TD 3 - UE
Modélisation de l'architecture racinaire (RSA)

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Formalisme: L-systems

- Introduit par A. Lindenmayer en 1968
  - Simulation of multi-cellular organisms
- Système dynamique à structure Dynamique [Giavitto, 01]
- Adapté à la modélisation de la croissance des plantes. Utilisé dans la communauté FSPM
- Contribution importante de Prusinkiewicz et al. en infographie / Modélisation

L-systems

- Un L-systems se définit par alphabet V, un axiome w et un ensemble de règles de productions P.

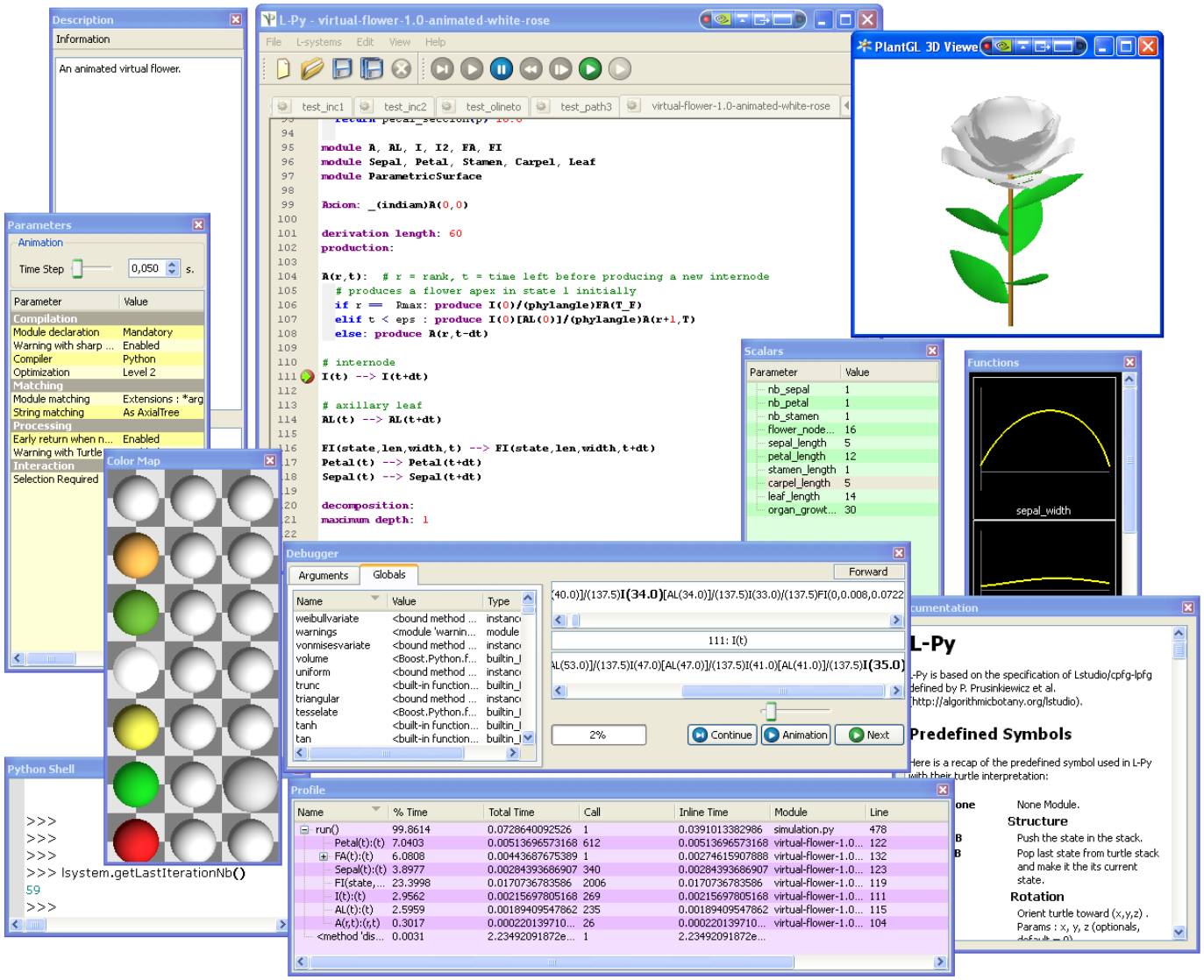
$$G = < V, w, P >$$

- Les Productions sont appliquées sur une “string” en parallèle.

$$left\ context < predecessor > right\ context \longrightarrow successor$$

Le logiciel libre L-Py

lpy.readthedocs.io



L-Py Syntax

- Combining L-systems and python

```
module A, I
Axiom: A
derivation length: 5
production:
A --> I / [+A] A
I --> II

interpretation:
I --> F
endlsystem
```

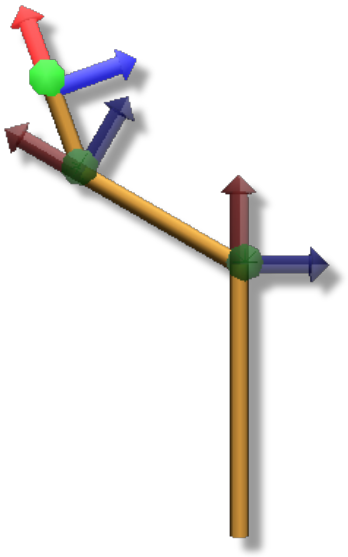
L-Py Syntax

- Combining L-systems and python

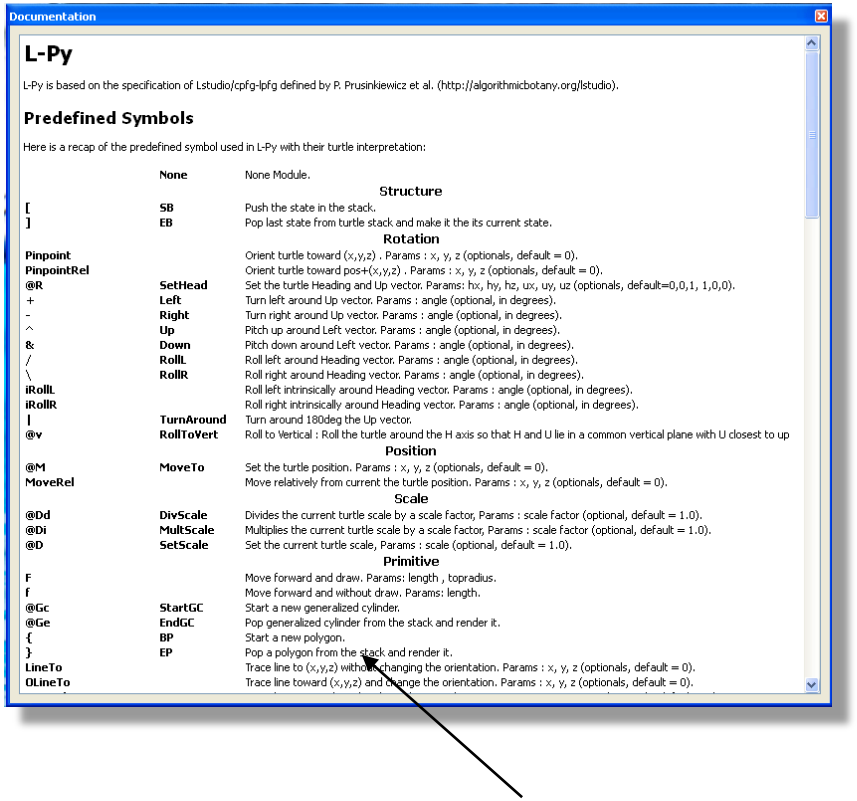
```
from random import random
MAX_AGE, dr = 10, 0.03 # constants
module Apex(age), Internode(length,radius)
Axiom: Apex(0)
derivation length: 5
production:
Apex(age) :
  if age < MAX_AGE:
    produce Internode(1+ random(),0.3)
            /(137)[+(30)Apex(age+1)]Apex(age+1)

Internode(l,r) --> Internode(l,r+dr)
interpretation:
Internode(l,r) --> _(r) F(l)
endlsystem
```

Turle Interpretation

- PlantGL Turtle



```
F(3)[+(60)F(2)[-(40)F(1)]]
```



Introspection

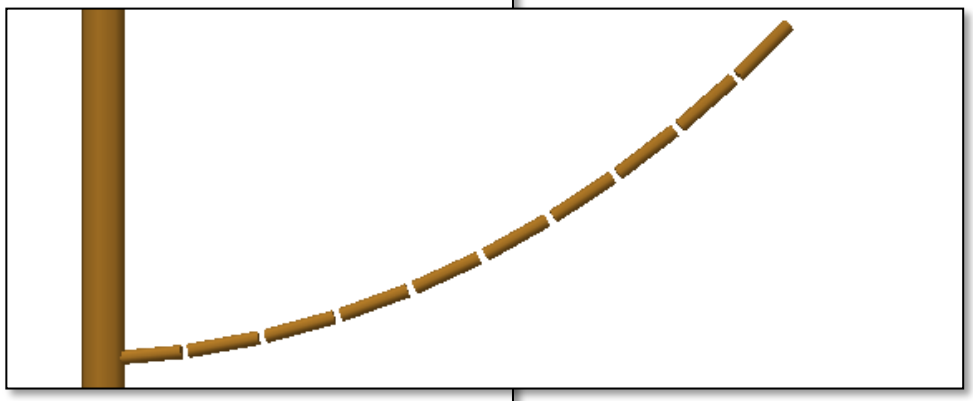
- Debugging PlantGL Turtle

```
Frame F(3)[+(60)Frame F(2)[-(40)Frame F(1)]]
```

Branch Geometry

- Use of tropism to change orientation of branch

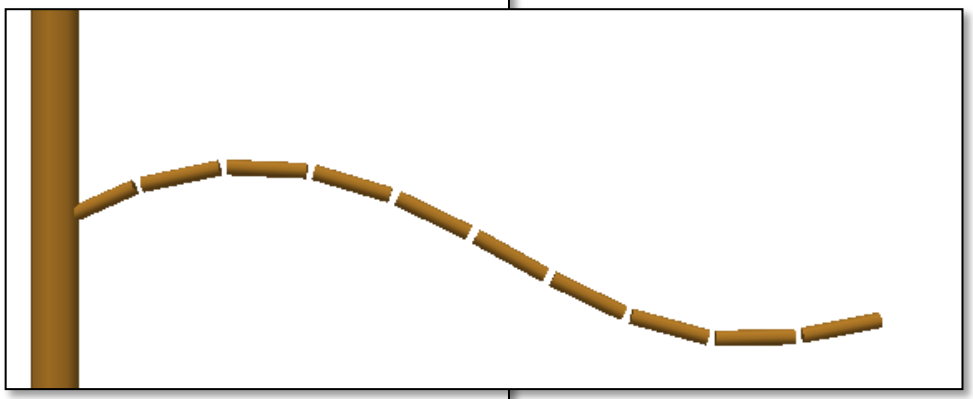
```
length = 10
Axiom: Elasticity(0.02) Branch(length)
derivation length: 1
production:


interpretation:
Branch(l) :
   for i in xrange(l):
    nproduce f(0.1) F(1)
endlsystem
```

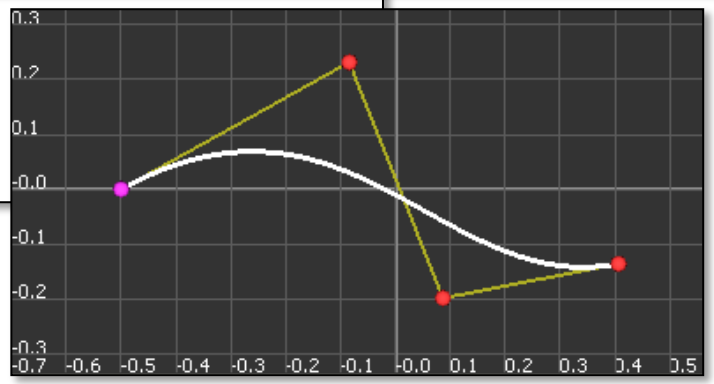


Branch Geometry

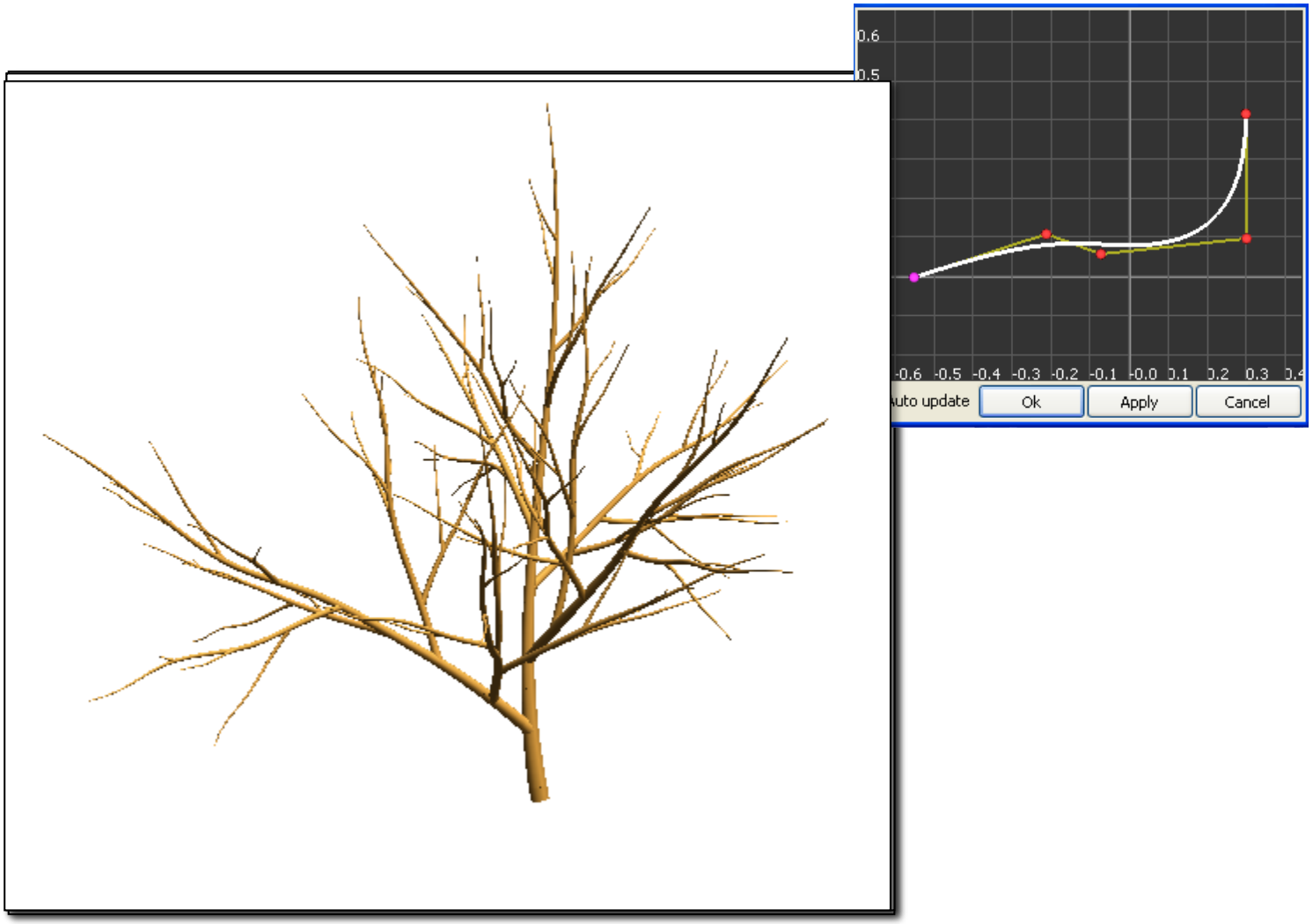
- Use of predefined geometrical embedding

```
length = 10
Axiom: SetGuide(path,length) Branch(length)
derivation length: 1
production:


interpretation:
Branch(l) :
   for i in range(l):
    nproduce f(0.1) F(1)
endlsystem
```





Example on a simple tree structure



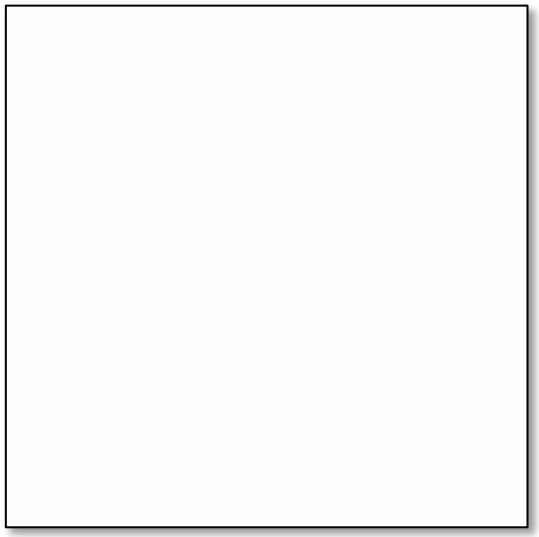
L-systems features

- Parametric L-systems
- Contexts and new contexts sensitivity
- Stochastic L-systems

```
A(x) :
    if x < 3:
     produce B(2*x)
```

```
C(z) < B(y) << A(x) > D(w):
```

```
A(x) :
    if random() < prob1 :
     produce B(2*x)
    else : produce C(0)
```



L-systems features

- Parametric L-systems
- Contexts and new contexts sensitivity
- Stochastic L-systems
- Environmental Interaction
- Pruning
- Group of rules
- Forward and Backward application, …

```
A(x) :
    if x < 3:
     produce B(2*x)
```

```
C(z) < B(y) << A(x) > D(w):
```

```
A(x) :
    if random() < prob1 :
     produce B(2*x)
    else : produce C(0)
```

```
module ?P(pos),?H(heading),
       ?U(up), ?L(left)
```

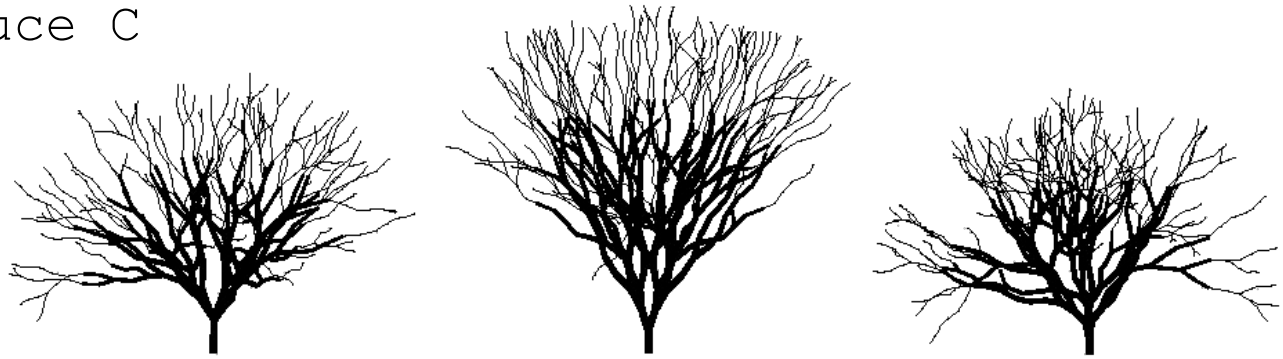
```
B(t):
    if t >= MAX_AGE:
       produce %
    else : produce B(t+1)
```

```
I(ri) << [ I(rl) ] I(rj)
                --> I(rl+rj+1)
I(ri) << I(rj) --> I(rj+1)
```

L-systems stochastiques

- Insertion d'une production stochastique

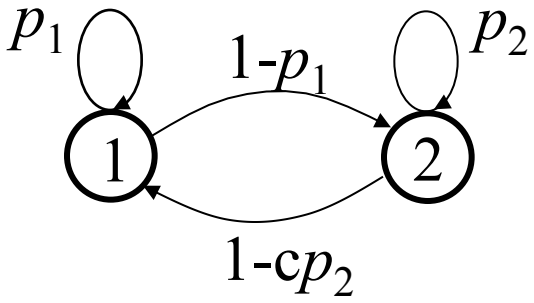
```
from random import *

Axiom: A
production:
A :
  if random() < 0.5: produce B
  else: produce C
```



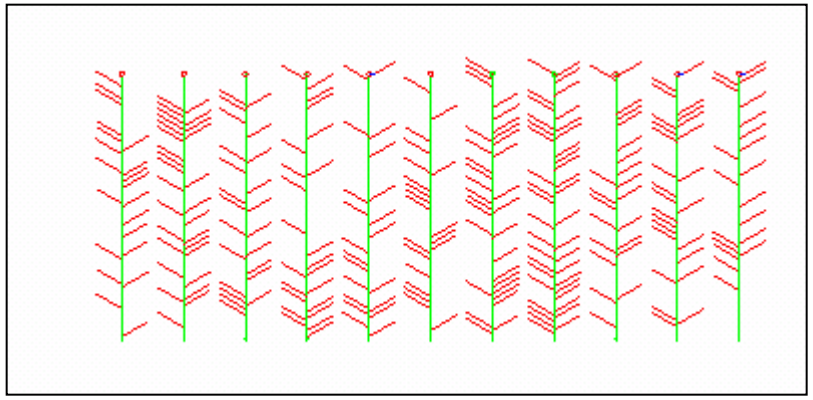
L-systems stochastiques

- Simulation d'une chaîne de Markov

```
Axiom: A

A : if random() < p1: produce I[M]A
    else produce IB
B : if random() < p2: produce IB
    else produce I[M]A
```

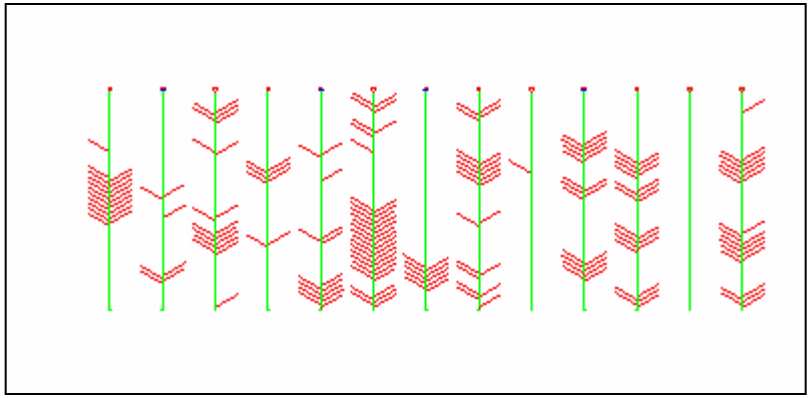


p_1=0.25, p_2=0.75



P(branching) = 0.25

p_1=0.85, p_2=0.95



P(branching) = 0.25

Architecture racinaire

- Définir les types racinaires (modules)
  - Root, Apex, Segment
  - Crown, CrownApex, CrownSegment
  - …
- A chaque module, associer des variables d'états
  - order
  - rayon
  - autres? (length, delay, …)

Architecture racinaire

- Définir les paramètres d'entrée de votre modèle architectural
  - max_time: nombre de jours
  - dt : pas de temps
  - number_crown, delay_crown
  - radius_apex
  - growth_rate
  - crown_angle
  - branching_interval