Informative Art: Information Visualization in Everyday Environments

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Thanks to advances in display technologies, it will soon be possible to have electronic information displays virtually everywhere. We have developed the concept of *Informative Art* as a way to integrate information visualization in the everyday human environment. Informative Art combines a dynamically updated information display with the decorative role of visual art, such as posters and paintings. We present four examples of Informative Art, where we borrowed the styles of various modern artists to show different kinds of information. For instance, a composition similar to the style of an abstract painter, Piet Mondriaan, showed the current weather in six different cities, while a piece of "landscape art" in the style of Richard Long gave a view of the last 30 days of global earthquake activity. We discuss how designing information visualizations for everyday environment introduces requirement that are different from those of graphical user interfaces for desktop computers.

CR Categories:

I.3.8 [Computing Methodologies] Computer Graphics – Applications; I.3.6 [Methodologies and Techniques] – Interaction Techniques; J.5 [Arts and Humanities] – Fine art; B.4.2 [Input/Output and Data Communications] Input/Output Devices – Image display

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1 Introduction

Electronic information displays are seemingly ubiquitous. We meet them not only the screens of the desktop computers we stare into at work and in our homes, but there are displays on mobile phones, on hand-held computers and video games, on VCRs and watches, and so on. Yet we may actually only have seen the start of their influence on everyday life.

Display technologies are becoming more affordable and unobtrusive every year, and soon there should be no need to limit advanced displays to professional use. Flat-panel LCD displays are falling quickly in price and can soon match CRT screens in affordability, yet offer much more flexibility in placement and use.

Data projectors are becoming smaller and less noisy, with increasing brightness. Even more exciting is the prospect of alternative display technologies that have yet to make it to the consumer market.

"Electronic inks" of different varieties promise to combine the readability of printed paper with the dynamics of computer graphics, for instance by allowing a seemingly ordinary newspaper or book to download new content on-the-fly [Jacobson et al. 1997]. For other purposes, a display screen can now be woven directly from electro-luminescent materials, creating a flexible, thin, high resolution display with no size restrictions [Visson 2002]. Yet another type of textile-based display may be created with photochromically coated threads, which change color dynamically when subjected to ultra-violet light [Holmquist and Melin 2001].

In the near future, we should be able to hang an affordable highresolution display on a wall in the same way as if it was a poster or a painting. Further down the line, with the help of other technologies currently in development, it should be possible to display computer graphics on almost any surface – imagine wall-paper, curtains, windows, tables, even clothing with dynamically updated computer graphics! But what happens when the computer application designer also becomes an interior decorator or a fashion designer? When creating computer graphics applications for everyday environments, we will discover that they have requirements that are very different from those we are already familiar with from designing user interfaces for traditional desktop computers.

2 Informative Art

Informative Art is a type of computer applications which borrow their appearance from well-known artistic styles to visualize dynamically updated information [Redström et al. 2000]. At first look, an Informative Art application might appear to be a static image, but its appearance will actually change continuously to reflect

Figure 1. An experimental environment with three flat-panel screens showing Informative Art

some source of information. Informative Art is designed with the intention to be displayed in the same places where we normally encounter art or pictures in our homes, such as the kitchen or the living-room, as well as in public spaces or in the workplace. Currently, it is most convenient to use projectors and flat-panel screens to display Informative Art, but in the near future we expect other, more suitable display technologies to become available.

For the sake of illustration, imagine that Figure 1 depicts a living room or workspace in the near future. There are what appears to be three different paintings on the wall. These ”paintings” are in fact wall-mounted displays, each of which is connected to a computer that runs a different Informative Art application. One of these applications might create an abstract composition of several black lines and colored fields, reminiscent of the famous abstract paintings by Dutch painter Piet Mondriaan. However, each of the fields in this ”painting” in fact represents a person, e.g. a member of a family or a workgroup. The size of each field represents the size of the person's e-mail queue, so that the more unread e-mail there is, the larger the corresponding field will be. Thus, the ”painting” will change its appearance depending on the situation – for instance, if it is a busy day with many e-mails being left unread, the image will be dominated by large colored

fields. Individual variations will also become apparent. If for instance someone is away for several days without reading mail, the field representing that person might grow much larger than the others. It is possible to imagine many other mappings between various types of information and the image: the color of a field might change depending on the person's location (at home, at work, etc.), or the size and placement of the fields might change to reflect relevant if a person is in a meeting or talking on the phone, and so on.

It should be pointed out that an Informative Art application does not necessarily provide exact information – for instance, one cannot tell the exact number of unread e-mails each person has in the above example, but only if there are "a lot" or "very few". Also, the display will change quite slowly, so that changes will usually not be noticeable unless one looks at the display for an extended period of time, or if there are long intervals between each time it is viewed. These are conscious design decisions that have been made to make the applications function more like a visually pleasing artwork, and less like animated computer graphics.

3 Related Work

Ever since computers with graphical output became available, there have been attempts to automatically create artistic images using computer algorithms, sometimes with results that mimic the style of human artists. In pioneering work beginning in 1962, A.Michael Noll created a number of computer-generated black-andwhite artworks [Noll 1995]. Of particular interest to our work are Noll's "Computer Composition With Lines", in the style of Piet Mondriaan's "Composition With Lines", and "Ninety Parallel Sinusoids With Linearly Increasing Period" which closely paralleled Bridget Riley's "Current" (both 1965). In our Informative Art applications we have used inspiration from other images created by the same artists, but we used different algorithms to create our images. Following on Noll's works, many other automatic computer art systems have been created. However, such research is mostly outside the scope of this paper, since our focus has been on the use of art as an information medium in the everyday environment, rather than on computer generation of visual art for its own sake.

The notion of distributing information displays in the everyday environment originally grew out of the concept of ubiquitous computing, where computing resources are distributed in the everyday environment rather than being confined to a desktop workstation [Weiser 1991]. In a development of ubiquitous computing the term Calm Technology was coined to describe technology that is "encalming", and reduces information overload by engaging both the center and the periphery

of our attention [Weiser and Brown1995]. An example of Calm Technology is the Dangling String. This was piece of cable hanging from the ceiling and connected to a small motor, which in turn was affected by the amount of traffic in the local ethernet. The more traffic there was in the network, the more the cable would shake, thus giving an inexact but very evocative indication of the activity in the network.

Another closely related concept that of Ambient Media [Ishii and Ullmer 1997]. Ambient Media are information displays that are designed to reside in the periphery of the user's attention, relying on the human capability for "background processing" of information. For instance, light from a lamp was directed through a water tank that in turn was affected by a motor, so that water ripples could be created, which would then be reflected in the ceiling. This motor could then be connected to an information source, so that for instance the level of activity in the local network would be reflected by intensity of the water ripples reflected in the ceiling.

Slow Technology is an area that grew out of earlier work in Informative Art [Hallnäs and Redström 2001]. The philosophy of Slow Technology is quite different from that of Ambient Media or Calm Technology, since it does not directly try to make human information processing more efficient. Instead, Slow Technology is was created to encourage reflection on the design and aesthetics of computational artefacts. A user interface based on such principles is the opposite of an intuitive interface, because it is explicitly designed so that it will "take time" to learn what it is and how to use it. This is reflected in some of our Informative Art applications, since users will need an explicit explanation to fully understand their function.

Some other recent projects where information displays have been developed with the intention to be integrated with everyday environments include the Information Percolator, where a decorative information display was created using a system of liquid-filled tubes and air pumps [Heiner et al. 1999]; Digital Family Portraits, where the border of a digital image was employed to convey information about the health status of a person in a remote place [Mynatt et al. 2001]; and Information Collages, where informational images were automatically generated from an aesthetic template based on paintings by artists such as Kandinsky [Fogarty et al. 2001].

Informative Art differs from previous work in the way it relies on inspiration from both the appearance and the function of traditional art. While other projects have played on familiar metaphors and natural phenomena (ethernet cables, water ripples, etc.) they have for the most part not attempted to supplant existing

Figure 2. We strived to create a home-like environment in which to exhibit Informative Art applications

decorative artefacts. On the other hand, projects such as Digital Family Portraits, InfoCanvas [Miller and Stasko 2001] and LumiTouch [Chang et al. 2001] use the physical form of paintings or photo frames, but the content is not designed with any obvious aesthetic considerations. Information Collages has used a similar motivation as our work, but did not elaborate on the practical implications of deploying information visualization in everyday environments.

4 An Informative Art Installation

We have created an installation containing a number of Informative Art applications, which was first exhibited at SIGGRAPH 2001 Emerging Technologies [Skog et al. 2001]. The applications were all written in Java to run on laptop PCs. The graphics were projected using standard data projectors. However, rather than using ordinary projection screens we decided to project the images onto large pieces of white textile. This choice was made to illustrate how Informative Art should be considered more as a decorative wall-hanging or a drapery, rather than

a computer application. In combination with carefully selected furniture, this arrangement gave our installation a considerably more ”home-like” appearance than a typical computer technology showcase (see Figure 2).

Each of the applications was inspired by the work of established 20th-century artists. When developing the applications we took inspiration from many printed reference sources on modern artists and styles (e.g. [Britt 1989; Hughes 1991]). It is illustrative to compare our results with their artistic inspiration, but for copyright reasons we can not reproduce any artworks in this paper. In the appendix we supply Internet addresses where examples of these works can be seen.

To illustrate how Informative Art is a general concept which can be used to visualize different types of information, we used a variety of information sources. These included global information that is readily available on the Internet, such as the current weather; and local information, such as the activity in the environment as perceived by a camera.

4.1 Weather Composition (Figure 3)

This application was inspired by the abstract compositions created by Dutch artist Piet Mondriaan in the 1920's, where he used the primary colors red, yellow and blue combined with black or grey lines on a white background. These works were part of the larger art movement ”de Stijl”, which produced many other similar works by Mondriaan's contemporaries. We took inspiration from this style to create an applications which displays the current weather in six different cities around the world.

The image consists of six colored squares, on a background of black lines forming an irregular grid. Each square is mapped to a particular city in the world. The placement is roughly based on a world map with the Greenwich meridian in the center, so that the position of each square corresponds to the ‘ approximate position of the corresponding city on the map. We chose a range of cities from countries around the world, which would have different temperatures and conditions. The upper row represents from left to right Los Angeles, USA; Gothenburg, Sweden; and Tokyo, Japan. On the lower row is Rio de Janeiro, Brazil; Cape Town, South Africa; and Sydney, Australia.

The position of the squares is fixed, but the current weather in the corresponding city affects the appearance of each square in two ways. The size of the square changes with the temperature in the city, so that the hotter it is, the bigger the square will get. The color of the square is determined by the weather conditions in the city. We took the same primary colors that Mondriaan used – red, yellow and blue – and mapped these to weather conditions. Yellow means clear weather, blue

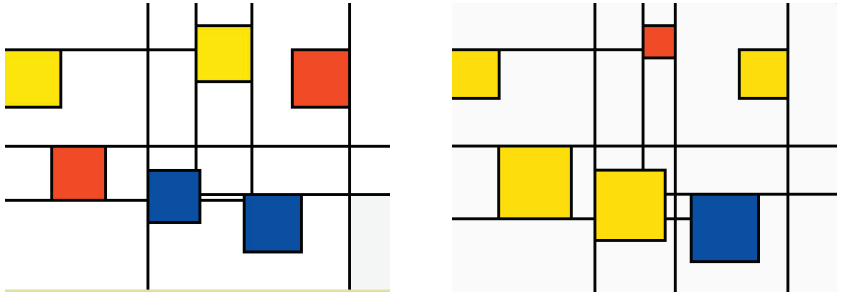

Figure 3. A weather display showing the weather in six international cities, inspired by Piet Mondriaan. The left image was generated in June 2001, the image to the right in December 2001, illustrating the differences in temperature between summer and winter on the north and south hemispheres.

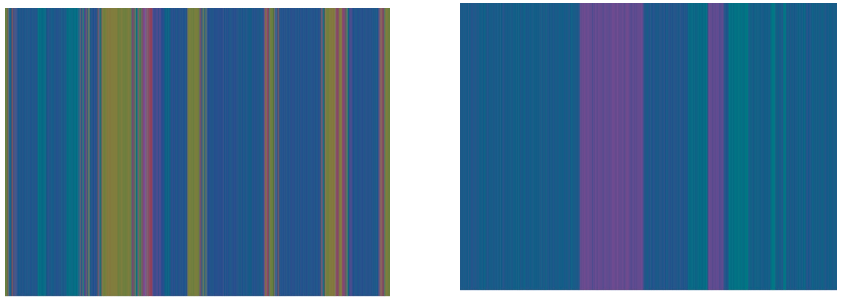

Figure 4. A reflection of the activity in a space over time, inspired by Bridget Riley's "Op-art". The image to the left shows several instances of high activity, whereas the right image reflects a periods dominated by low activity.

represents some kind of downfall (rain or snow), and red means cloudy weather. We reasoned that yellow would be associated with sun, and blue with water – the remaining color, which was red, then came to mean cloudy conditions.

The weather data was downloaded from the Yahoo! Weather service (weather.yahoo.com). A dedicated server application ran on a separate computer, continuously downloading and parsing the weather information. The server sent data to the client approximately once per minute, which made adjustments to the visuals accordingly. The position of the squares and lines was hard-coded into the application; the size and color was then adjusted according to the incoming data.

4.2 Motion Painting (Figure 4)

Here, our main sources of inspiration were the bright and colourful "Op-art" patterns created by British artist Bridget Riley in the 1970's and 80's. The application relies on information about the movements in a room, as registered by a digital camera. Over time, the application will create an image that reflects the level of activity in the area visible to the camera.

The application works by continuously painting thin, parallel vertical lines in shifting colors from left to right. When the far-right side of the image is reached, the painting starts over on the left, covering the entire image in about 30 minutes. The color of each line is determined by the amount of motion in the area overlooked by the camera. On start-up, the camera is calibrated to the current level of activity in the room, and a base color is selected by the user. During painting, each line differs more or less from the hue of the base color depending on the amount of activity, so that if the activity level is similar to when the camera was calibrated, the lines are very close to the base color, but if the activity is different, their hue differs more or less radically from that of the base color.

The application captured images from a standard Web cam, using Sun's Java Media Framework (available at java.sun.com/jmf). The level of activity was measured by capturing an image from the camera and comparing it to a previously captured image. A numerical value of the difference was created by subtracting all the pixel values of the two images – the higher difference, the more activity would have taken place between the two captures. The value was then normalized by dividing it with the number that was derived when calibrating the application, so that when the activity level was similar to that during calibration, the resulting number was close to 1. The resulting numerical value was then used to determine the hue of the currently painted color, by multiplying it with the hue of the base color, so that the more the number differed from 1, the more different would the painted color be from the base color.

4.3 Stone Garden (Figure 5)

This piece was inspired by ”landscape” artists, such as England’s Richard Long, who create art from natural elements, for instance by placing patterns of stones on grass lawns. We appropriated this style to visualize a very ”earthly” type of information, namely global earthquake data.

Similar to the Weather Composition, the lawn corresponds to a world map, with the Greenwich meridian in the center. Whenever an earthquake occurs, an image of a stone is placed on the lawn. There are 10 different stones, and the size of the current stone corresponds to the magnitude of the earthquake on the 10-graded Richter scale. The position of the stone directly corresponds to the latitude and longitude of the earthquake. The application has access to information about the last 30 days of earthquakes, thus giving a comprehensive view of recent earthquake activity. Clusters of stones will be formed in areas where there is high activity, making it possible to discern geographical areas with high geological activity, such as Japan and the Californian coast.

A dedicated server application downloaded and parsed earthquake information from the home page of IRIS, the Incorporated Research Institutions for Seismology (www.iris.edu). The client, running on a separate laptop, queried the server for data and updated the display accordingly. The visualization was updated every minute, so that when a new earthquake was detected, it would show up almost immediately. The graphical elements that made up the image – the lawn and 10 stones of different sizes, one for each number on the Richter scale – were based on digital photographs taken by the authors.

4.4 Soup Clock (Figure 6)

This piece was inspired by the early 1960’s works of American ”Pop” artist Andy Warhol, where images from advertising and popular culture were repeated over and over with small variations. We took the iconic image of a Campbell soup can, as used in many of Warhol’s works, and created a form of clock or ”egg-timer”. This application would show the passing of time by gradually replacing the image of one kind of soup with another.

The image consists of 55 soup cans of two distinct flavours and colors: asparagus soup (yellow), and tomato soup (red). When the countdown starts, there will only be asparagus soup cans, and the dominating color is yellow. As time passes, one by one the asparagus cans will be replaced by tomato soup, so that at the final moment when the countdown is over, there will only be red soup cans left. The clock can be set to start and end at any time, for instance to keep track of a lunch

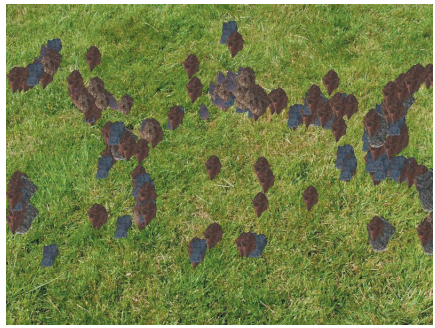

Figure 5. 30 days of global earthquake activity displayed as "landscape art", inspired by Richard Long. The left image was generated in June 2001; the image on the right is from December 2001. Earthquake-prone areas such as the Californian coast are clearly visible.

Figure 6. A count-down clock or "egg-timer" inspired by Andy Warhol's paintings of Campbell soup cans. In the left image, only a little time has passed; at the right, most of the time has passed.

break or the time it takes to cook an egg.

The application relied on the computer's internal clock to tell the time, with starting and ending times supplied as parameters on startup. The placement of the tomato soup cans was based on a pseudo-random algorithm, so that each new can would be added at a random place, but since the random seed was always the same, the same pattern of placement would be repeated every time the application was run. The graphical elements were based on touched-up digital photographs of actual Campbell brand soup cans, taken by the authors.

5 Discussion: Designing Information Visualizations for Everyday Environments

Informative Art illustrates some important ways in which the requirements for computer applications for everyday environments are different than those on a desktop screen.

5.1 Movement and Animation

Informative Art occupies a place somewhere in between an animation and a static image. They are not static, because the images do change depending on the information source; but they can hardly be called animations either, since changes usually take place very slowly. It is actually not uncommon that uninformed viewers mistake Informative Art for static images, because unlike with most computer applications, "nothing happens" to show that the applications is running.

This "slowness" represents a conscious design decision. As is well known from research on human perception, quick movements and animations in the periphery of human vision will attract a person's attention [Sekuler and Blake 1994]. If an Informative Art application incorporated too much movement, it would continually draw attention to itself, much like a switched-on TV set. Several times in our own work, we have been forced to tone down the animation in an application, for instance by letting only a small portion of the image change at a time rather than the whole picture. This means that even if a dynamic visualization works well on a desktop screen, the same visualization might be so distracting in an everyday environment that it is practically unusable.

5.2 Interpreting Information Over Time

For an uninformed viewer, it is difficult or even impossible to figure out what kind of information is shown in a piece of Informative Art. To be useful, each of them

will require an explanation. Wecould have made the applications in our examples easier to understand at first sight, for instance by providing captions which identified each city on the Weather Composition. However, we believe that not only would this have made the images less attractive and detract from the clean artistic styles we were striving for – it would in fact be unnecessary.

A piece of Informative Art is designed to be present in the user's everyday environment for an extended period of time, and therefore, instant comprehension is not crucial. If someone installs a piece of Informative Art in her home, she will make sure that it fits her interests as well as her taste, and will thus probably be well informed of its functions from the outset. Similarly, if a piece is installed in a public place, there should be some kind of explanation available (e.g. a caption) but one should trust users to be able to find out the details over time. If the piece is well designed, users will then have no problems explaining it to others, and the information will spread. At the SIGGRAPH exhibition, we observed how visitors were first puzzled, but after having been given an explanation of the installation, they were immediately able to explain it to other visitors. Informative Art thus represents a different approach than the traditional one user / one application philosophy of personal computing. We are currently performing preliminary experiments in public places to explore how this kind of "mouth-to-mouth" information spreading works over time.

5.3 Exact Information vs. Overview

Informative Art will generally not provide the viewer with exact information. For instance, in the Weather Composition, it is not possible to see exactly what the temperature is in Tokyo, but only e.g. if it is "warmer than in Sydney" or "very cold". In the same way, the Warhol Clock does not give the exact time, but gives a "sense" of how much time has passed. We believe that the information provided in these cases is quite sufficient for everyday use, and for detailed information it is always possible to turn to newspapers, Web sites, etc. It is actually possible that users in time will learn to "read" the visualizations in such detail that they might eventually be able to get just as detailed information from Informative Art as from a list of numbers.

However, Informative Art provides something which other mediums do not provide: a continuously updated overview of a complex information source. While the current weather is available (and in more detail) from other sources, to get the same information as the Weather Composition it would be necessary to visit 6 different web pages once per minute. Similarly, information like the global earthquake activity shown in the Stone Garden is also available on the Web, but

only in a format that is difficult to interpret for most users. This means that in reality, users have no easy way to access the information provided by our applications. Thus, Informative Art provides a possibility to ”reveal” information that is otherwise hidden or hard to interpret, and make it available in everyday settings. We believe that there are many types of information that would be suitable for this kind of visualization. For instance, the financial or organizational state of a company might be displayed publicly on the company's premises using Informative Art, to give employees a continuously updated view of the situation.

5.4 Aesthetic Concerns

Everybody decorates their personal space to make it more ”livable”, and the configuration of furniture, plants, photos, posters, etc. directly reflects and influences the personality of the inhabitants. Informative Art must be able to fill the same role. Since the concept is based on the idea that Informative Art should occupy the same kind of places that paintings and posters currently do, it was crucial to make our applications visually appealing. However, the authors are not artists and have no formal training in the visual arts. Instead we chose to ”borrow” inspiration from famous works in the history of visual art. Many of the original artworks we used for inspiration are available as poster reproductions, bearing out their popularity as decoration in everyday spaces.

But ultimately the choices we made, and the choices that everyone else will have to make in the design of computer applications for everyday environments, must be based on aesthetic concerns. This is an area that still remains largely unexplored in user interface research, although it is starting to gain attention. In particular, it has been suggested that when computers start to permeate everyday spaces, our attitude towards them will have to shift from one of ”use” to one of ”presence”, as is already the case in areas such as furniture design and architecture [Hallnäs and Redström 2002].

6 Future Work

Our work in Informative Art is still at an early stage. We believe it is an area that gives rise to many important questions. We also believe that it is rife with possibilities not only in user interface design, but also in related areas including computer graphics and display technology.

6.1 Long-term Evaluations

We will need to study more closely how Informative Art can be incorporated into the everyday human environment, in particular for long-term use. The effects of Informative Art can not be easily evaluated using laboratory studies in a limited environment, but should instead be studied in real-life settings. This will require advances in the robustness of our applications, ideally so that they can run for several months with no need for supervision. It also puts demand on the physical environment and installation of display equipment. Initially, we plan to install Informative Art in public places that people spend time in and often return to, e.g. cafés or the lobby of a company, and study the effects using qualitative methods such as interviews and ethnographic studies. We are also working with display manufacturers to develop displays than are suitable for displaying Informative Art in everyday environments.

6.2 Display technology

We have been using mainly data projectors and flat-panel LCD or plasma displays. These technologies have problems that need to be addressed before they become a viable option for use in everyday environments. Many issues that are not a problem when a display is used professionally may become a serious concern in everyday use. Fan noise from projectors that is acceptable during a presentation will not be tolerated in a living room. Excessive heat is another problem, especially with many displays in the same room. Current displays (particularly LCD-based screens and projectors) are often sensitive to burn-in when an image is displayed for a long time. Finally, power consumption and the associated costs must be considered, especially if a display is to be running at all times.

All of these problems might be solved in future technologies such as electronic ink and electro-luminescent fabrics. However, we believe that traditional display technologies could also become suited for everyday use, if they were designed from the start with such use in mind. Electronics manufacturers have already introduced products such as electronic picture frames to which an image can be downloaded from the Internet, but much research still remains before a computer display can be laced in a home with the same ease as a painting or a drapery.

6.3 Application of Computer Graphics Techniques

There are several areas of computer graphics which would be suitable to apply in Informative Art. In particular, in the field of painterly rendering, many rendering techniques have been developed that imitate the styles of individual artists or even

entire artistic movements (c.f. e.g. [Hertzman 1999]). By using these, it would be possible to create works of Informative Art that closely mimic the work of human artists. For instance, it would be possible to create images that look like they had been painted with water color, but which dynamically change their appearance according to an information source.

One might also use generative techniques such as L-systems, cellular automata, etc., could be utilized in informative art, since the output of such systems is often visually appealing. These techniques have already been used extensively for the realistic rendering of plants [Prusinkiewicz and Lindenmayer 1990], and such botanical images have recently been applied to the visualization of complex information [Kleiberg et al. 2001]. In Informative Art applications which incorporate natural phenomena, such our Stone Garden, generative computer graphics techniques should offer many possibilities.

6.4 End-user Customization

Some of the mappings between data and visualization in our examples may seem arbitrary, and would not represent a natural choice for many users. For instance, people would sometimes interpret the colors in the Weather Composition differently. Some associated blue with blue skies, i.e. clear weather; others though that blue meant cold and red meant warm. The reason for this is that our current applications were designed completely by us, with no input from prospective users. However, we believe that future Informative Art applications would benefit from end-user customization, so that prospective users might change the mappings according to their tastes. Similarly, the types or instances of information should also be possible to change. In the weather display, most users would probably want to change the application to show cities that were of direct interest to them, rather than those chosen by us. Similarly, rather than seeing the current weather, they might want to see the weather forecast, or perhaps some completely different information, like the traffic congestion on a nearby highway.

This type of end-user customization will require an amount of modularity and generality that our current applications do not have. Ideally, a user should be able to connect any information source to any visualization, so that for instance the activity in a room might be visualized using an Andy Warhol motif, or the weather forecast shown in the style of Bridget Riley. It should also be possible to combine Informative Art applications provided by different authors or companies. Providing this kind of flexibility will provide a challenge in many areas including software engineering, information visualization and user interface design.

7 But Is It Art?

The final issue that must be addressed is Informative Art's relationship to "real" art, as created by professional or amateur artists. The authors' position is clear: Our Informative Art examples are not art. The purpose with this work has been to explore new ways of introducing information displays in the everyday environment. We do not consider ourselves artists and do not have any artistic intentions or training. However, from the outset it was clear to us that our applications would benefit from the aesthetic sensibilities that an artist could provide. Therefore, we "appropriated" what we considered good visual art that we believed would be suitable to display in an everyday environment. This can be likened to how musicians "sample" sounds and melodies to create a new work.

The work also raises the question of copyright, and the relation of our applications to the specific artworks that served as inspiration. We have in no case used copyrighted materials in our applications, but instead we paraphrased a general style or visual appearance. Perhaps some of the artists would have been dismayed to see how we used their work as influence. For instance, whereas Mondriaan painstakingly composed each of his images, our paraphrases are much less carefully constructed and would probably not stand comparison with any of the works produced at the height of De Stijl. On the other hand, Warhol's interest in pop culture and repetition should have been well served by today's computer technology. Therefore, we believe that having artists as collaborators will be beneficial in the future design of Informative Art, and we plan to work with artists and designers in forthcoming projects.

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