Data Gardens[†] : Visualizing the Evolution of Complex Dynamic Data using the Garden Metaphor

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Abstract

We suggest in this article a new paradigm for the representation of data, which is best suited for the real-time visualization and sonorisation of complex systems, real or simulated. The basic idea lies in the use of the garden metaphor to represent the dynamic evolution of interacting and organizing entities. In this proposal, multiagent systems are used to map between given complex systems and their *garden-like* representation, which we call *Data Gardens (DG)*. Once a satisfying mapping has been chosen, the evolution of these *Data Gardens* is then driven by the real-time arrival of data from the system to represent and by the endogenous reaction of the multiagent system, immersing the user within a visual and sonorous atmosphere from which he can gain an intuitive understanding of the system, without even focusing his attention on it.

Topics:

garden metaphor, data visualization, virtual ecosystems

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1. Context

Let's imagine a virtual garden whose visual and sonorous aspects continuously change to reflect the passing of time and the evolution of weather conditions in a distant place. Looking at it or simply listening to its musical rhythm will make you feel just as if you where there, looking at your garden through the window. Connected to real meteorological data, it really functions as a virtual window, opened on a distant reality. This is what the computer-art project called *The Garden of Chances* [Hutzler et al. 97] is all about. Beyond its artistic interest, we believe it to have important implications for the representation of complex systems by means of visual and sonorous metaphors, a position we develop with *Data Gardens* (*DGs*).

Keeping a close watch on meteorological data in order to secure airplanes landings, monitoring the physical condition of a patient during surgical operations, observing Stock Exchange fluctuations so as to determine the best options, are examples of situations where decisions are subjected to the real-time monitoring, i.e. understanding, of complex systems, respectively physical, biological, and social or economical. In this context, the basic proposal of *DGs* is to organize the perception, not only the representation, of complex dynamic data around the garden metaphor, and more generally the ecosystem metaphor.

After briefly presenting the artistic work that founds, and legitimates, the whole approach, we're going to analyze the reasons why we feel the garden metaphor to be well adapted to the problem of complex dynamic data perception, and how it can be applied.

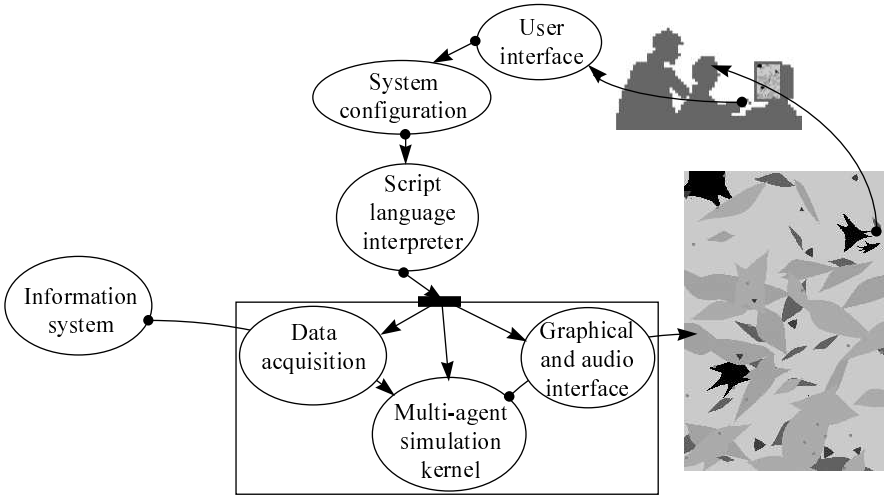
2. *The Garden of Chances*

The philosophy underlying this artistic work is to let the automatic generation of images be directed by the (pseudo)real time incoming of real world meteorological data, extracted hourly from airports weather reports. The aim is to make the climatic atmosphere of a given spot accessible to a direct and almost physical, emotional perception, as opposed to a neutral quantitative display. When functioning continuously all year long, the animation makes the computer screen become a kind of virtual window, giving access to a very strange world, both real and poetic, imaginary landscape anchored in real world.

To this end, color variations are carefully chosen in order represent such things as temperature or clouds coverage. But the main point is the use of the weather data to give life to a set of two-dimensional abstract shapes, so as to create a metaphorical representation of a real garden. In this virtual world, each graphical creature is able to grow up like a plant, benefiting from the presence of light and rain, competing against similar or other hostile shapes, reproducing and dying like any living creature. By so doing, the goal is definitely not to produce accurate simulations of natural ecosystems nor realistic pictures of vegetation. The focus is rather put on enabling the artist to experiment with lots of different abstract worlds until he obtains some imaginary ecosystem fitting his aesthetic sensitivity and corresponding the most closely to his own experience of weather. From an artistic point of view, this is very close to traditional painting work whereby a painter experiments light, colors, shapes in order to express and communicate emotional states. Only the medium changes and the system could finally be described of as an "automatic abstract impressionist", trying to catch visually the luminous atmosphere of a distant place.

3. *Data Gardens*: Complexity Perception Systems

Inspired by the *Garden of Chances*, the purpose of *Data Gardens* is not so much to catch luminous atmospheres than to dynamically represent the functioning of complex systems. They constitute an attempt to construct a new type of man-machine interface, devoted to the interaction with complex systems, from which one receive information, and in which one has to make decisions. Like human perception systems, *DGs* simultaneously handle data-driven and conceptually driven processing, closely associating man and machine in a single complex perception system (figure 1). Data-driven, information received is organized spatially, temporally and hierarchically by a multi-agent system whose evolution is directed both by the real-time arrival of data and by its endogenous dynamics, reproducing or not the dynamics of the complex system to represent. Conceptually driven, the user can interact dynamically with the system, either in "learning mode" to make the system adapt the representation to the user's preferences, or in "operational mode" to make it focus on specific aspects of the complex system to monitor or change the granularity of the representation.



At the heart of the system is the garden metaphor. But the metaphor doesn't lie so much in the visual symbols chosen to display the representation as in the inner mechanisms of the multi-agent simulation kernel used to organize incoming data. The visual similarity of the representation with a virtual ecosystem is only a logical consequence of the underlying dynamics. Applied to the real time monitoring of complex systems, we've found that this ecosystem metaphor had some interesting properties that made it a good candidate as a generic metaphor. To summarize, one could say that it is both complex enough in its inner functioning, and simple enough to perceive from the outside.

- ***Inner complexity***

If one wish to represent complex systems dynamically, one has to address the problem of organizing the data received. If the complex system is composed of thousands of interacting entities, one cannot seriously imagine to fill the screen with thousands of colored shapes, without controlling the way they are to be arranged spatially. But it isn't adequate either to calculate means over these thousands of entities because almost everything would be lost from the complex system's dynamics. The proposed solution is to integrate this dynamics into a virtual ecosystem, mapping the complex system to represent into a virtual ecosystem analog. For each complex system, a lot of mappings can be found that are more or less significant

with respect to what the user wants to monitor, either representing each complex system's entity as one or several analog organisms, integrating the data received as the meteorological conditions to which an imaginary ecosystem is subjected, or using yet other garden-inspired metaphors.
In the virtual ecosystem so defined, mechanisms inspired from physics, biology or ethology can be used to make relevant data become represented by dominant organisms of the ecosystem. One can imagine for example to copy mechanisms present in natural societies in which hierarchies spontaneously emerge from originally identical organisms (in some species of social ants for example). Or, in a more general perspective, the different organisms in the virtual ecosystem can get engaged in a Darwinian competition in order to get the user's focus. Organisms compete with one another (analog to a natural selection) but they can also get selected by the user himself (kind of artificial selection).
At the visual level, this virtual ecosystem can also be represented in a variety of ways according to user's tastes. But it remains very simple, consisting for each agent in a geometrical 2D colored shape without any texture, like those shown in figure 1 (picture on the right). One could imagine a lot of other representations, maybe more precise or realistic but it is far from sure that it would make the perception of the whole easier. On the contrary, a host of individual details would probably distract the user from global, more interesting patterns.

- ***Outer simplicity***

As we just explained, an ecosystem can be very complex in its functioning and in a lot of different ways. Yet, the garden metaphor is very familiar to anybody, everyone making the daily experience of gardens, public parks, or bigger ecosystems. This enables a very fast and intuitive perception of the global functioning of complex systems, first step before more detailed investigations can be carried out on specific parts of the system. Moreover, it doesn't require a sustained attention, since it relies on peripheral perception mechanisms, following the same principles as those that make us perceive weather conditions effortlessly when we go out for a walk. Projected on walls of rooms, *DGs* would immerse users into meaningful and familiar environments, from which to gain in real time a global understanding of real world complex systems.

4. Perspectives

As a result, *Data Gardens* should be designed as “meaning operators” between the flow of data and the user, who is supposed to identify and follow, in the evolution of the system, that of the outside world. However, it must be clear that they are not intended to replace the existing environments used to track and trace data (histograms, textual presentation, curves, etc.), which are still the only way to know the precise value of a variable. They are to be viewed as complementary tools that allow an instantaneous and natural perception of complex situations and propose a global perspective on them. *The Garden of Chances* is the first of such systems and it should now be studied in a systematic way, and with an experimental perspective, in order to develop operational design and evaluation methodologies.

5. References

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