Environmental Framework to Visualize Emergent Artificial Forest Ecosystems and Differential Evolution for Parameterized Procedural Woody Plant Models Reconstruction

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Problem

⇝ The problem tackled covers modeling of **forests and trees in a virtual environment** on a computer, i.e. a domain of artificial tree and ecosystem animation.

⇝ The technology platform is **computer science** support in **forest-based sector**.

⇝ The forest ecosystem animated here, includes a **tree growth simulation** model for a landscape-sized area.

⇝ **Individual modeling of tree species** morphology, view, and ecosystem living conditions is included with the simulator.

⇝ A novel tree modeling using differential evolution also enables **reconstruction** of morphological tree models from multi-view photography images.

⇝ The aim of this presentation is to connect with other researchers to **gather new research data** from forest-based sector and to form a **broader project team** on common implementation level for EU 20-20-20.

Contributions

Artificial tree distribution confirmation:

- **visually**, the natural look is confirmed from rendered sequences, and
- **statistically**, using population dynamics from graphs for tree species.

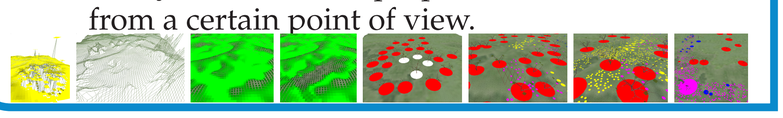
Several **patterns emerge** permanently:

- the number of trees in empty ecosystem increase **exponentially** and
- trees begin to grow in **communities**.

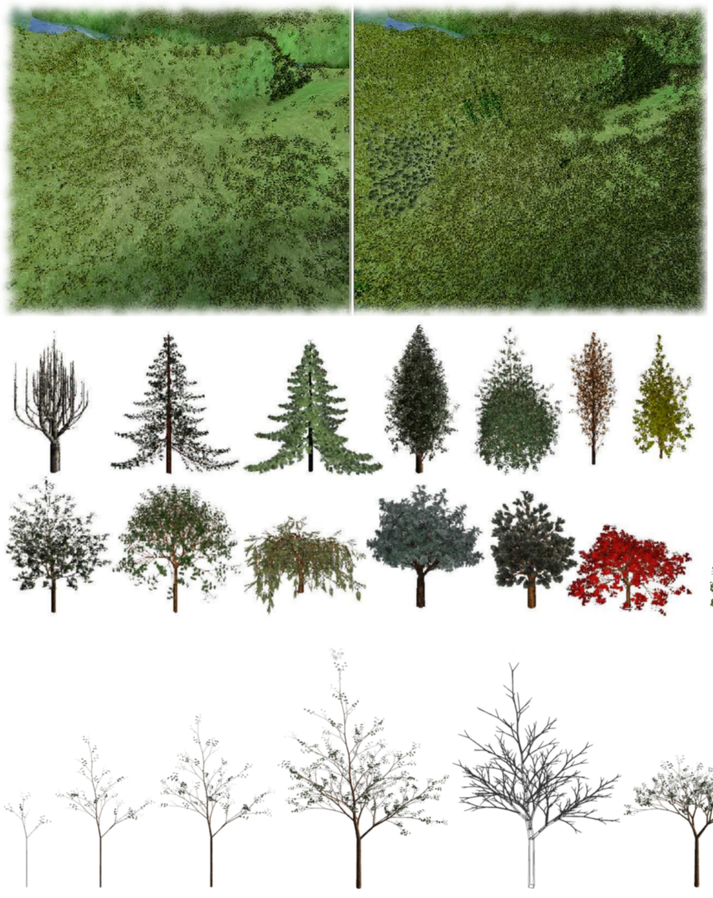
Method

An interconnected application software system develops and animates a **spontaneous afforestation process** within an environment. The system considers several environmental properties (see Results, top right) and combines **computer animation** with **artificial life**.

1. Simulates woody plant forests for **ecosystem visualization** (see Results, top left).
2. Growth of individual trees is animated (see Results, left in middle): from development of **branch complexity** to **per-leaf precision**. This allows a much realistic perception of the **emerging ecosystem**.
3. A flexible and adaptable **procedural 3D model** is used to visualize trees.
4. The visualization of trees is sped up by **progressively lower-details** proportional to the distance from a certain point of view.



Results



- Afforestation **over several centuries**,
- simulates tree **locations** and **maturity**.
- Rendering forest **computer animation**:
  - shows yearly iterative afforestation of **natural environments** and
  - for **visual analysis** of landscape natural look credibility.
- **Tree growth is simulated** and the simulation factors are **biologically inspired**.
- A bottom-up agent model emerges an **artificial tree distribution**.
- The **spontaneous afforestation** process
  - is modeled as an **ecosystem**,
  - within, **trees struggle for survival** on terrain **living conditions**.

Background: Tree Geometry

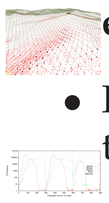
The novel tree geometry reconstruction approach:

- a new approach for **reconstruction of procedural three-dimensional models** of trees [2].
- The reconstructed tree models (see Results, the seven images bottom right) visualize emergent forest ecosystems.
- The procedural tree model **recursively computes** all building parts of a **three-dimensional tree structure** by applying a fixed procedure on a given large set of **numerically coded** input parameters. The parameterized procedural model is thereby used for computer animation.
- **Differential evolution algorithm** [2] reconstructs a tree model by fitting a set of its *rendered images* to a set of given *reference images*, thereby **evolving** a parameterized procedural model from the reference images.
- The comparison is done on **pixel level** of the images through the integration of distances to the nearest **similar pixels**.
- The obtained results show that the presented approach is viable for modeling of woody plants for computer animation by **evolution of the numerically coded procedural model**.

Future & Challenges

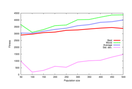
Future challenges to address:

- Fit models of natural laws and tree interactions to **real-world data**.
- Impact of **pollution** to forest growth.
- In-depth analysis of **complex patterns emerging** from local behaviors.



- Impact of **tree growth mechanism** on the global tree distribution.
- Simulator engine for a **virtual reality**.
- Use in **energy policy** and **sustainable development**.

- **Low-carbon economy planning** including **EU 20-20-20 goals** of



  - **greenhouse gas reduction** and
  - **energy efficiency** improvement.

References

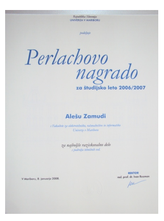
[1] A. Zamuda and J. Brest, "Environmental framework to visualize emergent artificial forest ecosystems," *Information Sciences*, vol. 220, pp. 522–540, 2013.

[2] A. Zamuda, J. Brest, B. Bošković, and V. Žumer, "Differential Evolution for Parameterized Procedural Woody Plant Models Reconstruction," *Applied Soft Computing*, vol. 11, pp. 4904–4912, 2011.

Awards

SIIF 2012 gold

IEEE CEC 2009 1st place



UM 2008 best research

IEEE SPCR8 2007 finals

Source Code

The **source code**, executables with an **interactive interface**, demonstration **videos**, documentation with **journals** and **conferences** publications at `http://ecomod.sourceforge.net/`