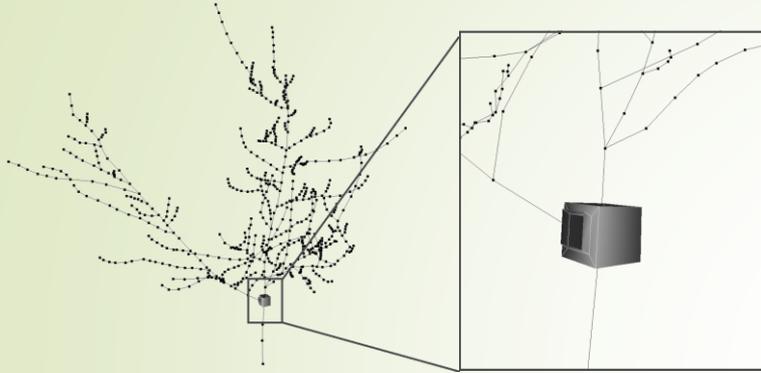
The effect of connection optimization

Before optimization

After optimization

3. Cut-paste scheme

2nd subdivision
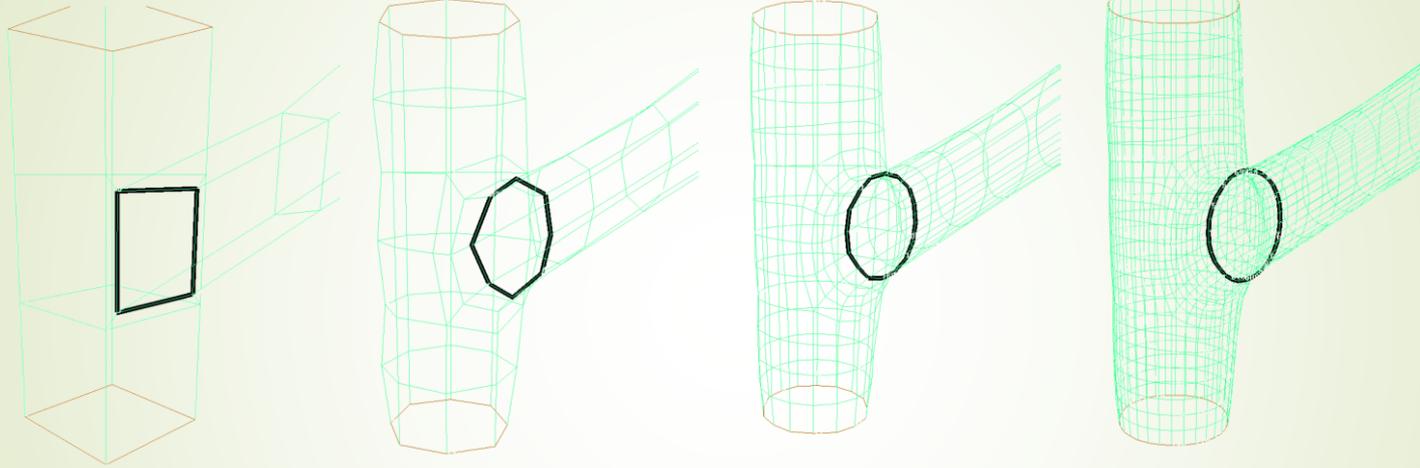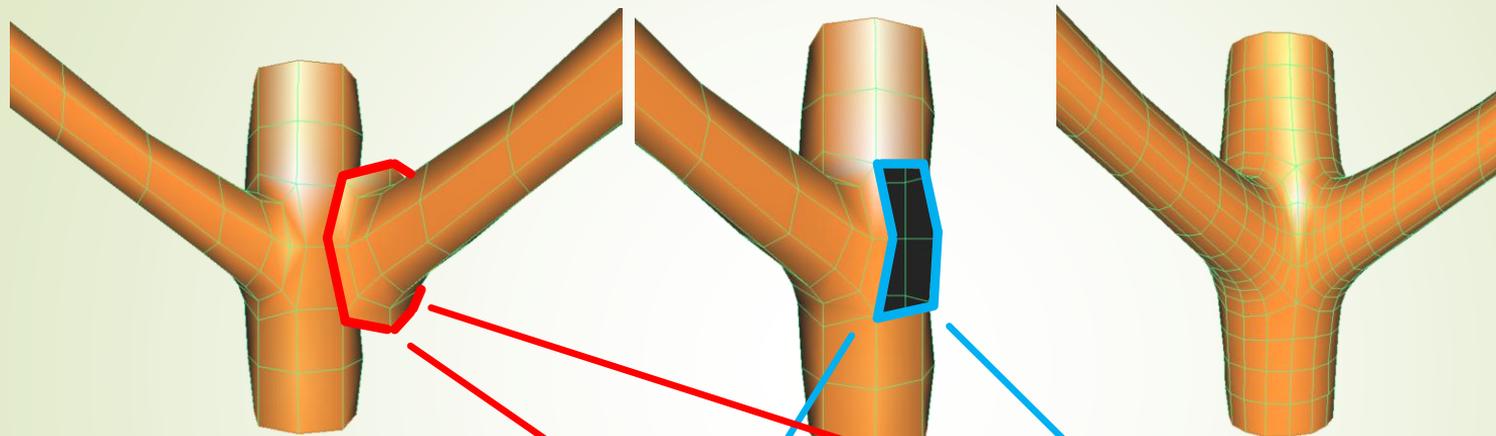
Step 3: Cut-paste scheme

1st subdivision

Boundary calculation
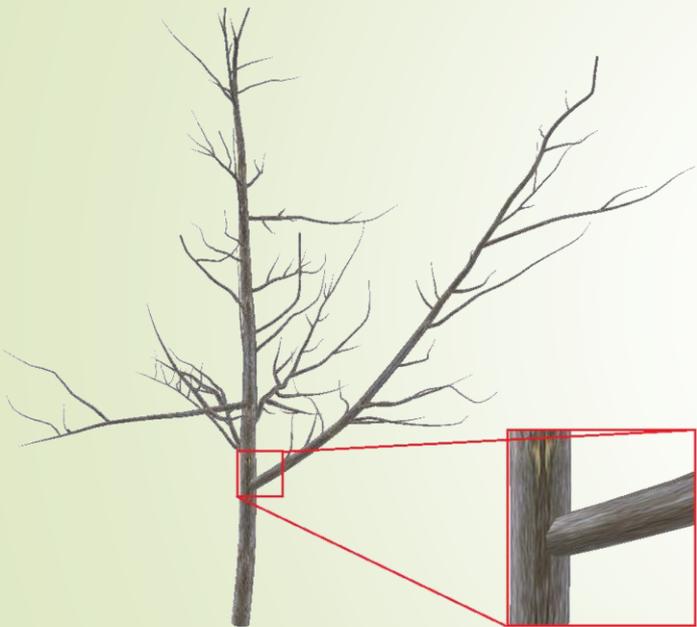

Boundary calculation after Catmull-Clark subdivision

Cut-paste for additional branches
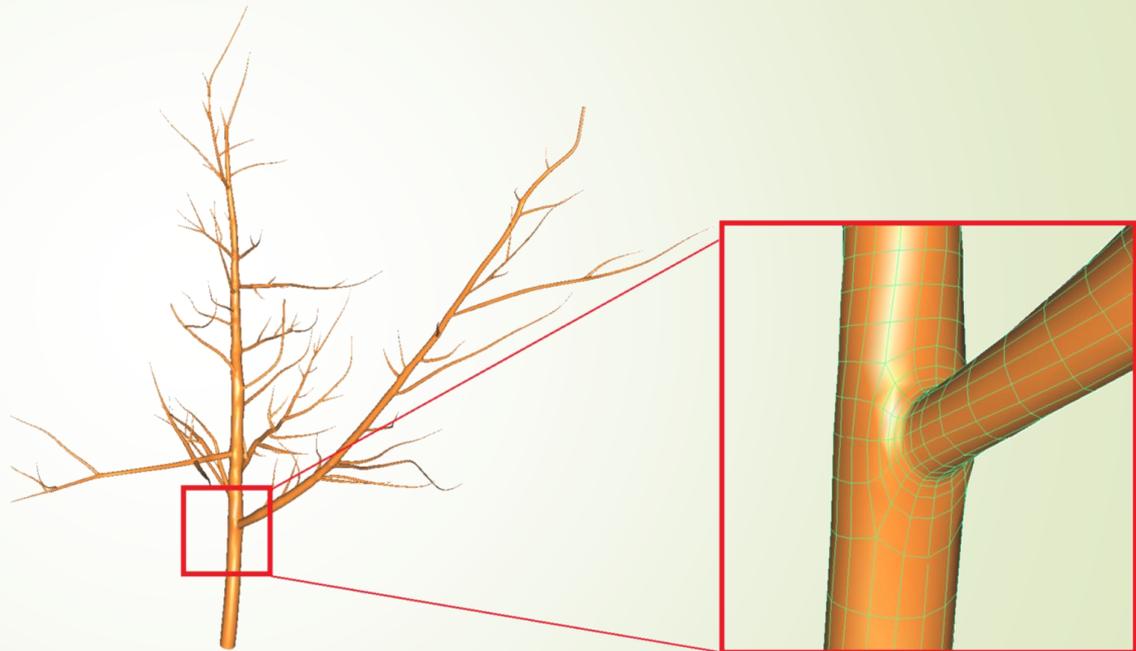

$$CP(Rem_{i,k}) = \beta \sum_{j=0}^{m-1} CosDistance(\vec{SB}_j^{(i)}, \vec{PB}_j^{(k)}) + (1 - \beta) \sum_{j=0}^{m-1} \|\vec{SB}_j^{(i)} - \vec{PB}_j^{(k)}\|$$

weight β=0.5

Results (1): reconstruct an apple tree

Generalized cylinder method

Our approach

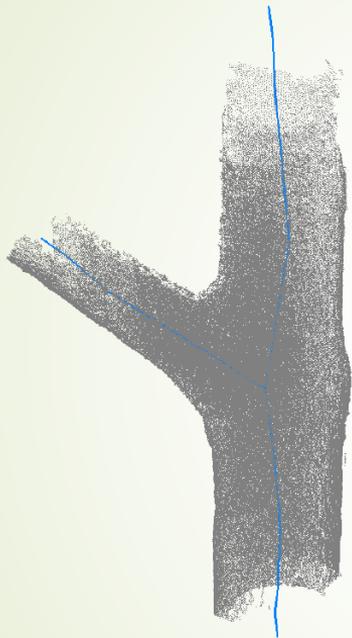# Results (2): verification for cut-paste scheme

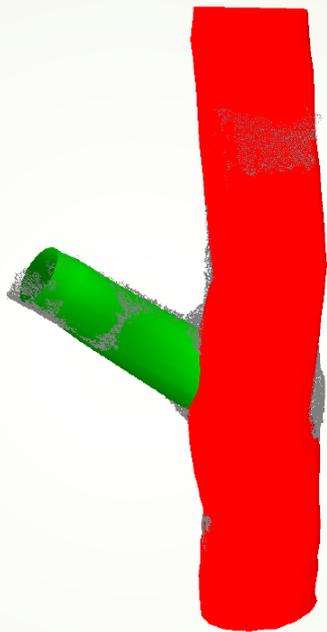Multi-furcation ramification construction
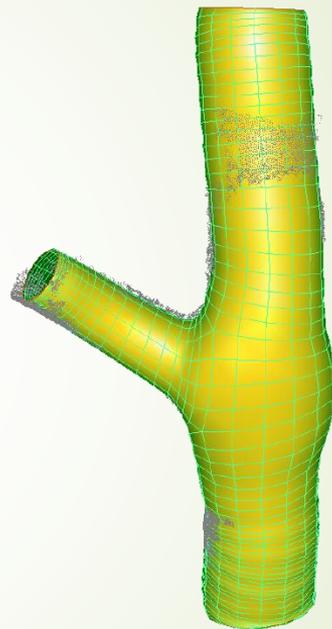
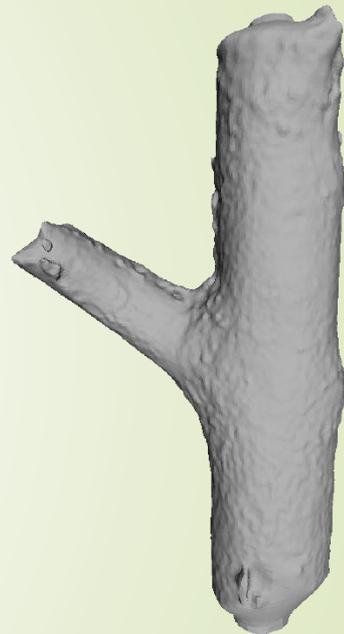# Results (3): examples of modeling a real tree ramification

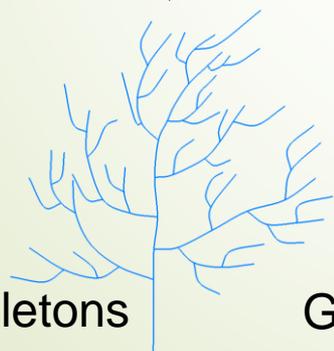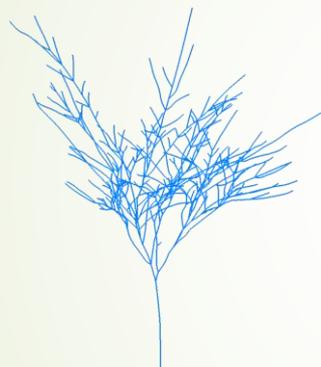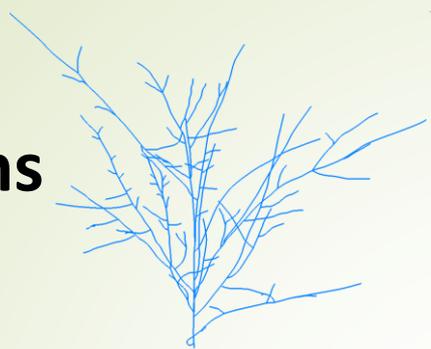Multi-view photos   Point cloud   Generalized cylinders   CC surface   Poisson surface
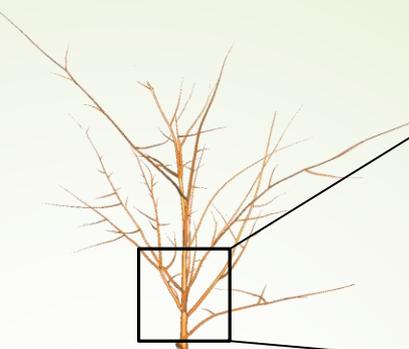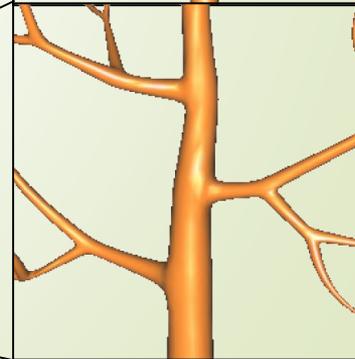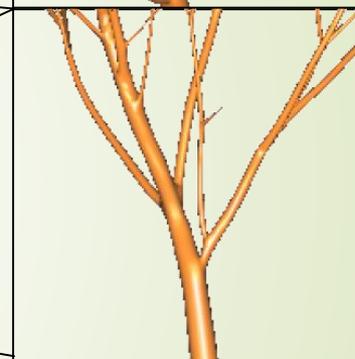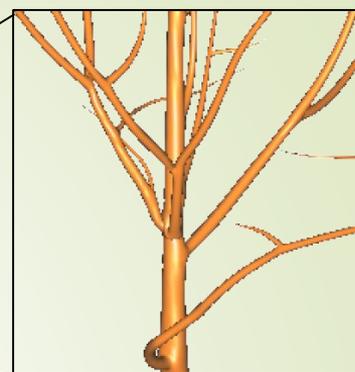
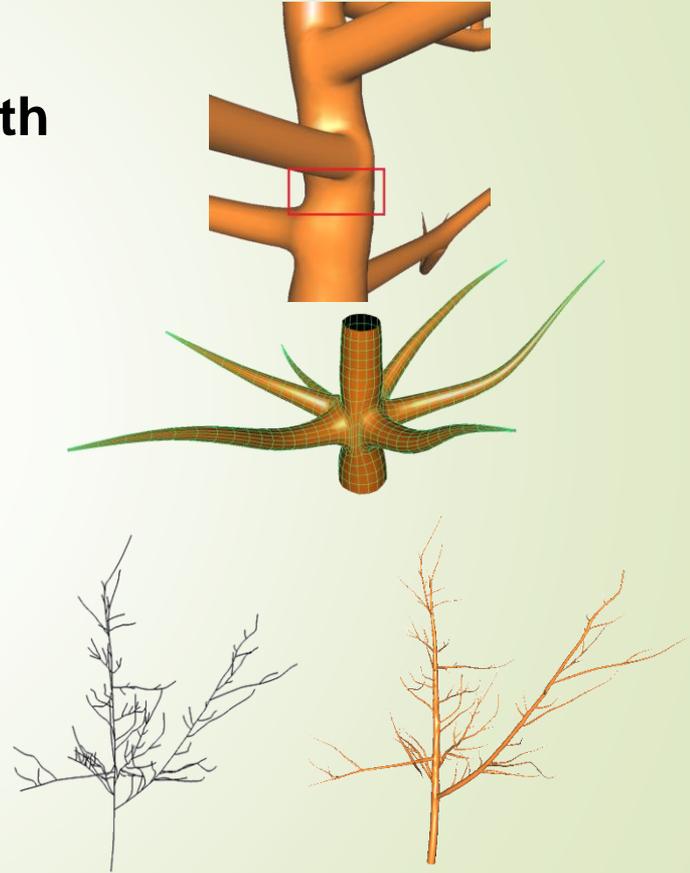**Results (4): tree skeletons → Geometries**

Tree Skeletons
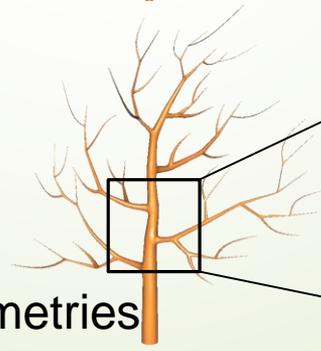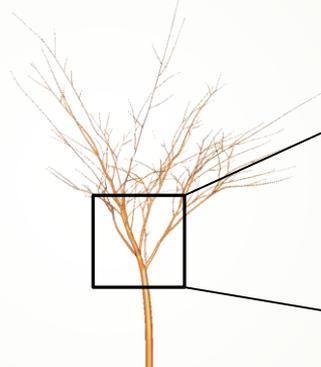
Geometries

Conclusions

➢ **Generate manifold quad-meshes of tree with** **smooth and continuous** **ramification**

➢ **Suitable for** **multi-furcation** **ramification**

➢ **Keep** **global** **impression**

Thank you!

Project page:
https://cie.nwsuaf.edu.cn/szdw/fjs/2010110086/index.htm