Notes I

- New irit logo
- Reva logo
- colonization strategies > objective
- do write ecosystem
- sum up of the presentation
- remove all overviews but after the forewords
- directed graph under genotype
- metabolism: picture?
- remove performed OF ....
- Overview > sample of diversity
- Leaves with classes (same with other three)
- CSR > jsut remove
- Organ count put fitness in whole letters
- No overlay for reproduction
- longer simulations (put numerics)
- Merge future work slides

Institut de Recherche
en Informatique de Toulouse
CNRS - INP - UT3 - UT1 - UT2J

ReVa

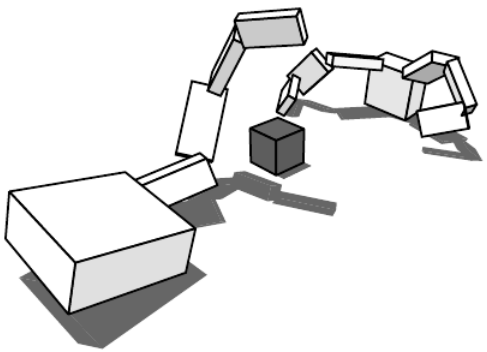
Self-sustainability Challenges of Plants Coloninization Strategies in Virtual 3D Environments

GODIN-DUBOIS Kevin & CUSSAT-BLANC Sylvain

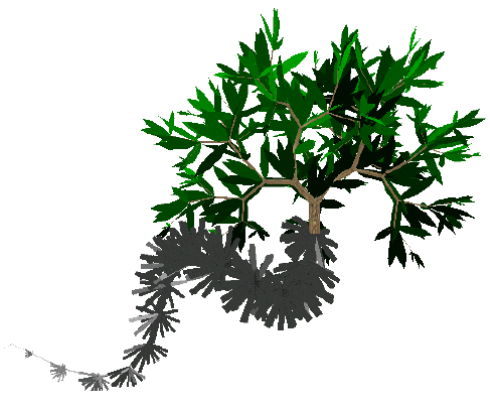
& DUTHEN Yves

April 25, 2019

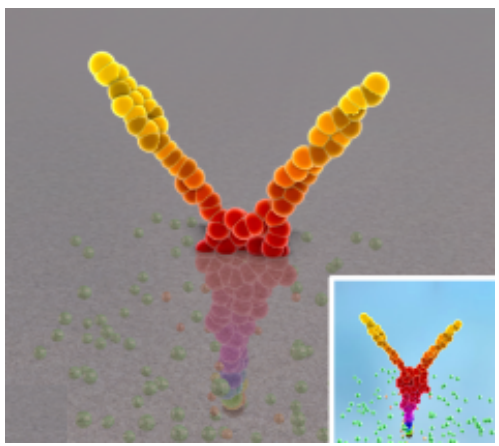
Morphogenetic engineering



Sims (1994)

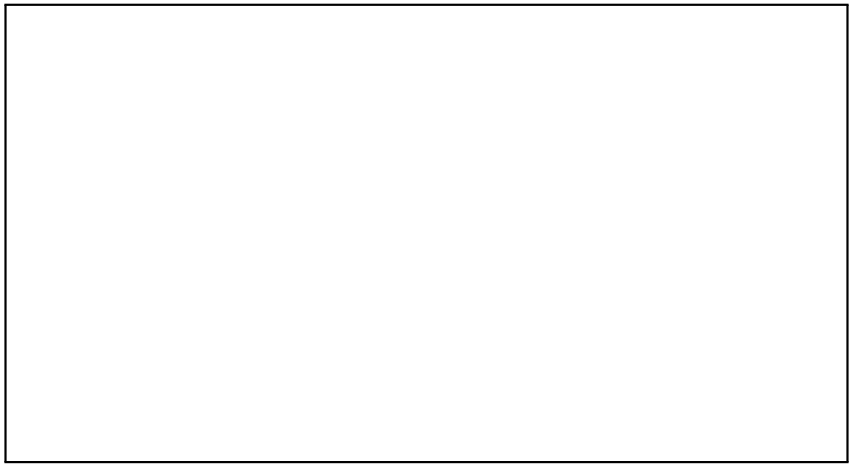


Bornhofen (2008)

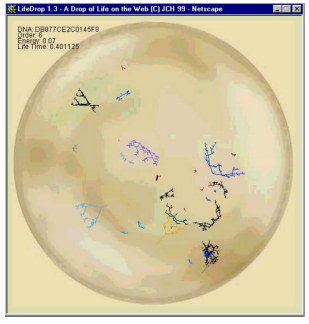


Disset et al. (2016)

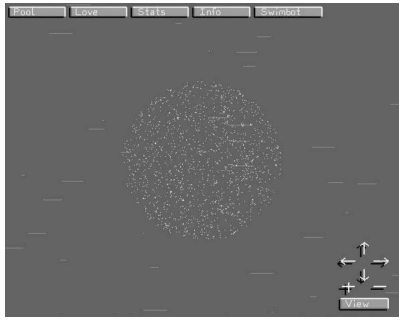
Replicators



Gardner (1970)

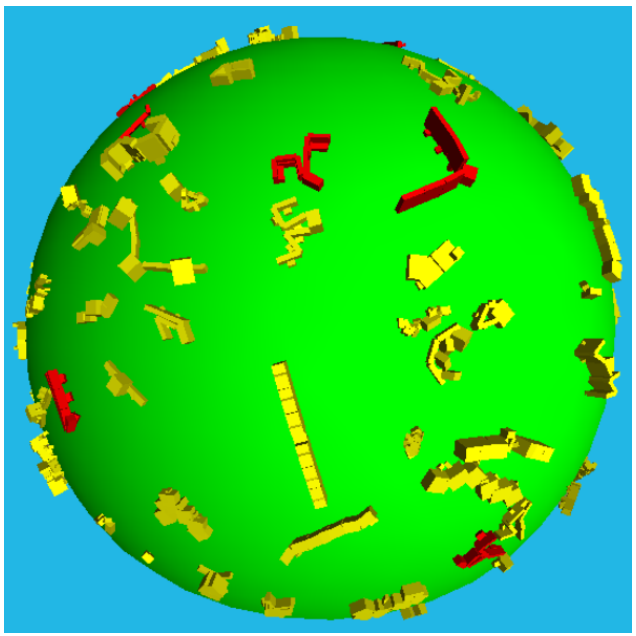


Metivier et al. (2002)

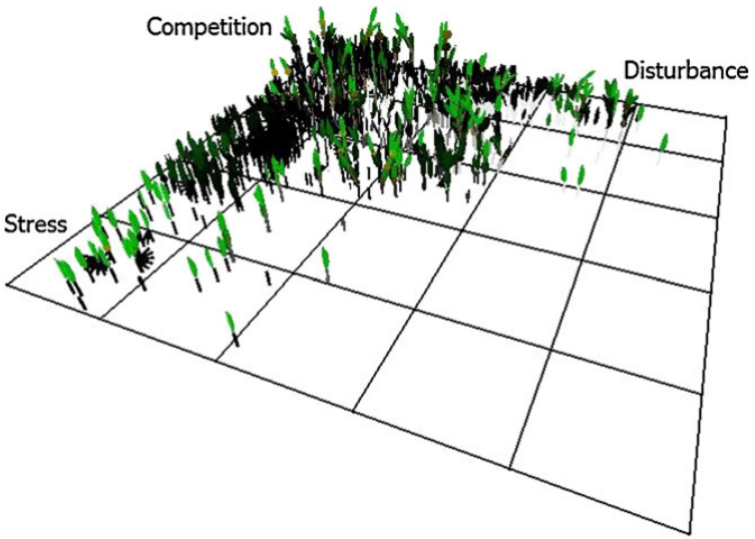


Ventrella (2005)

Ecosystems



Miconi (2008)



Bornhofen et al. (2011)

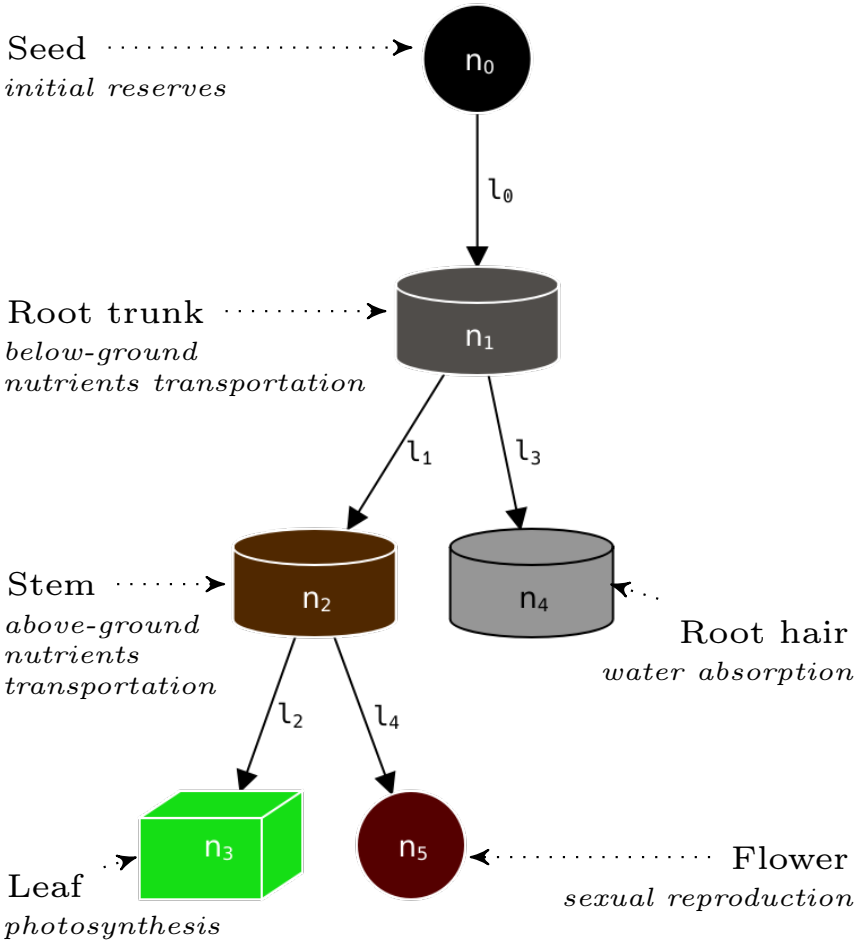
Objective

- Graphtal-based genotype & autonomous reproduction
- Collaboration/Competition strategies
- Ecosystem self-sustainability

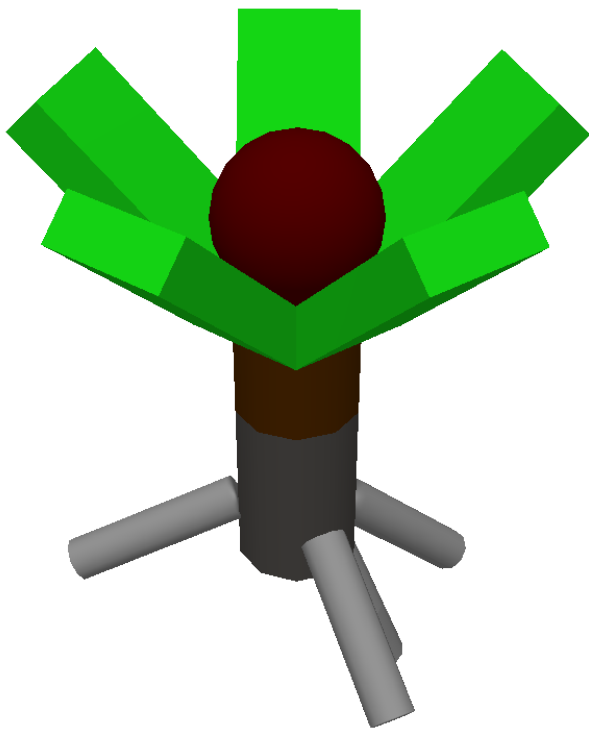
Overview

- Context
  - Morphogenetic engineering
  - Replicators
  - Ecosystems
  - Objective
- Model
- Experiments
- Conclusion

Plants



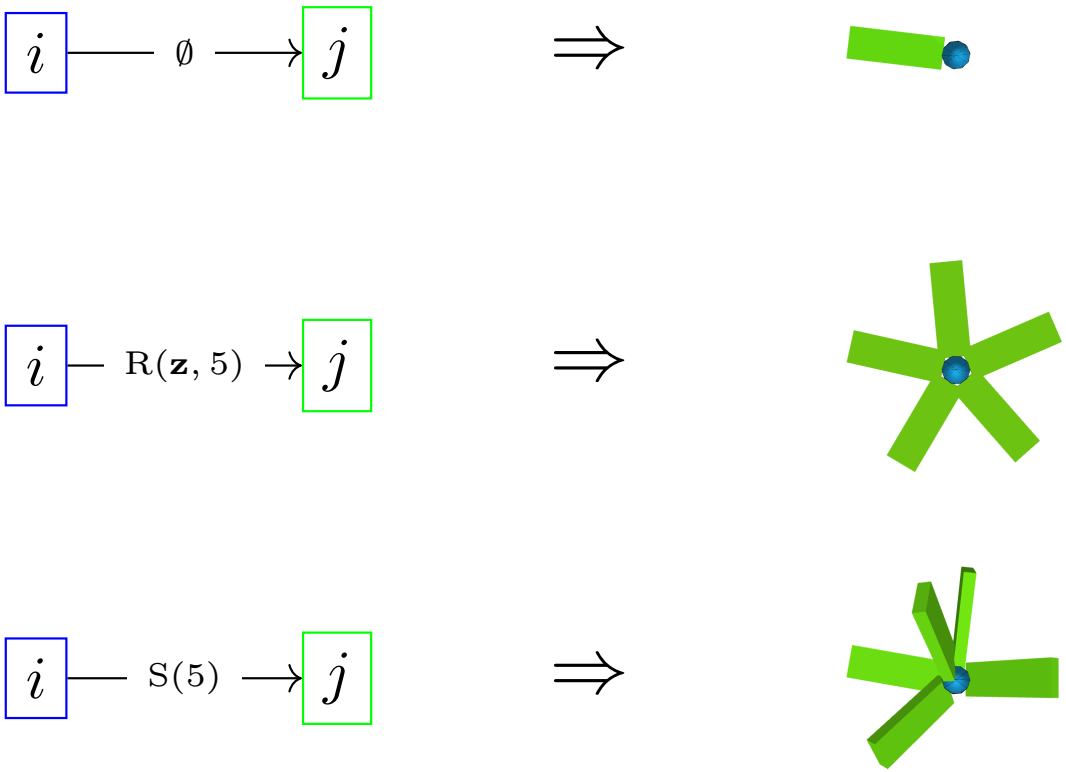
Genotype
(Directed graph)



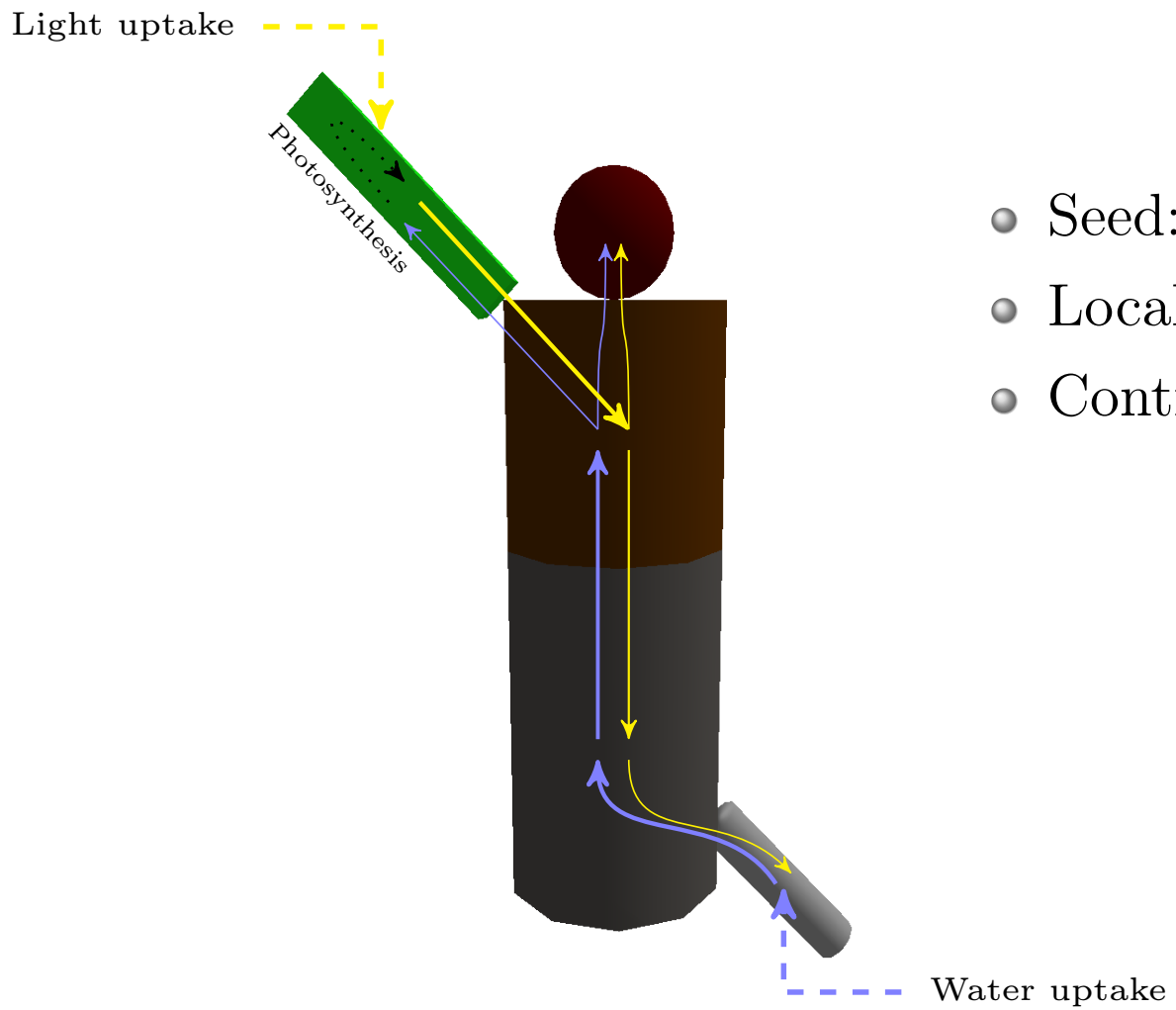
Phenotype

Plants

Repetitions

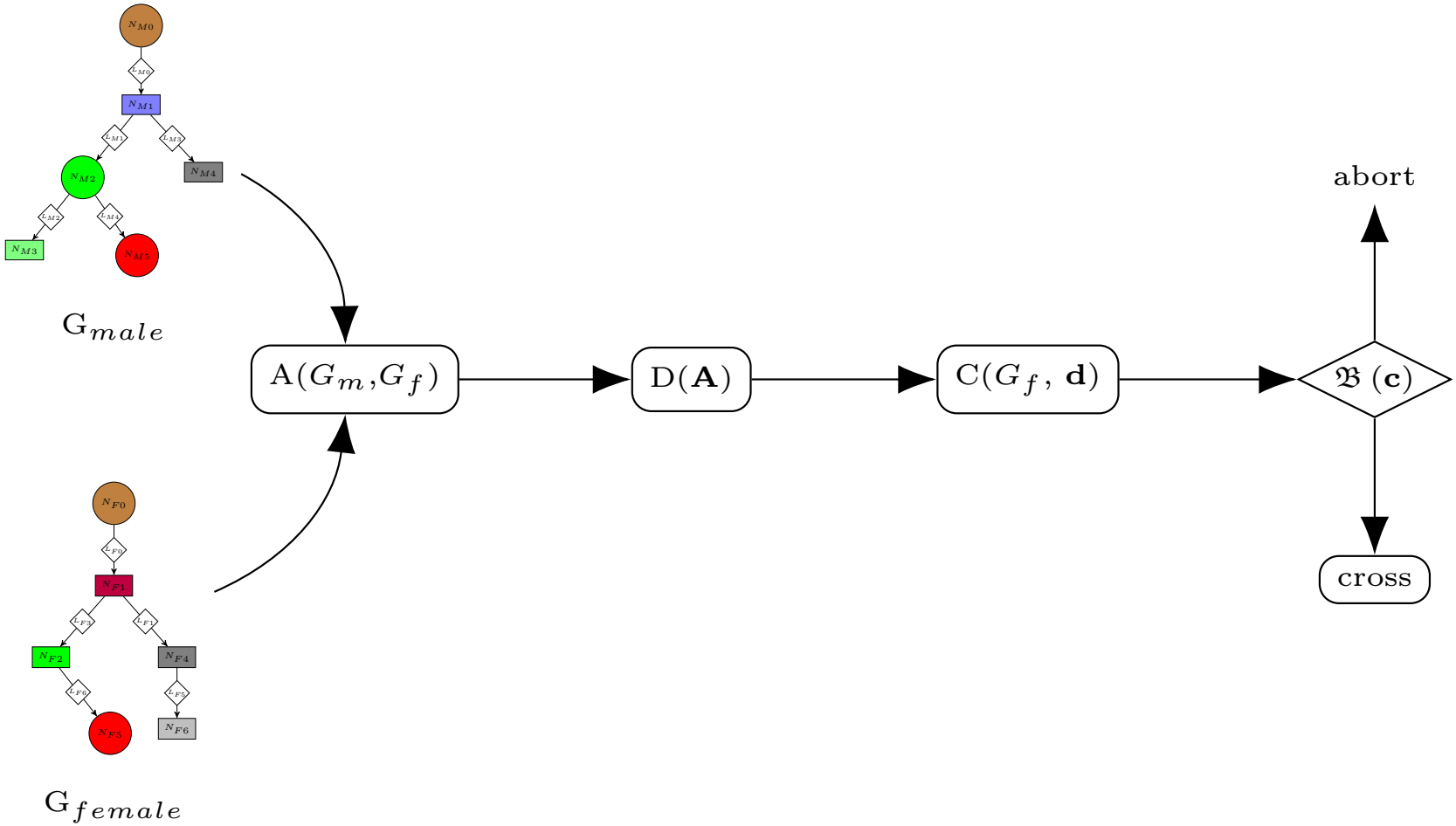


Metabolism

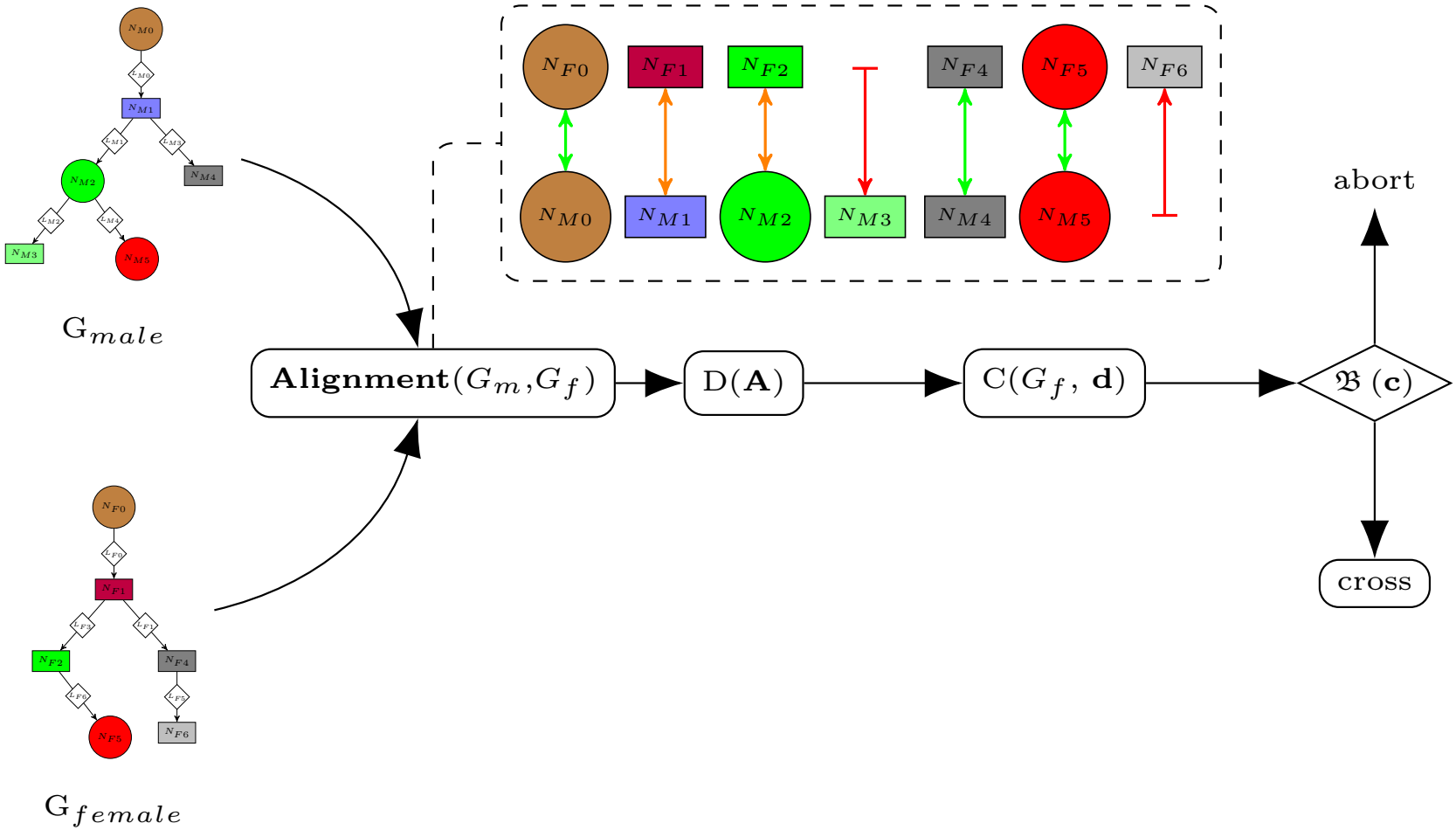


- Seed: Initial reserves
- Local diffusion
- Controlled by $\mathbf{A}, \mathbf{S}$

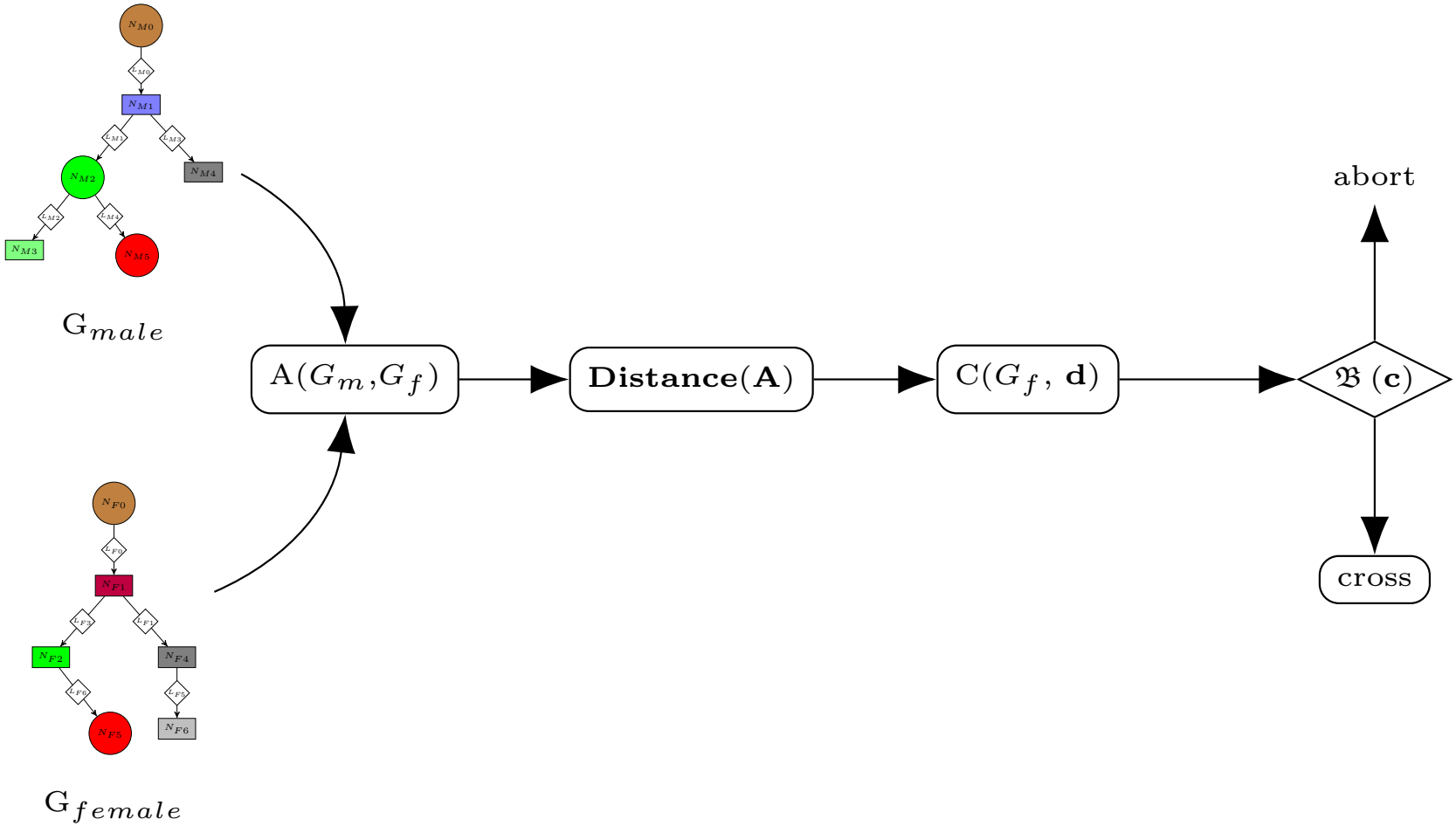
Reproduction



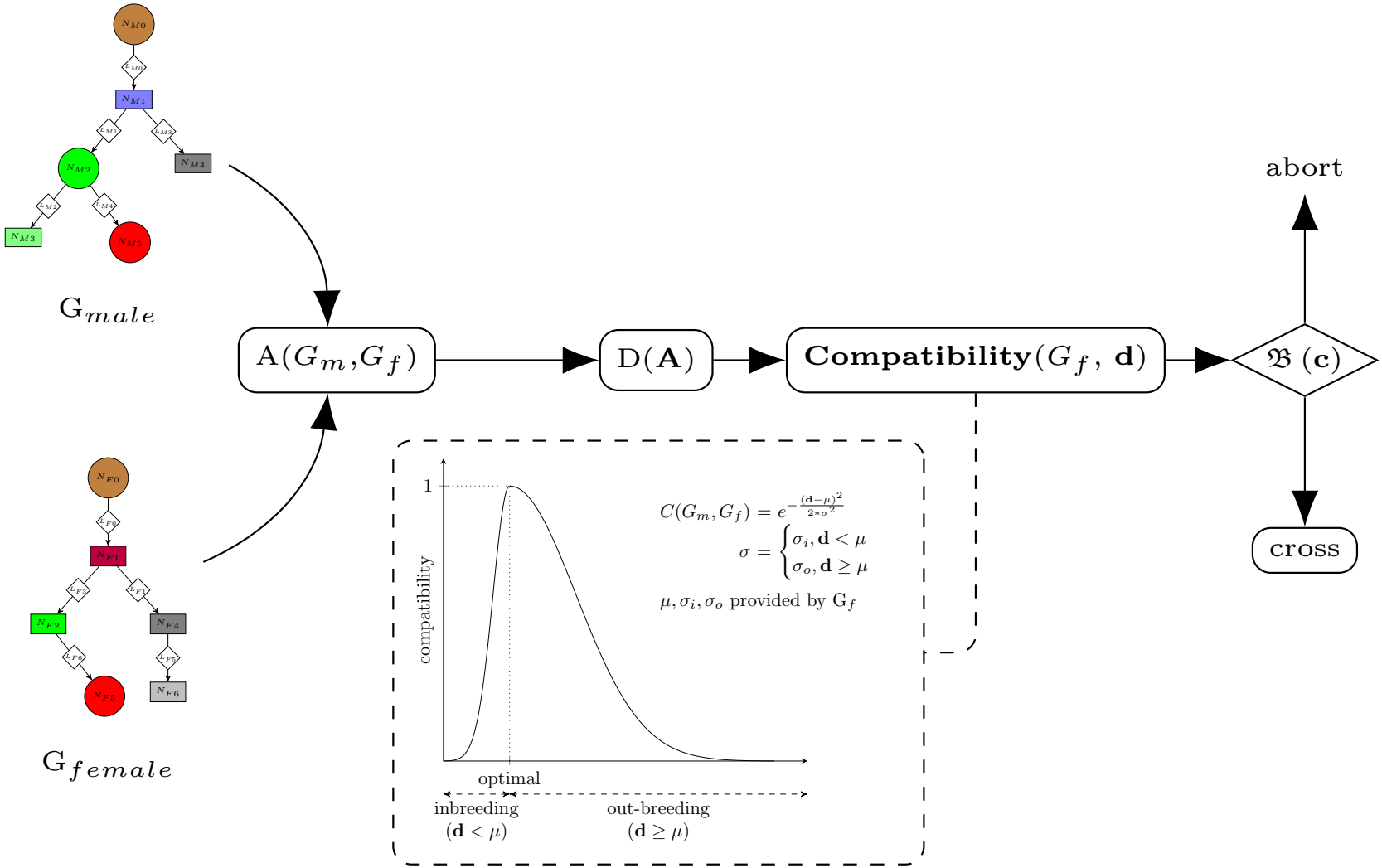
Reproduction



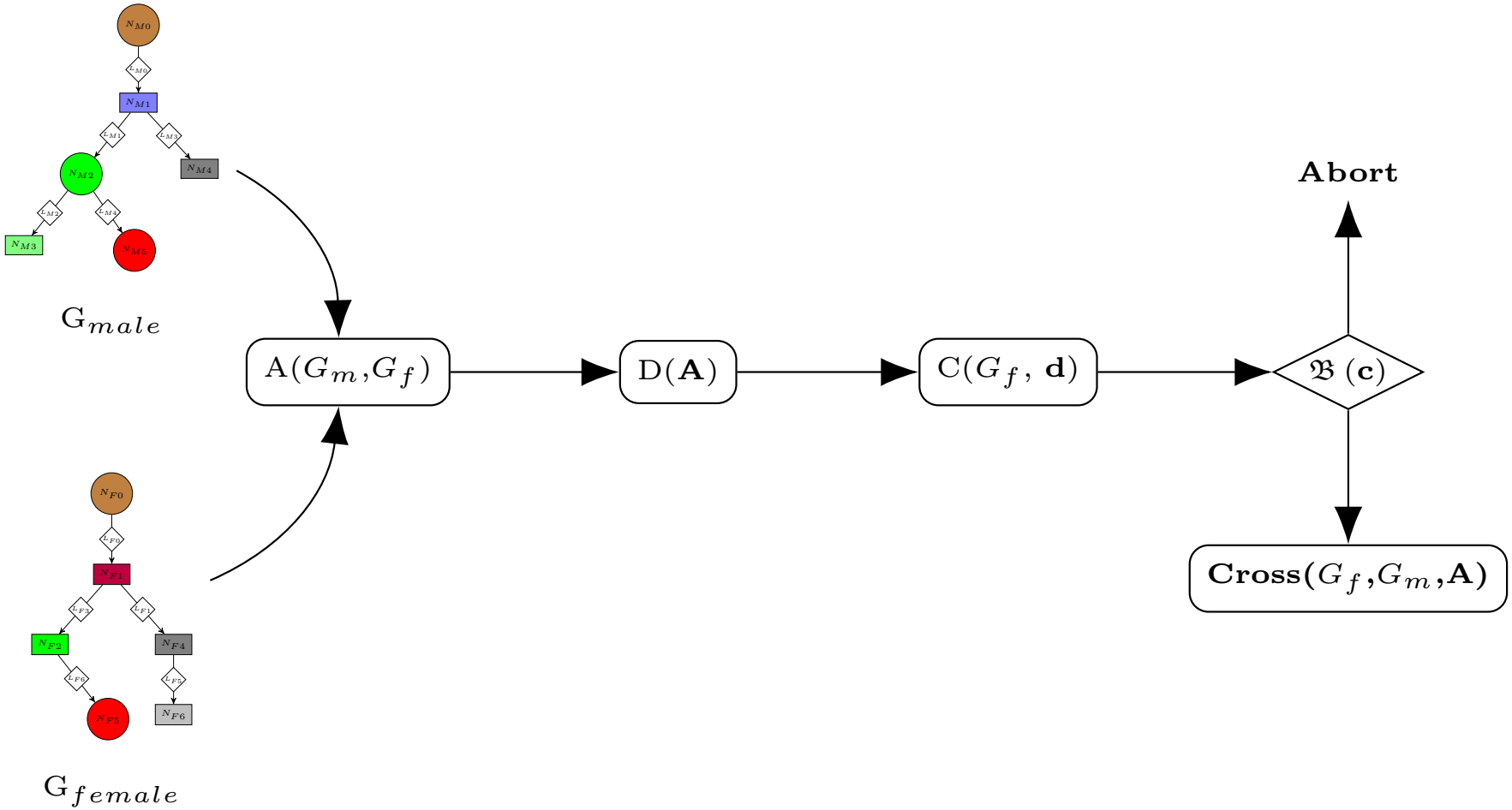
Reproduction



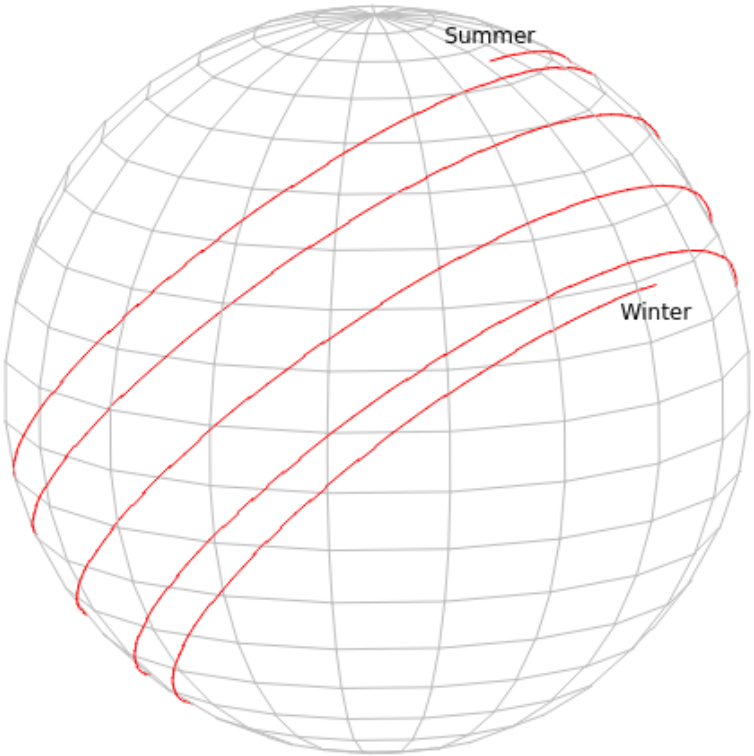
Reproduction



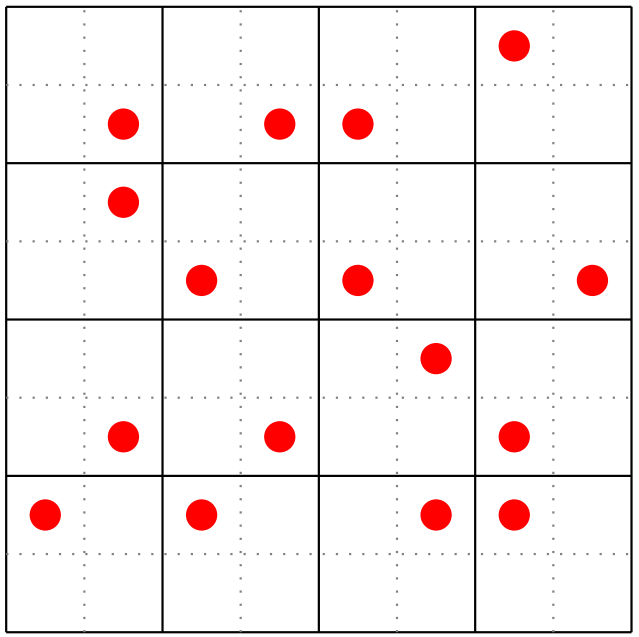
Reproduction



Environment



Dynamic sun



Populating

Overview

- Context
- Model
  - Plants
  - Metabolism
  - Reproduction
  - Environment
- Experiments
- Conclusion

Fitnesses

$$F_b = \nu \sum_{t<N} \sum_{p \in P} biomass(p,t)$$

$$F_p = \nu \sum_{t<N} \sum_{p \in P} production(p,t)$$

$$F_c = \frac{\nu}{W^2} \sum_{t<N} surface(t)$$

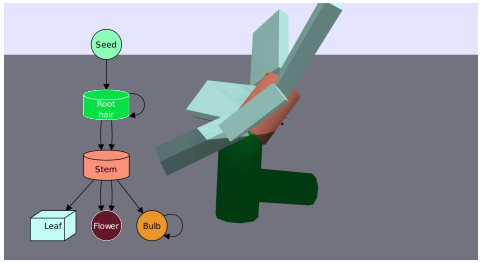
$$F_a = \nu \sum_{p \in P} lifespan(p) * 2^{-\alpha_p}$$

F_m : Multi-objective

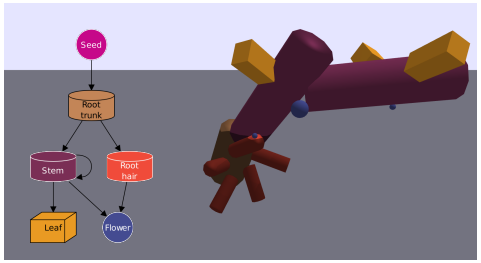
W	Environment size (10m)
N	Simulated steps (60000)
$\|P\|$	Initial plants count (100)
P	Plant population
ν	$1/NP$

Morphologies

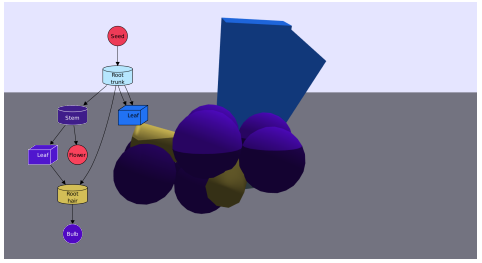
Diversity sample



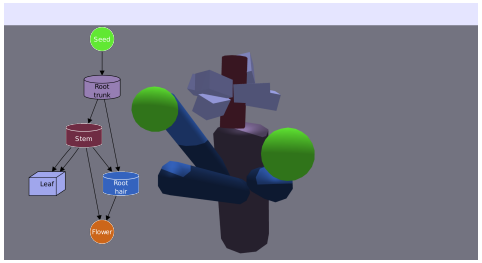
Radial - F_c



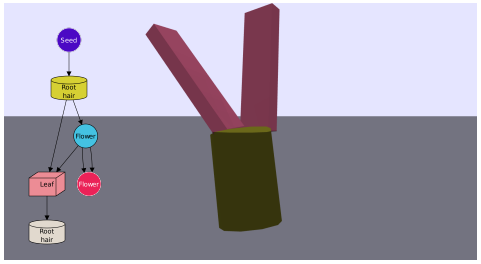
Balanced - F_{ma}



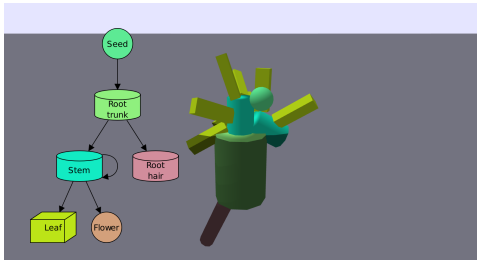
Storage - F_{mb}



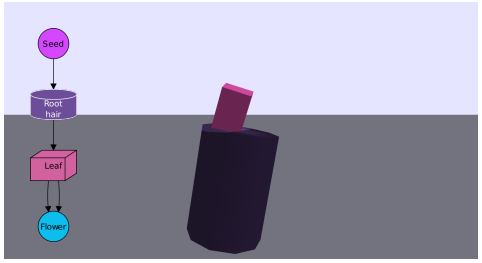
Shoots - F_a



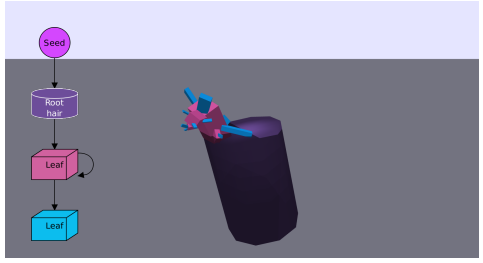
Massive - F_b



Scattered - F_{ma}



Reproduction - F_{ma}

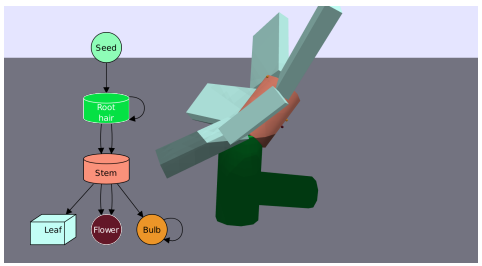


Survival - F_{mb}

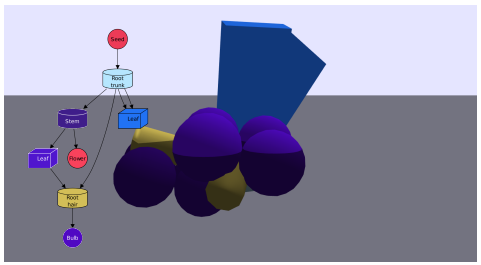
Morphologies

Leaves

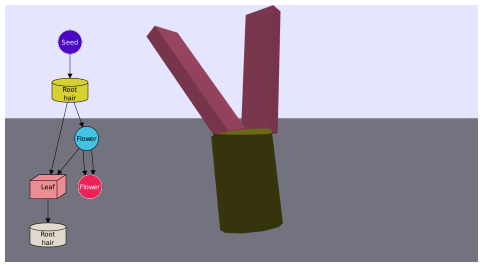
Large, fixed orientation



Radial - F_c

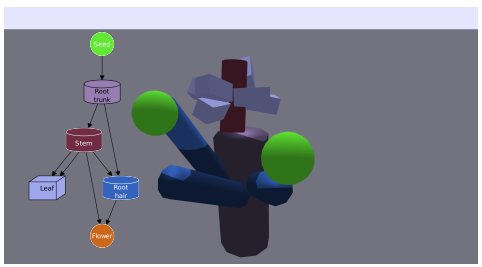


Storage - F_{mb}

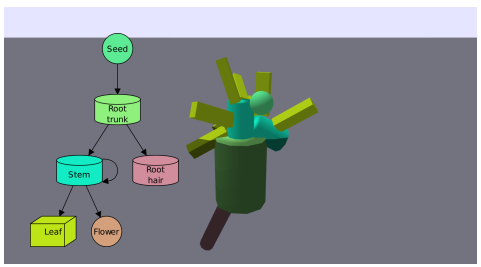


Massive - F_b

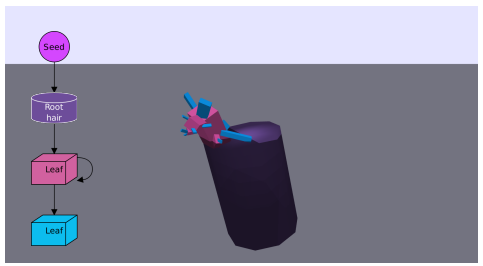
Small, multiple orientations



Shoots - F_a



Scattered - F_{ma}

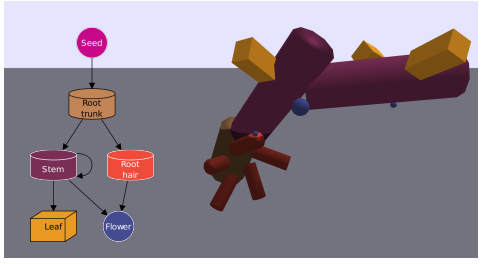


Survival - F_{mb}

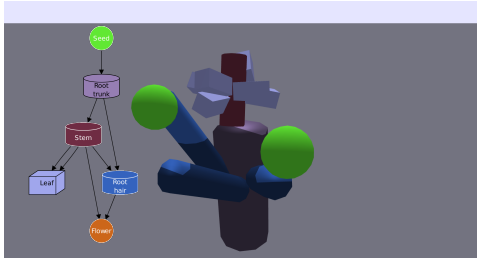
Morphologies

Roots

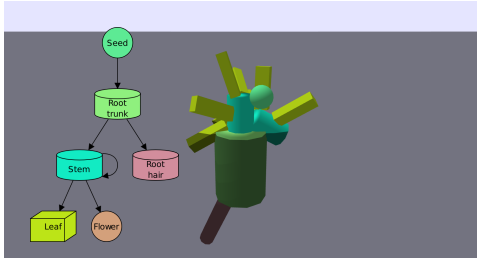
Single trunk



Balanced - F_{ma}

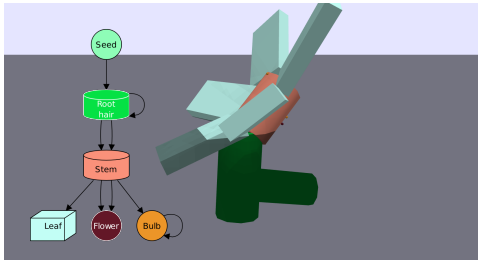


Shoots - F_a

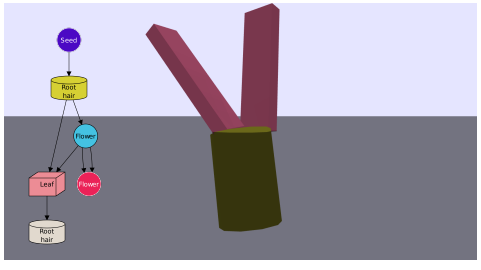


Scattered - F_{ma}

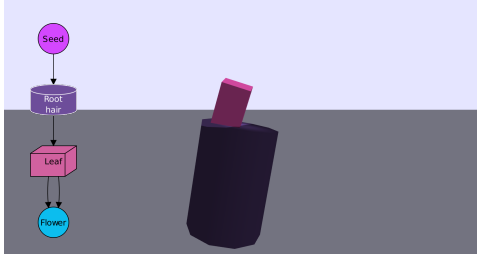
Direct connection



Radial - F_c



Massive - F_b

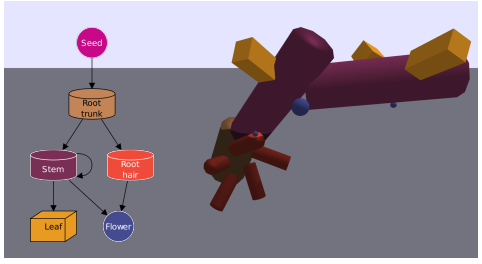


Reproduction - F_{ma}

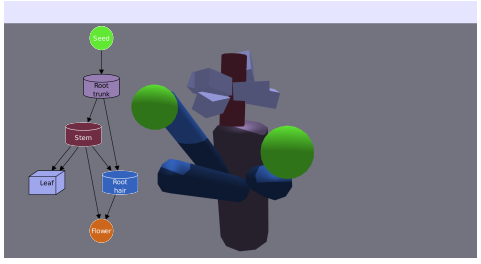
Morphologies

Fruits

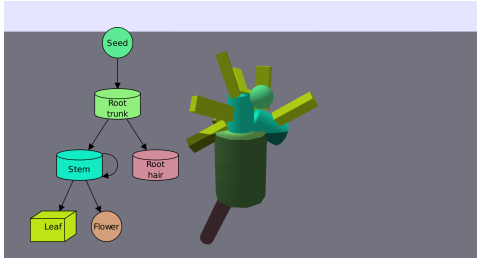
Marginal



Balanced - F_{ma}

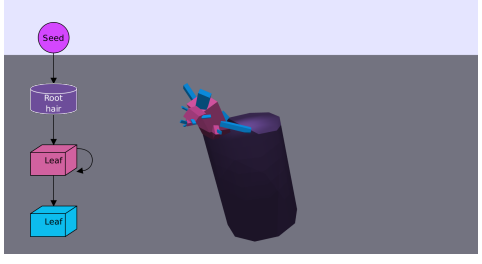


Shoots - F_a



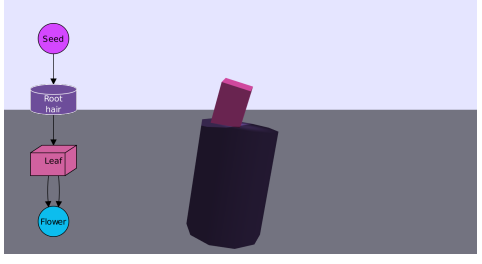
Scattered - F_{ma}

Sterile



Survival - F_{mb}

Optimized



Reproduction - F_{ma}

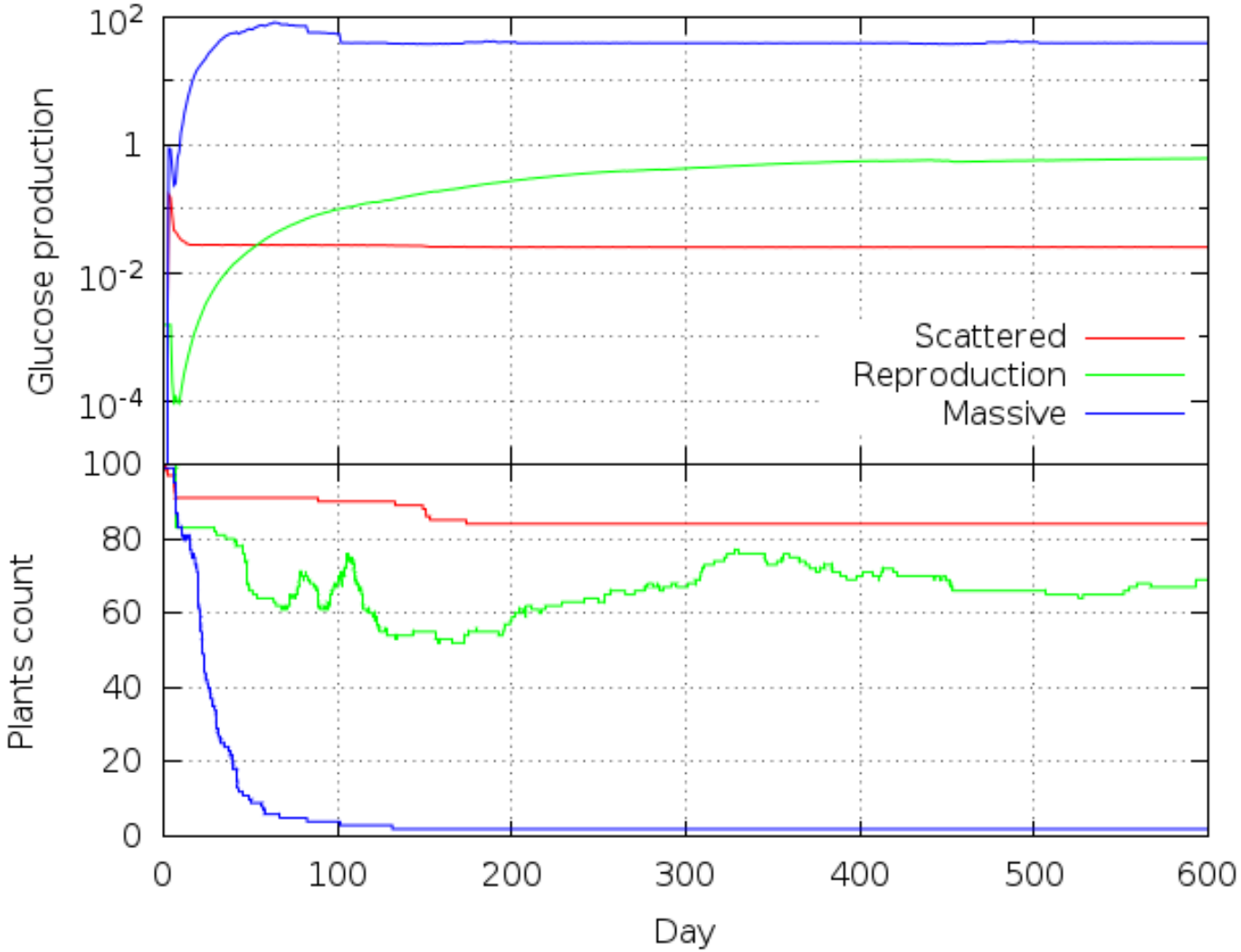
Radial

Massive

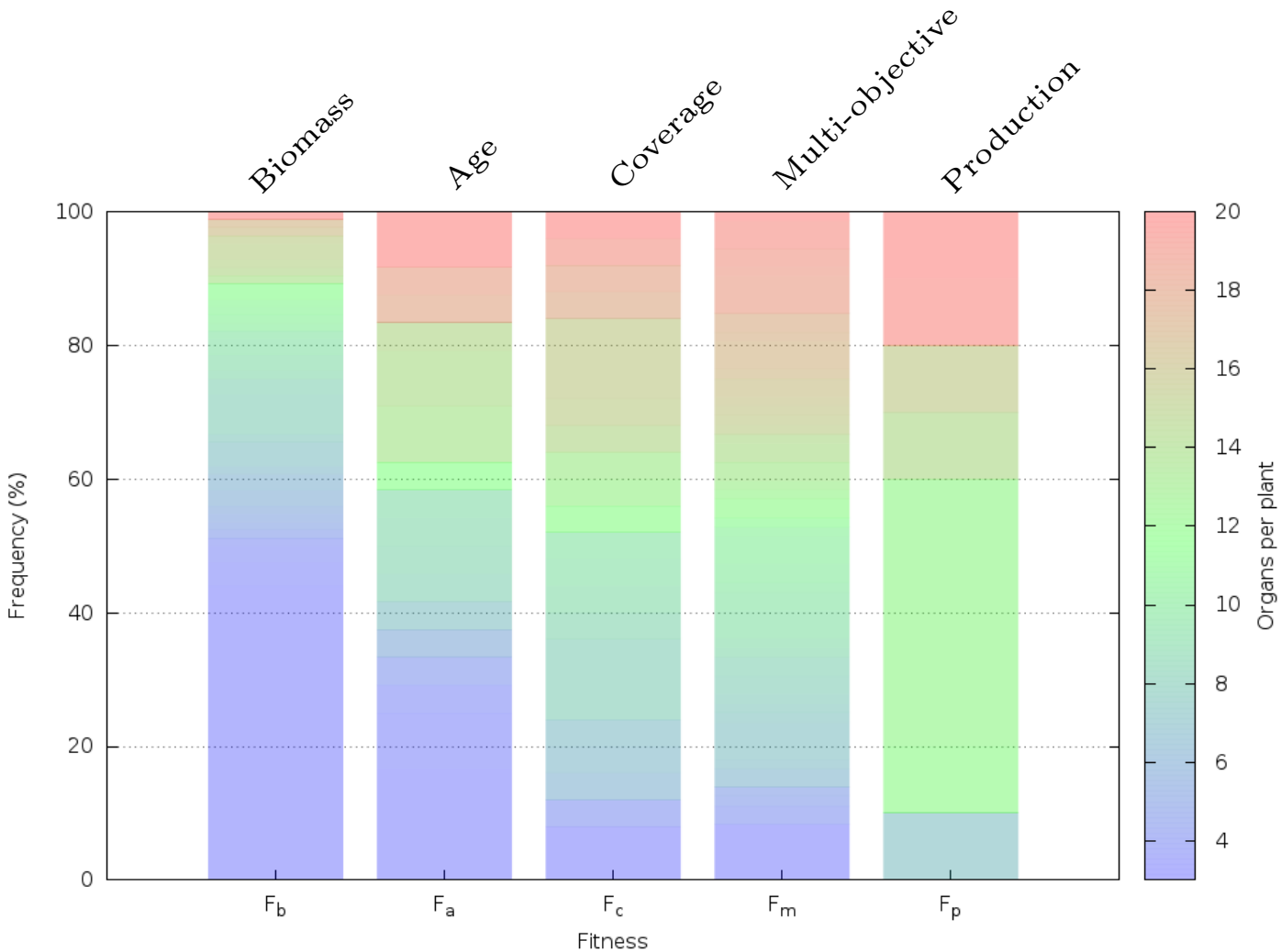
Scattered

Reproduction

Main strategies



Organ count repartition

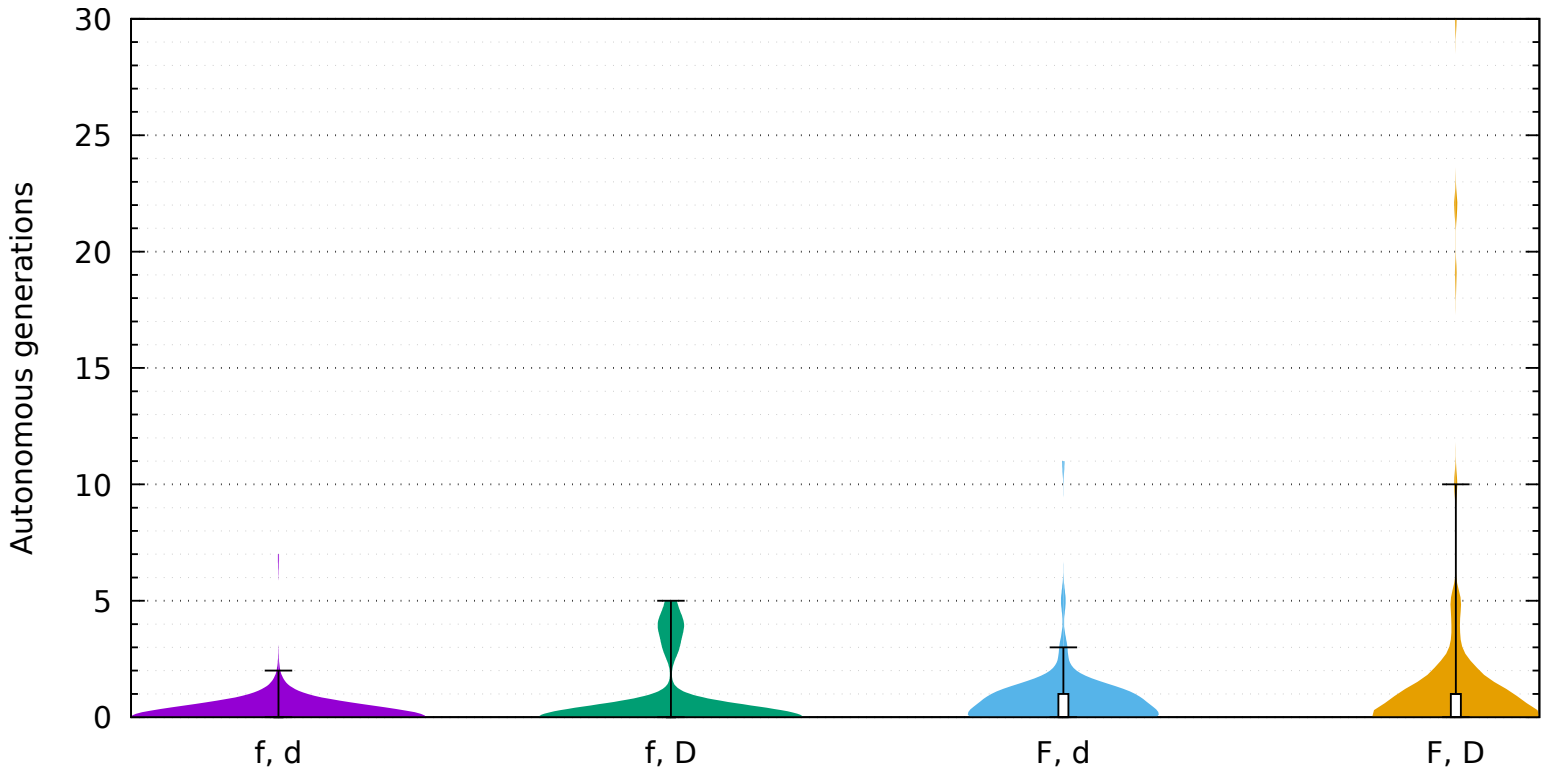


Reproduction

Hypothesis on self-sustainability

F Bootstrapping fruit dissemination

D Death-related stress



Reproduction

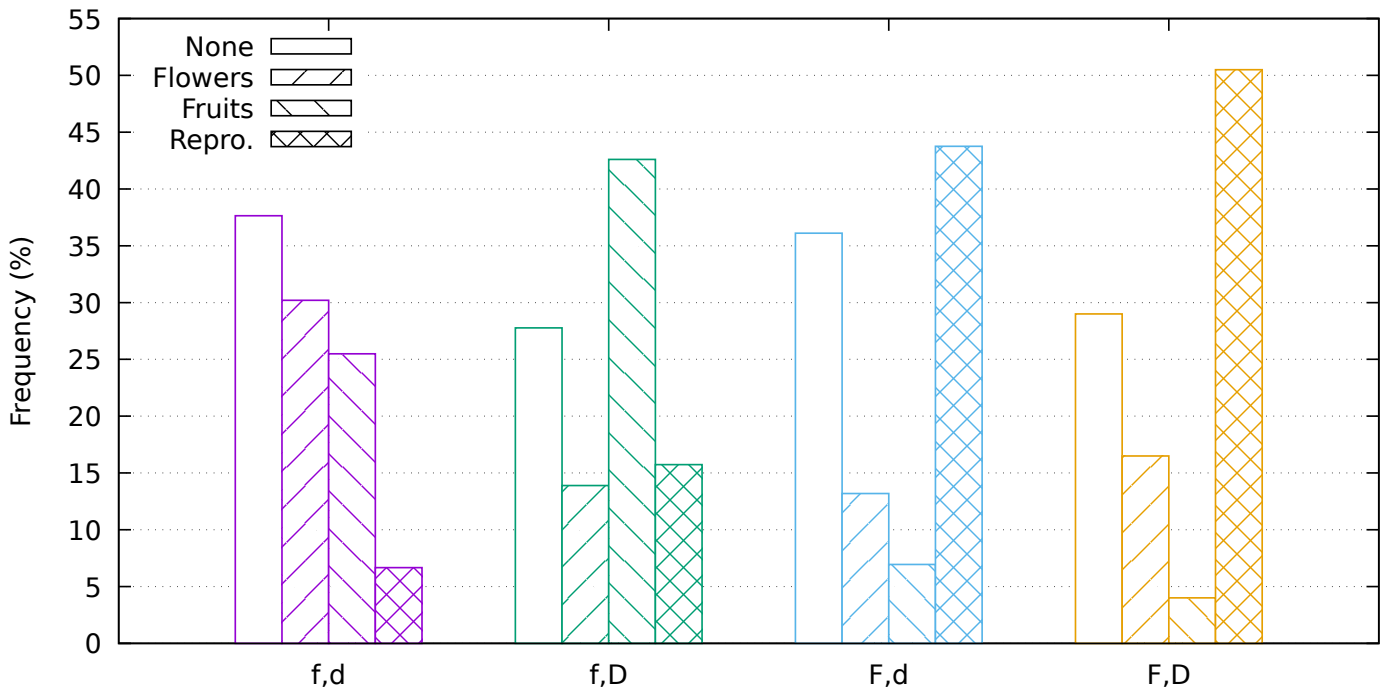
'Checkpoints'

None No sexual organs

Flowers Unfecundated flowers

Fruits Unplanted seeds

Repro. Self-reproduction occured



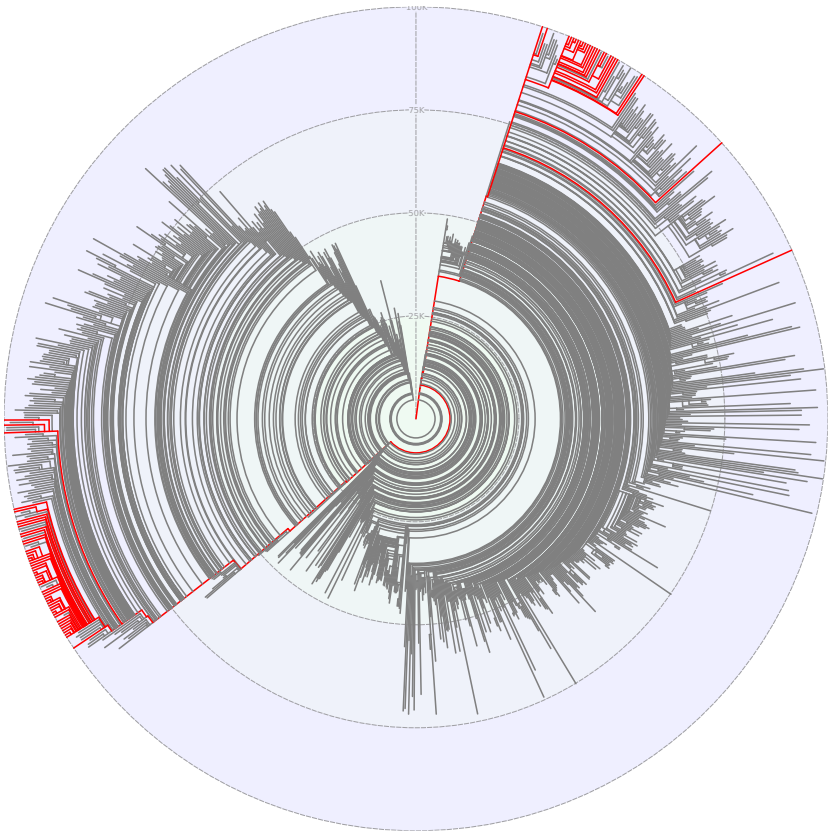
Conclusion

- 'Graphtal'-based plants
- Environment-impacted morphogenesis
- Self-reproduction scheme

Conclusion

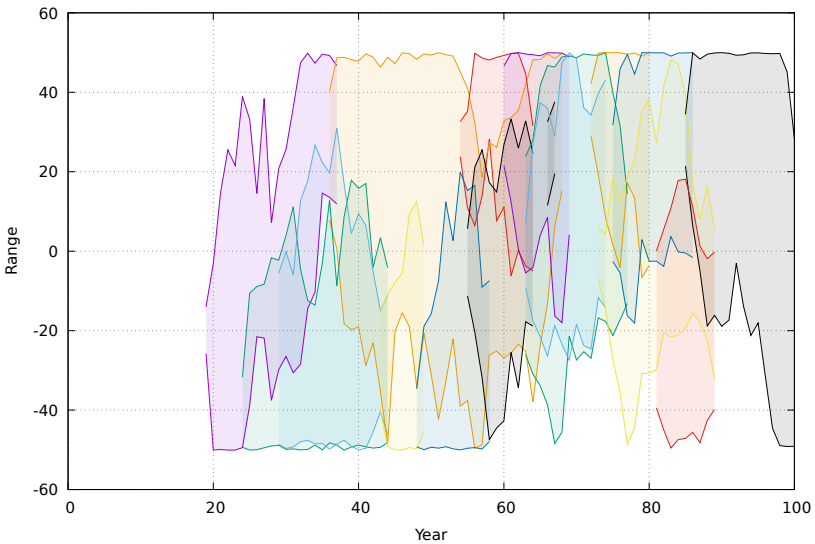
- Survival/Reproduction schism
- Robustness improved by multi-objective fitness
- Validation of hypotheses **F** & **D**

Future work



Automated phylogeny

- More dynamical environment (topology, hygrometry, ...)
- Simplification for longer simulations (100K years)



Species dynamics

Annexes

- References

References

S. Bornhofen, S. Barot, and C. Lattaud. “The evolution of CSR life-history strategies in a plant model with explicit physiology and architecture”. In: *Ecological Modelling* 222.1 (Jan. 2011), pp. 1–10.

Stefan Bornhofen. “Emergence de dynamiques évolutionnaires dans une approche multi-agents de plantes virtuelles”. PhD thesis. Paris 11, 2008, 1 vol. (180 p.)

Jean Disset, Sylvain Cussat-Blanc, and Yves Duthen. “Evolved Development Strategies of Artificial Multicellular Organisms”. In: *15th International Symposium on the Synthesis and Simulation of Living Systems (ALIFE XV 2016)*. Cancun, Mexico: The MIT Press, 2016, pp. 1–8.

M Gardner. “Mathematical games: The fantastic combinations of John Conway’s new solitaire game "life"”. In: *Scientific American* (1970). arXiv: arXiv:1011.1669v3.

Marc Metivier et al. “A Stress-based Speciation Model in LifeDrop characters”. In: *Artificial Life* (2002).

Thomas Miconi. “In silicon no one can hear you scream: Evolving fighting creatures”. In: *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Vol. 4971 LNCS. 2008, pp. 25–36.

References (cont.)

Karl Sims. “Evolving 3D Morphology and Behavior by Competition”. In: *Artificial Life* 1.4 (1994), pp. 353–372.

Jeffrey Ventrella. “GenePool: Exploring the interaction between natural selection and sexual selection”. In: *Artificial Life Models in Software* (2005), pp. 81–96.