

Informative Art Display Metaphors

Alois Ferscha

Institut für Pervasive Computing
Johannes Kepler Universität Linz
Altenberger Strasse 69, 4040 Linz, Austria
ferscha@soft.uni-linz.ac.at

Abstract. Informative Art display systems have been proposed to provide users with information considered relevant at arbitrary points of work or living engagement, originating from many different –mostly geographically dislocated– sources and presented at the periphery of human (visual) perception. Having the displays operate at the periphery of a user's attention allows other user tasks to sustain primary. Much like the information presented by wallclocks, posters, paintings or windows, peripheral displays move to the center of attention only when appropriate and desirable. Abstract art has been proposed to serve as the visualization paradigm, encoding information into graphical or pictorial artwork by subtly modifying its shape, color and appearance details or its overall impression. This paper approaches a systematic elaboration of visual metaphors able to deliver information via peripheral displays in an aesthetic, artful way. In our approach, the choice of metaphors is driven by the aesthetic appeal of the visual appearance of the display as a whole, out of which certain dynamic emblems or symbols are used to conotate information in a visual style. From experiments we find, that such metaphors are considered by users as a means of personal emotional expression, and that controllable aesthetic attractiveness turns out to be the dominant factor of display appreciation. The choice of aesthetic themes, as well as the control of emblem and symbol dynamics are supported and implemented in our *peripheral display framework*, a general purpose software framework for informative art display systems.

Keywords: pervasive display systems, informative art, peripheral displays, ambient intelligence, intelligent user interfaces

1 Hidden in Artwork

“The rate at which computers disappear will be matched by the rate at which information technology will increasingly permeate our environment and determine our lives” [23]. As an example from the current Pervasive and Ubiquitous Computing literature, the above to the point statement reflects an observation, that computing devices are continuing to pervade into everyday objects in such a way, that users do not notice them anymore as separate entities. Appliances, tools, clothing, accessories, furniture, rooms, machinery, cars, buildings, roads, cities, even whole agricultural landscapes increasingly embody miniaturized and wireless, thus invisible information and communication systems. Information technology rich systems and spaces are

being created radically changing the style of how we perceive, create, think, interact, behave and socialize as human beings, but also how we learn, work, cultivate, live, cure, age as individuals or in societal settings. A major issue in such technology rich settings is how we perceive information, how we interact with digital media, how we manage to sustain attentive to information of interest, how we stay aware of the dynamics and changes of information, or how we manage perceptual complexity and information overload.

Peripheral displays were proposed to provide users with information considered relevant at arbitrary points of work or living engagement, originating from many different –mostly geographically dislocated– sources, and presented at the periphery of human (visual) perception [12]. Having the displays operate in the periphery of a user's awareness allows other user tasks to sustain primary [8] [13]. Much like the information presented by clocks, posters, paintings or windows, peripheral displays move to the center of attention only when appropriate and desirable. Computational counterparts of such displays have been designed to support for group awareness in work groups in virtual [5] [6] [7] or in physical [20] [22] [23] [24] space settings, for knowledge dissemination in enterprises [17], for users of instant messaging systems [2][3], for deaf users [9], to keep in touch with family members [19], or to display a cities health information in public places [1] – to name a few. Metaphorically, abstract art has been proposed to serve as the visualization paradigm for contextual information [21], design principles and guidelines have been developed [11] [14], upon which software frameworks and development toolkits [15] [16] have been built. Evaluation guidelines have been developed [11][14] and assessment studies have been conducted, e.g. relating comprehension of peripheral displays (i.e. how well a user understands and uses such artifacts) to the time span of their use [10].

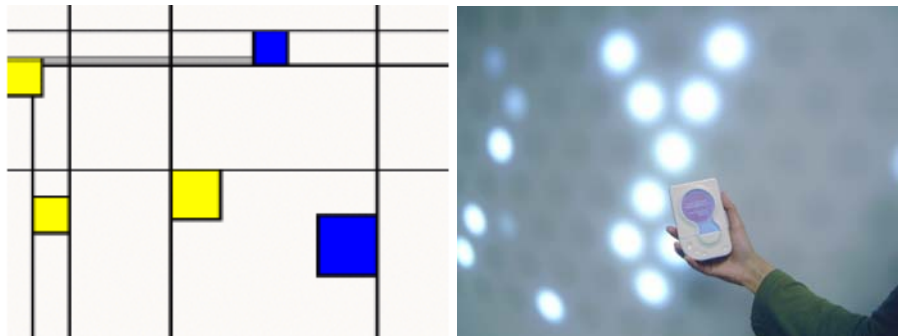


Fig. 2. Abstract Informative Art [21] (*left*), inspired by Mondrian, in real time shows the expected weather situation or urban bus traffic situation; The Hello.Wall [24] (*right*) displays abstract aesthetic patterns of mood or presence in work teams, and provides interaction patterns for personalized or group related communication among remote team members.



Fig. 3. Figural Informative Art like in People Garden [27], shows user activities in terms of message densities from posting onto a message board (*left*); InfoCanvas [18] (*right*) displays multiple sources of information ranging from NASDAQ Composite Index to the number of employees present at work in real time in a beach scene.

Informative Art [25] displays particularly addressing (i) the *cultural context* within which information is being displayed, (ii) the *aesthetic appeal* exploited to address personal emotional expression, and (iii) the *continuity of comprehension*, so as to deliver information free of disruption caused by abrupt changes in the visual appearance of color, light, smoothness, shininess, brightness, etc. have been studied in [5]. A software framework, the *peripheral displays framework* has been developed, that covers the path from collecting potential awareness data from sensors, to the discovery of meaning in that data, the distribution of awareness information according to publish subscribe principles and restraining it with respect to the preservation of personal interests. The so obtained awareness genotypes in the categories environment, artefact and person are then mapped to artwork phenotypes respecting cultural background, preference wrt. aesthetic appearance, and personal settings. A control engine finally steers the dynamics of the physical awareness display. A typical artwork theme of this framework is shown in Figure 4, based on a “Stilleben” by Jan David de Heem, a dutch painter in the early 17th century.



Fig. 4. Aesthetic awareness display based on “Stilleben” by Jan David de Heem with mappings of e.g. weather conditions, plant watering, garage monitoring, etc. [5].

2 Informative Art Displays

Computer displays delivering information of interest to the periphery of attention of a user, or making users aware of the remote presence of other users or their circumstances have been studied extensively in the context of Informative Art [26] [27]. The issues of designing such display systems have been outlined as of critical importance [25] in order to improve on awareness, i.e. the understanding of the activities and contextual situation of other users or entities, as well as on connectedness, i.e. the “positive emotional appraisal which is characterized by a feeling of staying in touch within ongoing social relationships”. Particularly to support the issue of distraction free perceivability of awareness displays we have developed design criteria and the corresponding framework architecture components, which we summarize as follows:

- (i) *Cultural Background*: Cultural background and understanding to a high degree determines individual appreciation of visual designs and the aesthetic appeal of artwork. Our framework for awareness displays offers a choice of artwork metaphors relating to the cultural context of its use, which we call “*themes*”, i.e. pre-defined, visually coherent images with the potential of informative connotation of the contained emblems and symbols. Our framework particularly supports original fine arts paintings (as an example see Fig. 4).
- (ii) *Aesthetic Appeal*: To provide means for a personal emotional expression our framework allows to modify the appearance of color, light, smoothness, shininess, etc. in themes by means of “emotional skins”. Controllable aesthetic attractiveness has turned out to be the dominant factor of display appreciation.
- (iii) *Environmental Context*: The aesthetic appreciation of a piece of artwork is always based on its context of exposure. Different settings of exhibit (like e.g. living room, office, public cafeteria, etc.) conceivably raise different levels of comfort with one and the same display theme. Our framework supports adaptation of themes at run-time, so as to satisfy the respective environmental requirements
- (iv) *Comprehension and Continuity*: From prototypical installations we have learned that spontaneous changes of the modes of display or the displayed emblems or symbols, severely disrupts the continuity of comprehension. To minimize distraction generated by the occurrence of status changes, very soft blending and smoothing techniques have to be deployed to the visuals and graphics. Updates in information must be encoded in subtle changes of the respective visuals.
- (v) *Periphery of Perception*: A critical affordance of Informative Art displays happens to be unobtrusiveness with respect to the primary task of the user, i.e. the display must not draw the focus of the users attention (by e.g. alerting), but stay calm in the background. The flow from the periphery to the focus of the users attention (and back) should be user controlled.

The way how a certain theme metaphor is chosen to serve a particular purpose (like awareness, connectedness, etc.) with a particular contextual relevance, and appropriate level of perceivability of the display elements (theme, symbol) follows a user-centered design approach: While the theme is allowed to be chosen by the user, the symbols are derived as the result of a metaphor driven structured design process.

2.2 Themes, Symbols and Connotations

There are no general rules steering the process of finding display elements in an Informative Art display, because they are highly dependent to the individual aesthetic appreciation of a user. In our framework we hence build on a characterization of the users preferences based on the individual ranking of personal aesthetic appeal coming from color, space, shape, level of abstraction, dimension and orientation. This is being deduced from Fine Art paintings, which are at the same time potential candidates for *themes* in the Informative Art display. A *theme* in our software framework is a visually coherent pictorial presentation like an artistic drawing or painting, a photograph, a technical illustration, a computer generated 3D scene, etc., with a certain aesthetic appeal and with the potential of an informative connotation of the contained emblems and symbols. Fig. 4 shows a theme borrowed from Still Life art, where typically inanimate (“dead”) subject matter of commonplace objects like natural fruits, or flowers, or objects of everyday use like drinking glasses, bottles, books, musical instruments etc. are depicted with colorful, highly detailed optical realism. We call the latter *symbols* or *emblems*, since –much like the intended (!) disguised symbolism in the artwork of the Netherlands in the 17th century– their props and setting represent carriers of connotated information delivering the overall “message”. *Symbols* are the active components of an iconographic program executing in a pictorial *theme*. Further *themes* with comparably more or less detailed realism, and hidden symbols can be found in Fig. 6 – 8.

As for the design of Informative Art displays, both the themes and *emblems/symbols* should be chosen metaphorically, so as to meet the intuition of the user with respect to the connotation. Much like a metaphor in language (“*a metaphor casts a first subject as being or equal to a second subject in some way*”, wikipedia.org) the *metaphor* of the *symbols* in a theme should ease to perceive the connotated information. On the other hand, when developing symbolic connotations, metaphoric symbols can be intuitively perceived (and economically described), because implicit and explicit attributes of the symbol can be used to enhance the description of the “message” to be delivered with the Informative Art display. Furthermore, aesthetic appreciation is another design constraint.

2.3 Metaphors

The main concern in our *theme* based Informative Art design approach is the choice of a *theme* which (i) meets the aesthetic appreciation of the user, and (ii) at the same time provides sufficient degree of metaphoric freedom within the contained *symbols*, to be able to encode the information to be delivered with the display. Previous work [21][23][26] has rather followed a creative artistic approach to design *themes* and *symbols*, and present the result, “as is”, to the user (see Table 1). We propose to involve the user already at the time of *theme* choice, and then in a structured way encode information into *symbols* contained in that chosen *theme*. As a consequence, our Informative Art software framework allows the user to even change or reconfigure *themes* at runtime (see Fig. 5).

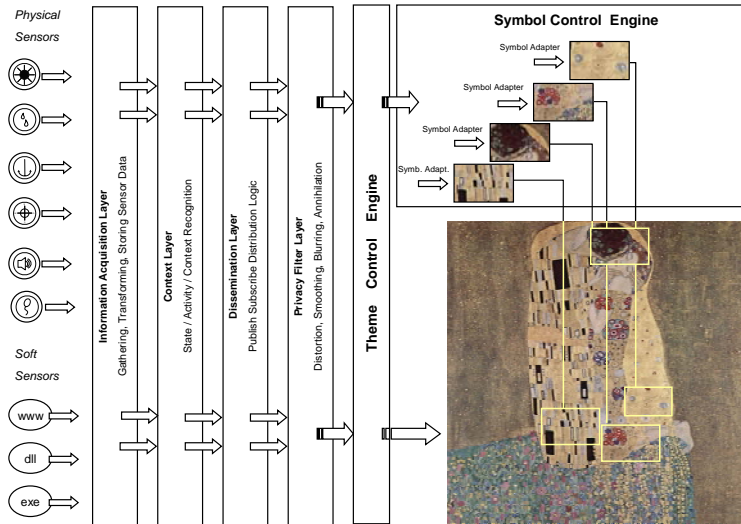


Fig. 5. Our Informative Art display framework collects information of interest via hardware or software sensors (Acquisition Layer), identifies the context (Context Layer), distributes context information according to a publish subscribe principle (Dissemination Layer) and restrains it with respect to privacy policies (Privacy Filtering Layer). The *theme* control engines generates the visual appearance from the chosen *theme*, the *symbol* control engine encodes information into symbol visuals (not necessarily rectangular), which are overlayed into the *theme*.

	Theme	Symbol	Connotation
Mondrian Informative Art [21]			<p>"two regular buses" "blue is shuttlebus" "red is shuttlebus"</p> <p><small>Pictures taken from http://www.dgp.utoronto.ca/~raviv/courses/csc2524/skog.pdf</small></p>
People Garden [27]			<p>"group with a dominating voice" "democratic group"</p> <p><small>Pictures taken from http://smg.media.mit.edu/papers/Xiong/pgarden_uist99.pdf</small></p>
Hello.Wall [24]			<p>Presence of team members:</p> <p>"few" "some" "many"</p> <p><small>Pictures taken from http://mc.informatik.uni-hamburg.de/konferenzbaende/mc2005/konferenzband/muc2005_10_streit_z_etal.pdf</small></p>
Aesthetic Awareness Display [5]			<p>"Teresa and Alessandro at home" "Amelie, Teresa and Alessandro ..."</p> <p><small>Pictures taken from http://www.pervasive2006.org/ap/pervasive2006_adjunct_3A.pdf</small></p>

Table 1. Previous work in Informative Art analysed wrt *Themes*, *Symbols* and *Connotations*.

The first step towards a pictorial Informative Art display is to select a *theme* according to the users appreciation. This choice should not be influenced or affected by any constraints rooted in design, implementation or technology. Once a choice has been made (Fig. 6 – 8 could be considered as potential candidates for *themes*), a *theme* analysis is conducted so as to reveal appropriate symbols and metaphors. In order to steer this process, we have developed guidelines for identifying metaphors in *themes* and *symbols* along (i) *color*, (ii) *space*, (iii) *shape*, (iv) *abstraction*, (v) *dimension* and (vi) *orientation*. We discuss them based on sample themes (Fig. 6 – 8).

Intuitive categories of metaphor are the (i) *metaphor of color* and (ii), the *metaphor of space*. An example of a *theme* illustrating in very impressive way combinations of ranges of color and scales of space is given in Fig. 6.



Fig. 6. Caspar David Friedrich (1774-1840), Das Eismeer (The Arctic Sea) – “Die gescheiterte Hoffnung”, (1823/24), oil on canvas, 96,7x126,9 cm, Hamburger Kunsthalle, <http://www.hamburger-kunsthalle.de> (left), and a set of symbol candidates (right) – referred to by (a) upper left, (b) upper right, (c) lower left, and (d) lower right.

Foreground-, background- and object-*color* variations (over the whole spectrum) are trivial means to express information. Above that, the scene in the painting encourages to alter the perception of *space*, i.e. to express information by subtle modifications of depth cues like shading, lighting and shadowing, occlusion, attenuation, changes in perspective of parts of the scene, stereopsis, accommodation and texturing. Candidates for symbols are the floe peak (a) for expressing e.g. dynamic information (at the viewers focus) by varying the shading and lighting, the distant peak (b) for less prominent information items by varying e.g. the attenuation from visible to totally invisible, the chunks of ice (c) to express information by modifying their texture and relative position to (a), and maybe the nuggets (d) to indicate discrete value information by e.g. adding and removing individual nuggets of different size, shape and color to the scene.

A second category of criteria for *symbol* identification in a *theme* are (iii) the *metaphor of shape*, i.e. to what extent shapes and form are offering degrees of freedom for harmonious variation, and (iv) the *metaphor of abstraction*, i.e. whether abstract or figural elements of the theme are exploited for information visualisation. A well interpreted piece of artwork expressing these metaphors is the picture in Fig.

7. While the female character in the painting is coated in a texture with strictly curly, circle like and roundly ornament *shapes*, the male character is coated in a strictly rectangular, geometric and squarish ornament shaped texture. Aside from what the art community has developed as interpretation of these abstract ornament shapes in Klimt's work, here it offers a broad range of possible shape variation (color, size, proximity, inclusion, alignment, direction, horizontal, vertical, inside, outside, cyclic, spin, connection, hole, crack, fissure, boundary, presence, absence, count). (b) is a good candidate for a symbol if the intent is to strictly stick to an abstract curly shape metaphor, just like (c) is for an abstract rectangular shape metaphor – (d) encourages (and supports) a mix of both. As for the degree of *abstraction*, (a) as a suggested symbol allows to combine expressive means rooted in abstract ornaments as well as figural elements. Connotating information into the facial expression of characters appears as a very rich, yet intuitively perceivable symbolic instrument.

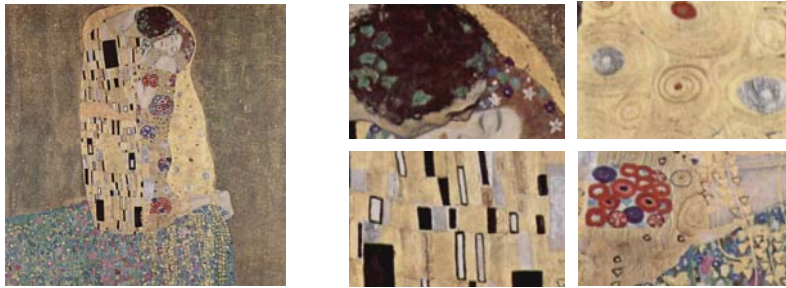


Fig. 7. Gustav Klimt (1862-1918), *Der Kuß*, (1907/08), oil on canvas, 180x180cm, Österreichische Galerie, Wien, <http://www.belvedere.at> (left), and a set of symbol candidates (right, (a), (b), (c), (d)).

Symbols can also be identified with respect to the embodied (iii) *metaphor of dimension*, and (iv) the *metaphor of orientation*. A *theme*, which due to its strictly geometric composition invites to connotate any sort of information and data on a metric scale is given in Fig. 8. Straight lines, segments, string cords, rulers, tickers etc. suggest symbols like (a) and (d) to express *dimensional* values on arbitrary metric scales, while (b) or (c) (a rendered sphere) suits for connotating *orientation* data.

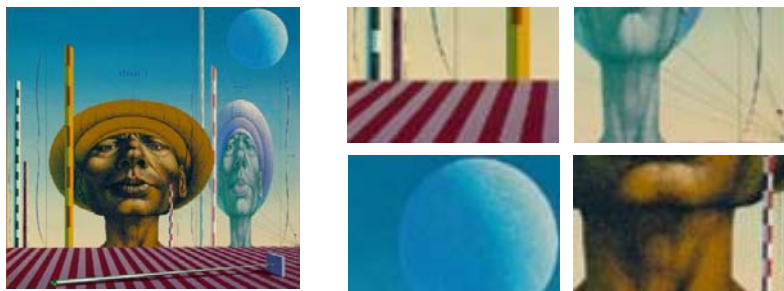


Fig. 8. Rudolf Hausner (1914-1995), *Adam maßstäblich*, (1972), 54,0x55,5cm, signed, <http://www.artnet.com> (left), and a set of symbol candidates (right, (a), (b), (c), (d)).

Findings and Conclusion

In its earliest appearance, "Informative Art" was considered as computer augmented pieces of art or computer generated artwork, turning an aesthetical object into an information display [21]. Several contributions have appeared in the literature, addressing the issue of encoding information of interest into aesthetical art installations, using the one or the other design driven approach. In most of these cases, the design work conducts information visualisation concepts, display strategies, as well as decorative, aesthetic and artistic composing, but not involving the user beforehand. Typically, the user is consulted once the informative art display system is ready at hand, and concerned for usability engineering studies.

The hypothesis of this work was, that users, based on their cultural background, cognitive skills, situative environment, contextual settings, but most of all their aesthetic appreciation, have dedicated, individual and personal attitudes towards the preferred overall appearance of an informative art display system. In our previous work we have found empirical evidence supporting this hypothesis [5]. Therefore, here we propose a *theme* based, *metaphor* driven design process that guarantees sovereignty of the user with respect to the choice of a display *theme*. Our process then identifies *symbols* or *emblems* out of the *theme* according to metaphors of *color*, *space*, *shape*, *abstraction*, *dimension* and *orientation*. These metaphors then help to find the right connotation of the information of interest and the respective *symbols* of a *theme* so as to meet the intuition and thus ease the perception of the user. We have used original artwork (C. D. Friedrich, G. Klimt, R. Hausner) to support our arguments for metaphor driven symbol selection. Our informative art design process is supported by a fully functional informative art software framework, within which many display systems have already been built. Currently we are generalizing and formalizing the concept of *symbols* (attributes and dynamics) in a markup language, so as to achieve *theme* independence. The prospect of this generalization is to let the user (or a process in a context sensitive way) "hot-swap" from one theme to another without any symbol reconfiguration.

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