From Computer Art to Ambient Displays

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Abstract. We report in this paper an original experience of a collaboration between a computer-scientist, G. Hutzler, and a painter artist, B. Gortais. This experience started with the development of the computer-art work called *The Garden of Chances*, which consists in a visual and sonorous representation of the meteorological conditions of a distant place. We then evaluated the efficiency of such a representation to convey useful information and to allow users to make appropriate decisions.

Key words: visualization, multi-agent systems, computer art, ambient displays

1. Introduction

Collaborations between artists and scientists are often reported, and similarities between the two approaches are often underlined. Most of the time however, such collaborations are unbalanced. One of the two partners acts as an expert for the other, but there's no mutual benefice for both of them. As far as computer science is concerned for example, either the computer scientist acts as an expert technician for the implementation of technologically advanced artworks [4][5][12], or the artist acts as an expert ergonomist for the design of visual representations [9][14]. None of the two approaches is entirely satisfactory because the interaction remains very superficial.

On the contrary, we experience a very close and deep collaboration in which the computer-art projects that we develop have always constituted an experimental ground for both of us. The project that we report in this paper, called *The Garden of Chances* (*GoC* to make it short), is based on three fundamental principles that need to be exposed in order to understand why and how this is not only a computer-art project but also a computer-science experimental framework.

First of all, *The GoC* is designed to propose a visual and sonorous representation of meteorological data dynamically retrieved through the Internet. This representation isn't meant to be a realistic picture of the meteorology of a distant place. Rather, it is dynamically evolving all day long and all year round in order to translate, by means of colors and sounds, the ambience that characterizes that place. From an artistic point of view, this turns the screen into a kind of artificial window, giving access to a very strange world, both real and poetic. From a scientific point of view, this raises an interesting visualization challenge for real-time data flux: how to build precise and synthetic representations to convey subjective information about the state of a system, on the basis of a number of numerical variables? In addition, how sonorous and visual clues may be combined together so that the information is conveyed more efficiently?

The second principle is to let the evolution of the pictures be similar to the development of a kind of virtual garden of colored shapes (hence the name of the project) whose evolution is conditioned by the more or less favorable meteorological conditions. From an artistic point of view, this introduces a great dynamism and renewal inside the graphical system. From a scientific point of view, this raises the question of artificial multi-agent simulations of biological systems in relation to real-world data, and the status that should be given to these mixed artificial worlds. This also raises the question of secondary visual clues to convey information: how the state of a biological ecosystem may help understand current and past weather conditions?

The third principle is to enable spectators or users to interact with the visual representation just like a gardener would do in his/her garden. From an artistic point of view, this introduces a new dimension inside the artwork, by giving the spectator an active role to play. From a scientific point of view, this raises the question of the role of the user in the construction of the representation that he/she is meant to use in the most efficient way.

More generally, we want to show in this article that the development of computer-art works can raise, on a radically new basis, some of the fundamental questions related to data visualization. It can thus enable to propose new solutions. We will first describe in more detail the construction of *The GoC* as a visualization system for meteorological data (section 2), before presenting several experiments designed to assess its performance: how precisely users may guess the values of the represented variables (section 3), how efficiently they may take decisions (section 4), and finally how comfortable is the use of the interface (section 5).

2. The Garden of Chances

The Garden of chances is the name of a computer-art project. It's also the continuous representation of a complex meteorological system, whose evolution is measured with variables dynamically retrieved through the Internet [24]. These variables correspond to simple parameters such as temperature, wind conditions (speed and direction), cloud cover or rain.

Basically, the picture is built following two complementary mechanisms. The first one is to have the picture evolve like a virtual ecosystem of colored shapes, whose development is conditioned by the more or less favorable meteorological conditions. This result in pictures that look like the one shown in figure 1 below.

The second mechanism is to design the colors of the shapes so as to reflect the passing of time (at different hours of the day and at different days of the year) and the changing climatic ambience. Like painter Claude Monet's series of Reims' cathedral, the picture is to reflect very subtle changes in lighting as the weather conditions change.

2.1. A virtual ecosystem

In the process of building a representation system for meteorological data, the design of the picture as a virtual ecosystem is not the crucial point. It helps the user, however, to consider the screen as a kind of a virtual window, opened to a distant world. In addition, the effects of the weather on the simulated vegetal help in giving visual clues of what the weather is like or what it was like in the past. Finally, the ecosystem is a useful metaphor to organize a visual display: plants are limited in their development by spatial constraints due to neighboring organisms; similarly, the number of items that you can display on the screen is constrained by the size of the screen.

The ecosystem functions at three different levels: a vegetal ecosystem linked to the weather conditions and a predator-prey system that live on it. Each of the three types of agents (vegetal, prey, predator) is characterized by a level of energy that define its health. The agent may reproduce when the energy is high or die when it's falling down to zero.

The first level, represented by leaf-shaped agents, corresponds to vegetal organisms that gain energy according to sunlight, rain and temperature conditions. The agents may lose some energy if too many of them are present. The second level, represented by triangle-shaped agents, corresponds to insect-like organisms that feed from the leaves. The third level, represented by star-shaped agents, corresponds to bird-like organisms that feed from the insects.

Fig. 1. The picture is organized like a virtual ecosystem of colored shapes

2.2. A representation of climatic ambience

Since the work is meant to function continuously over the year, the colors of the shapes are basically designed to reflect the alternation of seasons and the daily alternation of nights and days. To this end, colors are represented using the Hue-Saturation-Brightness model (HSB), and the value of each color component is given using a specialized curve editor (figure 2). Different hues are associated to different seasons. Saturation and brightness of the color are specified as a function of the day of the year and are altered as a function of the time of the day (figure 2).

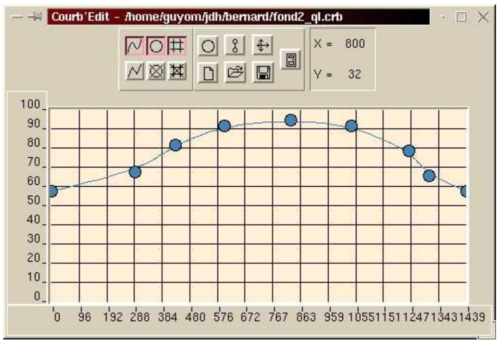

Fig. 2. A specialized curve editor enables to define the alteration of the colors components as a function of time or as a function of a given variable. The above curve represent the modification of the brightness of colors as a function of the time of the day

Additionally, the temperature and cloud cover are taken into account by altering the colors of all the agents using two simple principles: the first one is to express the cloud cover by a diminution of brightness; the second is to express low temperatures by a diminution of saturation, which produces pale, cold colors.

Some of the aspects of the weather conditions are also expressed, not only by means of color variations but also by means of shapes evolution or movements. A high cloud cover for example, results in the proliferation of cloud shapes, by increasing their reproduction rate, whereas low cover causes their disappearance by stimulating their death. Wind conditions for their part induce the movement of the shapes, especially leaves and clouds, along wind direction and at a speed proportional to that of the wind. Lastly, the occurrence of rain is shown as a multitude of small dots, whose number and size are related to the strength of the rain.

3. Precision of the representation

Although *The GoC* was designed in an artistic prospect, the representation that it gives to real-time weather data had to be evaluated with an ergonomic approach. First of all, one has to assess the precision with which the data can be perceived.

The five variables that were evaluated are:

- Temperature: from 0°C to 25°C
- Cloud cover: from 0 (clear sky) to 8 (overcast sky)
- Rain: from 0 to 60 minutes/hour
- Wind speed: from 0 to 150 km/h
- Wind direction: from 0° to 359°

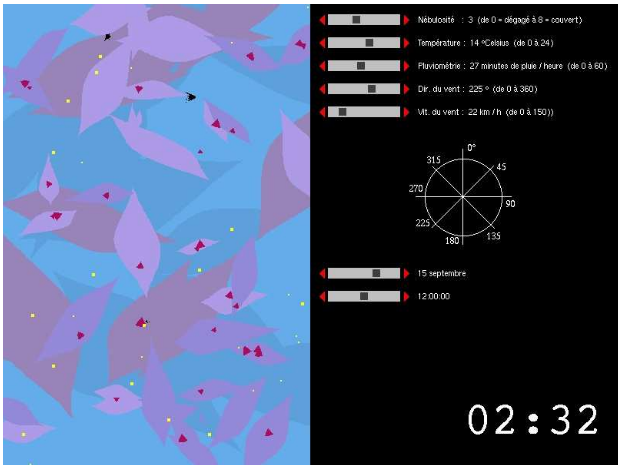

Fig. 3. The user manipulate sliders to modify the variables and see how they are represented

The protocol used was the following:

1. *The GoC* project is presented to the user;
2. The different steps of the experiment are explained;
3. The experiment itself proceeds as follows:
   (a) The user has three minutes to familiarize himself/herself to the way the variables are represented by manipulating sliders controlling the variables (figure 3);
   (b) The user undergoes two blank tests so as to understand precisely how these tests proceed, namely:

i. the computer chooses random values for the five variables and shows the corresponding *GoC* representation;
ii. the user adjusts the sliders to indicate what values he/she thinks are represented and validates;
iii. the computer displays the actual values and allows the user to alternate between the representations corresponding to the values chosen by the computer and those given by the user;

(c) After the two blank tests, the user has three minutes more to be familiarized to the *GoC* representation.
(d) The user finally undergoes ten real tests.

The experiment has been done by ten different users and by the two authors who designed the representation (ten complete experiments in a row for G. Hutzler). The raw results are presented in table 1.

	Cloud cover	Rain	Temperature	Wind dir	Wind speed
G. Hutzler	0,3	3,4	2	5	14,9
B. Gortais	1	2,7	2,7	11,6	18,4
User 1	0,7	5,6	2,3	8,2	32,1
User 2	1,7	8,7	2,9	6,6	16,4
User 3	0,7	3,8	2,7	14	13,5
User 4	1,6	6,5	3,3	7,1	27,3
User 5	1	12,2	3,8	11,2	19,4
User 6	1,2	6	2,8	10,1	30,1
User 7	0,3	3,3	2,2	11	25,1
User 8	1,1	6	4	7,2	18,1
User 9	0,9	3,8	2,9	15,5	22,2
User 10	1	6,2	3,5	9,5	29,7
Mean	1,02	6,21	3,04	10,04	23,39
Min error	0,3	3,3	2,2	6,6	13,5
Max error	1,7	12,2	4	15,5	32,1

Tab. 1. Raw results for the precision experiment. For each user and each variable, the value is the mean error (in absolute value) computed over the ten tests

A first analysis shows that it is indeed possible to perceive the weather data with some precision, after only a quarter of an hour of manipulation of the representation. Temperature for example can be perceived with a precision of +/- 3°C. The results obtained by G. Hutzler, with errors about half the mean errors of new users, show that some learning is possible. These raw results however are difficult to interpret since the ranges are quite different from one variable to the other. Figure 4 shows the same results using a relative scale, for which errors are divided by the variation range of the variable. The error appears to be close to 10% for new users and can fall down to 5% with some training, with some differences between the variables. The question then is "how good is 5 or 10%?". The answer may be that it's not inherently good or bad, but that it may be considered good only if it allows to make appropriate decisions.

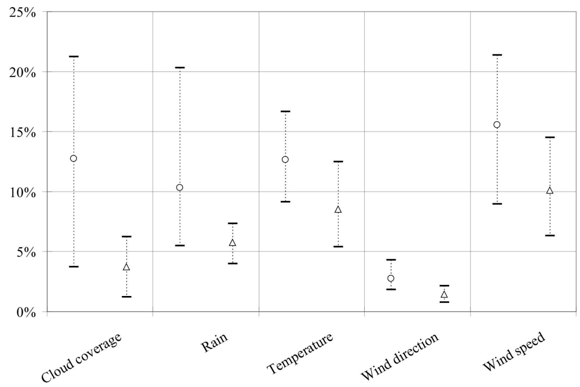

Fig. 4. Relative errors for the five variables. Mean errors for the ten users (circles) and for G.Hutzler (triangles)

4. Ability to make decisions

One can't say that the representation is good or bad independently of what it is supposed to be used for. As an artistic representation, the results are clearly good enough. But what if the representation is to be used to make practical decisions? To assess this point, a second experiment was designed in which the perception of the current meteorological conditions had to be used to decide whether to take an umbrella, a raincoat, gloves, a fan or sun lotion. Each of the five choices is constrained by the values of one or more of the variables. For example, gloves should be taken if the temperature is less than 10°C, and a raincoat or an umbrella if the rain lasts (e.g. more than 20 min/hour), but the raincoat will be a better choice if the wind is blowing (e.g. more than 50 km/h), and so on.

In this experiment, the criteria were to make correct decisions and also to respond as quickly as possible. To be able to compare the *GoC* representation with more classical representations, the same experiment was done with a simple textual view of the five variables, and with a pictorial view (fig. 5).

Fig. 5. Text and pictorial views used for comparison with the *GoC* representation

The results clearly reveal three different modes of perception (figure 6): while perception using the textual representation is precise but very slow, it is very fast with the *GoC* but rather imprecise, and it is both precise and fast with pictographs.

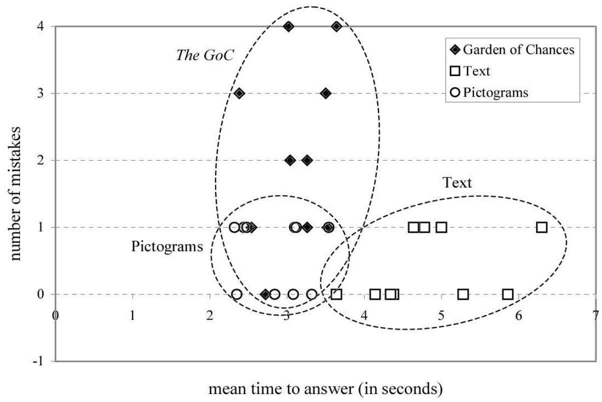

Fig. 6. Number of mistakes versus time to answer for the three different types of representations

5. Comfort of use

However, the previous experiment has at least two limitations: first, decisions are made one at a time and not continuously as it is generally the case when controlling an industrial complex system; in addition, a choice is either right or wrong with no gradation between the two which is not necessarily a valid assumption. This new experiment is therefore an extension of the previous one in which the meteorological conditions are continuously changing, requiring that choices be revised to take these new conditions into account. Starting with an initial credit, penalties are given whenever a choice is inadequate, the penalty being proportionate to the error that is made (e.g. if gloves are not taken, the penalty is greater if the temperature is 0°C than if it is 9°C). The experiment ends when the initial credit is exhausted.

What the experiment revealed is that the *GoC* representation needed considerably less concentration and efforts than the other two. Textual and pictorial representations are fragmented and require constant attention on each individually represented item of information. On the contrary, the *GoC* representation is global and the corresponding perception is also global. Being natural and intuitive, it doesn't require the user to focus all of his/her attention on it. It may therefore be useful as a complementary visualization tool to more classical items such as counters or graphs. The latter are based on focalized perception while the *GoC* relies on ambient perception [15].

6. Conclusion

We showed that *The Garden of Chances*, an artistic graphical work, can convey some usable information, which means that this information may be used to make correct decisions in a control/command context. These results have to be confirmed with the transposition of the design principles of *The GoC* in the context of a real application. However, we can easily imagine to make the correspondence between some variables from a system to control and the weather variables of *The GoC*. The visual representation built from these variables could then be analyzed in terms of good or bad weather, indicating that the corresponding system is operating well or not.

In addition, this project illustrates a fruitful collaboration between art and computer science. More precisely, this is a collaboration between a painter artist and a computer scientist, in which reciprocity is the rule: computer science helps in designing original works of art, while art helps in designing and developing efficient solutions to visualization problems. This reciprocity is a real richness, which probably explains why our collaboration lasts for more then ten years.

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