Growth - Crecimiento - Rast

Project description

In short, our goal is to combine techniques from classical grid-based cellular automata experiments with more expressive and realistic but also computationally more expensive simulations of biological systems, using everyday personal computers to do the job.

We wil be trying to understand the role of the genetic program in influencing the control flow of morphogenesis by observing visualised and sonified simulations of multicellular growth.

We want to see and hear the difference between the head to foot axis and the front to back one, and understand how the relationship between our insides, outsides, and the intervening membranes starts and grows.

Our work is inspired by many related who came before us, but we will single out some of them: Alan Turing with his two-morphogen ring of cells, John Conway with the game of Life, Humberto Maturana and Francisco Varela with biological models like computational autopoiesis, Ilya Prigogine with dissipative structures and Kurt Fleischer with work on multicellular development models.

We are creating an audio-visual growth engine that runs a simulation for each specific individual from the original cell to a size of a few thousand cells. On each run it produces the final graph of cells, a movie showing the growth in simulated time and the sound derived from the indivudual.

Sonification - transforming mathematical datasets to sounds and listening to them - can give interesting clues about their overall structure not perceptible by looking at the outside appearance, graphs or cross-sections.

The sound of an organism will be modelled by using its genetic sequences and final cell state. Crecimiento will control the parameters of the sound synthesis involved, like granular synthesis or reverberation by granular convolution for instance. We are using Pure Data (pd) - a free software platform for flexible sound synthesis, analysis and manipulation - as the audio engine in our system.

We will try to breed a population of virtual micro-plush-toys resembling adult animals with two approaches:

- an evolutionary approach where the desired final form will guide the selection of genomes created by recombination and random mutation in a genetic algorithm

- a hacking approach where we will try to hand-craft suitable genomes for the development of the target form, cutting and pasting interesting genes found by evolution and attempt to write 'original' genetic programs after studying the possible control paths in the used chemistry

The first challenge has been to develop a workable model for the development of a multicellular organism based on a spatial graph structure with links between atomic cells, with simulated chemical and physical cell state and interaction.

Growth proceeds in the model by cells dividing iteratively, each one simulating its chemical and physical state and links to the neighborhood and eventually reaching maturity, where division stops, or even dying off.

Chemical state is modeled with morphogens, an idea of Alan Turing, they are the signalling technology of the genetic program. In our model they are abstract chemicals which react with one another in many possible, but pre-set ways and diffuse inside cells and in between them.

While it would be possible to use realistic biochemical reaction pathways, we beleive this will not be necessary and will try to use an artificial, randomly derived, smaller-than-real biochemistry for the model.

The genome of an organism specifies all possible morphogens that can be created, under the right conditions, in one of its cells. Cells have only a simple mathematical state in our model, so this effect will be built into the engine, magical, like real chemistry and physics outside of the scope of these experiments.

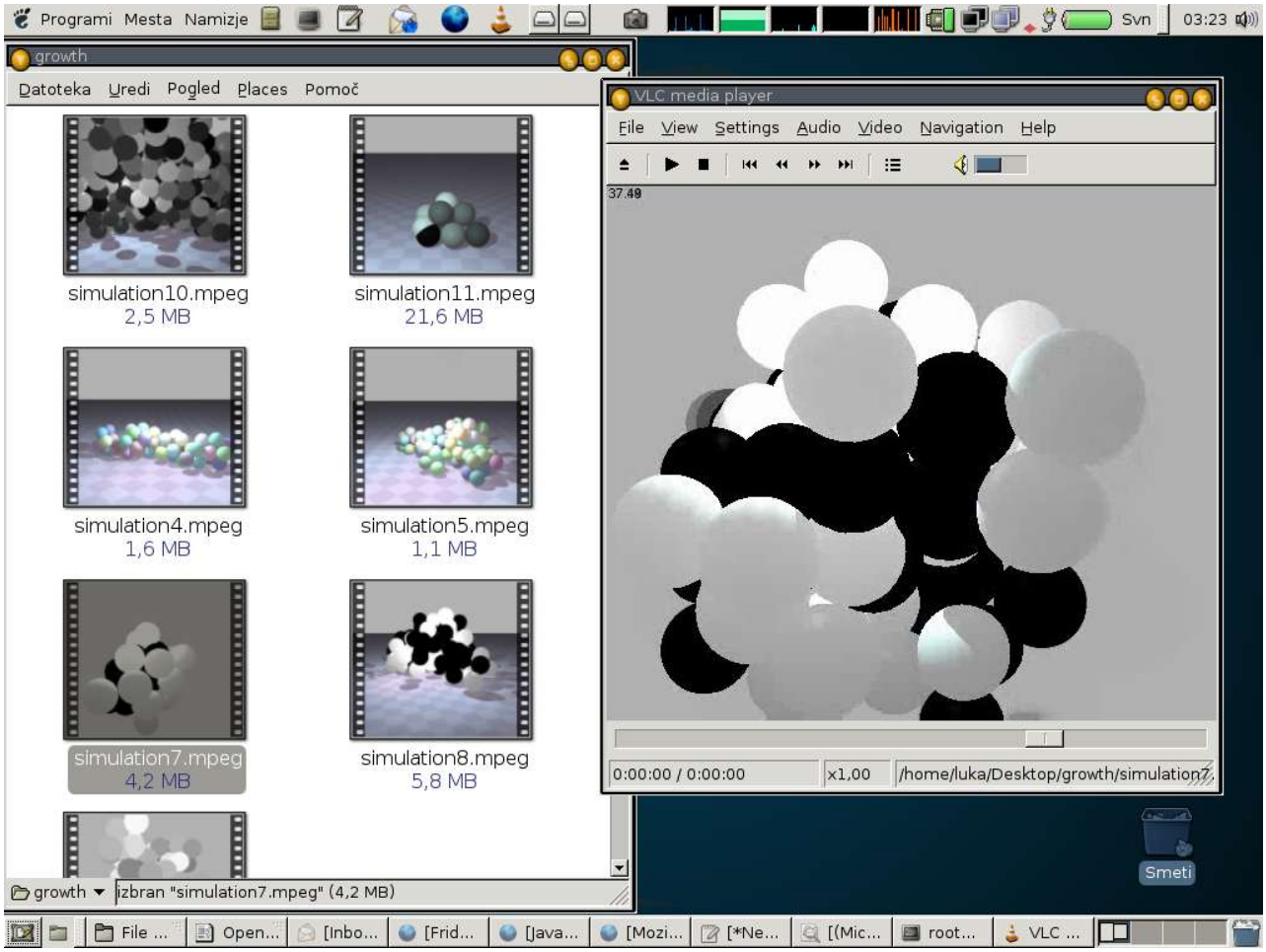
Physical parameters and appearance of each cell will be determined by its current chemical state. Cells form a graph structure connected by springs simulated with an existing physical simulation library, giving our artificial embrios their shape during growth and in their final form

We hope to be able to reproduce many of the typical growth patterns found in developing animals, like folding, coiling, segmentation, splitting, connecting and network development (meshing) and demonstrate processes like hierarchical development of organs and tissues or skin formation.

By building the engine to run on todays ordinary personal computers, keeping the simulation small enough to produce satisfying results quickly, publishing all the source code created for the project, documenting the used mathematical models and using existing open source tools for the project whenever possible, we will create a new accesible stepping stone for anyone wishing to experiment with smilar growth models in the future.

In our preliminary work we have already used to our advantage the Breve simulation environment and the Graphviz graph layout framework, both excellent open-source scientific tools, and Pure Data, the definitive free platform for sound experimentation.

You can see some of animations resulting from our tests on a CD-ROM included with this document. They are also available on the web from http://www.ljudmila.org/~luka/growth/



Proposal for exhibition

A selection of the most interesting simulation results will be made and displayed on a back-projected screen starting at floor level. The desired illusion is that the organisms inhabit a real space inaccessible to the viewer, similar to visiting an aquarium or zoo. Organisms are visually of approximately human size. The sonification of each organism is played on the speakers while the movie of its growth is playing.

Four computers in pillars with LCD screens on top running the engine and producing new organisms. Viewers can guide their genetic algorithm with a mouse, but this interaction is optional – when left alone, the system will use randomness and previous choices.

Posters on the wall document the project, model and the used software. The information in the posters is also avalable on the project web site.

We hope to be able to install this exhibiton around June 2006 at the Telefónica gallery in Santiago de Chile.

Financial estimate

Production	4500 EUR

This includes costs of studio, communication and support of artists life during the 3-month intensive phase of the project

Exhibition	1500 EUR

Costs of installation, renting equipment and producing the exhibition materials

Travel	1400 EUR

Plane ticket Europe – Chile and return

Promotion	800 EUR

Production of the catalog and other promotional materials for the exhibition

Total	**8200 EUR**

Planned schedule

The initial feasibility tests have already been completed at the time of writing this.

We plan to continue work on the engine and model over the internet for a period of about six months (Oct05 to Mar06).

After the model and engine are stabilized, we wil finish the project with a three-month intensive work period in Chile. At the end of this period, planned in June 2006, we will present the project with an exhibition.

We will document the progress and publish interesting results on the website during the whole project. The hosting and technical support for the website will be provided by Ljudmila - Ljubljana Digital Media Lab.