Efficient modeling of entangled details for natural scenes

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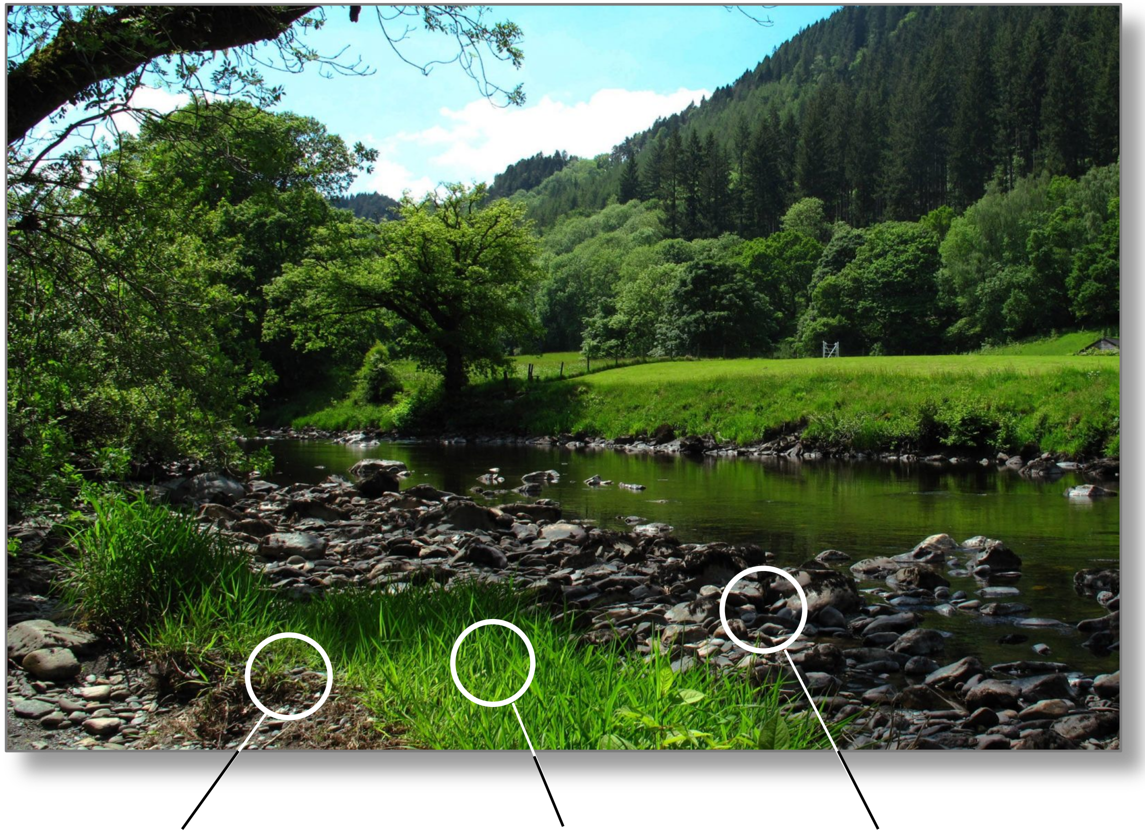
Introduction

Context/problem

- Natural scenes
  - Numerous details
  - Entangled
  - Different kinds

⇒ Tedious authoring



Related work

Simulations

[Hsu 2010]
[Desbenoit 2006]

- + Realistic
- – Limited user control
- – Does not scale

Procedural

[Alsweis 2006]
[Peytavie 2009]

- + Efficient
- – Specific
- – Memory

Interactive editing

[Grosbellet 2016]
[Emilien 2015]

- + Control
- – Specific
- – Interpenetrations

Our approach

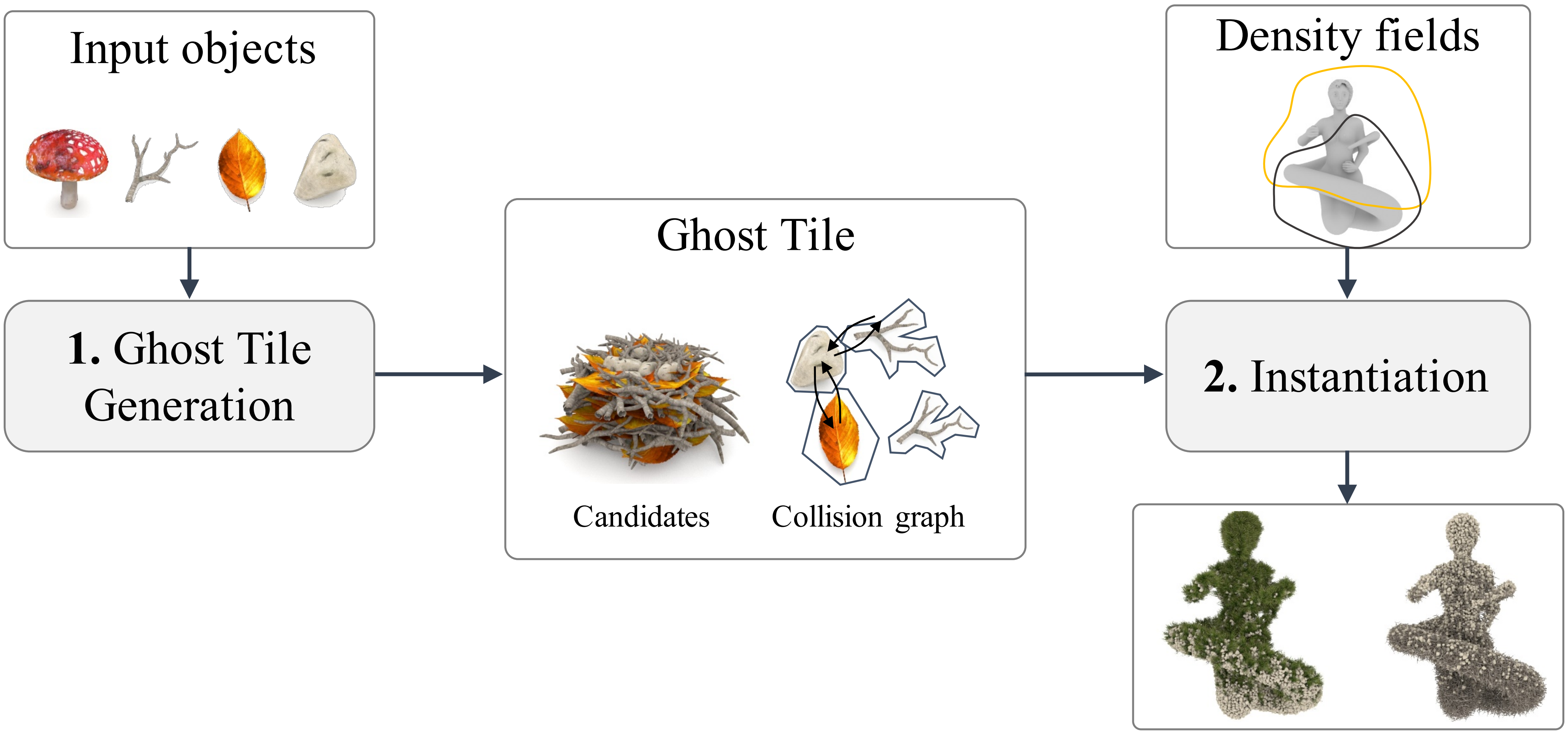
- Key observation: if not regular, repetitions are not visible

- Split the process into two steps
  1. Pre-compute collisions in a very dense tile
  2. Fast Instantiation
- Multiple control types

+ Realistic
+ Efficient
+ Not object-specific
+ Light in memory
+ Scalable
+ Controllable

The method

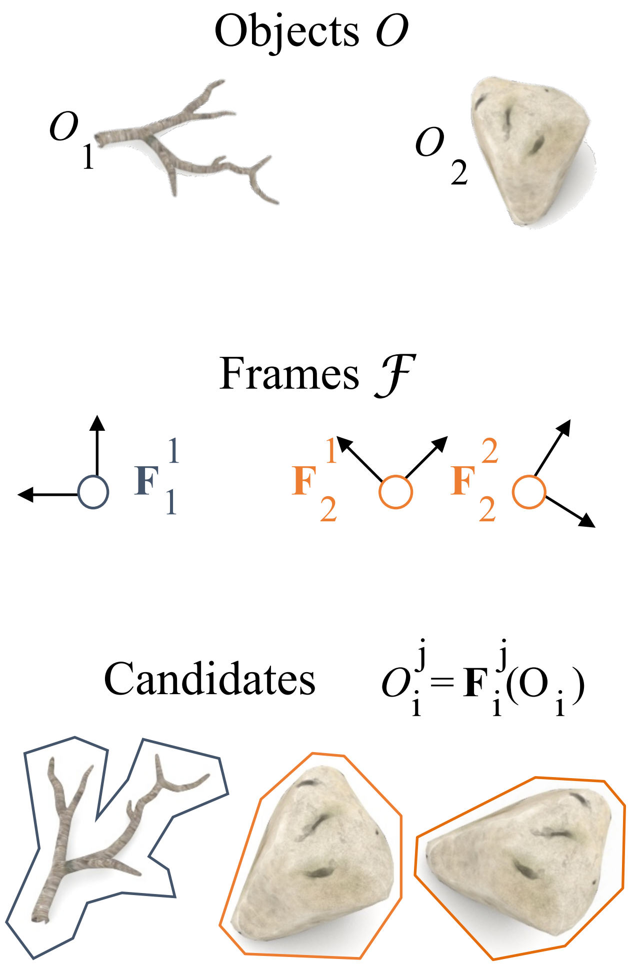
Pipeline in 2 steps



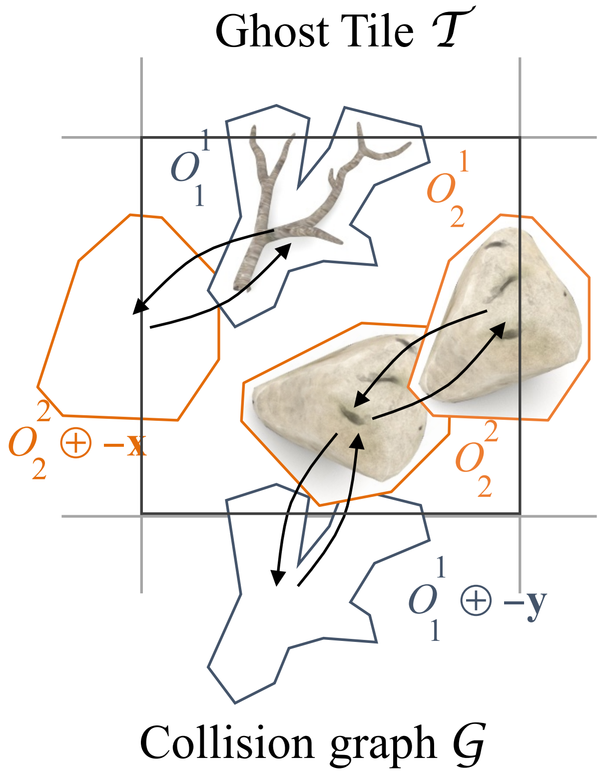
The method

Step 1 – Ghost tile construction

Ghost tile



Objects O
O_1
O_2
Frames $\mathcal{F}$
$\mathbf{F}_1^1$
$\mathbf{F}_2^1$
$\mathbf{F}_2^2$
Candidates
$O_i^j = \mathbf{F}_i^j(O_i)$



Ghost Tile $\mathcal{T}$
O_1^1
O_2^1
$O_2^2 \oplus -\mathbf{x}$
O_2^2
$O_1^1 \oplus -\mathbf{y}$
Collision graph $\mathcal{G}$

Ghost tile construction

Algorithm

1. Pick a random frame in the tile

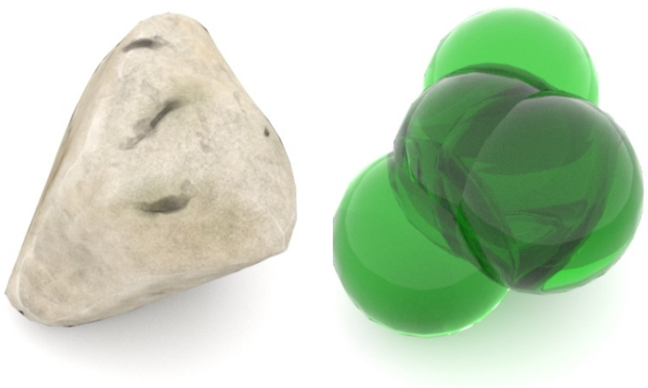
2. Compute intersections
   inside the same tile
   in the neighbor tiles

3. If intersection, add two reciprocal arcs in the graph

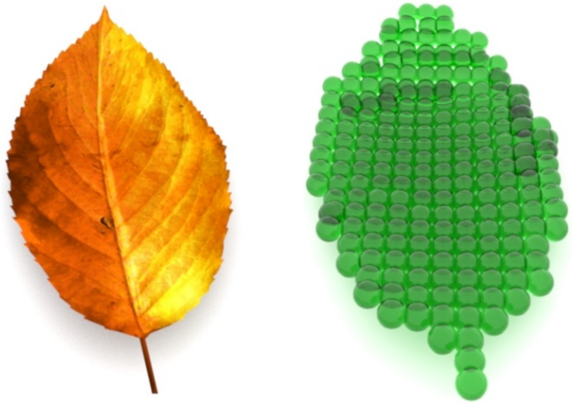
$\Longrightarrow$ Repeat (and use a spatial acceleration)

Collision detection

- Volume approximated by spheres
- Automatic or manual according to the context



Stone



Leaf

Distance between unions of spheres is easy

$$d(\mathcal{A},\mathcal{B}) = \min_{i,j} ||\mathbf{b}_j - \mathbf{a}_i|| - (r_i + r_j)$$

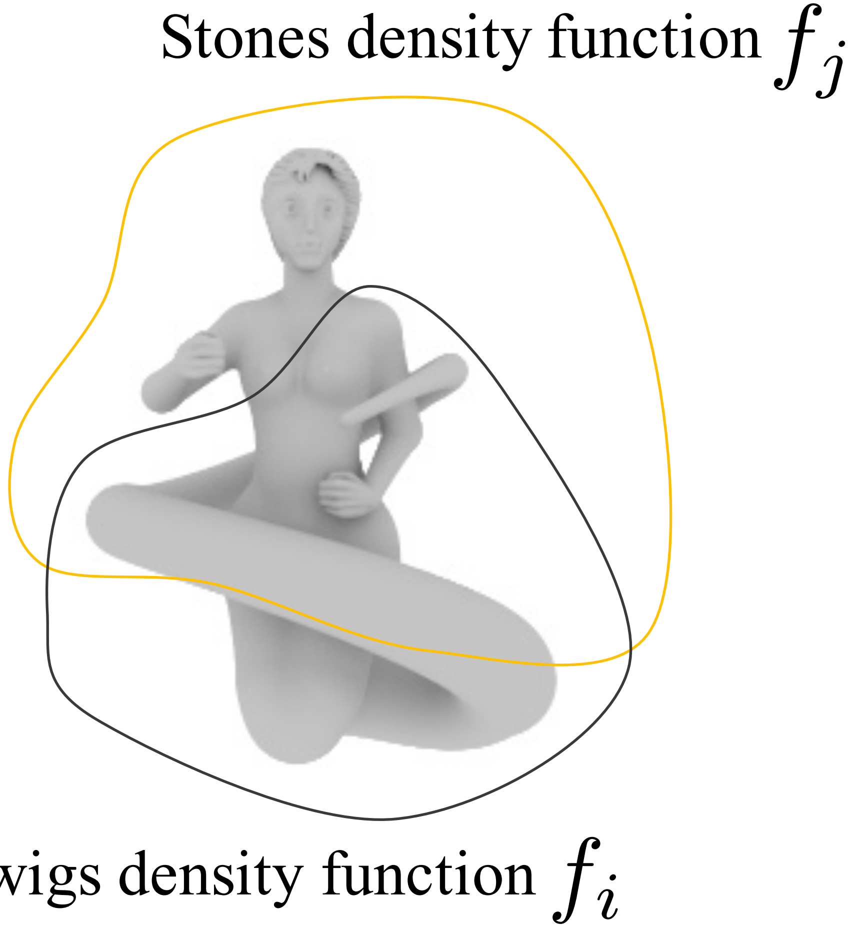
The method

Step 2 : Instantiation

Density description

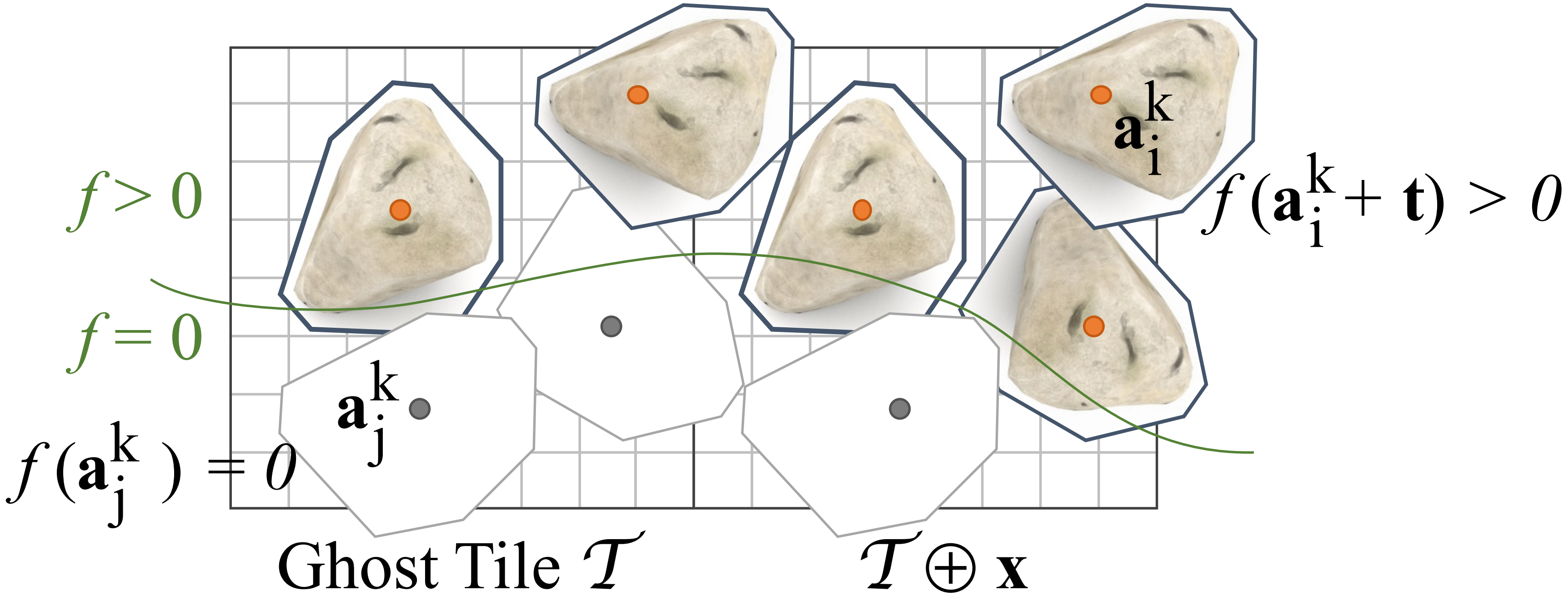
Density functions

$$f_i : \mathbb{R}^3 \to \mathbb{R}$$



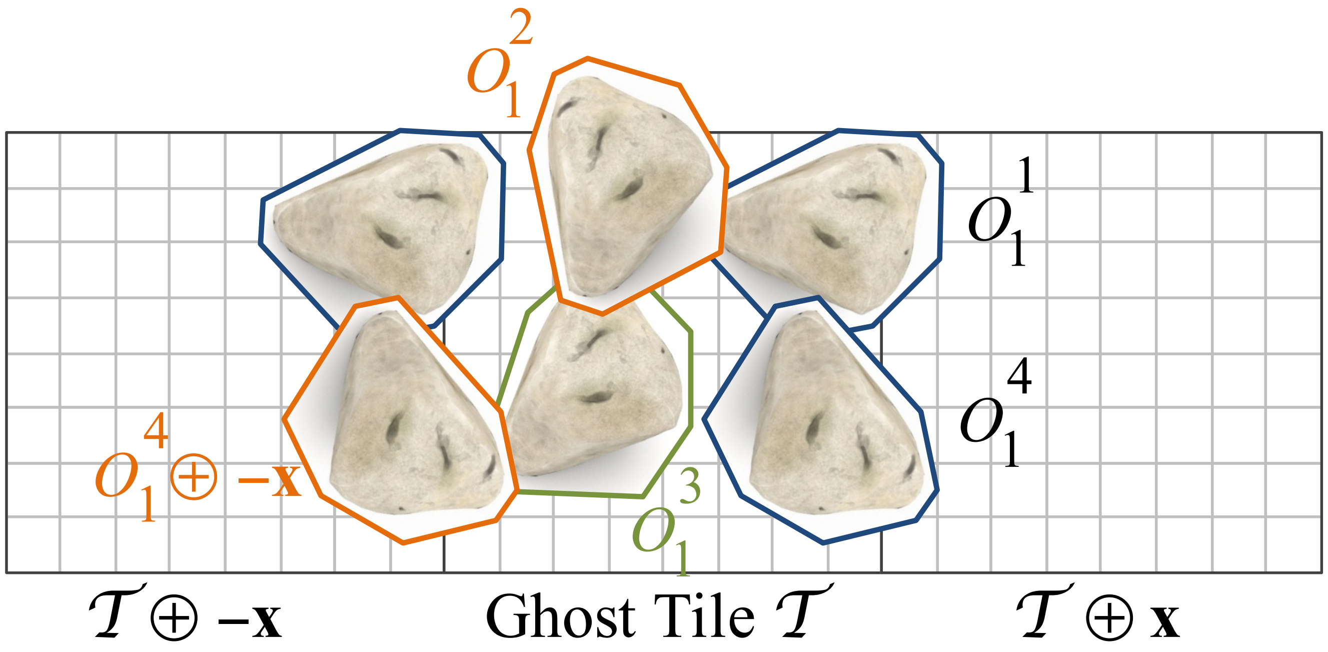
Culling step

- Remove candidates whose density vanishes at anchor point(s)

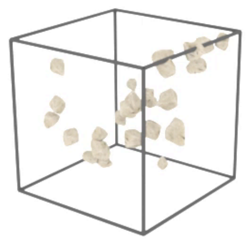


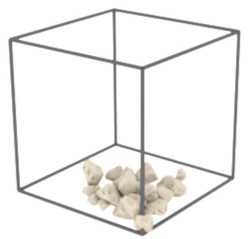
Instantiation step

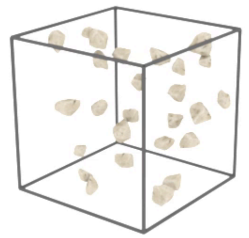
- Select the highest priority candidate (green)
- Discard colliding candidates (orange)

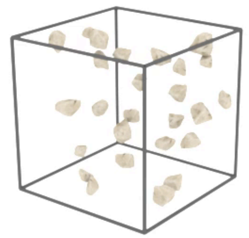


Priorities









Random	Altitude	Distance to the boundary	Distance to the boundary + partial filling
4.3k instances	4.5k instances	4.5k instances	3.8k instances

Results

Volumetric objects

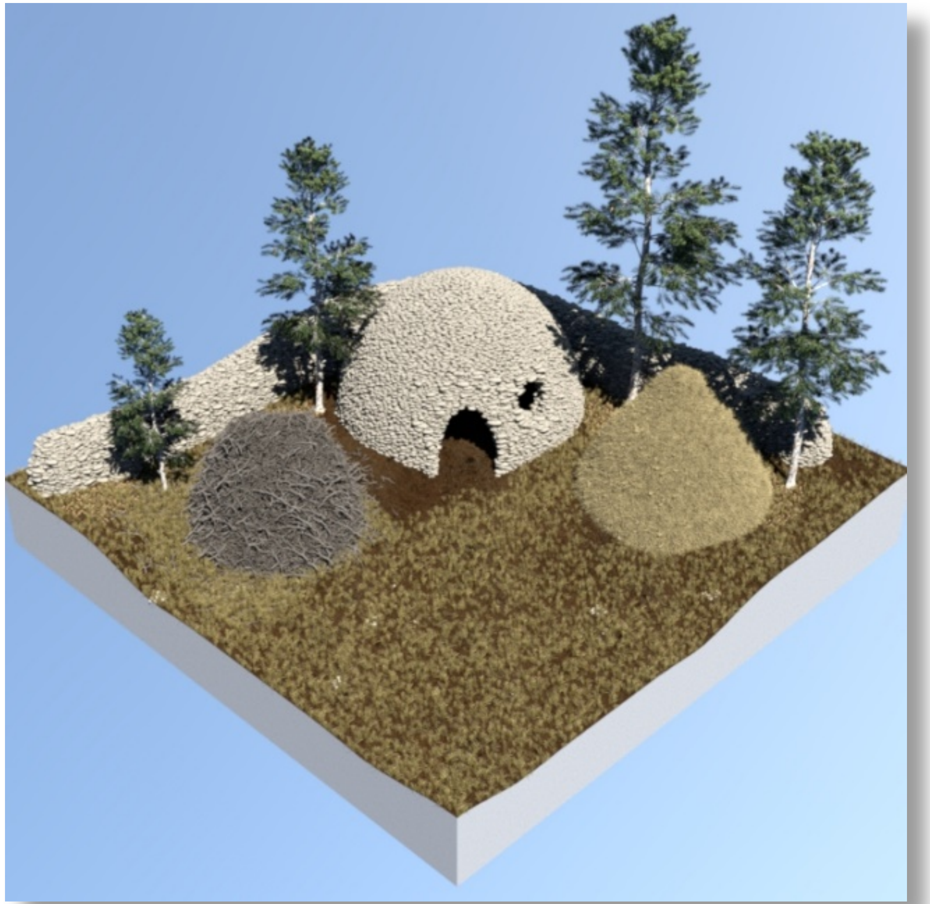
Method that accounts for volumetric objects

Control over density

Density functions to control the relative density of each object type

23k instances | 19k instances | 18k instances

Complex scenes - Borie

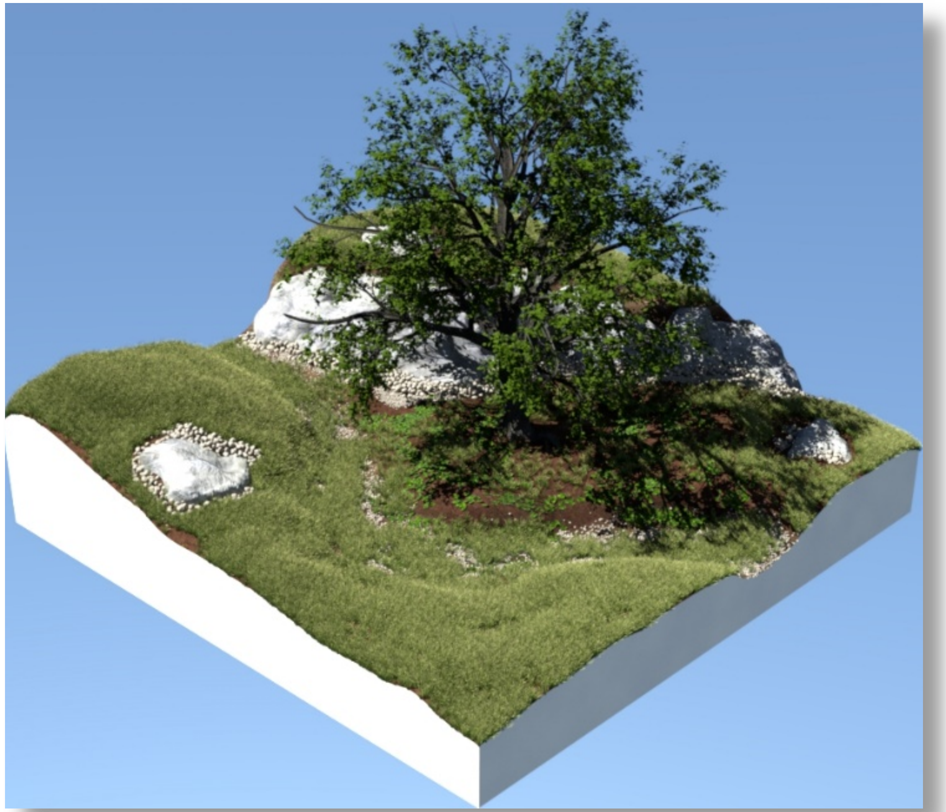


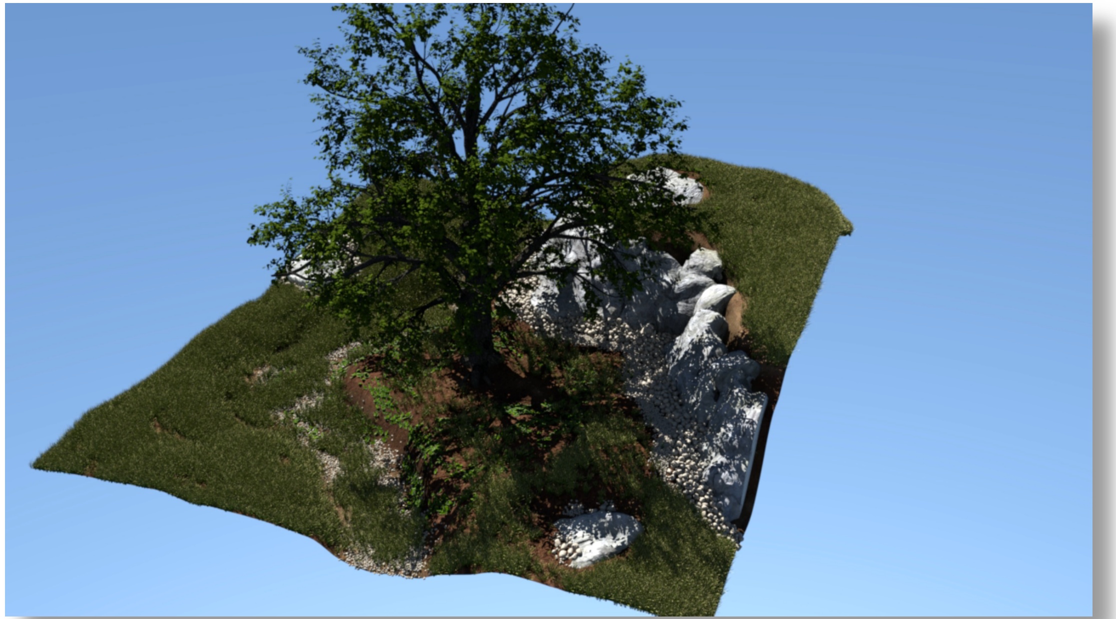
63k flat stones
Instantiation time 17s

Complex scenes - Field

4.3M straw instances
Instantiation time 54.6s

Complex scenes - Meadow





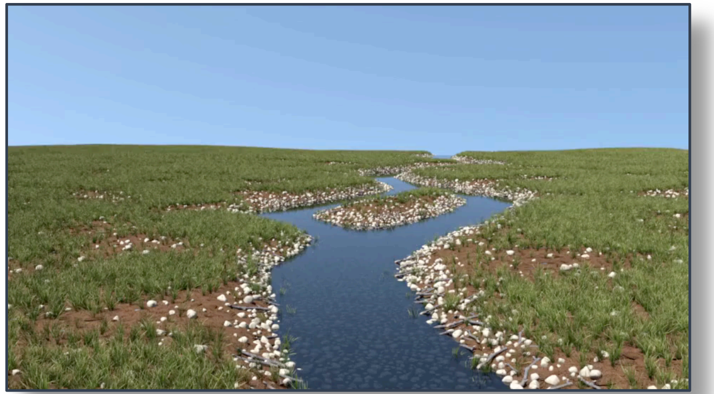
Interactive authoring
Standard stroke
1k instances in 1.5s

Conclusion

Conclusion

- Limitations
  - No structure
  - No animation
- General framework to model entangled details
- Two steps
  1. Offline pre-computation
  2. Instantiation
- Efficient
- Handle interpenetrations
- Several user controls

Thank you for your attention!



See video and more on:
http://liris.cnrs.fr/eric.guerin/efficient-modeling-of-entangled-details-for-natural-scenes/