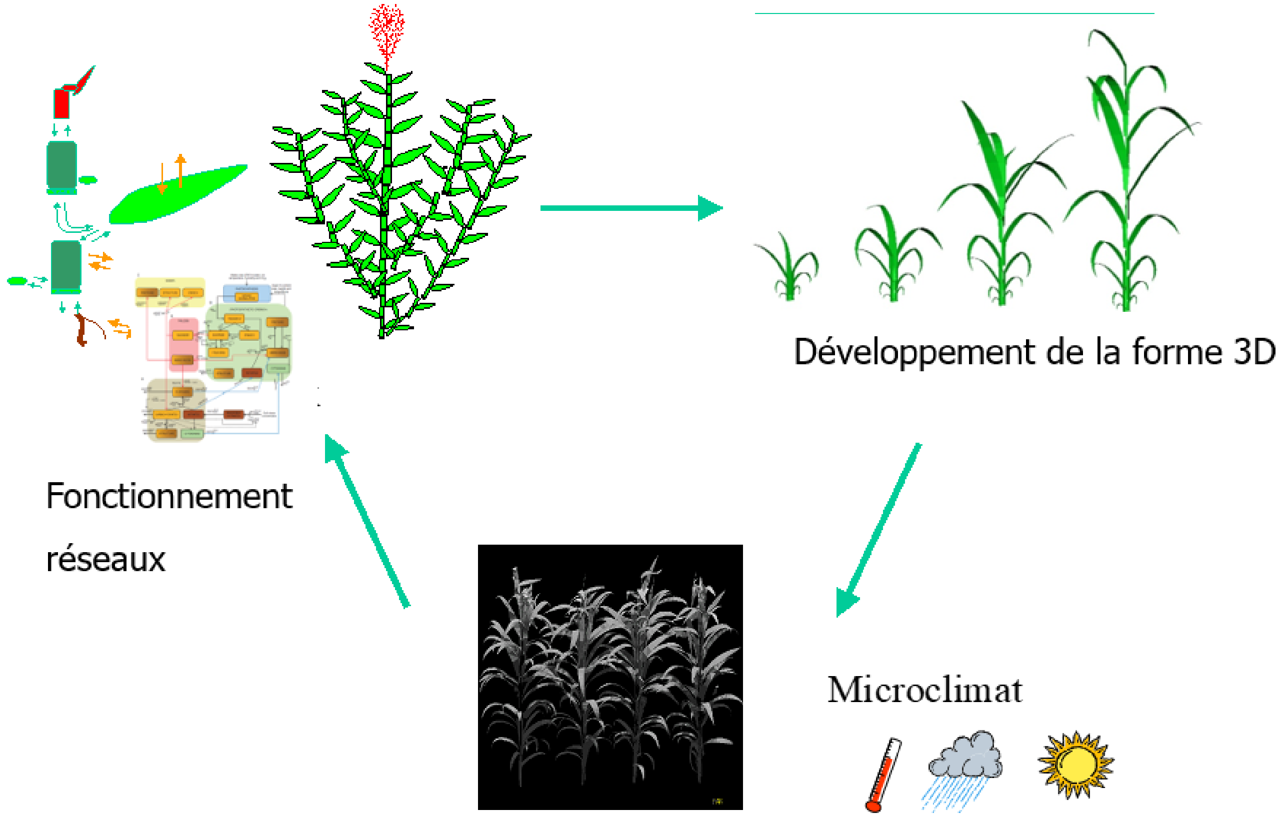
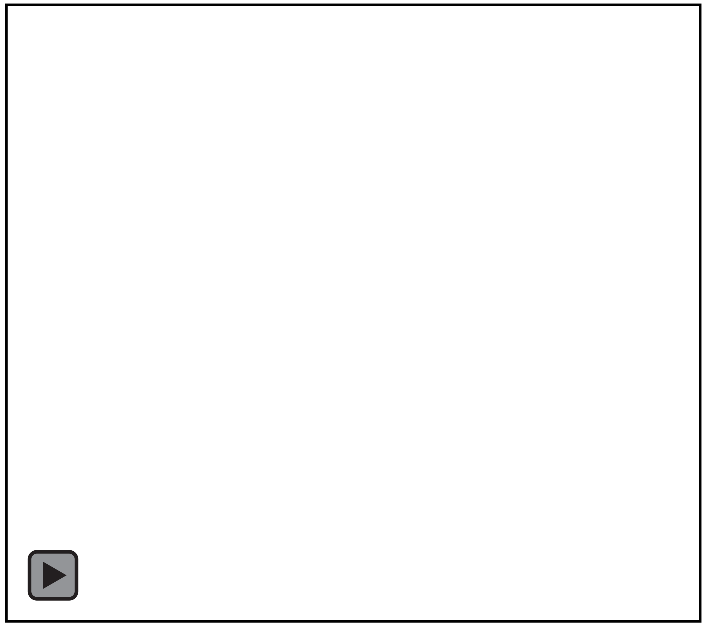
UED Introduction à la modélisation

Modélisation et simulation du développement de l'architecture des plantes

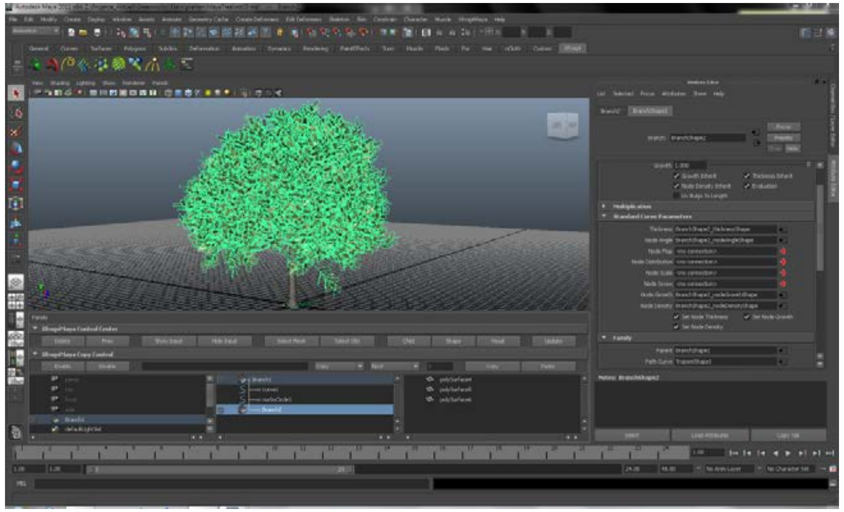
C. Fournier

Modèles Structure -Fonctions

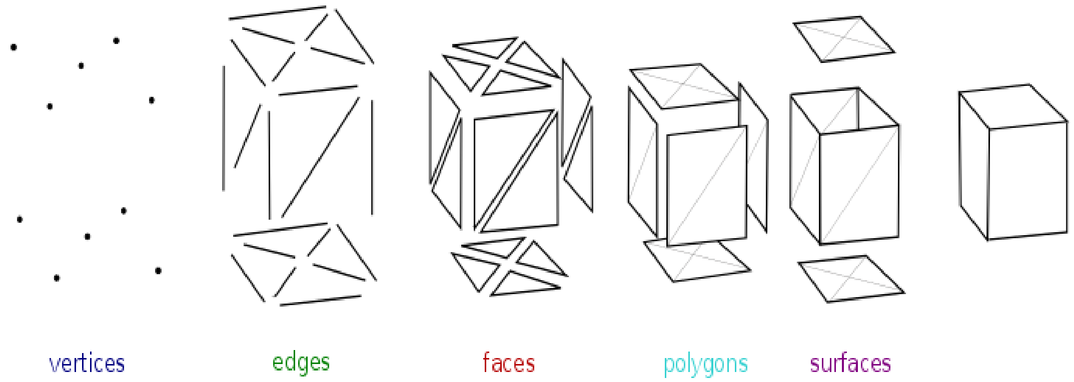




Modelling Geometry



Geometry as 3D Meshes



Face-Vertex Meshes

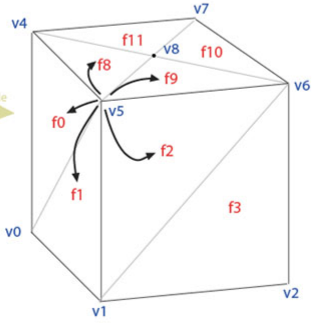
Face List

f0	v0 v4 v5
f1	v0 v5 v1
f2	v1 v5 v6
f3	v1 v6 v2
f4	v2 v6 v7
f5	v2 v7 v3
f6	v3 v7 v4
f7	v3 v4 v0
f8	v8 v5 v4
f9	v8 v6 v5
f10	v8 v7 v6
f11	v8 v4 v7
f12	v9 v5 v4
f13	v9 v6 v5
f14	v9 v7 v6
f15	v9 v4 v7

Vertex List

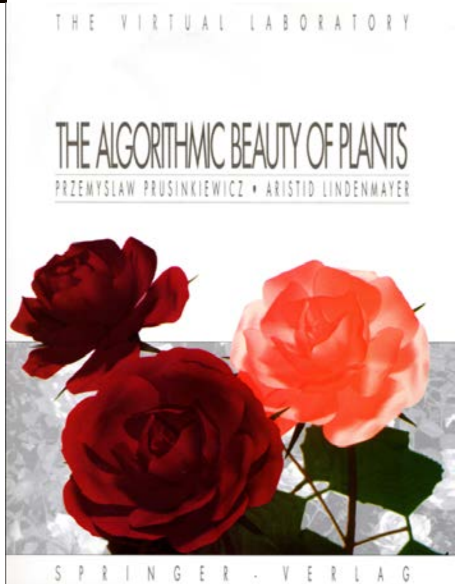
v0	0,0,0	f0 f1 f12 f15 f7
v1	1,0,0	f2 f3 f13 f12 f1
v2	1,1,0	f4 f5 f14 f13 f3
v3	0,1,0	f6 f7 f15 f14 f5
v4	0,0,1	f6 f7 f0 f8 f11
v5	1,0,1	f0 f1 f2 f9 f8
v6	1,1,1	f2 f3 f4 f10 f9
v7	0,1,1	f4 f5 f6 f11 f10
v8	.5,.5,0	f8 f9 f10 f11
v9	.5,.5,1	f12 13 14 15

example



Modélisation des plantes avec les L-Systèmes

- Issus de la botanique …
- …formalisation mathématique et algorithmique…
- … simulation du développement de l'architecture des plantes



Concepts

Lsystem: 1

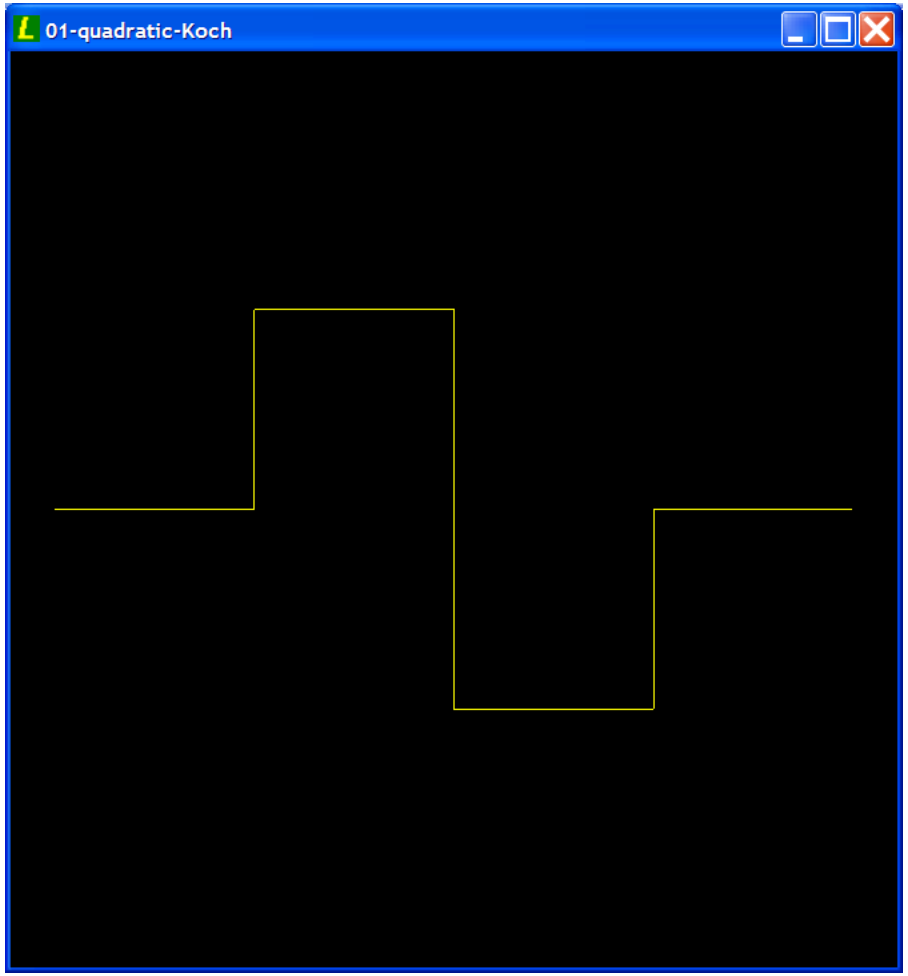
derivation length: 4

Axiom: -F

Productions:

F --> F+F-F-FF+F+F-F

endlsystem



mini-TD & exemples

- Flocon de neige

L-systèmes et plantes

- Plantes = ensemble structuré de module

- Développement comme système de réécriture parallèle et répété des modules
  - Physiologie
  - Croissance
  - géométrie

- Lsystème = état initial (axiom) + règles de développement

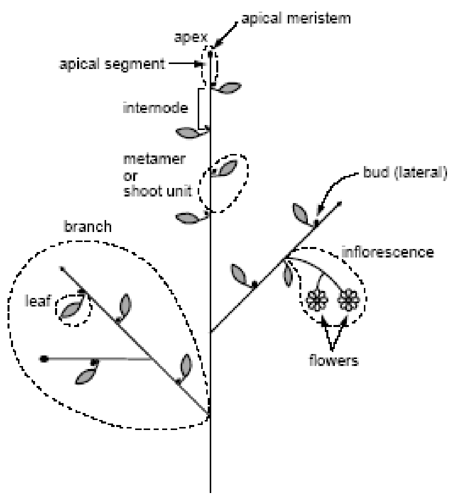
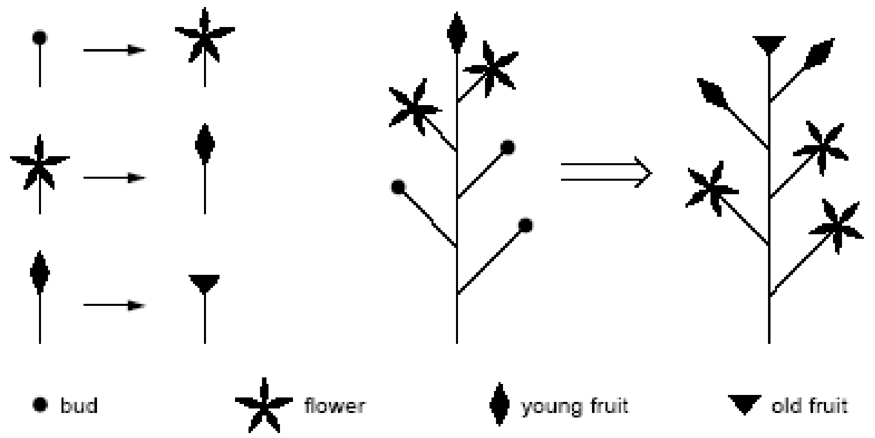


Figure 1: Selected modules and groups of modules (encircled with dashed lines) used to describe plants



Interprete the growth

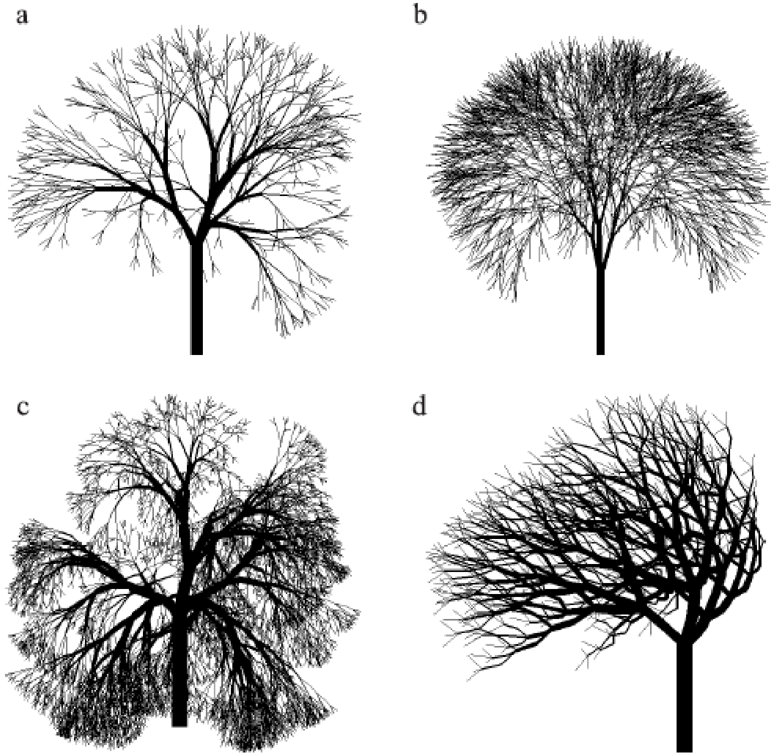
Computer language for plant growth

Leibniz Universität Hannover

INRA Institut National de la Recherche Agronomique

$n=7$, $\delta=22.5°$

```
ω  :  A
p1 :  A → [&FL!A]/////'[&FL!A]///////'[&FL!A]
p2 :  F → S ///// F
p3 :  S → F L
p4 :  L → ['''∧∧{-f+f+f-|-f+f+f}]
```




```
#define d1 94.74       /* divergence angle 1 */
#define d2 132.63      /* divergence angle 2 */
#define a 18.95        /* branching angle */
#define lr 1.109       /* elongation rate */
#define vr 1.732       /* width increase rate */

ω  :  !(1)F(200)/(45)A
p1 :  A : *      → !(vr)F(50)[&(a)F(50)A]/(d1)
                   [&(a)F(50)A]/(d2)[&(a)F(50)A]
p2 :  F(l)  :  * → F(l*lr)
p3 :  !(w)  :  * → !(w*vr)
```

The algorithmic beauty of plants (Prusinkiewicz and Lindenmayer, 1990)

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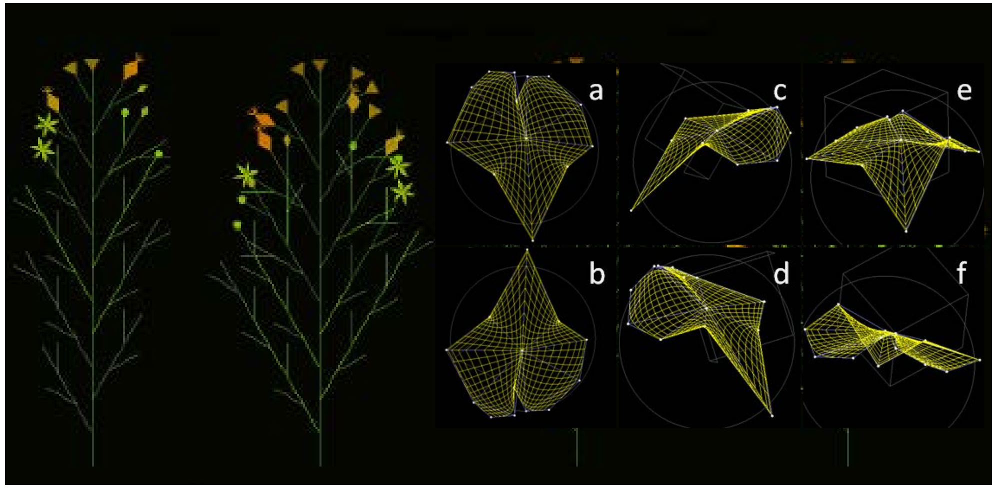
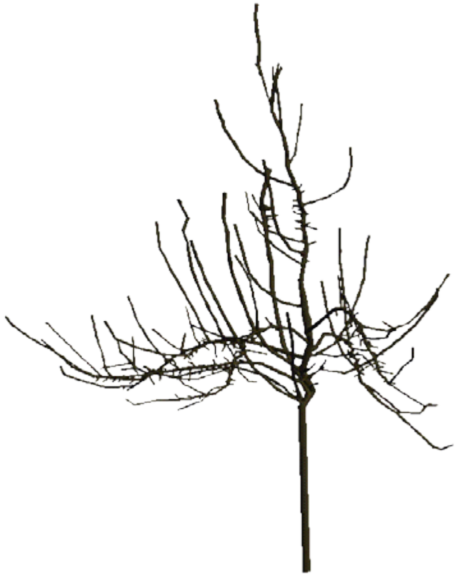
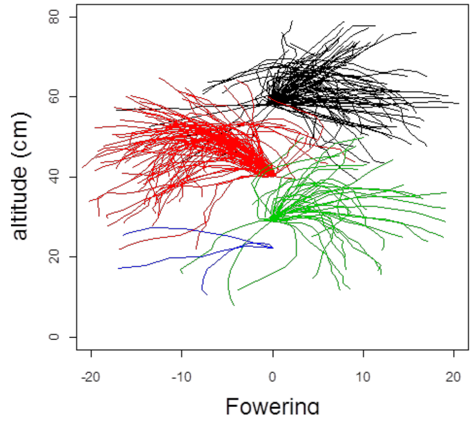


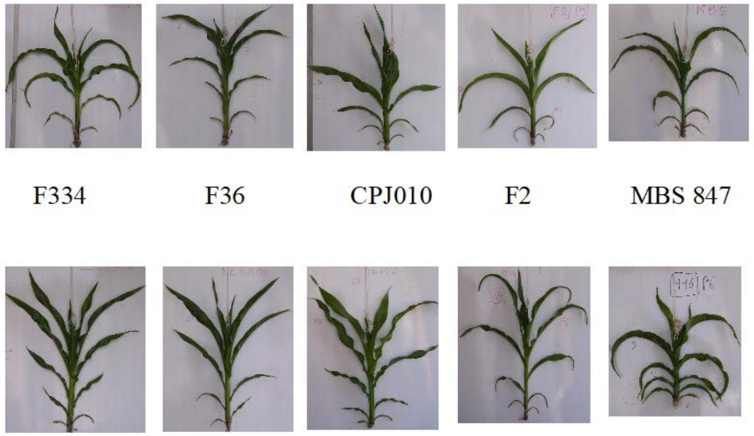
The algorithmic beauty of plants (Prusinkiewicz and Lindenmayer, 1990)

Leaf & plant geometry

Gramineous Leaf Shapes





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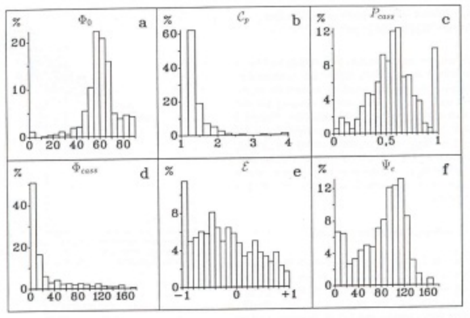
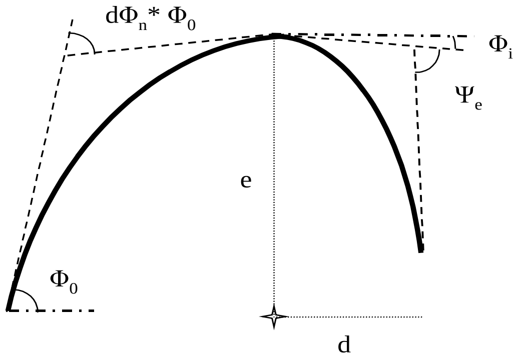
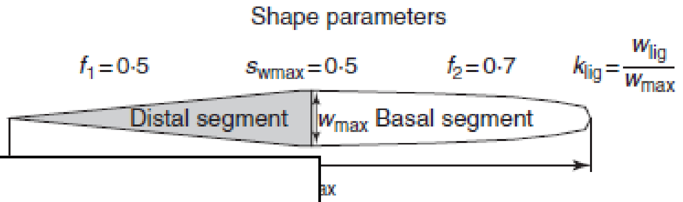
Mathematical models

- Based on Data
- Parcimonious
- Limited flexibility
- Control ad hoc

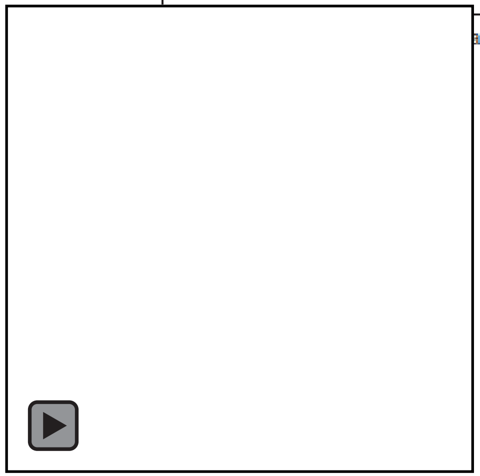




Prévot,1991, Espana1999, Fournier 1998, 2003



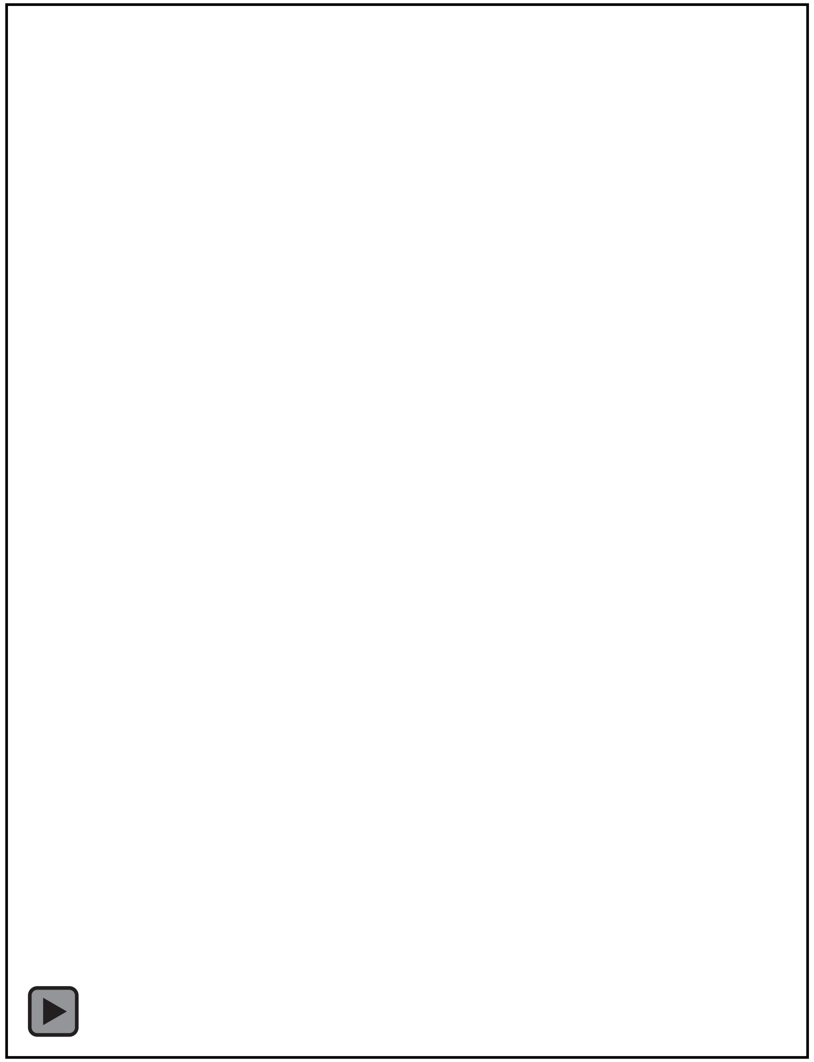
Dornbuch, 2010

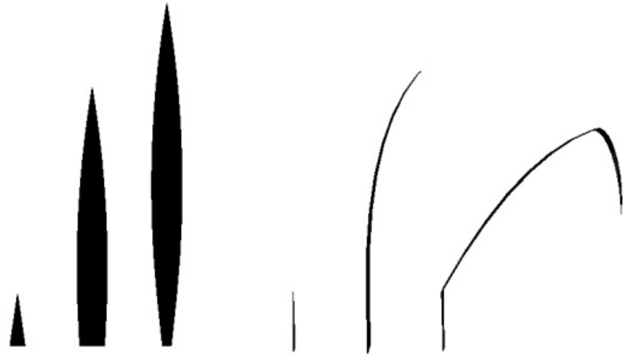


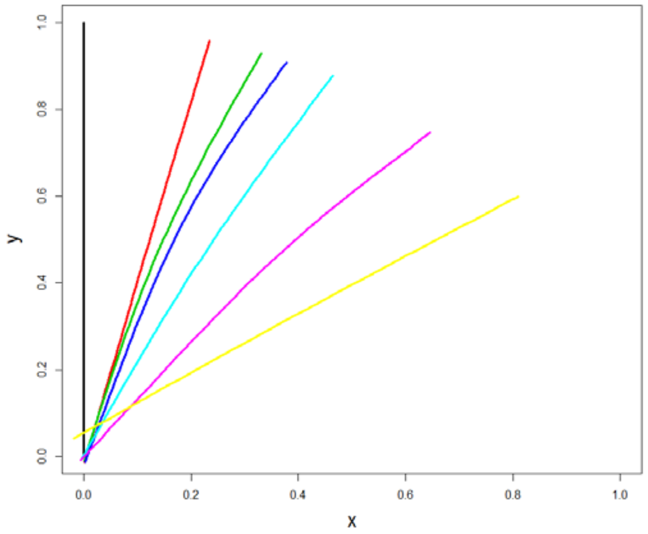
Fournier, 1998

Flexibility

Dynamics of shape evolution

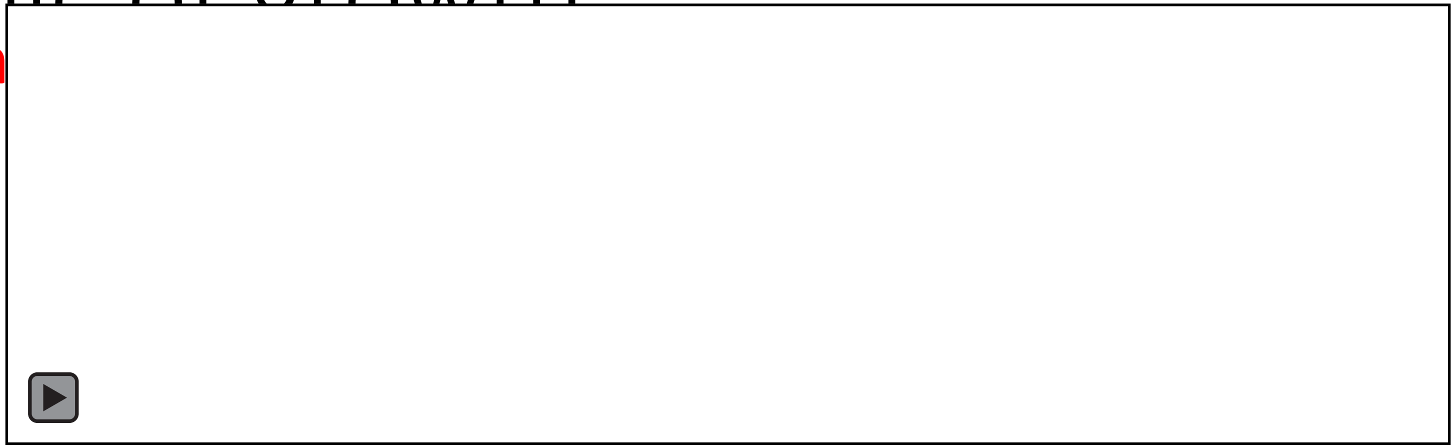


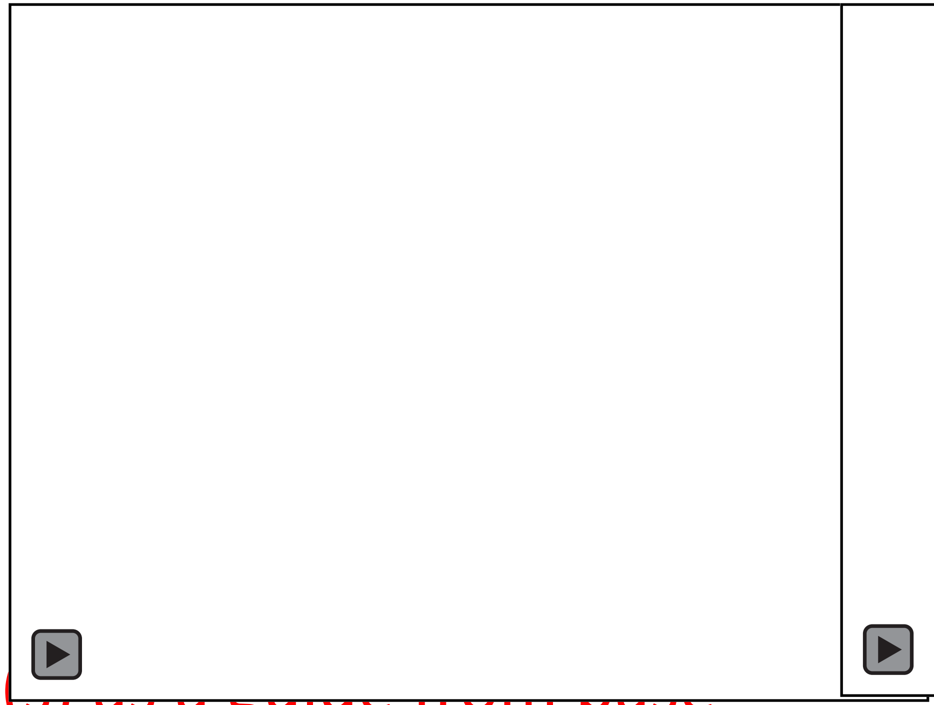




Dynamic of growth

Trun

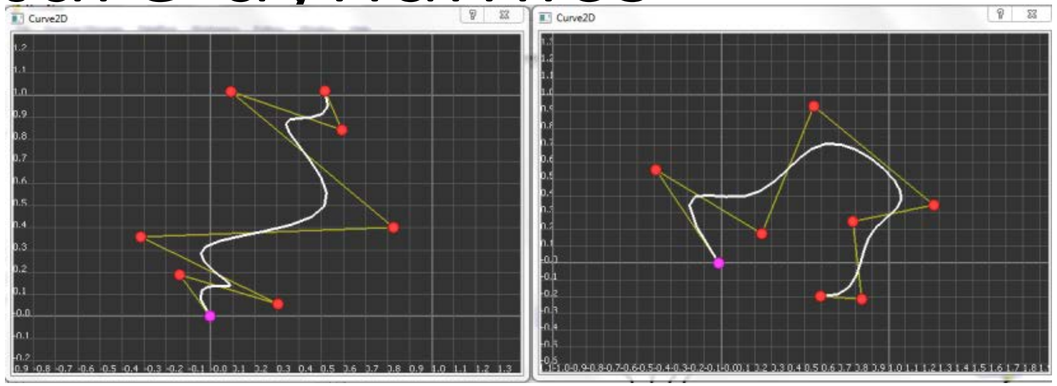




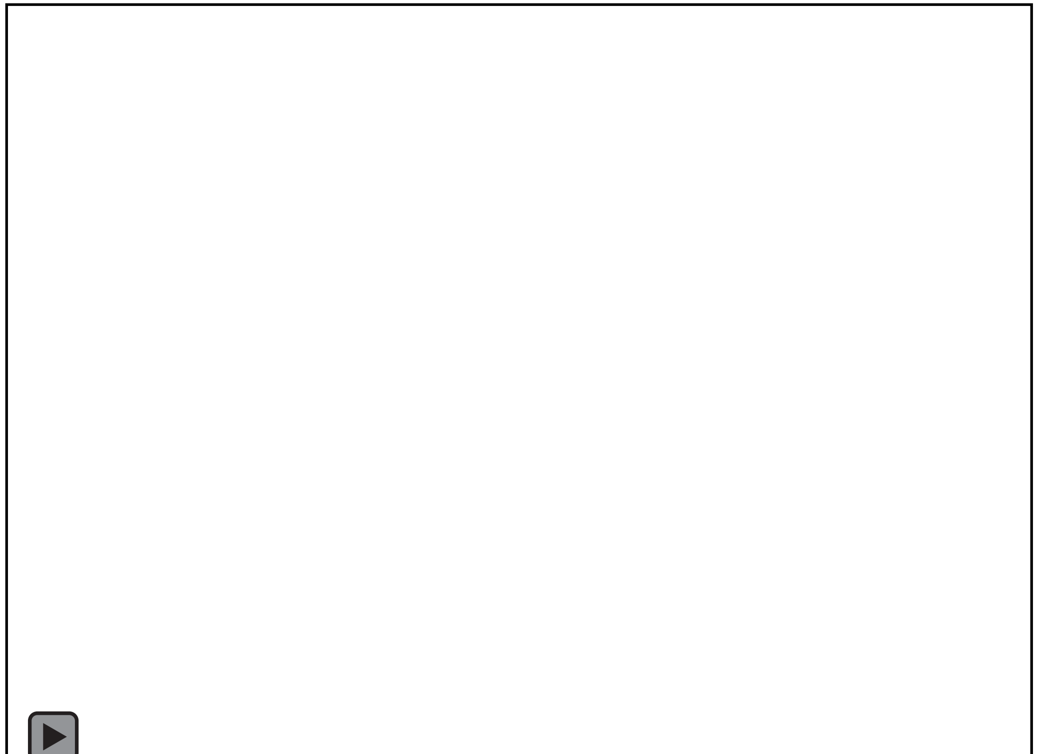
N(s) as a guide from base

N(s) as a guide from top

Curvature dynamics

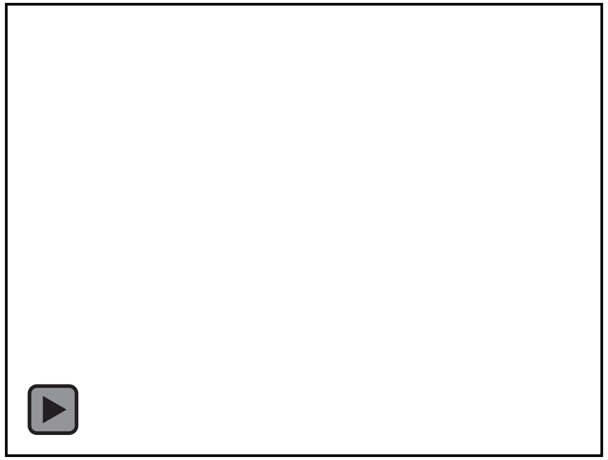


Curvature
Interpolation

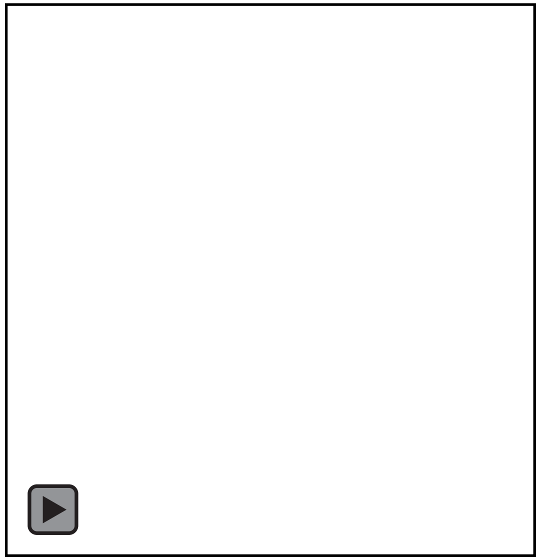


Growth and curvature dynamics

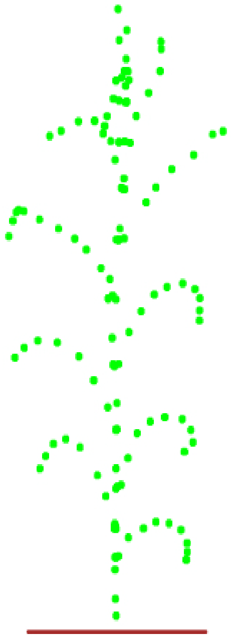
- Example 1:
  - N(s,a)
  - N(s) as a guide from base

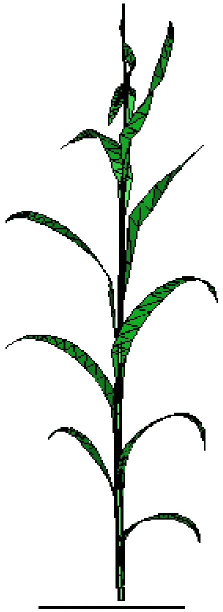


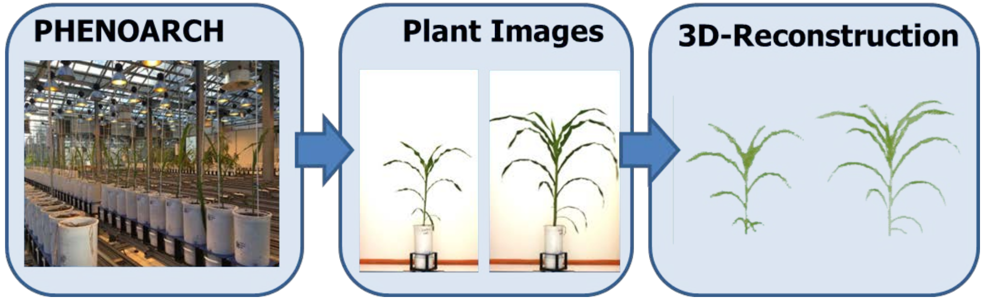
- Example 2:
  - N(s) -> curvature, angle
  - Curvature * f(t)
  - Angle *f(t)

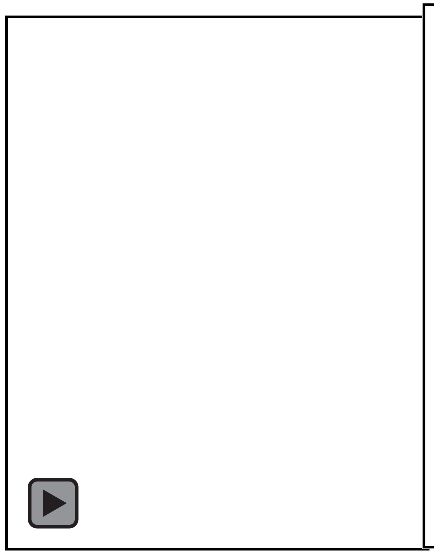


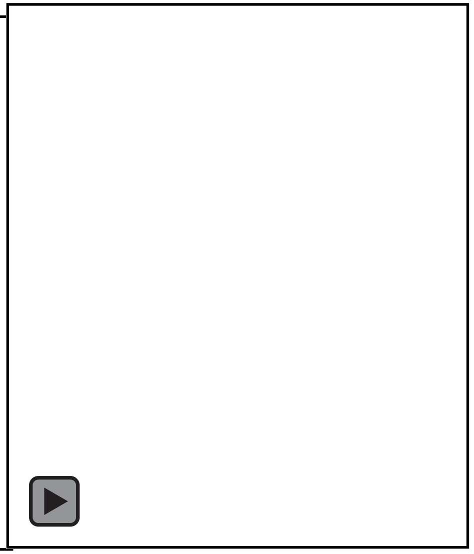
Measuring 3D geometry











Measuring 3D geometry

Laser-scan + model assisted reconstruction

To be continuated...