Guided Ecological Simulation for Artistic Editing of Plant Distributions in Natural Scenes

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● Commercial tools for virtual landscapes

● Benefits and shortfalls

● Improvements and contributions

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Guided Ecological Simulation for Artistic Editing of Plant Distributions in Natural Scenes

Ecological modelling provides a basis for realistic vegetation cover, drawing on research in biology.

Editing these models in a realistic way is a challenge but can be overcome by involving the artist in the simulation.
Commercial tools
Commercial content generation tools

- (Multi-class) random placement
  - brush-based or area scatter

- Procedural placement (simulation) according to certain terrain-based rules

- Good model variety
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- Fine-grain control of model appearance and location
- High level of automation from procedural and random approaches
- Potentially faster workflow
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- Fine-grain control of model appearance and location post-generation
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Disadvantages
Shortfalls

- Don't result in truly natural-feeling scenes (repetitive, lack organic-ness and lack variety)

- Unintuitive control of edits (link between parameters/result is unclear)

- Lack editing based on natural parameters and phenomena (arguably more intuitive)
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State of the art: summary

Tools fall into two main categories:

- Scattering brush/area solutions do exist but lack realism
- Simulations also exist, but are hard to control and harder to modify realistically
Our aims:

● A better trade-off between usability and realism

● A locally controllable / editable system that allows selective control of the underlying simulation

● Result: simulation 'fixes' unrealistic changes
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Example – adding a feature

- Clearing/lake:
  artist doesn't have to think about brush strokes appearing at transition regions any more

- Mountain ranges:
  species adaptation to the altitude
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Challenges

Designing tools which mimic natural phenomena is non-trivial

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Furthermore, they must also maintain the simulation's realism, even after heavy editing.
Contribution
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- Combine ecosystem simulation with editing operations (global and local)
- Iterative artistic control
- Intuitive parameters for natural scenes: editable maps (elevation, rainfall, soil, masking)
- Editing maintains realism of the initial simulation
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Method
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- Draw on the state of the art in ecosystem simulation
- Expose the simulation's time axis
- Develop means of artist interaction

Ch'ng 2009
Method

• **Draw on the state of the art in ecosystem simulation**

We use abiotic landscape maps to control a forest simulation using simplified rules found in nature:

- Large species phenotype bank (max. height / canopy size / age / seeding, adaptation / tolerance parameters to maps)
- Competition for, and adaptation to, resources (light, soil, water)
- Output: instance genotype (height, canopy size)
- Follows the landscape stability principle (resistance to change)

\[ \text{Phenotype} = F(\text{environment}, \text{neighbours}, \text{genotype}) \]
Method

input
abiotic environmental maps
elevation soil rainfall

phenotype

species
genotypes

simulation
sense env. conditions $C_i$
compute adaptations $A_i$
update phenotypes (size, growth rate, etc.)
kill plants with zero energy
spawn seeds from mature plants

number of iterations

output forest

a) Ecologically-based simulator for plant distributions
Method

- Draw on the state of the art in ecosystem simulation
- Expose the simulation's time axis
- Develop means of artist interaction
Method

- Expose the simulation's time axis

  Allow navigation in temporal dimension:
  - Rewind, fast-forward, undo, redo

  Allow operations to control the rate of simulation in a region
  - Adaptive edits
Method

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Method

- Develop novel means of artist interaction
  - Brush-based sparsification/densification operations rerun simulation according to new constraints
  - Temporal feathering of the simulation

b) We introduce operators for guided editing
Results
Densify operator

Initial state, burn-in (120 years), adaptation to new abiotic maps (increase precipitation), densify NE side. Rendered from NW.
Sparsify and feathering operators

Given a simulation using the earlier abiotics and mask:
(a) sparsification, (b) feathering (c) densification (d) feathering
Creating pre-defined environments

(a) Random initialisation, (b) desert, (c) boreal forest, (d) temperate, (e) tropical.
Simulation and Editing
Limitations and future work

- Large data footprint
- Still a time-consuming task and lacks efficiency
  - but scales linearly doesn't yet exploit GPU
- Interaction rate:
  - 400K trees per second, Intel Core i7 (1.6GHz) with 16GB RAM
- Apply concepts to clutter generation
- Investigate using instances vs clusters
Summary

- We achieve a better trade-off between realism and editability

- Interactive and realistic editing of simulations
  - Artist remains in the loop and edits are ecologically supported
  - Iterative editing towards desired result

- Scales linearly with number of instances – local simulation only
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