

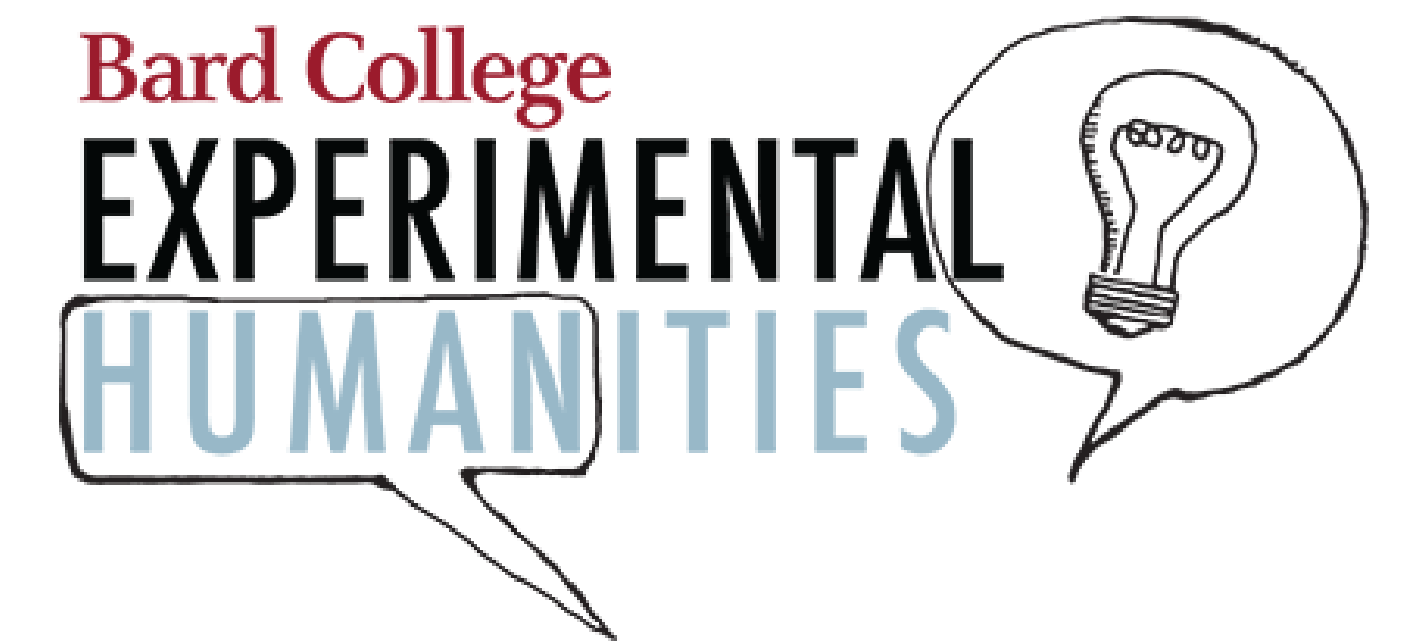


Advisor: Keith O'Hara

# Branching Boogaloo

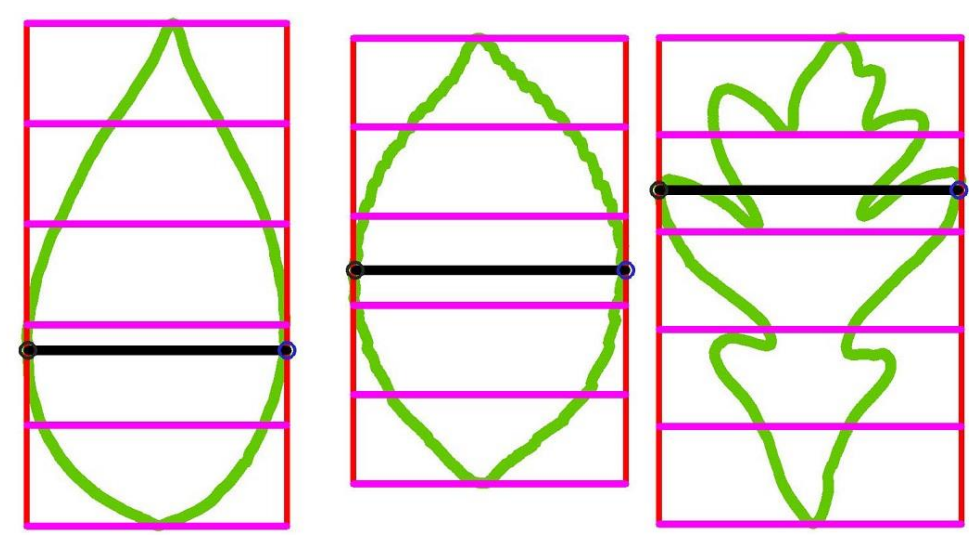
## Botanical Adventures in Multi-Mediated Morphologies

Diana Ruggiero



**FormaLeaf** is a software interface for exploring leaf morphology using formal grammars called L-systems.

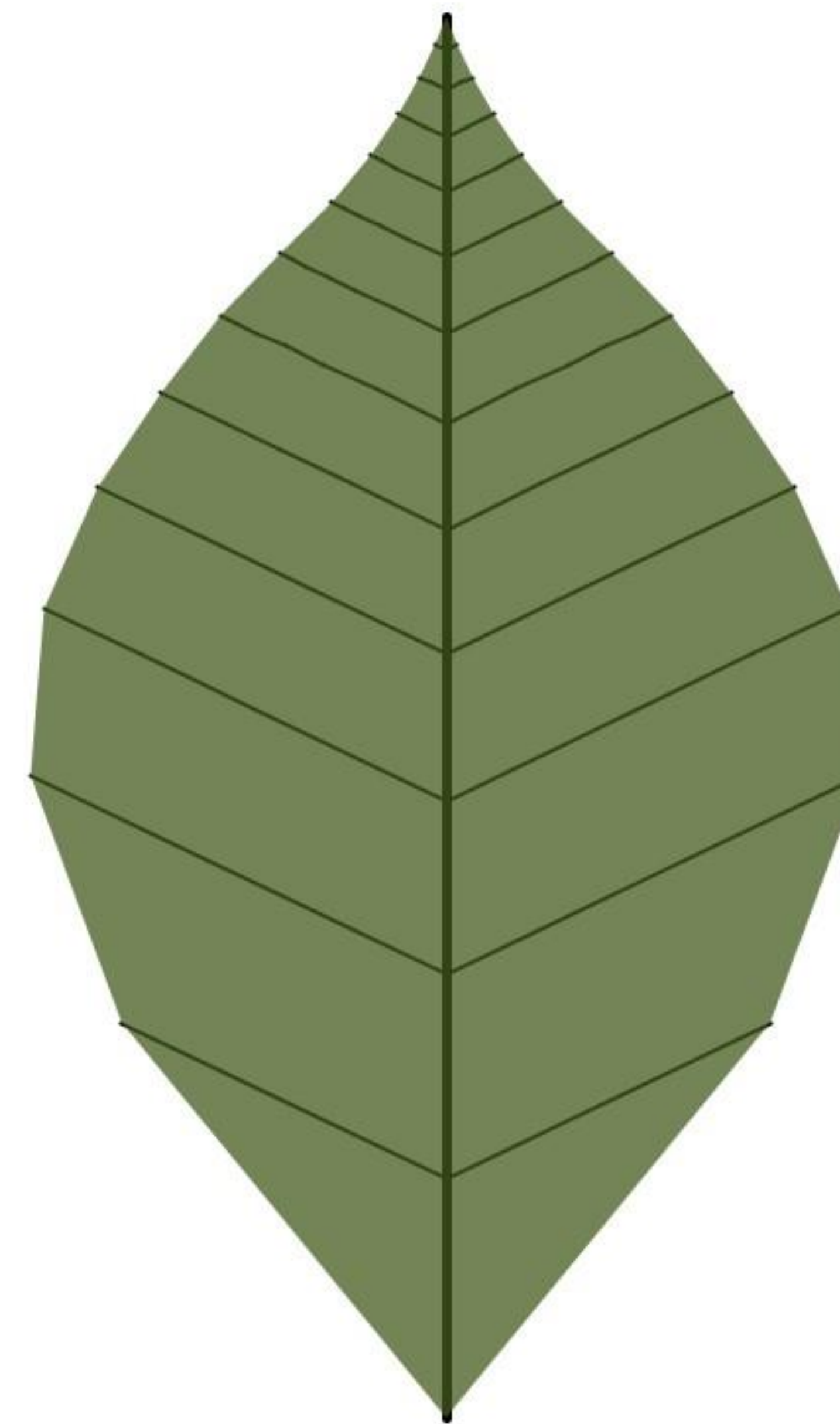
Morphometrical analysis is done with computer vision library OpenCV and displayed in side panel.



Shape class: *Ovate, Elliptic, Obovate*

Parameter sliders allow user to control lengths, growth rates, and angles of generated leaf's venation, changing external shape.

Morphometric Information:	
Input Leaf:	
Leaf Number:	1
Length:	727.0
Width:	446.0
L:W Ratio:	1.6300448
Area:	210685.0
Perimeter:	1892.6846
Shape Class:	Elliptic
Generated Leaf:	
Template:	Pinnate
Leaf Number:	1
Length:	720.0
Width:	428.0
L:W Ratio:	1.682243
Area:	181064.0
Perimeter:	1814.4247
Shape Class:	Elliptic
Similarity:	94.12277

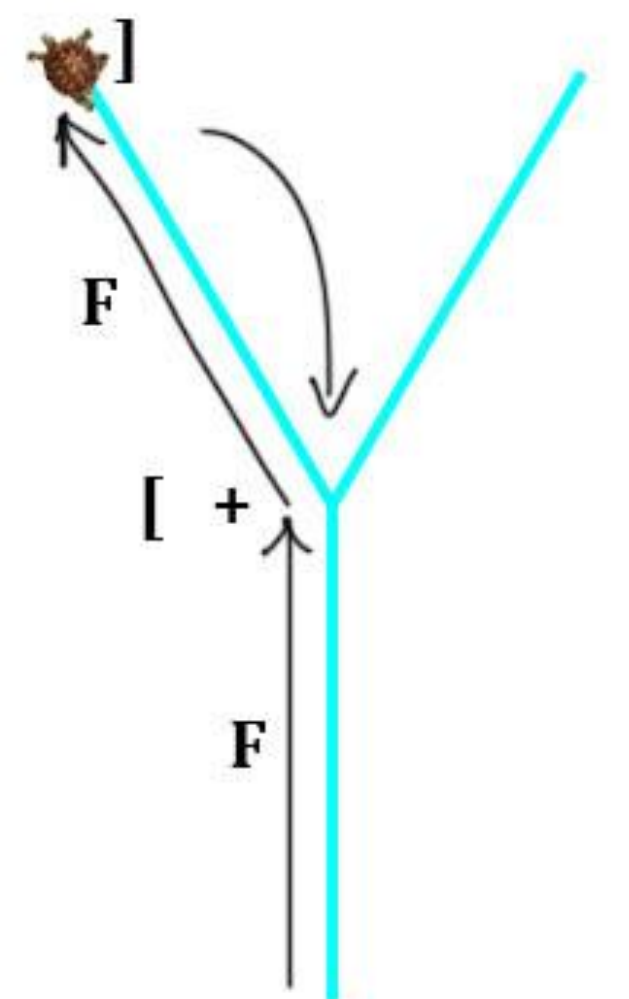


**L-systems** are parallel string rewriting grammars.


- Consist of axiom and set of production rules.
- Like normal Chomsky grammars, but at every step a production rule is applied to *every* symbol in the string.
- FormaLeaf uses Parametric L-systems, which means symbol actions can be parameterized.
- Ex: **F(3)** could mean "Go forward and draw for 3 units."

L-system Graphics use LOGO-turtle interpretation of strings:

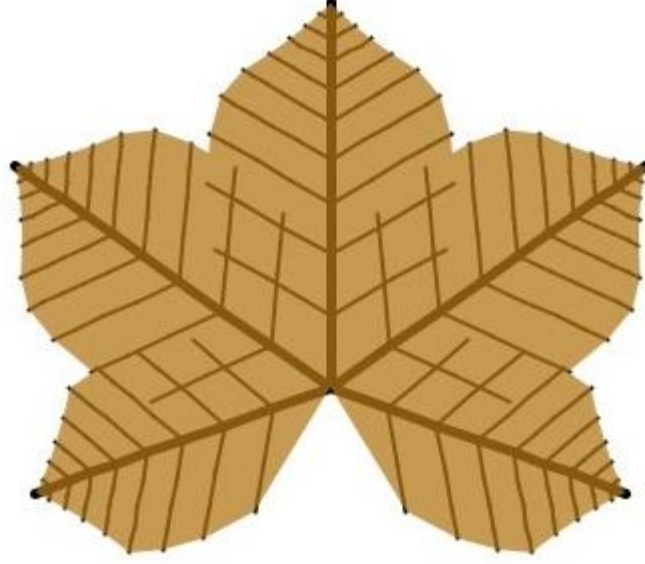
- Turn Left: +
- Turn Right: -
- [Bracketing] uses stack operations for branching.



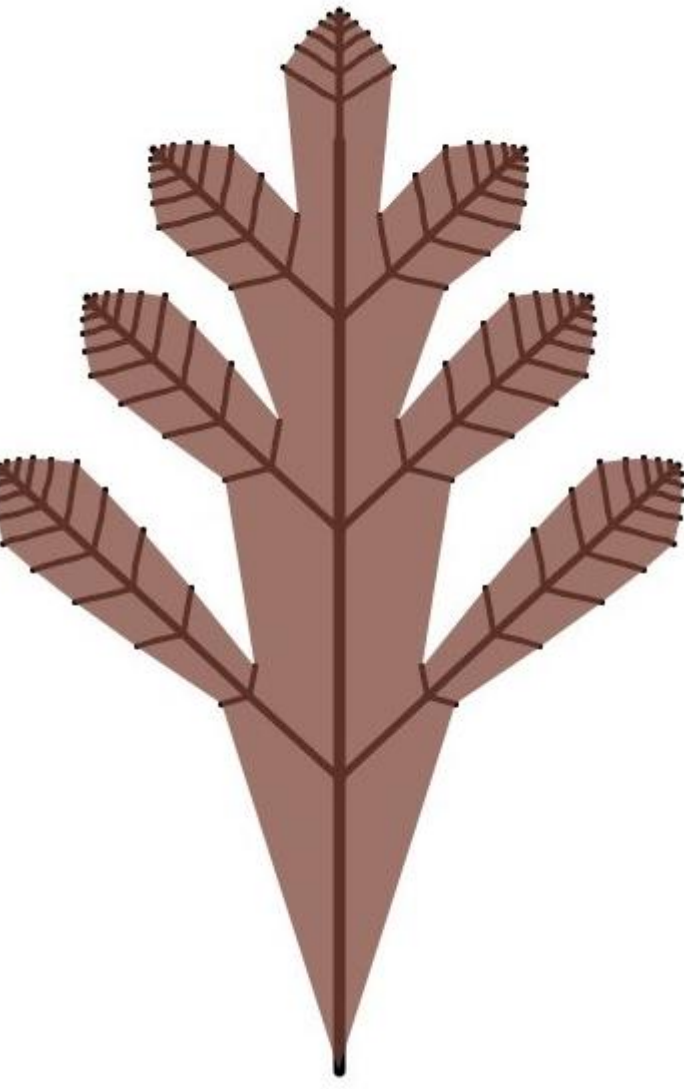
### Template Leaves:



**Pinnate**



**Palmate**



**Pinlobed**

```

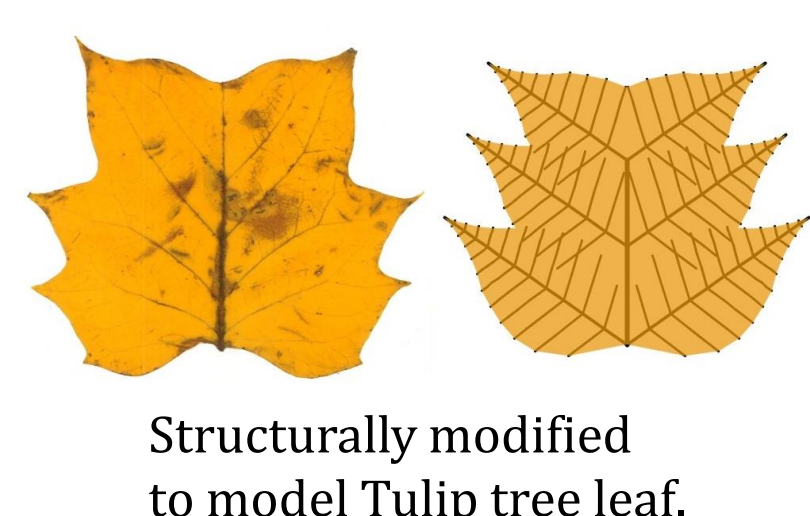
omega: { . P(0) }
p: P(t) -> ! (5) G(LP, RP) [- (AN) L(t) . ] [P(t+1)] [+ (AN) L(t) . ]
p: L(t) -> ! (2) G(LL, RL) L(t-1)      iff: t >= BE
p: G(s, z) -> G(s*z, z)
LP: 2.0 - 4.3
RP: 1.0 - 1.25
LL: 1.0 - 1.9
RL: 1.1 - 1.38
BE: 0 - -1
AN: 40 - 80
        
```

**Parameters:**  
LP: Primary vein length. RP: Primary vein growth rate.  
LL: Lateral vein length. RL: Lateral vein growth rate.  
BE: Affects basal extension. AN: Vein branch angle.

(L-system taken and modified from *The Algorithmic Beauty of Plants*)

Built from Pinnate leaf template arranged radiately; overlapping leaf surface models become lobes.

Built by replacing lateral pinnate veins with Pinnate leaf template.



### Summary:

- FormaLeaf is excellent at automatic image generation.
- The grammatical structures of the template leaves are morphologically interesting.
- Search Mode visually assess shape similarity of input leaf and generated candidates to search for a leaf with matching shape and venation.

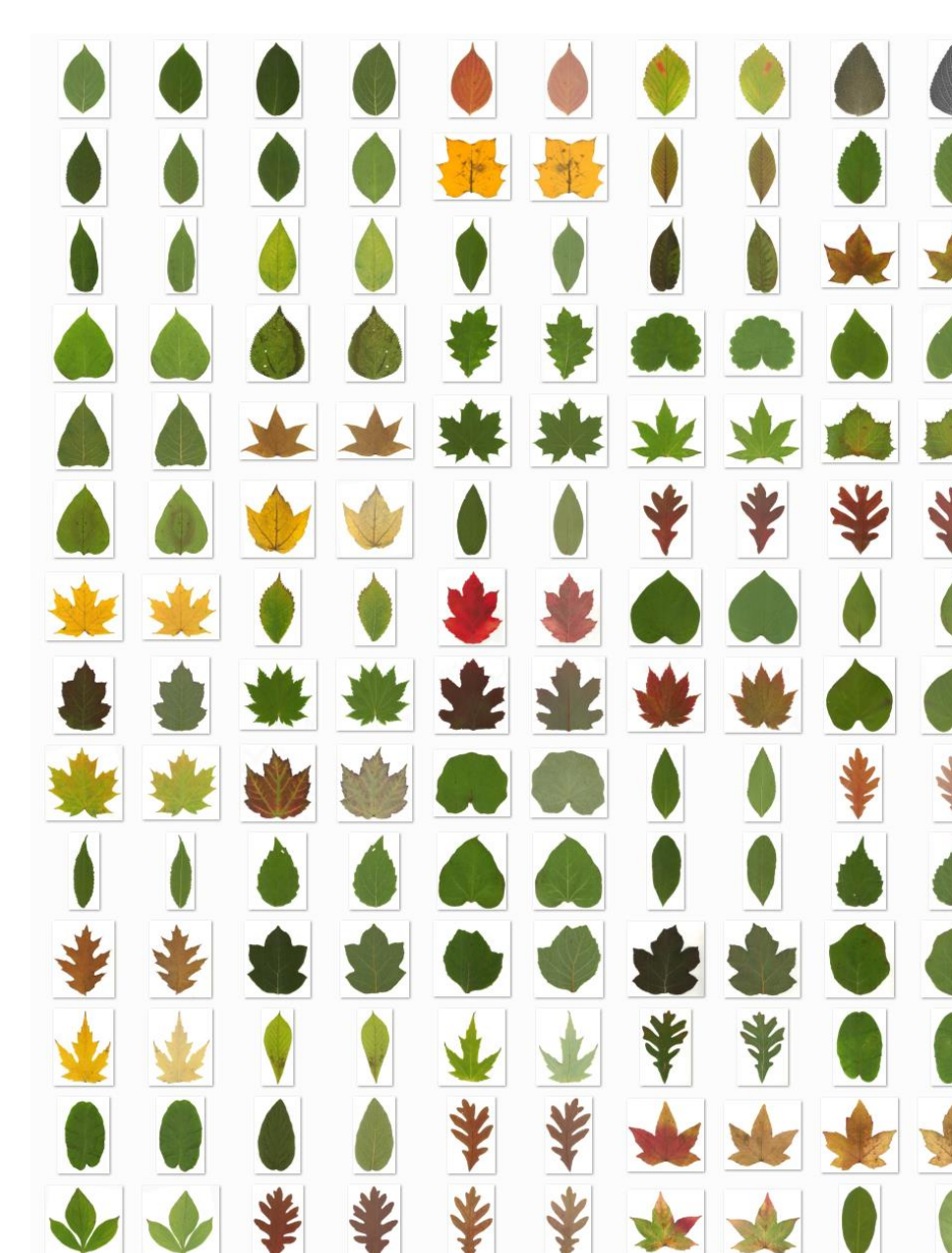
### Future work:

- Improve fitness function and search procedure.

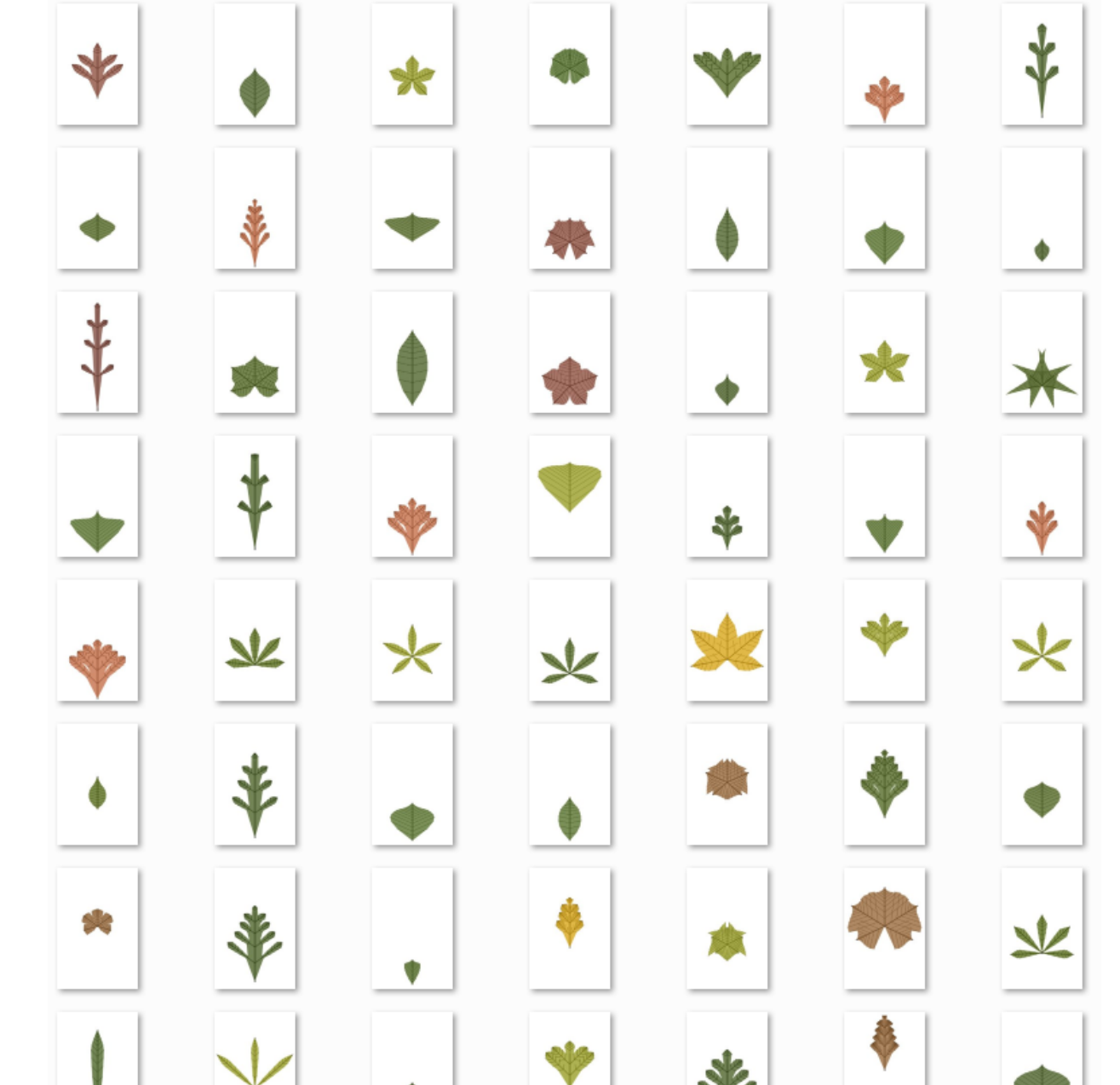
### Randomly Generated Leaves:



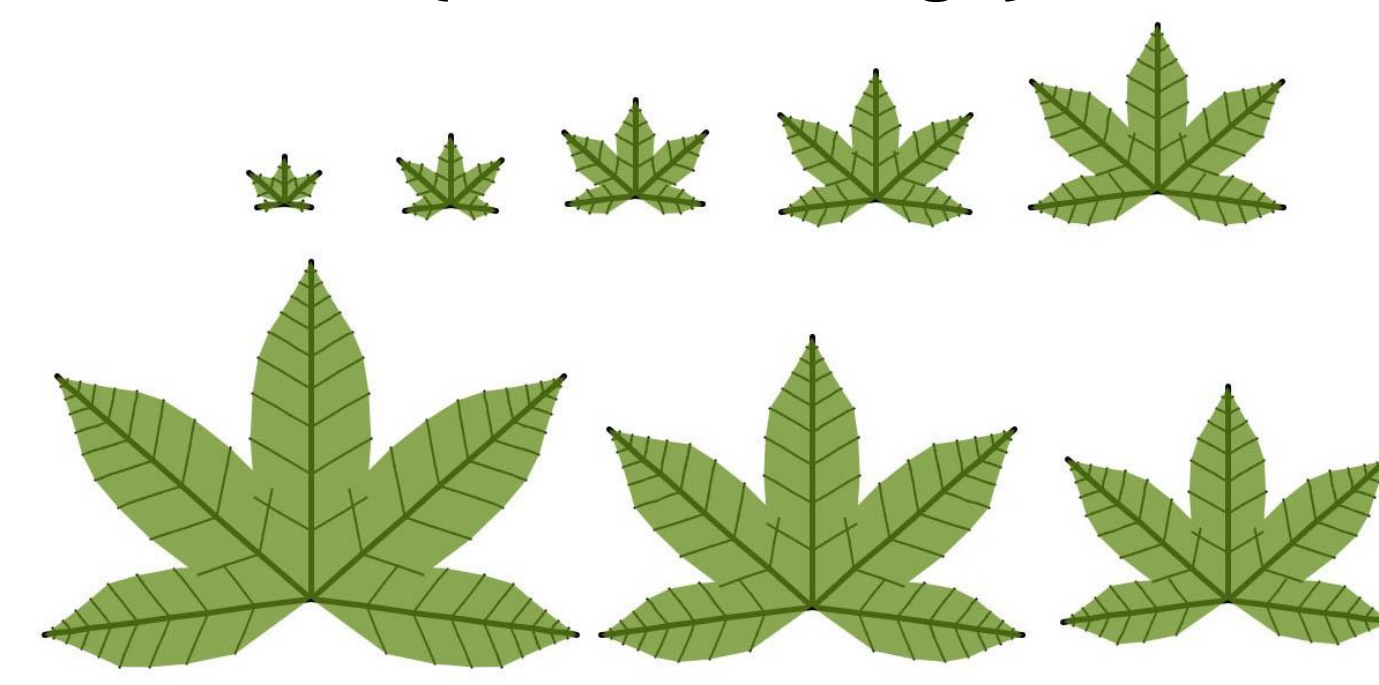
Scanned Leaf Samples:



Random Candidate Leaves:



Developmental Sequence: (Iterative Change)



Metamorphical Sequence: (Parametric Change)

