Improving procedural tree generation

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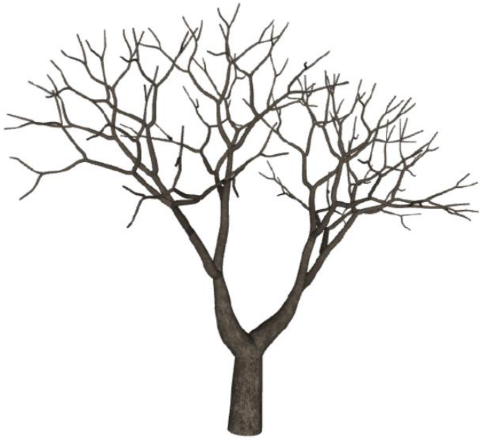
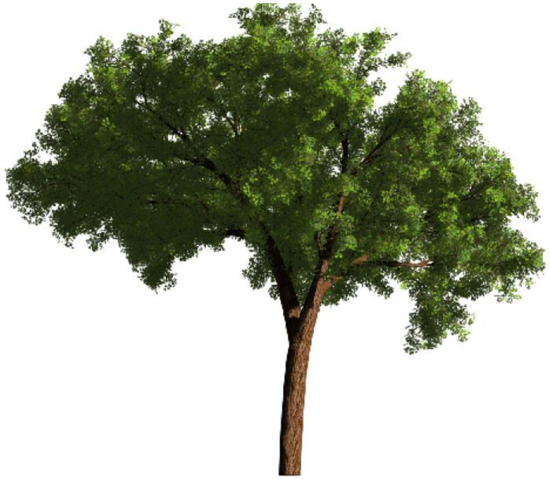
Project Summary

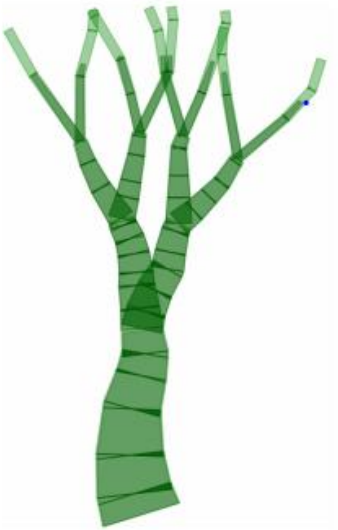
- Our project builds on an existing system that procedurally generates trees using parameterised L-systems
- The aim is to increase realism of the generated models
- The end result of the improved system will be a tree model that has foliage, more natural branch joints and is textured with a user specified sample.





Tree Draw

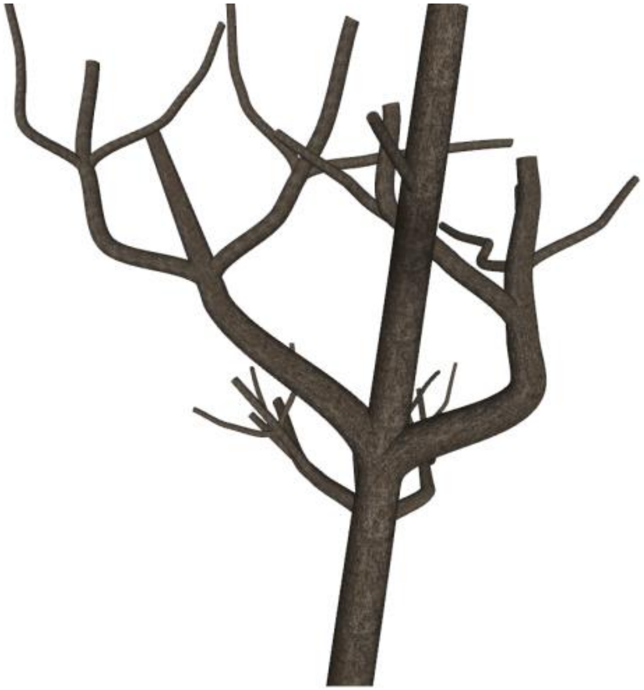
- Developed as an Honours project last year by Matthew Black, Mark Donaher and Neil Goldberg
- Users sketch the outline of the tree they would like to generate
- An L-system interpreter converts the sketch into an L-system
- L-system is then used to generate a 3D model
- Can generate multiple similar trees from one sketch



Tree Draw

Limitations:

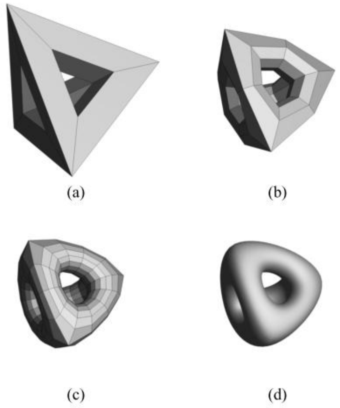
- The branches are modelled as a set of generalised cylinders.
- It is textured by tiling a single sample
- The current system does not generate any leaves

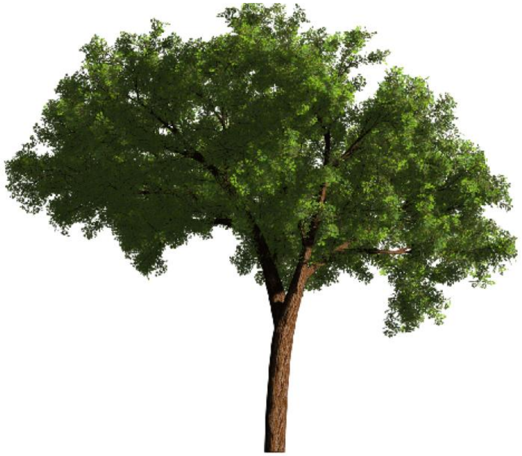


Problem Statement

Improve the realism procedurally generated trees through the addition of:

- Surface subdivision of the trunk and branches
- Texture synthesis of bark
- Procedural leaf distribution based on user sketches

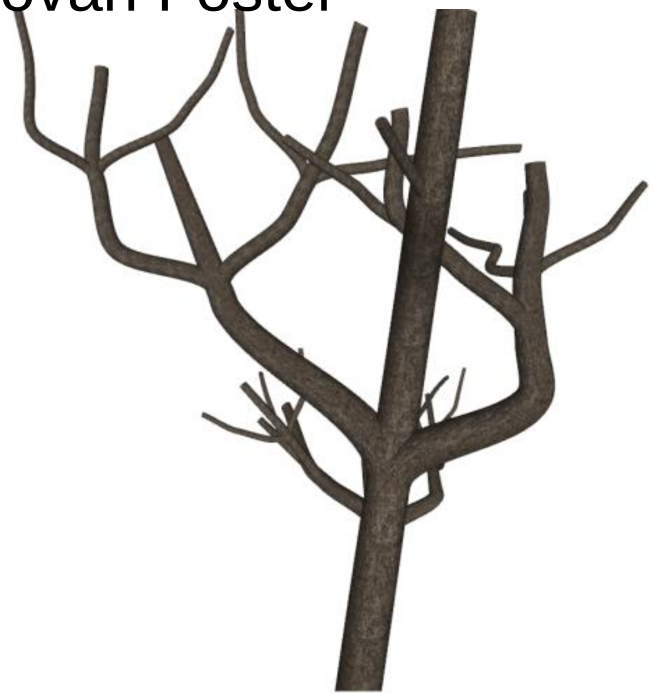




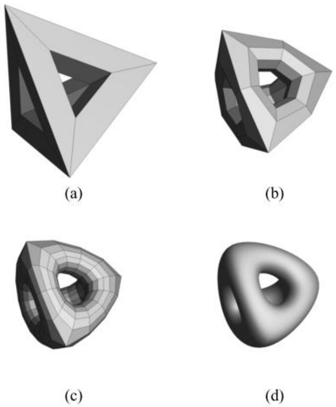
Proposal Overview

- Research areas:
  - Subdivision surfaces - Richard Pieterse
  - Texture synthesis - Ryan Mazzolini
  - Procedural leaf distribution - Donovan Foster

- System and work allocation
- Evaluation plan
- Timeline



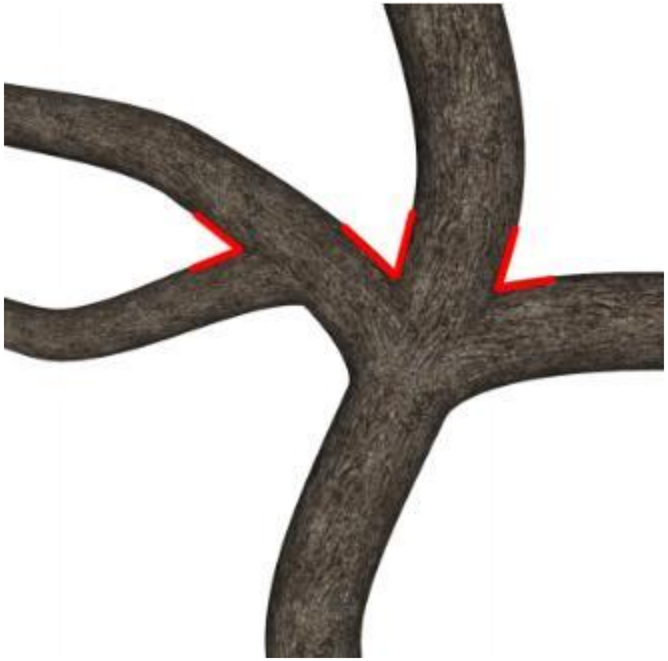
Subdivision Surfaces



(a) (b) (c) (d)

Subdivision surfaces Research Question

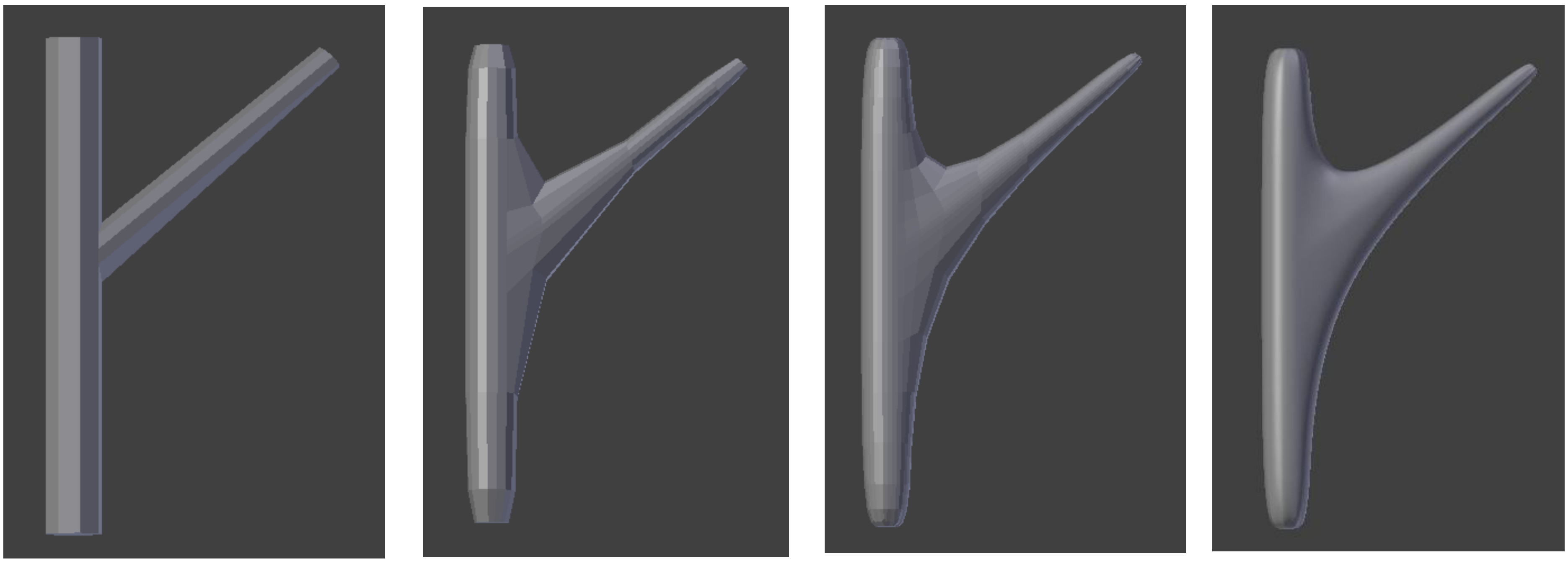
Can subdivision surfaces be used model more natural curves where branches meet?



Unnaturally sharp joins produced by Tree Draw

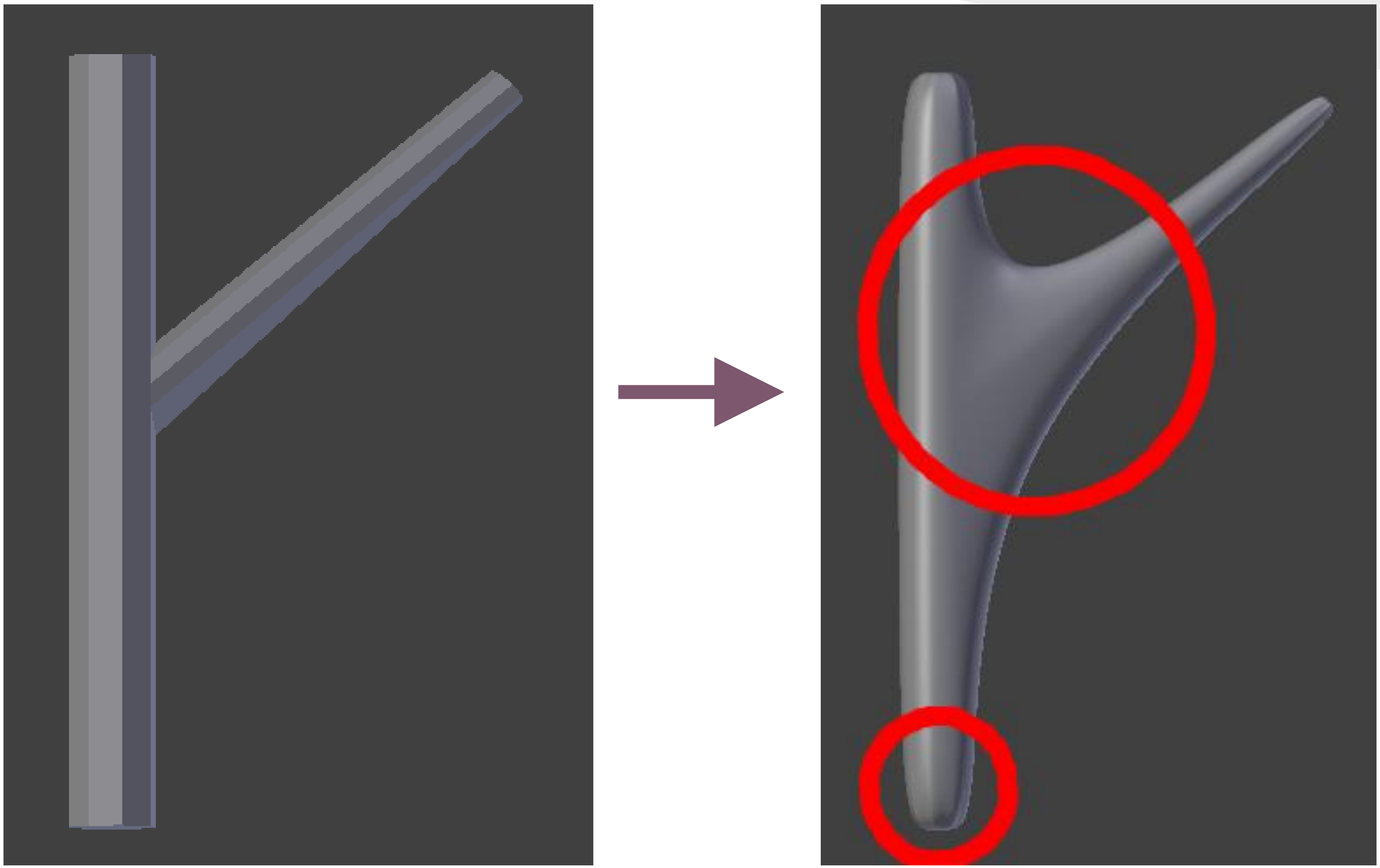
Natural curve of a real tree

Subdivision surfaces
An example



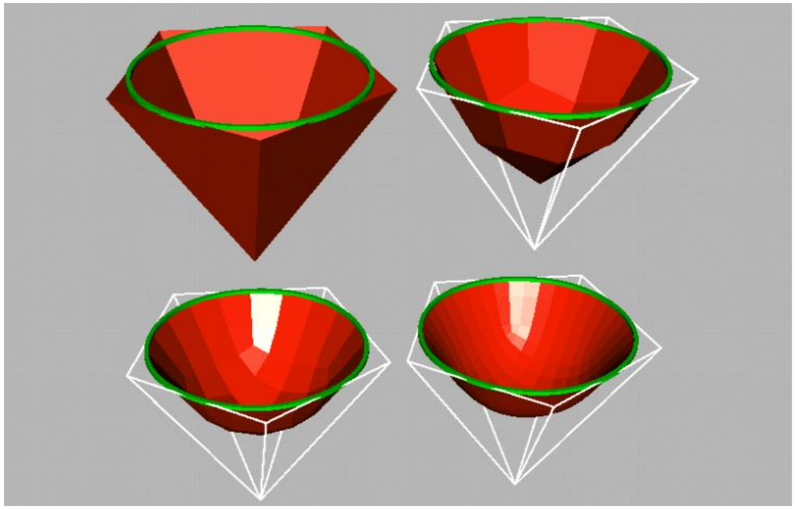
Control mesh subdivided using the Catmull-Clarke method

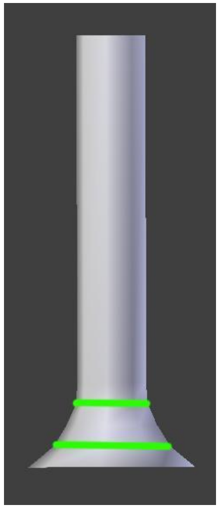
Subdivision surfaces
An example



Subdivision surfaces Quasi-Interpolation

- Users to specify nets of parametric curves
- Subdivision surface conforms to the curves
- These curves could be banded around the base of branches





Texture Synthesis

Texture Synthesis Research Question

Can the realism for bark on tree models be improved through the use of texture synthesis?

- The texture should be *accurate* according to user specification
- Visual artifacts should be *minimised* eg. artifacts across branch joints etc.
- Performance should be *transparent* or at minimal cost to the user

Texture Synthesis

The existing system uses a single tileable texture specified by the system for the bark.

This produces:

- Artifacts across the joining areas of the branches
- Repeating patterns
- Smooth shading emphasises that the image is wrapped over a cylinder

Texture Synthesis Background

There are two existing texture synthesis methods.

Texture synthesis through *procedural generation* and through *example-based methods*.

Three example-based methods:

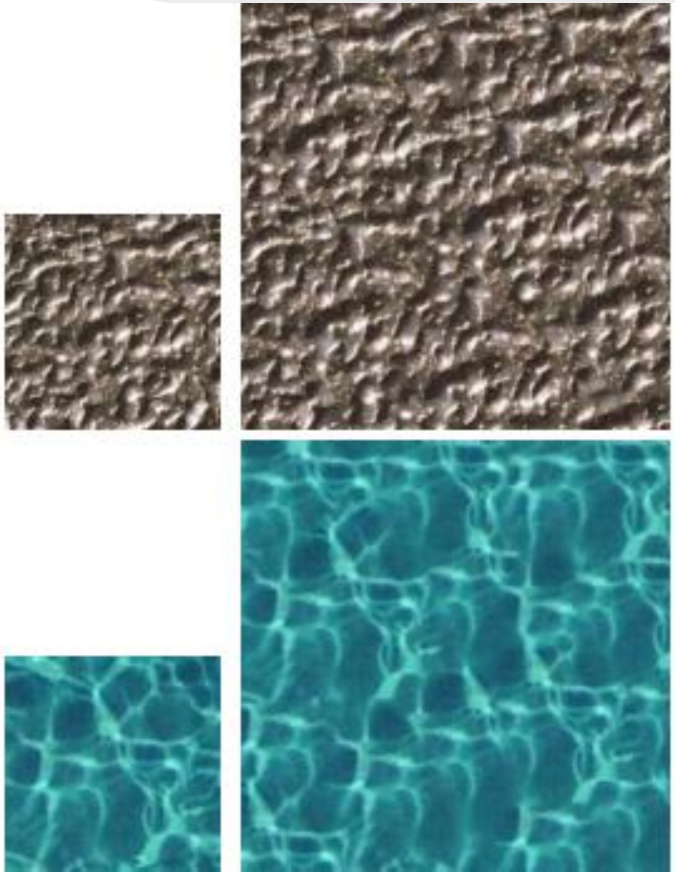
- Pixel-based
- Patch-based
- Tile-based

Texture Synthesis Proposed Solution

The proposed solutions are *example-based* techniques.

The first is a *pixel-based* approach proposed by Ashikhmin specific for natural textures. (2001)

A possible alternative is the patch and pixel-based hybrid method by Kwatra et al. (2005)



Texture Synthesis Proposed Solution Extensions

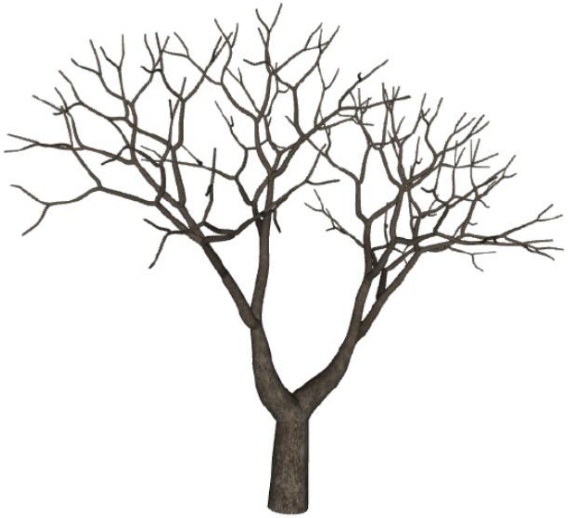
Possible extensions to the texture synthesis part of this project include:

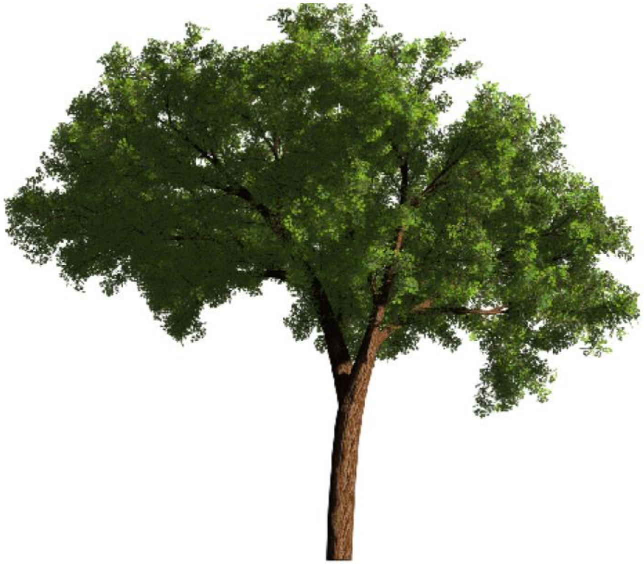
- Fracture simulation over the barks surface
- Bump-mapping
- Texture placement on arbitrary manifold surfaces

Procedural Leaf Distribution

Procedural Leaf Distribution Research Question

- Can the realism of a procedural tree be improved with the addition of leaves?



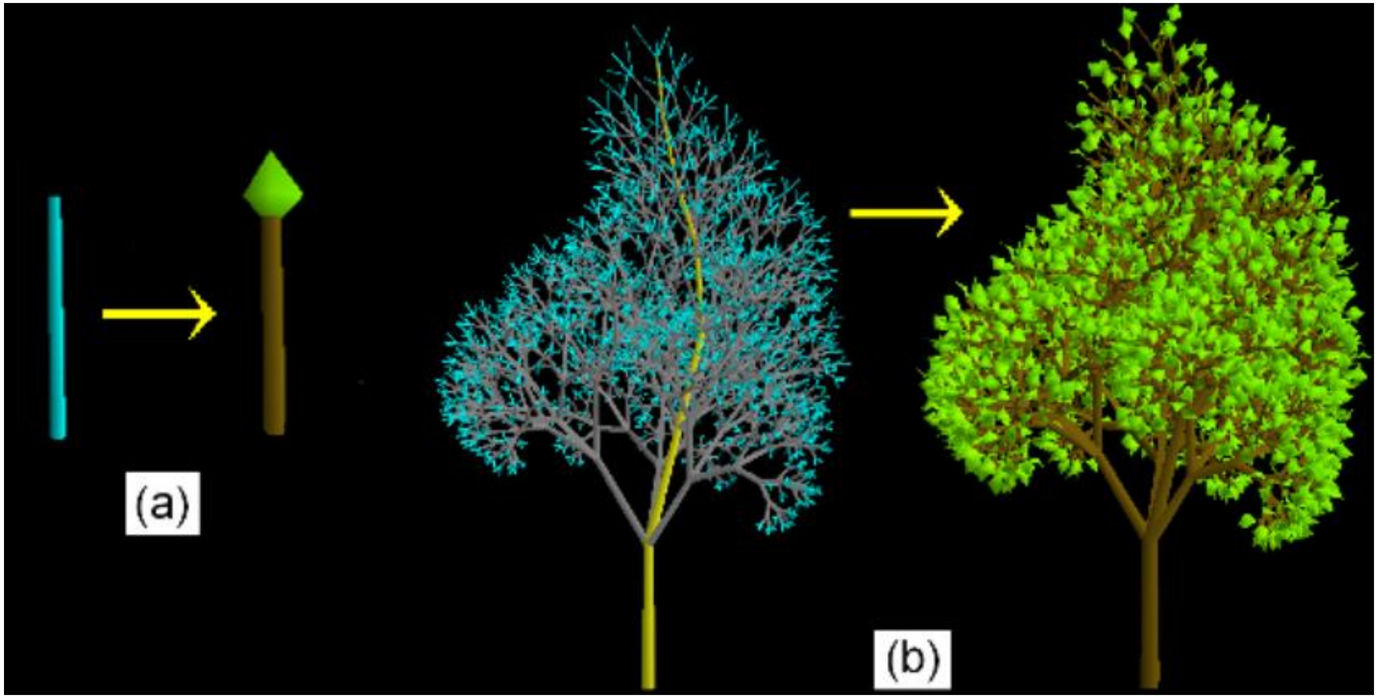


- Can leaves be added to a procedural tree using a sketch-based interface?

From TreeDraw and Sketch-based tree modeling using Markov random field.(Xuejin et al. 2008)

Procedural Leaf Distribution Background

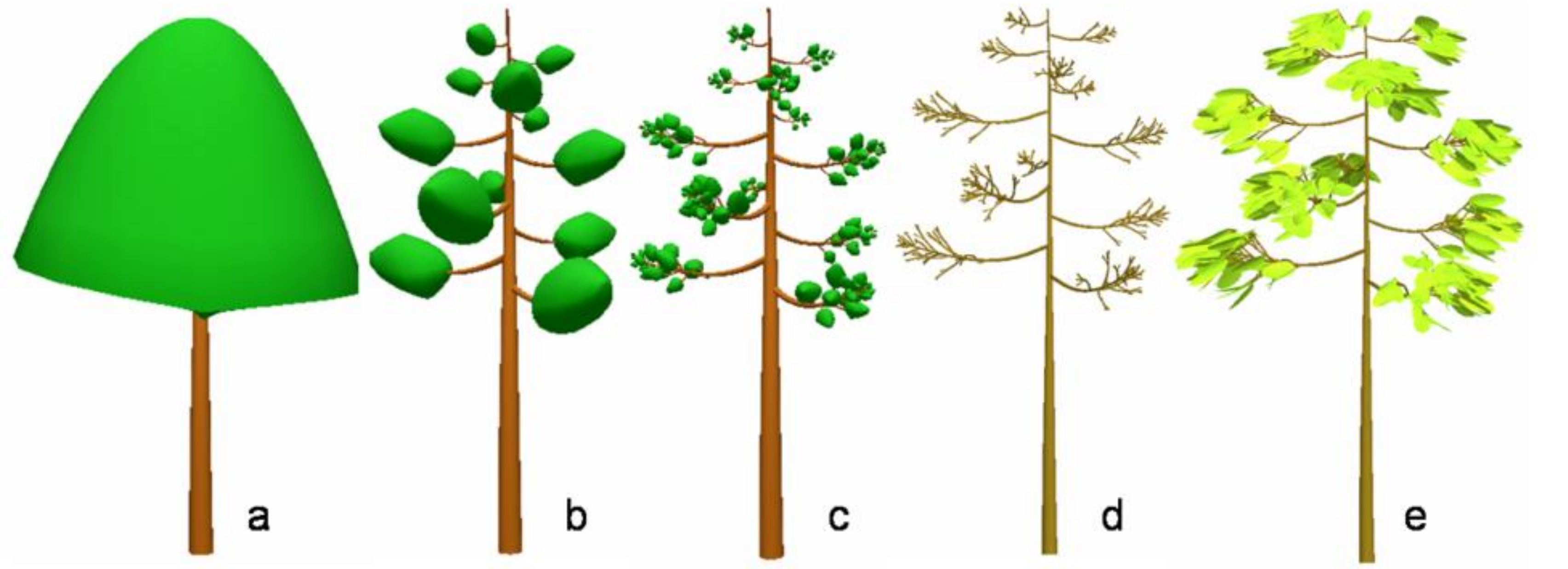
- Phylotactic Distribution
  - Placed based on generation rules



From:The sketch l-system: Global control of tree modeling using free-form strokes (Ijiri et all 2006)

Procedural Leaf Distribution Background

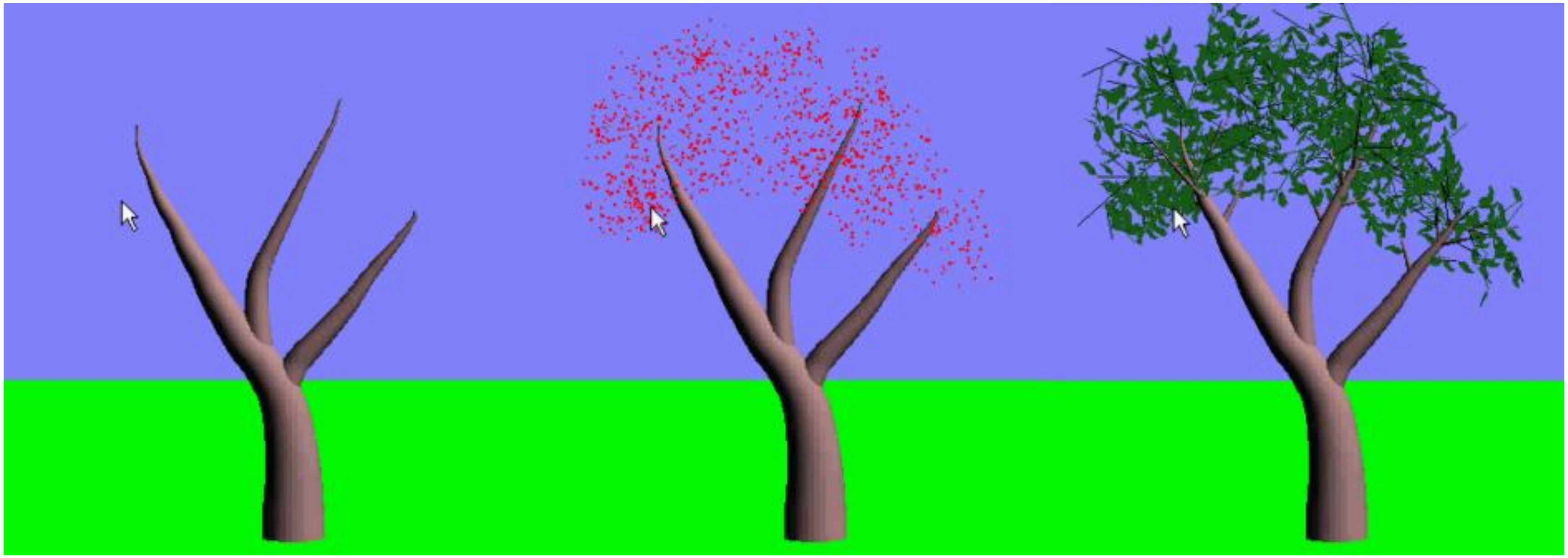
- Global-to-local
  - 3D Bounding volumes for leaves



From: The Use of Positional Information in the Modeling of Plants (Prusinkiewicz et al. 2001)

Procedural Leaf Distribution Background

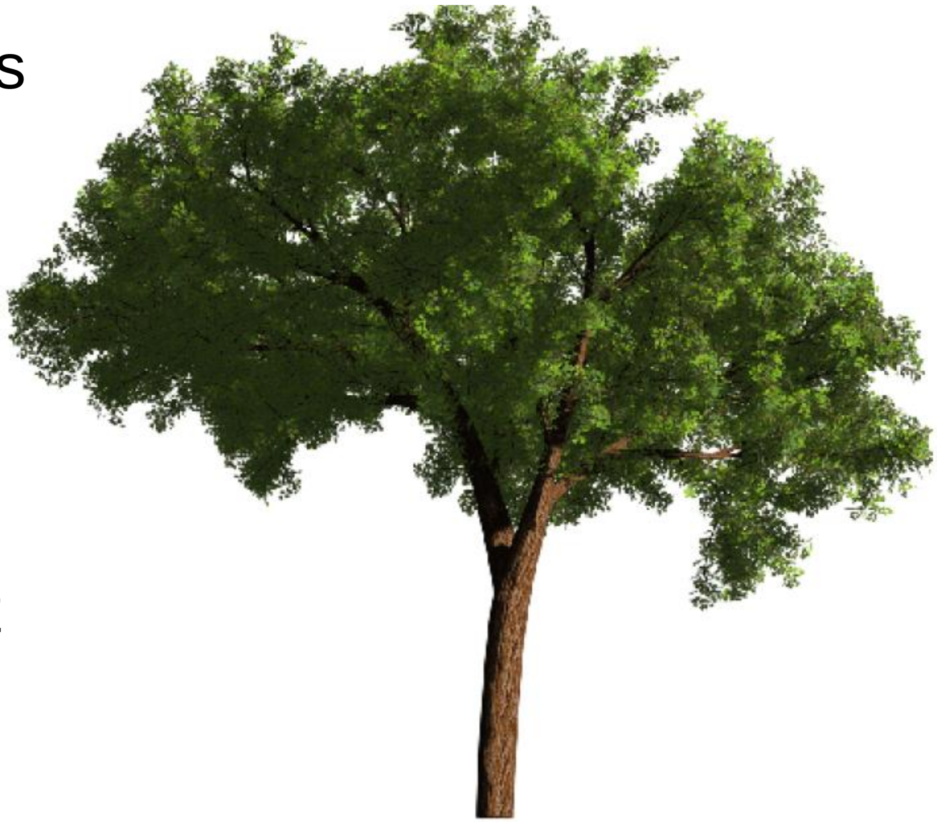
- Sketch-and-Spray
  - 3D spraypainting of leaves



A Sketch-and-Spray Interface for Modeling Trees(Shukri et al. 2007)

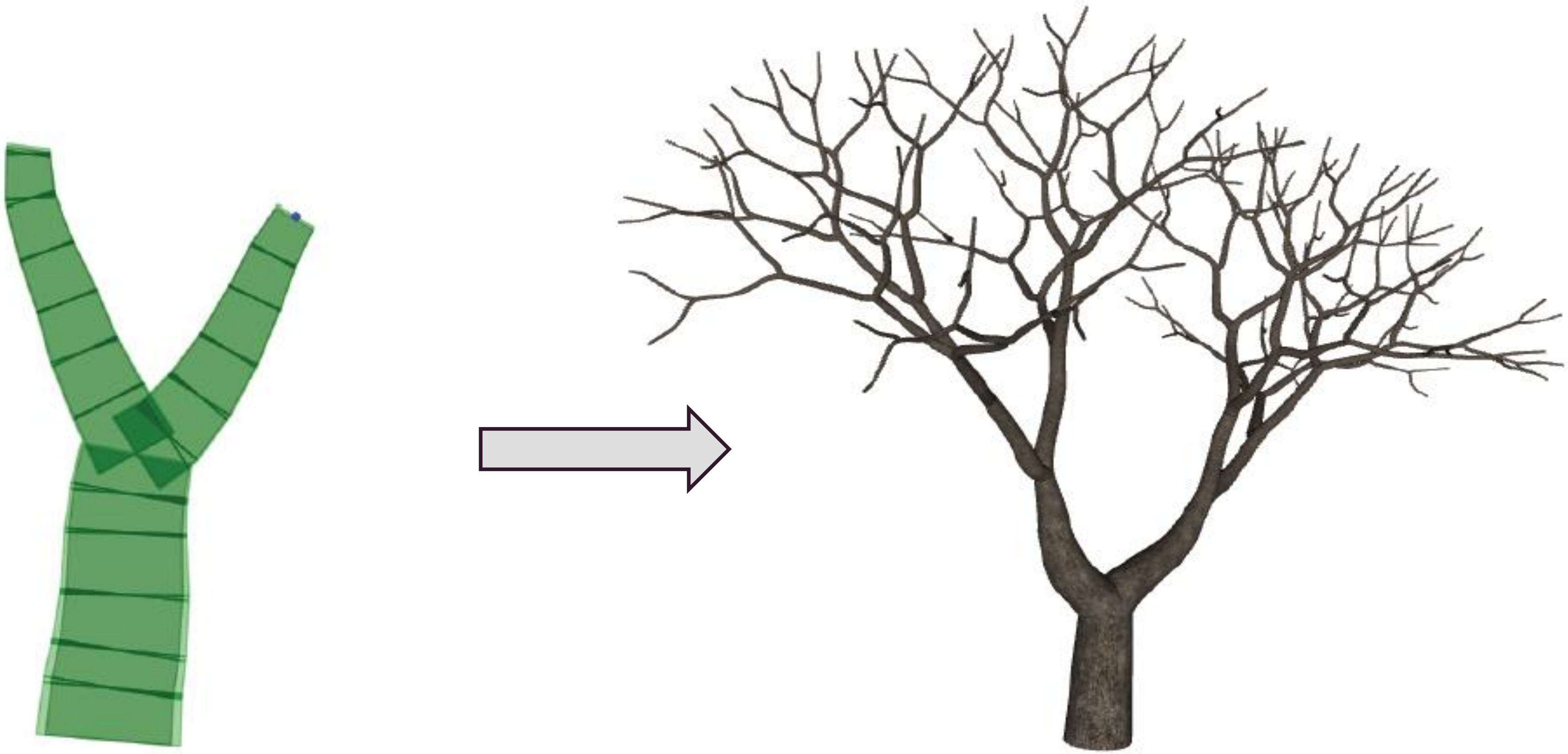
Procedural Leaf Distribution Proposed Solution

- Sketching Interface
- Overlays tree sketching interface
- User-specified parameters
  - Placement
  - Leaf density
  - Colour
  - Leaf type (Texture)
- Will try several solutions
  - Parameter adjustment
  - Sketching interface
    - Bounding volumes



Procedural Leaf Distribution Proposed Solution

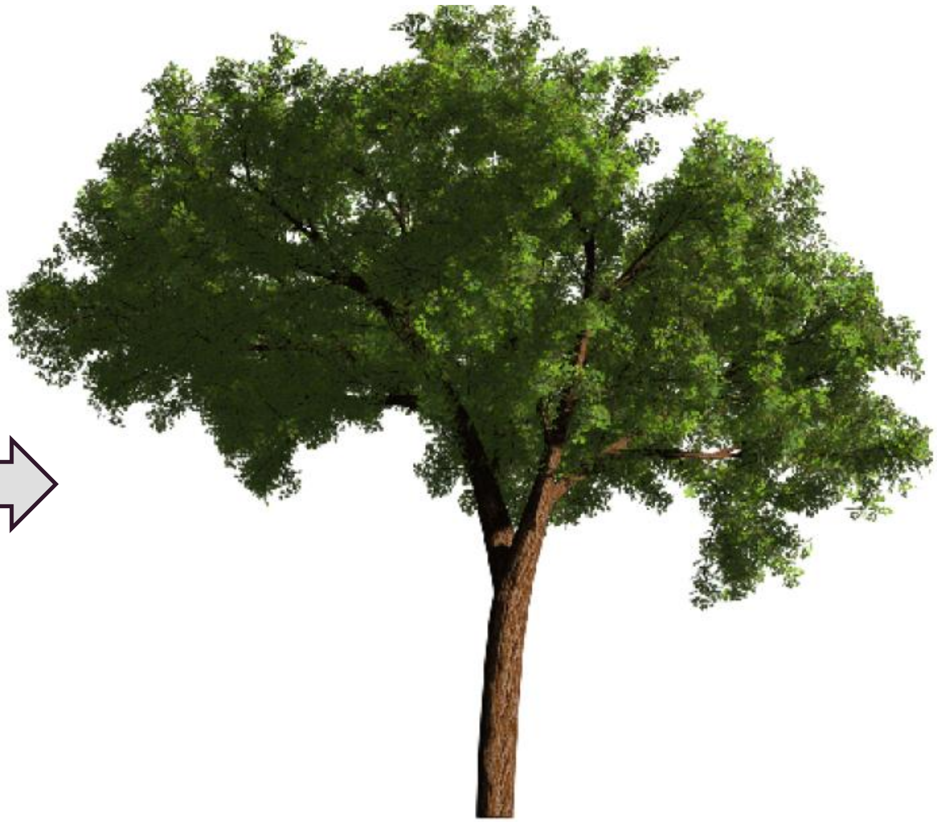
- Current Solution



From TreeDraw

Procedural Leaf Distribution Proposed Solution

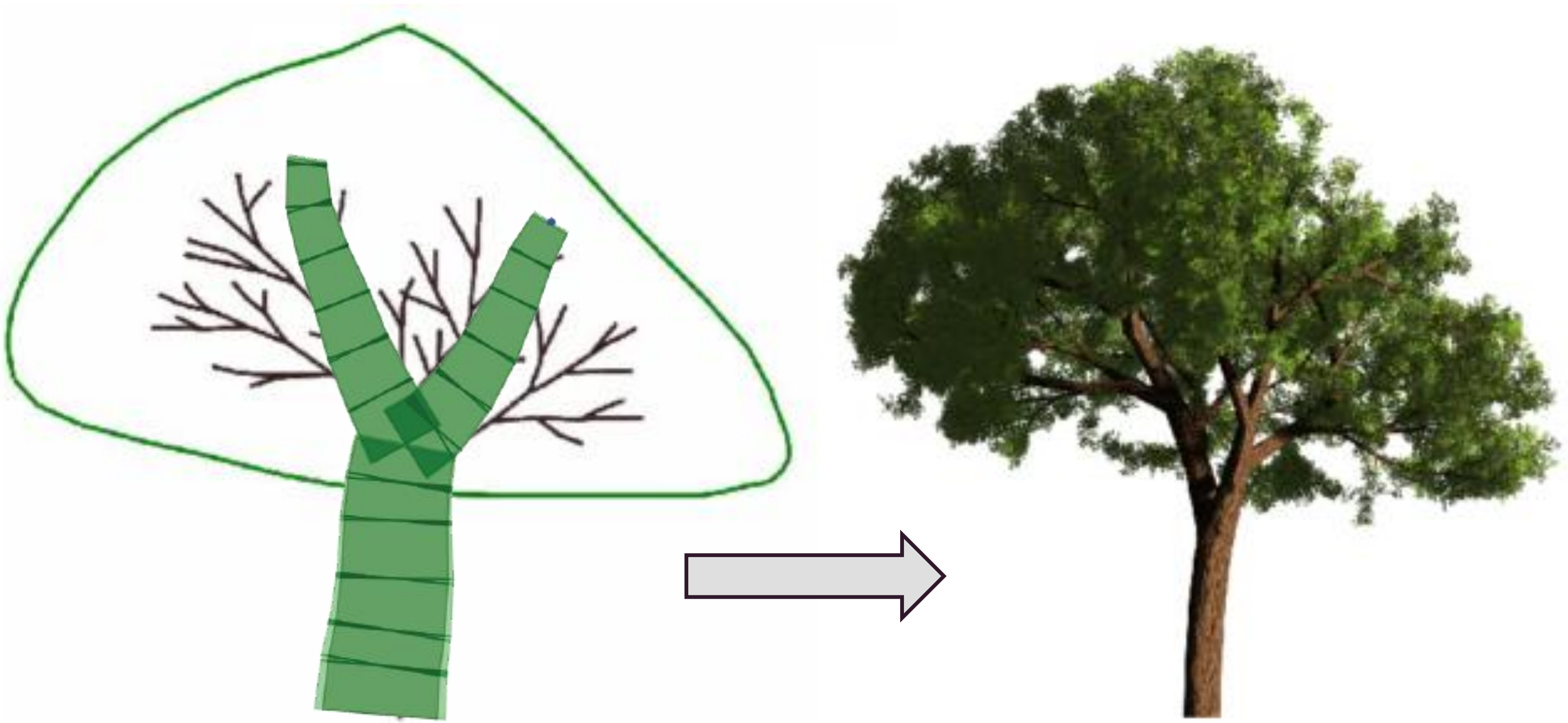
- Adding leaves to branches



From TreeDraw and Sketch-based tree modeling using Markov random field.(Xuejin et al. 2008)

Procedural Leaf Distribution Proposed Solution

- Bounding Branches
  - Sketch volumes



From Sketch-based tree modeling using Markov random field.(Xuejin et al. 2008)

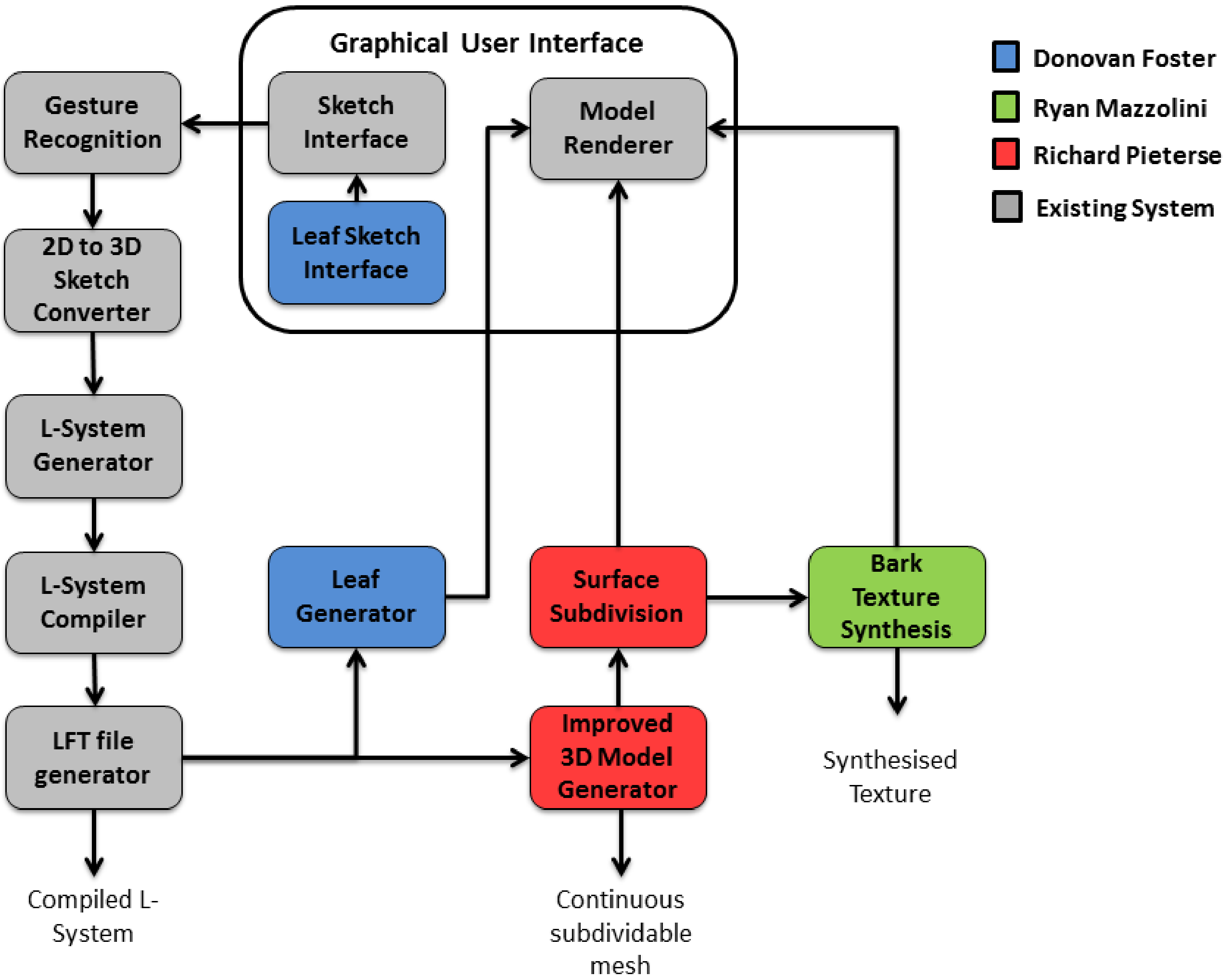
Procedural Leaf Distribution Possible Extension

- Painting foliage

From Sketch-based tree modeling using Markov random field.(Xuejin et al. 2008)

Development Plan

System and Work Allocation



Evaluation Plan Quantitative

Numerical measurements of:

- Performance
  - Execution time will be recorded of each component as well as and the entire system and compared to the existing system
- Stability
  - The number of faults that occur during user testing will be numerically recorded

Evaluation Plan Qualitative

User Testing

- Usability
  - Users asked to recreate a sketch
- Accuracy
  - Users asked to recreate a 3D Tree from the system
- Realism
  - Generated trees will be placed into real environments and shown to who will be users will be asked to identify the real tree

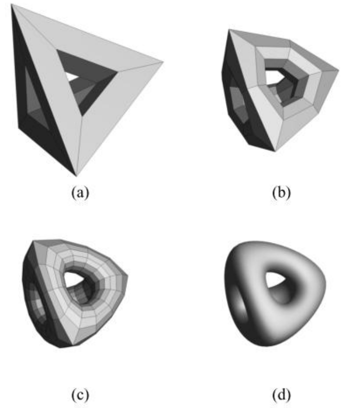
Users will be asked to comment on their

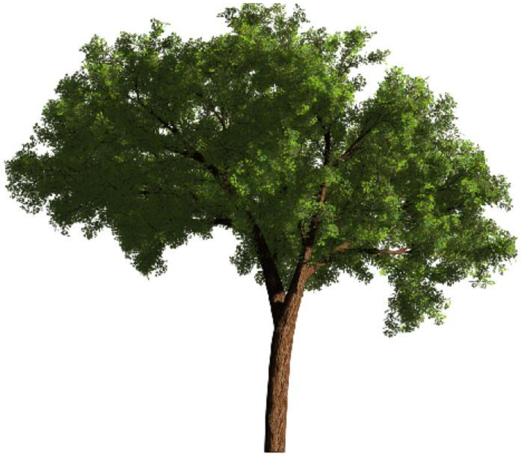
Timeline

1. Internship (4 weeks)
2. Design (1 week)
3. Initial implementation (3 weeks)
4. Initial user testing (1 week)
5. Implementation (4 weeks)
6. Final user testing (1 week)
7. Final project integration (1 week)
8. Final prototype and testing (2 weeks)
9. Write up (4 weeks)
10. Final due date (28th September)

Questions?

Questions?





Risks

- Scoping
- Difficulties understanding the existing system
- Flaws or faults in the existing system
- Ethical clearance denied
- Member becomes unavailable
- Data loss
- Irregular project meetings and updates
- Internship Issues

Evaluation Plan Qualitative

Who are the users for user testing?

- Feasibility demonstration
  - Project supervisor and other lecturers
- Initial user testing
  - Small group of students
  - industry members(Triggerfish)
- Final user testing
  - Large group of students

Our project supervisor will be asked for feedback on a weekly basis throughout development

Realism vs. Interactivity

- *Interactivity*: time taken for the tree to be generated and rendered

- The interactivity of the current system is 30 seconds

- The improved realism from our sections will likely increase the generations and reder time

- Users must be able to prioritise between realism and waiting time

- The proposed components must all have variable quality settings

Evaluation Plan
Metrics

- *Usability*: ease of use and learnability
- *Accuracy*: resemblance to what the user intended
- *Realism*: resemblance to a real tree
- *Performance*: response time for task competion
- *Stability*: the robustness of the system