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AMBIENT ART: CREATIVE INFORMATION REPRESENTATION

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Abstract: *Ambient art is the aesthetic presentation of information, using artistic techniques to achieve a pleasing image that also contains hidden depths, where exposure to it over time allows a viewer to understand something about the information sources that it represents. This paper reviews the artistic and computational background of ambient systems, and presents two case studies of systems developed by our research team, from their initial design to the experiences of the people encountering them. The first case presents a photo mosaic of images based on the news headlines coupled with a structured picture based on the weather; the second presents stylistic perspectives on activity in a public space. Both are evaluated and demonstrate that different forms of aesthetically pleasing displays can convey information to viewers.*

Keywords: *ambient technology, art, case study, public displays, information representation.*

AMBIENT ART: SETTING THE SCENE

In our technologically enhanced modern world it is becoming easier to collect, collate, and represent all sorts of information about our immediate and wider environment, about people, weather, news, and so on. In addition, many approaches exist to visualize this complex, multidimensional information. However, traditional information visualization has not often focused on creating aesthetically pleasing visualizations as a priority: It aims to present abstractions and representations of complex data in a manner that is as easy to understand as possible (Card, Mackinlay, & Shneiderman, 1999), although some beautiful structures have often emerged (Hendley, Drew, Wood, & Beale, 1995). However, most information visualization work assumes that users are paying full attention to the system, not having it exist in the background. Yet people are often in situations in which they want to know only approximately what is happening without having the time or inclination to pay full attention to the details. With ambient art, the focus is not on providing a direct mapping between information and representation, but rather on the creation of a representation of what might

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be termed the "mood" of the information. Ambient art can therefore be defined as artwork that provides representations of complex information in an aesthetically pleasing manner. This information can be about the immediate environment, or remote data, or user data, or a combination of these. One of the goals of ambient art is to produce attractive artwork that is meaningful and useful.

An example of an existing system is the ambient orb (ambient, 2006). This product is essentially a desktop lamp that glows with different colors depending on the state of the information that it is monitoring. On the company's Web site, the example is monitoring the state of the stock market, glowing green if stocks are rising through to yellow, and red if they are falling. This primitive example of an ambient information display does raise some interesting points about the advantages of ambient displays. Ambient's site claims "'People want information, but they don't want to invest a lot of time in getting it,' says Ambient president David Rose. 'This makes getting information a "glanceable" thing.'" (final ¶). The ambient orb is interesting because it quickly and accurately communicates simple information to the user. While Hiroshi Ishii's work at the MIT Media Lab focuses on tangible interfaces (Ishii & Ullmer, 1997), he has developed an installation that uses powered versions of children's windmills to represent the state of the stock exchange, thus giving rise to an overall impressionistic conveyance of complex, multidimensional information streams (Dahley, Wisneski, & Ishii, 1998; Wisneski et al., 1998). He also has incorporated the ambient information into architectural spaces (Ishii et al., 1998) This reflection of information in imprecise but aesthetically pleasing forms is also echoed in Weiser & Brown's (1998) work, which illustrates the activity of a network by animating a hanging string as bits pass by on the ethernet cable.

Related work in this area includes the Hello.wall (Prante et al., 2003; Prante, Stenzel, Röcker, Streitz, & Magerkurth, 2004; Streitz, Magerkurth, Prante, & Röcker, 2005; Streitz, Röcker, et al., 2005), in which information is presented to users via a very large public display that uses lights to create patterns. The display looks pretty to the passing visitor but also has meaning to the initiated. Close-up interaction with the Hello.wall is possible by using hand-held devices that communicate with individual cells in the wall. The Hello.wall provides awareness information, and changes according to the people passing by it, making it an informative artwork that uses a simple representation of light patterns in a 2-D array to communicate its message. Heiner, Hudson, & Tanaka (1999) use air bubbles in a collection of tubes in a similar way, to provide environmental information in an aesthetic, peripheral manner. However, these systems focus on producing abstract representations of information using simple displays, and rely on their peripherality and calm nature (Weiser, 1999) as the keys to their aesthetic benefits. The Kimura system (Macintyre et al., 2001) addresses related problems as it tries to present peripheral information to a user in providing an awareness of background tasks and context. The system splits the user's computer desktop into two parts, a central one that contains their current work, and in the other projects peripheral displays that contain montages of images relating to other recent or ongoing activities. This emphasis on contextual awareness is also considered in the work of Matthews, Dey, Mankoff, Carter, & Rattenbury (2004), with their Peripheral Displays toolkit. This toolkit provides structured support for managing user attention through abstracting raw data, providing notification levels to capture the relative importance of different information, and transitions for updating peripheral displays when necessary.

Our[1] approach attempts to focus more on creating representations that are intrinsically artistic rather than simply pleasing, in line with the Kandinsky system (Fogarty, Forlizzi, & Hudson, 2001). The Kandinksky system provides an artistic template that is matched to a series of images based on ambient information, and it has the primary aim of being artistic and aesthetically pleasing, rather than being informative. Redström, Skog, & Hallnäs (2000) also explore elements of the design space of informative art, which they define as computer augmented, amplified artworks that are aesthetically pleasing and yet still convey information, though most of their works focus on aesthetic presentations of one particular information stream.

WHAT IS ART?

Art explores and expresses our aesthetic relation to our environment and ourselves. However, since the rise of photography, the value ascribed to art's representative power has waned. In its place are explorations of the poetics of each piece, the way in which an object's materiality intervenes in the space (and time) in which it is sited, its authorship, the role of the viewer, and so on. These concerns and the opportunities offered by connected, powerful computers and displays offer themselves uniquely to the development of a new medium, an exploration of the way in which ambient information can be represented in a visual format. We are particularly interested in the use of abstract representations to present background information to people. Abstract art is any art form, be it photography, sculpture, or painting, that partially or completely neglects the true form of the subject (Currier Museum of Art, 2005). The artist may choose to represent an everyday object as a collection of lines, colors, or shapes and, in turn, make it completely unrecognizable. Through the medium of abstract art, the artist is better able to represent his or her true thoughts and feelings rather than create a perfect image of the original subject that lacks any underlying emotion or information. It is this abstraction process that makes abstract art perfect for displaying information to a computer user, which they can then interpret consciously or, ideally, subconsciously.

From an art theory perspective, it could be said that the artist is successful in his or her intervention to the extent that s/he manages to engage the viewer's intuition and allows him or her to experience something new. The viewer creates his or her own qualia of experience in the face of any artwork, that is, how s/he feels about the experience when interacting with it. The temporal nature of ambient information means that one has to consider how pieces work over time as well as in the immediate experience. In the case of the artist, there is a physicality to the process of creation that requires the existence of a corresponding temporal component. A piece such as Richard Long's (1986) "Ten Days Walking and Sleeping on Natural Ground" (a text work depicting a walk Long made in Scotland in 1986) has a temporal component that almost outweighs the conceptual. The work is delivered by a fragile skein of text, but its temporal component is present nonetheless. Jackson Pollock's (ArtCyclopedia, 2007a) process-oriented work provided the starting point for much of the movement towards the focus on the performance element of art. Pollock's paintings are more the residue of the art (his act of making) than the art itself.

Acceptable digital 2-D images with an aesthetic that works are not trivial to produce, and digital art that is responsive, slowly transforming, and evocative is taking artistry firmly into

new media territory. The notion of what works is a nebulous one at best: It seems to describe the extent to which the viewer can find coherence between his or her own (intuitive) response to the work and the cultural "ground" from which s/he approaches it. However, there are a number of theories—based on art theory and concepts, as well as sound psychological principles tapping into known emotional responses to color, shape, order, and chaos—to provide researchers with some guiding principles. This type of work has a precedent in the artistic creations of James Turrell (ArtCyclopedia, 2006), although his work was not digital and its interactive element is linked to the physical movement and physiological response of the viewer rather than a feedback process within the work itself. In addition, the novelty of the artifact initially compensates for its potential artistic weaknesses: It can be interesting to see and interact with, but you may not want one in your home for a few years yet.

One of the motivations for our work is to discover whether it is possible to provide effective ambient information to people who can then absorb it without realizing it (Merikle & Joordens, 1997; Merikle, Smilek, & Eastwood, 2001; Rock, Linnett, Grant, & Mack, 1992). One example of this effect is the sound given off by a modem dialing into an Internet service provider: Users are often able to infer the status of the connection by the tone and nature of the sounds produced, without consciously listening to it. In our work, we want to achieve the same by presenting useful information in an understandable yet often abstract and aesthetically appealing manner. One application, thought of as informative art by its developers, produces on a screen in an office a series of blobs that represent the arrival times of the next few buses. The researchers report that users become rapidly adept at understanding the abstract art, and timing their departure from the office based on the state of the image (Skog, Ljungblad, & Holmquist, 2003). While some general analysis suggests that motion is a strong attention-focusing technique (Maglio & Campbell, 2000), and Mankoff et al. (2003) have provided some revised heuristics for the evaluation of ambient displays, the complexities of the relationships between the familiarities of users with systems, the representations, and how those representations change are not yet fully understood.

In the following sections we discuss two experiences of creating and evaluating ambient art systems. In both systems we were interested in whether one can convey meaningful information in an aesthetic manner, trying to produce pleasing images that are also informative.

NEWS MONTAGE

We decided to develop an abstract representation of current news stories. The reason for deciding on news representation was reached from two different perspectives. First, we undertook a small survey with 10 randomly chosen participants in our building (predominantly computer science students); selected results are shown in Tables 1 and 2.

Clearly, news is a commonly accessed resource, and is accessed for a reasonable amount of time a day. These results are supported by other studies (Beale, 2005; Miller, 2003) that show that users regularly monitor news sites for information.

The second perspective came from informal discussions with users about art and ambient art. We repeatedly heard comments relating to representing the news, such as, "It would be possible to have a news input, this would retrieve headline news, text and pictures over a web feed from a site like BBC news[*sic*]" (Shuster, 2004).

Table 1. Information Sources Consulted by Users.

Which of the following types of information do you check regularly? (mark *any* that apply)

Option	***Number Of Votes***
News (International)	10
News (Local)	9
Weather	6
Email	8
Web site (Please Specify)*	5
Blogs (Please Specify)	2
Other**	1

* Three of the Web sites mentioned were news or newspaper sites, and therefore should have received a vote under news instead. The other two Web sites mentioned were a football team's homepage and eBay.
**The information source mentioned was for stocks and shares in newspapers and on teletext.

Table 2. Temporal Nature of Information Access.

How much time a day to you spend checking the following information?

Option	***Less than 5 Minutes***	***5 to 29 minutes***	***30 to 60 minutes***	***Over 60 minutes***
News (International)	0	2	6	2
News (Local)	1	1	8	0
Weather	3	7	0	0
Email	3	7	0	0
Web site (Please Specify)*	5	0	3	2
Blogs (Please Specify)	8	0	2	0
Other**	9	0	1	0

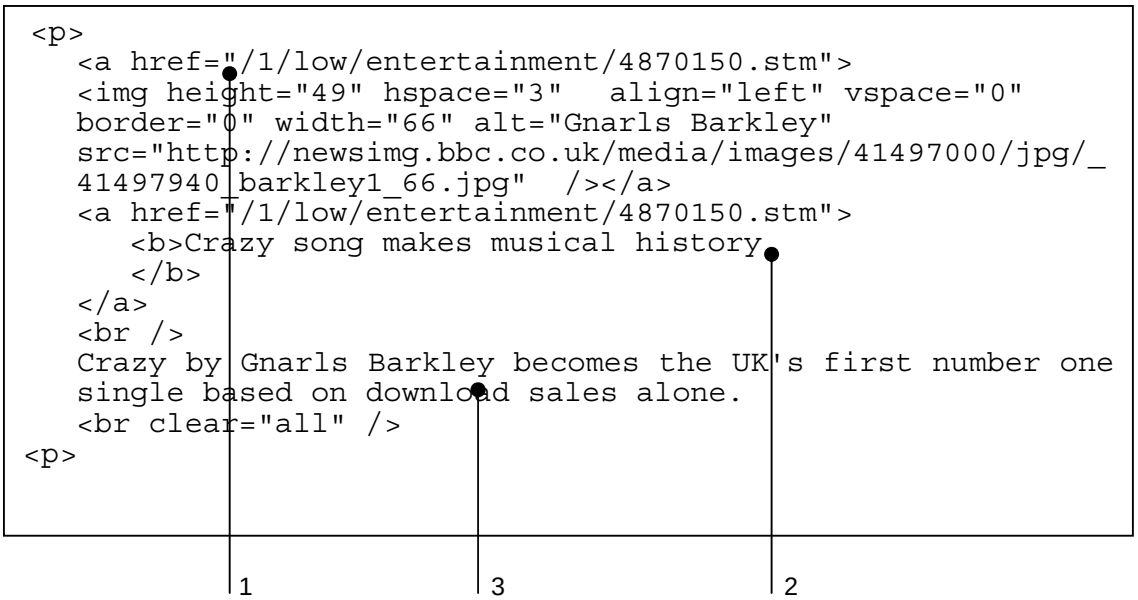
* Three of the Web sites mentioned were news or newspaper sites, and therefore should have received a vote under news instead. The other two Web sites mentioned were a football team's homepage and eBay.
**The information source mentioned was for stocks and shares in newspapers and on teletext.

Design

The fundamental concept was to parse a news site for the main stories, to extract keywords from the headlines and story, and then to produce a montage of photographs to represent that story. The concept was that the photographs would change as the headlines change. To retain the abstraction, we did not want to use news photographs as the images, since these tend to be focused on conveying details of the story itself; instead we used a variety of different images that might capture the emotion and mood of the stories.

News Information

The BBC News Web site provides up-to-the-minute news articles. Using the low graphics version of the site, it is possible to see a list of all the latest stories, the first story being the most recent. This information can be accessed through an RSS reader, or by simply parsing the HTML of the site. Figure 1 shows the HTML code of an example news article.



1. By adding the prefix "http://www.bbc.co.uk/news" to this text, a link to the Web page of this news article is created, in this case; http://www.bbc.co.uk/news/1/low/entertainment/4870150.stm.
2. This is the title of the news article.
3. This is the story of the news article.

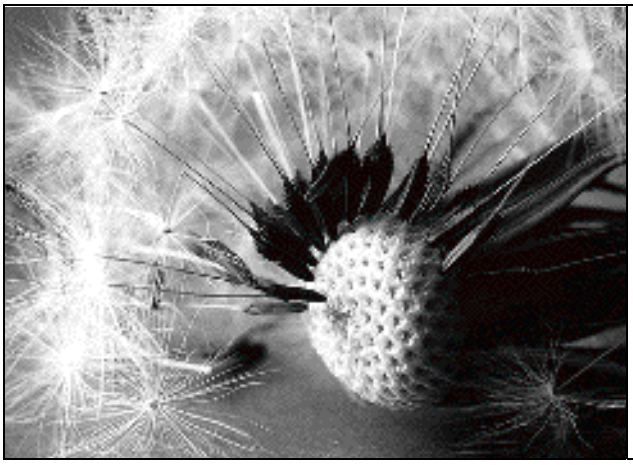
Figure 1. Elements of the BBC Web site to be parsed.

By parsing the title and story, it is possible to identify useful keywords in the text. We extracted the text, removed the common words, and produced a list of interesting keywords using a probabilistic measure (Beale, 2005).

Pre-Existing Images

In order to use pre-existing images, we needed to find a large collection of images that we could use without fear of copyright restrictions. One such collection is the photograph sharing Web site Flickr (Flickr, 2006). Flickr is a Web 2.0 site, which means it puts a strong emphasis on social networking. One advantage of this is the use of Web 2.0 tags. A tag is a text label that is added to multimedia items on the Internet to add extra information to the item. In the case of Flickr, the tags give an insight into the message that is being communicated by the photographer. These tags not only tell us more information about the photograph, such as the location it was taken and some details about the subject matter, but they also give us an insight into the feelings that the photographer felt when they took the picture. For example, consider the image shown in Figure 2.

The tags associated with this photo are provided by the photographer, and there is no restriction on their content. They are presented as an unordered, unnumbered list in Flickr, but here we have clustered them according to various types: 1 presents descriptions of the subject and the subject area; 2 covers emotions associated with the image; 3 describes the aesthetics of the photo; 4 is a descriptive of the image type; 5 provides geographical information; and 6 provides technical details. The evolution of social tagging is a recent phenomenon, and tags



Tags

1. Dandelion; flower; plant; nature; wildlife
2. Death; life; hope
3. Pretty; beautiful
4. Image; closeup; bw; photo; Black and White
5. Great Britain, London; England
6. 2005; Olympus; macro; focus; zoom; upclose

Figure 2. Flickr photograph and selection of associated tags.

tend to combine both personal expressions and the accepted norms of the domain (e.g., the use of "bw" to indicate a black and white photo) that are acquired by observation and use in that domain. Thus Flickr provides a repository of images that are tagged with both descriptive and emotional content. Together, the tags allow access to images that may reflect the mood of the photograph, rather than just trying to present images that directly match descriptive keyword nouns.

The Flickr site has a search page that allows access to photographs by tags alone or by tag, title, and description. We can parse the resulting page as shown in Figure 3.

```
<p class="StreamList">
   <a href="/photos/james_2005/9469994/" title="Death of
a dandelion">
   <img
src="http://static.flickr.com/5/9469994_df9cb70ab5_t.jpg"
width="100"    height="71" alt="Death of a dandelion" /></a>
   <br>
   From <a href="/photos/james_2005/">THX 1981</a>
</p>
```

1 2 3 4

1. By adding "http://www.flickr.com" to this text, a link to the photographer's homepage is created, in this example, http://www.flickr.com/photos/james_2005/9469994/
2. This is the photographer's nickname, THX 1981.
3. This is the location of the image: http://static.flickr.com/5/9469994_df9cb70ab5_t.jpg
4. This is the title of the image, "Death of a dandelion."

Figure 3. Flickr HTML parsing.

System Architecture

The system architecture is shown Figure 4. The headlines are taken from the BBC News Web site, and parsed to produce keywords by the news generator. These keywords are transferred to the Flickr site and used to retrieve the best matching images from that site. Photos are chosen on the basis of their match to the keywords, and their popularity on Flickr; thus the images chosen are the result of a social process of tagging and cross-referencing over which no one individual has specific control and which can change over time. The system was configured to retrieve 10 images for each news story, to cover the range of possible emotions and information within the story and to create a more interesting montage. The News Generator communicated with the Picture Information module in order to retrieve sufficient images, and these images were then passed to the Graphics Generator.

While we envisaged producing a mosaic montage as the most artistic output, we wanted to investigate how well the images were able to actually communicate information to observers. So we provided slightly more structured information for evaluation purposes: The 10 images for each news story were presented on the right-hand side of the screen in two rows of five photos, allowing the ability to cycle through three stories at a time. On the top left-hand side of the screen, larger versions of the images were displayed, as shown in Figure 5.

Each set of 10 thumbnails represented one news article. Since different news articles must be quickly and easily distinguished by the user, alternating sets of images were given slightly different background colors. It was also decided to add extra information to each thumbnail: The user could roll the mouse over the image to view a text description of the keyword that the image represents. We added this in response to comments from the early prototype users who were highly confused regarding what the individual images were. The unfamiliarity of the system made it too difficult for them to simply accept the representations as they appeared. They needed to be able to interact with it to discover a little more about the images before they started to understand how the system produced its results. During this prototype testing stage, it also became apparent that users sometimes wished to be supplied with more information than simply the images relating to a news article. We decided that, to increase the acceptability of the system, the user should be able to view more information

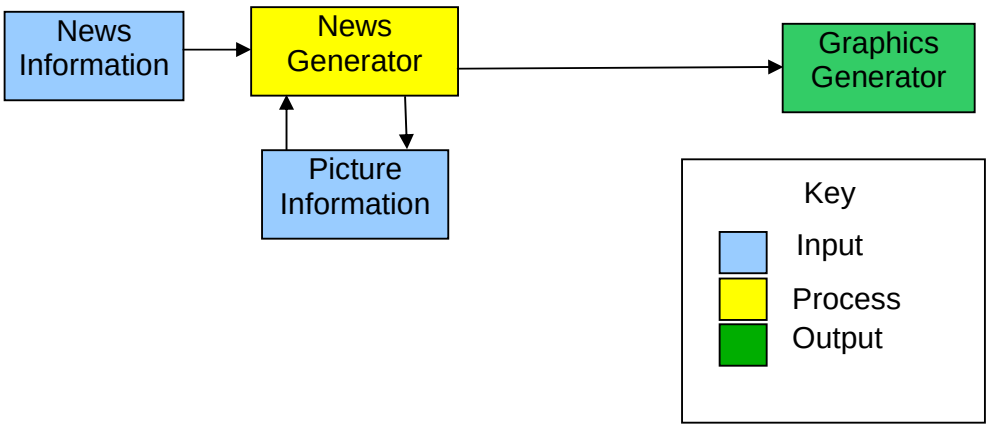


Figure 4. The overall system architecture for news headline art system.

Figure 5. The evaluation version of the news information display[2].

about the story. Therefore if the user clicked the Show button, the system launched a Web browser and navigated to the Web page of the story. Users accessed this function when they were first exposed to the system, allowing them to develop an understanding of the images, but it was used less as time went by.

Further evaluation highlighted that the users sometimes wished to be supplied with more information about the images that were presented. Therefore we included the title and photographer of the selected picture on the screen. Clicking this link navigated them to the photograph's Flickr entry in a browser.

Presenting Weather Information

We also experimented with presenting weather information to the users on the same system by constructing images from basic elements, much like the existing symbolic weather charts. This work bears some resemblance to the InfoCanvas (Miller, 2003; Miller & Stasko, 2001), in which a structured template for artwork was parameterized and populated with images that gave an overall perspective on information, a work subsequently evaluated by (Plaue, Miller, & Stasko, 2004). An example of the symbols used in our project is shown in Figure 6.

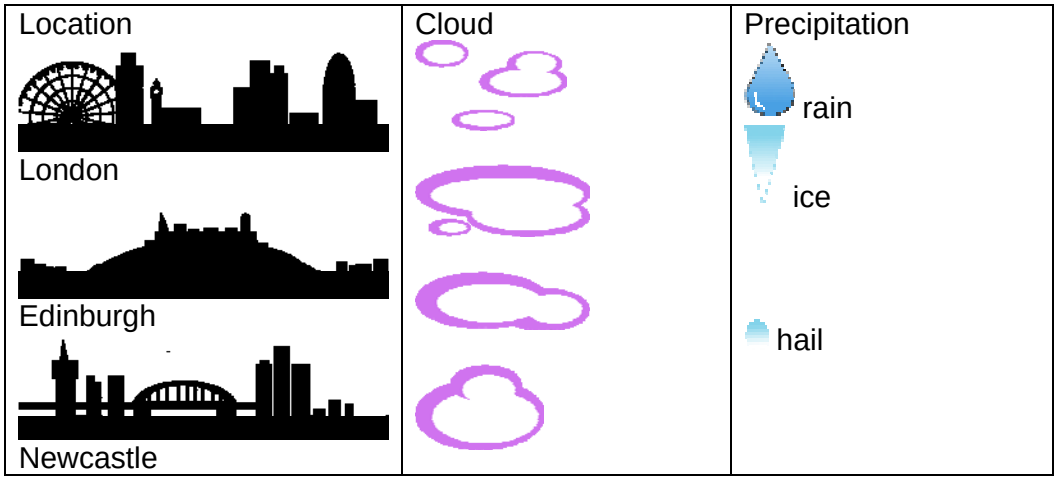


Figure 6. Weather symbols.

The image background was colored appropriately for the time of day, with the appropriate weather elements added to produce images as shown in Figure 7. The data for this was extracted from the METAR Data Access on the U.S. National Weather Service Web site (U.S. Department of Commerce, 2004) on May 12, 2006. Weather information is collected by every airport in the world and published on the Web site every 30 minutes. The information is complex, but is efficiently stored as a single line of text, which can be broken into the sections presented in Table 3.

Figure 7. Weather view: early evening in Birmingham, with localized altostratus (mid-level clouds), no precipitation.

Table 3. Sample METAR Data.

ID	TIME	WIND	VIS	WEATHER	SKY	T/DP	ALT	REMARK
EGBB	311850Z	1902G26KT	9999	-SHRA	BKN070	12/08	Q1011	RMK A02

Data retrieved May 12, 2006.

The ID is the identification of the airport at which the weather reading was taken. In this case, EG indicates England and BB indicates Birmingham International Airport. The TIME is the time and date at which the current reading was taken. Readings are taken approximately every 30 minutes, but the information may not be updated if there is no notable difference since the previous reading. The 31 is the day of the month, 18 is the hour of the day, 50 is the number of minutes past the hour and Z indicates the time code that is being used (ZULU or Universal Time Code). The WIND holds information about the wind speed and direction. In this example, 210 is the direction of the wind as a compass bearing between 000 and 360; 11 is the average wind speed; G indicates that there are gusts and 26 is the average gust speed; and KT shows that all speeds are in Knots and indicates the end of the information. VIS holds information about the visible distance in kilometers; 9999 indicates that there are no obscurities, such as fog or smoke. WEATHER holds information about the current weather conditions and obscurations. In this example, the minus symbol (-) indicates light or moderate precipitation, SH represents showers, and RA represents rain. SKY holds information about the clouds above the airport at which the measurements are being taken. BKN represents broken clouds, and 070 represents their height, 7000 feet. T/DP holds information about the current temperature and dew point. Dew point is a measurement of how much moisture is in the air. Both values are in degrees Celsius. ALT holds information about air pressure, in this example it is 1011 hectopascals (hPA). REMARK simply contains information about the weather station.

We parsed this using the same systems architecture as for the news, and presented a simplified picture of the current situation, superimposing the symbols on a stylized image of the location's skyline. The aesthetics of the image are therefore much more predetermined, with the informative content adjusting the presence and positioning of elements in the picture.

Evaluation

Evaluating these systems posed many interesting questions. As informative visualizations, their understandability and expressive power may be important; as pieces of art, these measures are irrelevant because critical analysis and engagement may be key. These systems sit somewhere between the categories of information and of art, and so offer different challenges (Redström et al., 2000). This is also reflected in Mankoff et al.'s (2003) revised heuristic evaluation techniques for ambient art. The aim of any evaluation has to be to gain knowledge about a certain domain, and in our evaluation we focused on users' self-reported perceptions of the system, reflecting their feelings about both its usefulness in conveying information and as a piece of artwork. One key principle for this study was that we wanted to understand their reactions once they had been exposed to the system for a period of time: We were not interested in its immediate understandability or first-glance reaction since we envisaged these systems being used for extended periods of time, existing on the periphery of attention yet being an integral part of the users' everyday environment. Ten users (computer science undergraduate and graduate students, randomly chosen males and females from a variety of cultural backgrounds) were allowed to explore the system for a week.

The system was running continually when the users were at their computers, providing an always-accessible display, which they were at liberty to interact with, or not, as they chose. Participants were, during the study, engaged in quite intensive computing work, and so

were exposed to the system for numerous hours per day. At the end of this time, they were presented with an open-ended questionnaire and their experiences in using the system were examined. A longitudinal study was necessary so that the users could become familiar with the system and begin to learn how the photographs were being selected and presented by the system and so that they could build up a mental model of the sorts of relationships between the information presented and the news items. This was assisted through providing limited interaction possibilities, to either view the news story in detail or to find out more about the photographs that appeared. We did not want users to learn the relationships between particular images and keywords, but instead to begin to pick up on the emotional and aesthetic content of the images, to relate those to the tone of news stories. As with the process of social tagging, we would expect some period of familiarization with the existing tags, images, and social protocols was required before these relationships became better understood.

News System

On a 5-point Likert scale (e.g., Very Good, Good, Average, Bad, Very Bad), users rated the aesthetics of the artwork, with 7 users giving Very Good and 3 Good. Comments made on the questionnaire supported this: "*I saw some really stunning photographs*," and "*Some of the photographs are really beautiful, while others are a little bit strange….*"

In terms of their comprehension, 7 users found it Average, 2 Hard, and 1 Very Hard to understand the news artwork. However, we can see from their comments that, although initially the system was difficult to understand, they started to learn what it represented "*At first I couldn't understand any of the pictures or what they were meant to symbolise, but then when I looked at the keywords* [by hovering over the thumbnail] *I see the relationship*"; "*Over time I came to recognise certain pictures and remember the keywords that are associated with that picture*"; and "*Although I understand that the pictures represent words from the news, I can rarely understand the news without using viewing* [sic] *the keyword*."

The results of these questions show partial success in the use of related photographs in creating an impression to communicate information. Impressions are conveyed, but not detailed information, and it takes time for the users to become used to the system and to start to understand the representations used.

Weather System

Aesthetically, this fared less well than the news system. When asked to rate the aesthetics of the artwork, 2 users responded Very Good, 7 Good, and one Average. One user commented, "*It's not as pretty as some of the photographs that are generated, but it does the job*."

In terms of comprehension, 3 found it Very Easy, 6 Easy, and 1 Average. One user sums up the system with a comment on how easy it was to understand the weather information, "*Very easy*,[sic] *it's not as aesthetically pleasing as the news, but you can instantly see what the weather is like outside.*" This was echoed by another, "*All you have to do is look at the screen and you can see if it's raining outside*." Another stated, "*It works, but it's not as detailed as the weather that you see on the television*," reflecting a perspective that the system was principally about communicating information, rather than being viewed primarily as an artwork with the information being of secondary importance.

Aesthetics Versus Information Comprehension

Ninety percent of our users claimed that the weather artwork was easy to understand; unfortunately 30% of the users also claimed that the news artwork was hard to understand. This comes as no surprise, as the weather artwork does provide a more direct mapping between artwork and information. However many users claimed that, over time, they did begin to understand the way in which the pictures were associated with the news keywords, and even began to learn what individual pictures represented. One example of this is shown in Figure 8 (Linny, 2005).

A number of users noticed that that this brightly colored duck was a common feature in the news. They also soon learned that it represented the keyword "UK." Therefore any story that showed this picture was obviously about the United Kingdom. Although this outcome was only achieved through a certain number of exposures to the system, the users all agreed that they had not actively sought to learn the meaning of this picture within the context of the system. A number of users also came to recognize those pictures that represented other common words in the news, such as *war* or *president*.

One user commented, **"***I can definitely see the potential of scanning over a few pictures to see if there is anything that interests you going on, then going to the website for more information*," suggesting that the system provides a rapid overview of the news, though this perspective wasn't universal. Another user, who had particular trouble deciphering the news articles, asked why we didn't simply collect pictures from the BBC news site, therefore creating a more accurate depiction of the news: "*Maybe it's just me, but I don't understand the pictures well enough for this to be a useful way of reading the news, maybe if the pictures were more relevant,* [sic] *why didn't you just get the pictures from the BBC website?*"
This comment provoked a serious conversation among the users and researchers during a debrief session about what differentiated artwork from visual information. However, the photography that is presented on the BBC Web site has an emphasis on information, even if it means that the picture itself is not particularly pleasing to the eye. In contrast, our approach focused more on capturing the mood and sentiment in the original subject in order to create a more aesthetically pleasing artwork. It appears from the results of the questionnaire that different users may be susceptible to varying degrees of abstraction, some preferring artwork, while others prefer simple information, such as presented in the weather system.

Figure 8. The Flickr photograph, titled "Mandarin duck in full color," was regularly returned from Flickr as the best match to the keyword UK, based on its Flickr tags and popularity.
Photo © Linda Bingham[3]. Used with permission.

Interestingly, one user compared the system to Makaton, a very simple version of British Sign Language, which the user happens to teach. According to the Makaton website, "Signs are often pictorial and convey the meaning more easily than words, which are more abstract" (Makaton, 2006, ¶4). The user expressed interest in the system and saw the benefits that it would provide for the deaf and dyslexic children that she teaches. This potential use was not originally anticipated, but it is possible that representing information as pictures may have a valuable use in education, aiding disabled users or those who cannot read English.

The images used to represent the latest news headlines were almost exclusively photographs, and they often had a very abstract relationship compared to the article that they represented, whereas the artwork that was created to represent the current weather was more obvious. The weather information lent itself towards more natural artwork; for example, if the weather is cloudy, clouds are shown on screen. The reaction to the weather artwork was more positive from an information sense, as all users were able to quickly interpret it and use the information that they had obtained. However, there was a lot of praise for the aesthetics of the news displays as well. A number of users have continued to use the program after the testing phase finished; they have reported that their knowledge of the meanings of recurring images has improved and therefore it has become easier to interpret the information.

REPRESENTING ACTIVITY

For the second experiment, we created a variant of the system to work with video input, processing the video and transforming it directly into abstractions that became the artwork. The principles behind the system remain the same; however the sensor data are combined and used to create a display that alters with respect to changes in the data streams it receives.

The experiment took place in a foyer of the Computer Science building at the University of Birmingham, UK. We used simple image processing algorithms on video images to track the movement of people around the foyer. An overhead camera captured images of people moving around, showing the people crossing the scene from one side to the other as they moved between rooms or labs, or moving from top to bottom or vice versa, as they entered or left the building, as in Figure 9 (top left). A simple image-tracking algorithm captured these movements (top right). One version of the art server created ghost-like figures that moved across the screen, corresponding to people in the foyer (bottom right). While these images are aesthetically pleasing, they also are very concrete and require attention to discern what is happening.

Extending this approach to produce more abstract art, the tracking output was transformed into either horizontal or vertical lines, based on the average movement of the person. The track of the user was reduced to a single horizontal or vertical line that best approximated their track across the foyer. The midpoint of the persons image from each snapshot was calculated, and the line chosen such that the sum of the absolute distances from each image's midpoint to this line was minimized. These lines were used to create an abstract image, inspired by Mondrian (Artcyclopedia 2007b), in which a rectangular canvas was split by these lines and colored in primary colors. We chose Mondrian since his geometric artistic style has clear parallels with the regular patterns developed in our representation. These images created a correspondence between the movement trails across or through the foyer and the dividing lines in the picture. The image therefore represented the current and recent

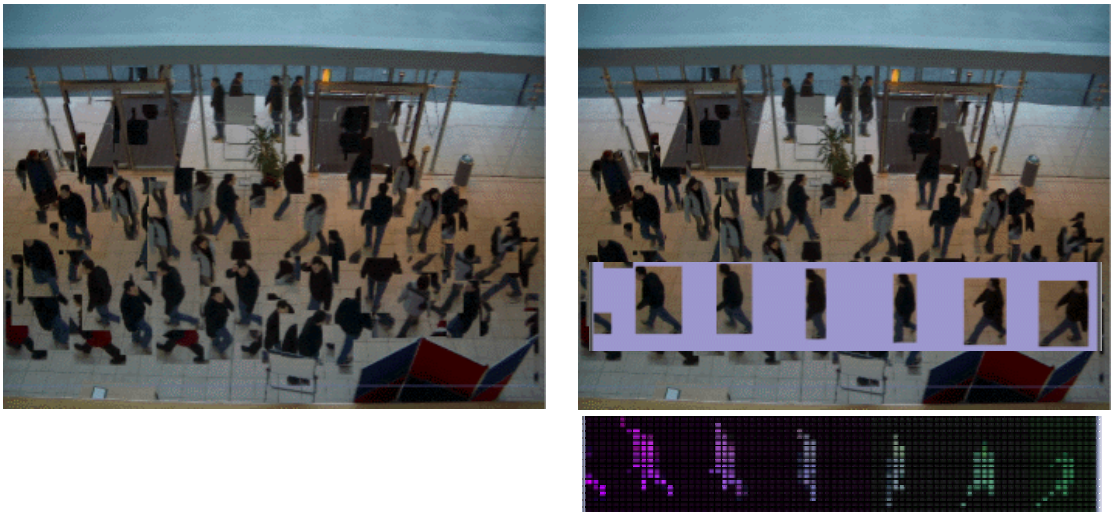


Figure 9. (top left) The video camera view of a foyer, composited with snapshots of activity; (top right) A tracking algorithm identifying the same person crossing the scene; (bottom right) Temporal ghost output created from the tracked figure.

activity in the foyer: If few people passed by, then very few lines split the picture and it is simple, whereas if the space was busy, then the image is much more segmented too. We did not try to capture the regularity and balance of Mondrian's images, but chose to map the lines into a slightly more meaningful concept (in a representational sense), and then use color to hint at the Mondrian style. The positions of the lines corresponded to the paths taken by the people moving through the foyer, mapped into the horizontal for those crossing the space and vertical for those entering or leaving the building. Images from a placid foyer, with few lines, reflect quite typical Mondrian images, which is less true for images from a busier space. A typical busy image is shown in Figure 10.

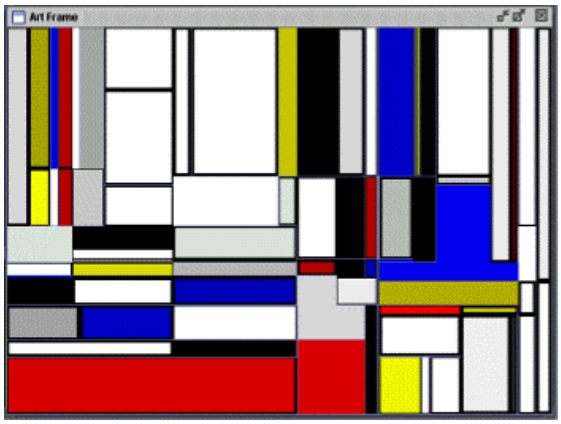


Figure 10. Foyer activity represented in a Mondrian-inspired image. Each horizontal line represents a user crossing from left to right or right to left, whilst each vertical line corresponds to a user moving into or out of the building. The cluster of vertical lines on the top left of the image show that more users entered or exited the building around that area than others. Most of the horizontal lines are around the middle third of the image, which shows that most people cross the foyer in the middle.

We evaluated the system over the course of several weeks, using it to demonstrate the technology and concepts to prospective students and parents on open days (days in which the University invites visitors to explore its facilities), and had it running during other periods of time for current students and staff. During the open day, visitors encountered the artwork as they entered the foyer at the start of the day. The artwork was active during their initial coffee and introductory session, and also during the buffet lunch. Visitors attended lectures, tours, and other demonstrations on campus, thereby entering and leaving the foyer three or four times during their time with us. They were given a direct demonstration of the concept after lunch and saw how the images develop over time as more people move around the foyer.

The image was projected onto a white wall around the side of the foyer, or, on another occasion, onto a screen, sized between 2m and 3m across, placed on the floor towards one wall. Evaluation of the system by the prospective students and their parents was informal, consisting of discussions with them about their experiences of the open day in general and the demonstrations they had experienced, of which the ambient art was just one. Approximately 50 people, from a mixture of backgrounds and usually with some interest in computer science, contributed comments to these discussions. They revealed that they found the art interesting and engaging, but that it lacked the aesthetic pleasure that the carefully constructed ratios of the Mondrian images have, and so was not overly pleasant to look at for any period of time.

However, particularly for those people manning the demonstrations, and for staff exposed to the images for longer periods of time, they found that they were able to tell immediately how busy the foyer was, and whether people had recently moved within the building, or had entered or left it. They found that they could interpret general information from the display without actually having to pay it explicit attention. However, this is not to say that these users were completely inattentive, but it reflects that they did not consciously have to examine the image to gain the information they needed.

CONCLUSIONS

In reviewing the concept for abstract aesthetic representations of information, one question that remains open is whether these representations are actually art at all. Some would argue that the aesthetic presentation of information is not sufficient to be called art; others may disagree. We believe that art needs to engage the user's intuition, and that it should allow a person to experience something new. Both of the systems described in this paper achieved this, but in significantly different ways. And certainly this question regarding what constitutes art has been raised not only regarding these systems: Much nonrepresentational artwork is subjected to the same inquiry.

Our studies looked only at the self-reported reactions of users to both the information content and their aesthetic response to the images, since our focus was on exploring the feasibility of creating systems that are primarily artwork, and only secondarily information presentation systems. Clearly, these perspectives limit the conclusions that can be drawn from the studies, and further work is needed to quantify the relationships between information transmission, peripheral attention, and aesthetic presentations.

Our experiences with ambient art demonstrated that it is possible to achieve pleasing representations that reflect ambient information. Users are more easily able to determine the underlying information when a more direct representation (weather images or ghosts walking) is used. Yet, the more abstract, and potentially more "artistic," images are also able to convey information. It also appears that the more indirect representations can provide the more aesthetically pleasing images. In these indirect systems (the news montage and the Mondrian images), the information conveyed was not so directly related to the underlying data streams: It did not attempt to provide an accurate presentation of complex data, but instead appeared to appropriately present an overall mood or impression. When considering ambient art for long-term interactions with such systems, we believe that high aesthetic quality and a broad overview of the underlying information is much more useful to the viewer than more detail in a less appealing representation, as is the ability not to require too much explicit attention. However, it is clear that many users will want to interact with their ambient art, allowing it to provide them with a general impression of the current underlying state of things (whether that be the weather outside, the foyer inside, or the world in general) and then be able to focus in when they become aware of things of interest. It also seems that interaction is important in the initial stages, as the users explore the relationship between the representations and the underlying data, especially in situations such as the news representations that are quite complex. This interaction is important in allowing them to develop an understanding of the system and how it works.

The time scales for the information we are now able to access digitally are widely varied, from the immediacy of current work tasks, the morning's weather, or the day's news, to the longer trends in stock markets, to the very long term, such as the state of a pension fund. These sources need to transmit information to us at differing rates: Knowing when the next bus is due is much more time critical than the overall performance of our investments. While time-critical information can be reflected in the ambient art systems, it requires more direct attention to notice the more rapidly altering information. Requiring less direct attention are the more abstract representations, which also tended to be viewed as more artistic and aesthetically pleasing, but were also were perceived to be less informative. It therefore seems that the rate of change of ambient and peripheral information will be a critical factor in determining the types of display to use. In the systems studied here, we found that longer time-scale phenomena tended to be better received when represented more abstractly, while shorter time-scale and more detailed ones were better when more directly interpretable. As the quantity of information available digitally increases—from, for example, local and remote environment information; the location, activities and moods of our friends; and the status of our many projects and activities—there is a clear need to find the means to represent these varying time scales, these differing levels of detail, to users in ways that go beyond immediate visualization and comprehension.

All of the systems reported here—the news montage, the weather picture, the activity in Mondrian style—are representations of public, nonpersonal information. The first two systems run locally on a user's PC, while the latter one was projected within a public space. On the PC, individual users could delve into the news in more detail, allowing them to follow items of personal interest. However, the public nature of the information allows it to be easily presented to a potentially wider, more diverse audience than could be done ethically with personal details. The issues of privacy and ambient displays have been addressed in different

ways: With the Hello.wall (Prante et al., 2003), users have to be physically proximal to the wall before they can access any more personal information, while InfoCanvas (Miller & Stasko, 2001) uses specific user-defined mappings known only to that user to achieve the relationship between the information and its representation. The issues of displaying private information has not been addressed in this article, but the longer time scales required to become aware of the meanings of information in abstract displays opens up an alternative approach to the personal choices used in InfoCanvas. Since the personal nature of the relationship between the information and the ambient presentation is not obvious to those other than the information owner, and requires long exposure to the display in order to be able to interpret it successfully, the individual user can guide the system towards presenting his or her more personal information in a manner deemed aesthetically pleasing while protecting his or her privacy.

Long-term interaction with such systems may well become very common in the information-rich future. Even today, our attention is ever more divided. Computer systems will be more effective if they can guide us towards monitoring and acting on only that which requires our intervention, while soothing, entertaining and enhancing our environment the rest of the time. We have demonstrated that ambient art can effectively contribute towards this wider goal, though the details of how this is best achieved are only just starting to be addressed.

ENDNOTES

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2. Photographs used within the Creative Commons License. For more information, see http://flickr.com/creativecommons
3. See at http://www.flickr.com/photos/linny/

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