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COMPUTATIONAL LANDSCAPE DESIGN WITH THE SEED SCATTERING SYSTEM

A case study in the Sony forest project

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Abstract. This paper proposes a computational landscape design method, called *the seeds scattering system* (SS system), which enables us to manage various environmental parameters in design processes, to create the 'natural forest' in urban environments. First, this paper discusses the drawbacks of the conventional methods for landscape design. Second, the paper outlines the components of the SS system together with the design process of the SONY forest project in Tokyo, and shows its advantages, including broad applicability to conceptual design, and capability of environmental simulations and spatial optimizations. Last, the paper summarizes the effectiveness of the SS system. By managing fundamental rules behind geometries in forest growth processes, the SS system showed us capability for constructing interactive relationships between design and their surrounding environments to produce design inherent in its site.

Keywords. Computational landscape design, parameter, tool customization, optimization, sensor network system.

1. Introduction

The objective of this paper is to propose a computational landscape method, which we (AnS Studio) developed in the SONY forest project in collaboration with Kazuhiko Yamanashi design team (Nikken Sekkei, an architectural design office). Our method is inspired by algorithmic design and algorithmic botany.

According to Kostas (2006), algorithmic design involves the designation of software programs that generate space and form according to rules inherent in architectures. On the other hand, algorithmic botany means the studies on biological modelling and visualization carried by a research group in the department of computer science at the University of Calgary. The group applies notions and methods of computer science to gain a better understanding of the emergence of forms and patterns in nature. What is common to the algorithmic design and the algorithmic botany is that they try to understand and handle fundamental rules behind forms. By applying these methods to landscape design, we developed a new landscape design method.

In the following Section 2, we discuss the drawbacks of the conventional methods of landscape design. To overcome these drawbacks, we propose the SS system. In Section 3, we describe a background of the SONY forest project. In Section 4, we present the functions of the SS system together with the design process of the project. In the last section, we summarize the effectiveness of the SS system.

2. The project background

In design processes, architectural designers mainly deal with buildings and artefacts; in contrast landscape designers mainly deal with plants and natural objects. Because every plant has its own suitable environments, a critical part in landscape design processes is to survey environmental conditions of project sites, and to select plants adaptable to those conditions. It is also critical to take plant growth into account in landscape design processes. For instance, in the SONY forest project, the average tree height is about five to six meters and that of the tree width is about two to three meters at the beginning; however, in 30 years, both tree height and tree width will be doubled. Therefore, it is very important to consider future environmental conditions for every species of plants in landscape design processes.

As noted above, environmental conditions and plant growth are key elements in landscape design processes. In addition, appearances of plants, such as plant geometries, colours, textures, blooming and foliage seasons, are also basic factors to be considered in landscape design. From a biological standpoint, all these factors are intricately interacting with each other. In conventional landscape design processes, landscape designers handle these factors separately in the following three independent design steps.

- **Design step 1**: Survey environmental conditions and select plants.
- **Design step 2**: Layout those plants by appearances of plants.
- **Design step 3**: Plan a program for managing plants from the present to the future.

Let us next discuss the current state of environmental researches including natural and urban environmental researches. In the past, tasks of environmental survey were time-consuming. They spent a lot of time in obtaining environmental data because sensor technologies were not so well developed as those of today. Even if they could get data, it took much time to analyze those data because current high-performance computers were not available at that time. Nowadays, owing to advanced technologies, we can easily obtain a huge amount of precise environment data, and analyze those data quickly. In addition, progress in computational fluid dynamics simulation systems with numerical methods and algorithms contributes to advancing in environmental researches.

At the same time, growing awareness of environments also accelerates developments in environmental researches. For example, in Japan, architects are required to assess the environments surrounding of a building when they propose large-scale building projects. As a result, various environmental researches and simulations are carried out before building construction. However, the resulting data are rarely used in design processes, and they are used only for checking legal obligation or persuading clients.

To solve the above mentioned problems, we propose the seed scattering system, which is characterized by the following two distinct features.

- **Feature 1**: The system can manage environmental conditions, plants growth and appearances of plants in an interactive manner in design processes.
- **Feature 2**: The system can manage a huge amount of environmental data.

3. The SONY forest project

The area of the SONY forest is over some 10,000 square meters surrounding of a new office building site of SONY, located in the redeveloped area near Osaki Station, Tokyo, Japan. The new office building is designed by Kazuhiko Yamanashi, who installed a façade system called 'Bio Skin' developed by Nikken Sekkei and TOTO. Bio Skin is made of ceramic with water pipes inside to reduce heat island effects by flowing water. The site for this project is a gently rolling hill with 10 meter difference in altitude. The goal of the project was to create a 'natural' forest around the SONY building. To this end, we developed the SS system. In this section, we present the components of the SS system together with the design process of the SONY forest project.

3.1. DESIGN 'NATURAL'

After the discussion about what kind of forest we should design, we decided to create a 'natural forest' rather than creating an artificial landscape. To embody the 'natural forest', we intensively discussed the following questions: how to design 'natural'?; does designing 'natural' contradict natural?; how to define a 'natural forest'?

Finally, we came to the conclusion that the natural forest is the forest where visitors can feel natural. The design methodology of the SS system is not to mimic the layout of trees in forests in the real world but to use a system that simulates the growth process of a natural forest controlled by urban environments, biological rules and designer's sense. The system consists of the following three design processes.

- **Process 1**: Find rules of environmental conditions.
- **Process 2**: Find biological rules.
- **Process 3**: Run the SS system to grow a forest using environmental parameters, biological characteristics of the plants and algorithms of plant growth.

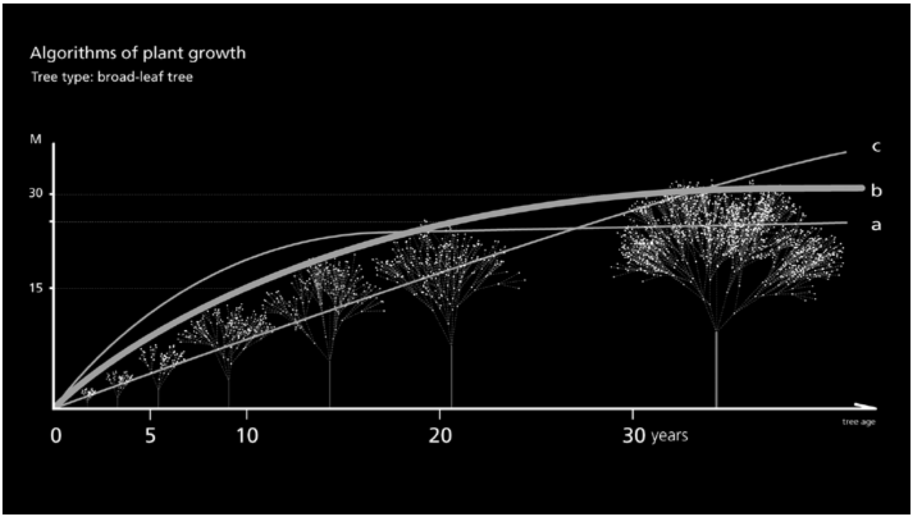
4. The seeds scattering system for the SONY forest project

4.1. FIND RULES OF ENVIRONMENTAL CONDITIONS

The first process is to survey the surrounding environmental conditions around the building project site, to construct their quantitative data and to convert them into an operational data set with a parameter set. In this project, we utilized the environmental assessments already carried out when the new office building was planned. Those assessments included natural environmental assessments, such as wind analysis, lighting analysis, soil conditions, and urban environmental assessments, such as pedestrian flows and traffic volumes.

4.2. FIND BIOLOGICAL RULES

The second process is to select plant species for the project site, to survey the biological characteristics of the selected plants, and to develop algorithms of plant-growth (Figure 1). The biological characteristics include suitable environments for every species of plants, and acceptable and critical values of environmental changes.

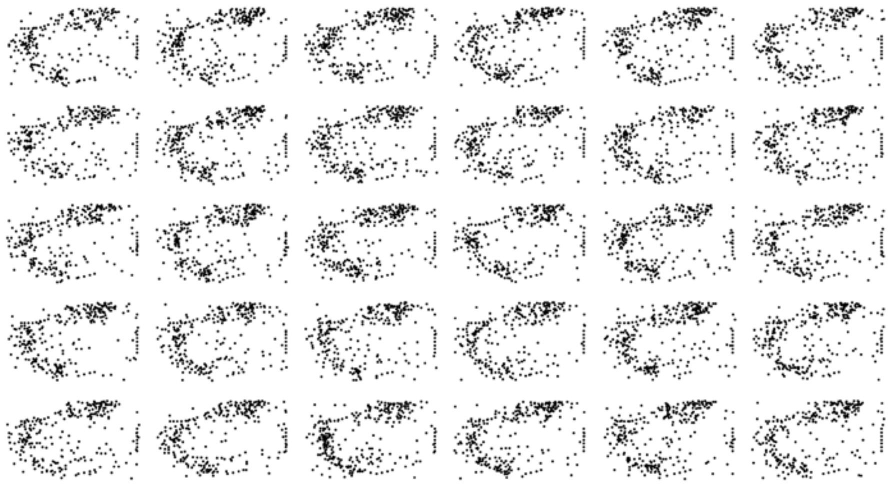


4.4. FIVE PROGRAMINGS TO GROW THE FOREST

The final process is to run the SS system incorporating the above-mentioned parameters, the data of biological characteristics of the plants and the plant-growth algorithms. In running the SS system, we grew the forest by controlling parameters and optimizing many environmental factors. It should be noted that this process is not the simulation of a forest growth process but rather a design process, because the parameter control and the optimization are based on biological rules as well as designer's rules. The advantages of the system are that designers can deeply understand about environmental conditions and biological rules, and that they can integrate design senses in the forest-growth process. The process consists of the following six steps.

4.4.1. Step one: Scattering seeds

Step 1 is to scatter seeds randomly according to a certain rule. Each seed contains the data of environmental conditions such as the amount of light, wind strength and so forth. By scattering seeds repeatedly, we can generate various layouts almost instantly (Figure 2). The possible variations are narrowed by the optimization processes in the following sections.



4.4.2. Analyze the distribution of seeds

Step 2 is to analyze the distribution of seeds with Delaunay triangulation, and to analyze neighbourhoods of the seeds determined by the Voronoi diagram generated by the seeds.

4.4.3. Natural selection program

Step 3 is to run the natural selection program that optimizes distances between seeds.

4.4.4. Generate plant communities and paths

Step 4 is to determine the distance between seeds to create clustered communities of plants. Foot-paths are generated in empty areas between the clustered communities. Because these paths are located farthest from the feet of trees, plant roots can be protected from human activities, and also the paths can be protected from being destroyed by the growth of roots.

4.4.5. Optimize the composition of plant species

Step 5 is to optimize the composition of plant species in response to the final layout of seeds (Figure 3).

4.4.6. Design in a four dimensional space

Step 6 is to grow the forest in response to the environmental conditions and plant-growth algorithms. The system can simulate and optimize future plant states at 10 years, 15 years, 30 years…. from now (Figure 4). We can design the landscape imagining the future forest appearance.

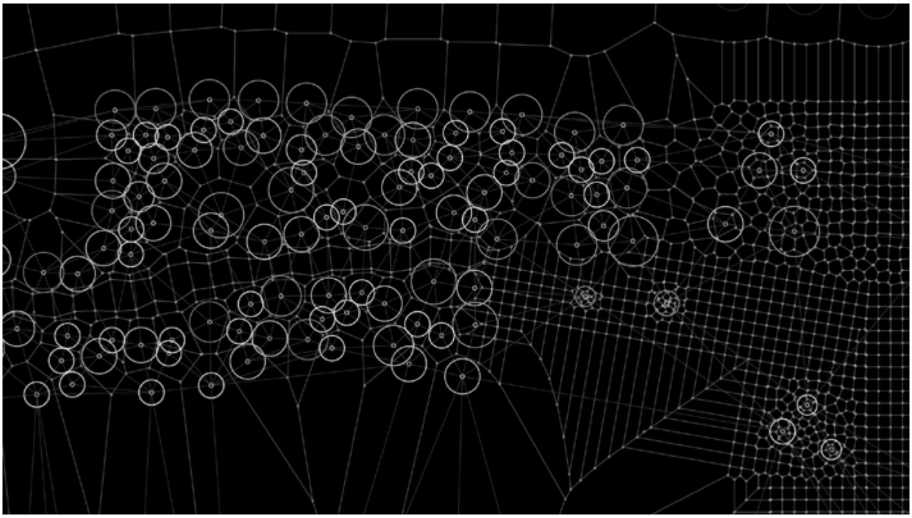


Figure 3. A part of the final plan for the SONY forest project.

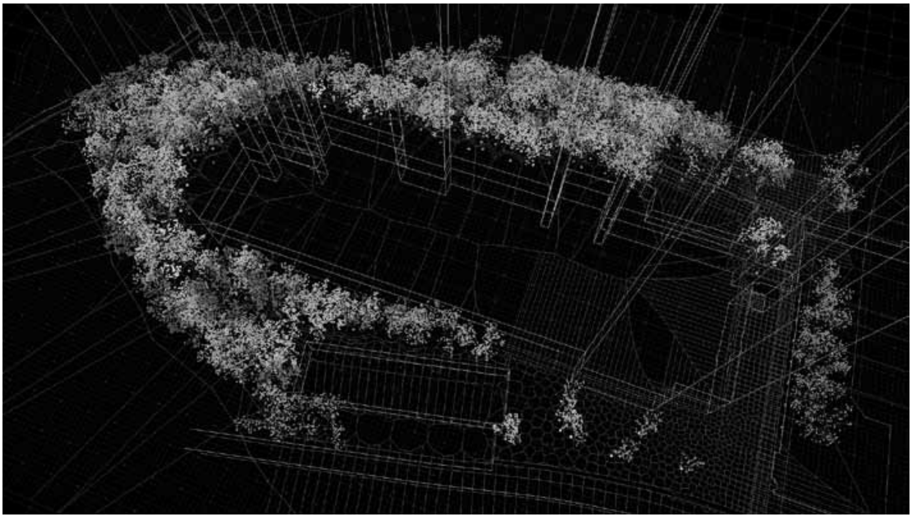


Figure 4. The forest appearance 15 years from now.

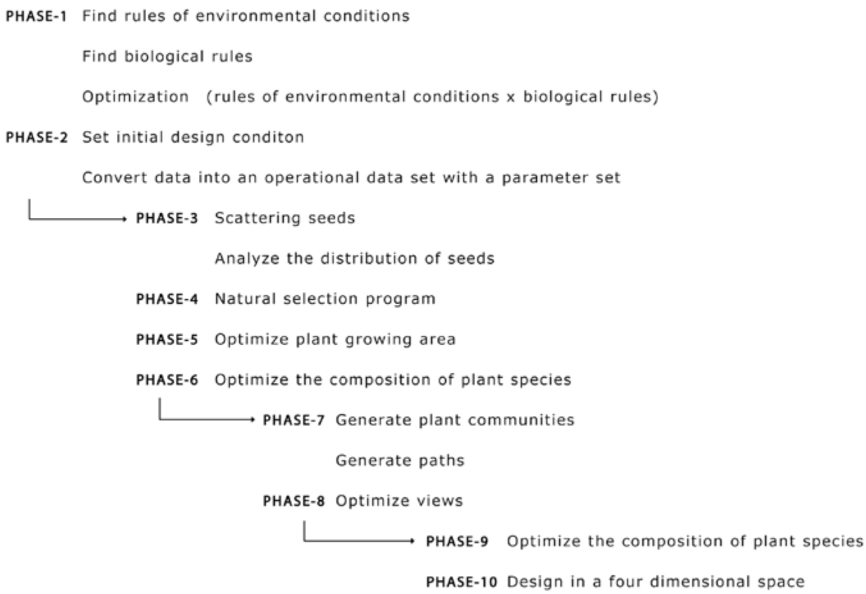


Figure 5. The whole design process in detail.

5. Conclusion

The construction of the physical plan in the landscape project started this September in 2010. At the end of November in 2010, there was an experimental occasion in which pedestrians could compare the layout of trees in our project site and that designed in a conventional way in the site adjacent to the project site. The difference was distinct. The pedestrians reported that in the newly designed site, they felt that the layout of trees was not merely random but meaningfully random reflecting the surrounding environments; this feeling was similar to the feeling experienced in the real natural forests.

In this paper, we proposed computational landscape design called the seeds scattering system. The SS system can manage environmental conditions, plant-growth and appearances of plants in an interactive manner in design processes. In addition, the system can manage a huge amount of data from environmental and biological researches. Designer's role in this system is not to manipulate geometries or compositions of trees but to design fundamental rules behind them. As a result, designers can design landscape in an interactive manner, and produce the landscape inherent in its site.

A further direction of this project is to develop this system in such a way that it can manage real-time environmental data obtained from a real-time sensor network system.

Figure 6. The SONY forest in the urban context (The construction site on Nov.19th, 2010).

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