Between Art and Architecture: The Interactive Skin

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Abstract

There are two current approaches to the realisation of interactive building 'skins': in architecture so called intelligent facades are being designed with an environmental science agenda; while in a parallel line of inquiry, artists are experimenting with media facades. It is proposed here that there is common ground between reactive environmental facades and data driven screens, in that both involve the design of kinetic process. Selected examples from kinetic and generative art provide useful precursors for such an approach and these provide the background to a framework for the design of interactive building skins. The aim is to locate the design parameters for practice where the art / architectural skin is a process based system, rather than a static object.

Introduction

This paper begins with an outline of intelligent facades in architecture - environmental control systems that use automated louvers and other devices to maintain internal temperature, lighting levels and air quality. This is followed by a summary of collaborations between artists and architects in which various forms of data driven media screens have been integrated into architectural cladding. Outside architecture, examples from kinetic art of the 1960's and generative process from contemporary electronic art, provide useful background for the design of interactive building skins. From the pragmatic to the ephemeral, this range of precedent is engaged here to inform art and architecture practice in which the role is to design kinetic systems. The objective of this paper is to outline the sphere of design activity for such an approach. That is, where does the design occur when the building skin is a process based system, rather than a static object?

Intelligent Facades

The use of environmental control systems which react to change in external conditions has a history at least as long as the invention of the rheostat. In the last twenty years advances in electronic control systems have progressed to where a building can be described as intelligent rather than responsive. A recent overview defines the basic criteria by which a building can be so considered [1].These are (a) input system, (b) a processing system which analyses this input, (c) an output system which reacts to the analysis of the input, (d) this response occurs with a consideration of time (e) learning ability (although earlier definitions of intelligence often do not include this last criteria). However, a survey of intelligent facades resulted in the declaration that a truly responsive, adaptive and controllable intelligent skin has yet to be found [2]. Most systems, while they may be able to consider a range of factors simultaneously and interpolate a response, fail on the criteria that they can learn from previous data. The idea that buildings should be some sort of intelligent entity separate from users, has not surprisingly being subject to debate. There are a few examples that break the closed system of sensor / controller/output to include the user in the monitoring and decision making process. The control system of the GSW headquarters building in Berlin makes recommendations to users about the selection of natural or mechanical ventilation by means of green or red lights on the window transoms. The user can decide to accept or override the recommendation from the control system, thus enabling a level of interaction. Such examples suggest a transition from the idea of the intelligent façade in terms of an autonomous machine, to that in which the user engages with and is part of the decision making.

In terms of material form, most environmental control systems are based on mechanically operated louvers or fins of varying materials, profiles and proportions. There are two general design approaches: either to embed the kinetic component or fin within the composition of the façade thus minimizing aesthetic impact; or to articulate the shading or ventilation elements as a separate prosthetic device which serves the building. In either approach seldom are the mechanics of the device articulated with any great aesthetic attention, perhaps reflecting the typical separation between architect and environmental engineering consultants. A notable exception that seldom finds its way into surveys of intelligent facades, is the Arab institute in Paris designed by Jean Nouvel in 1988. The southern wall is protected from the sun by a 60 meter wall composed of multiple panels composed of variously dimensioned metallic diaphragms. These operate like a series of camera lenses, shrinking and widening in response to sensors, to control the penetration of sun light into the building. Even when at rest the tectonic quality and detail of this wall is stunning, while the dappled light which results generates seductive internal spatial qualities. This iconic building sets a precedent for the integration of functional

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performance and aesthetic effect that has yet to be surpassed.

Media Screens

The development of intelligent facades is driven by an environmental performance agenda, which arguably continues the functionally determinative trajectory of architecture as a built form of design science. According to recent critique, the continuing dominance of this agenda results in such facades being socially inert, despite the potential inherent in such kinetic systems [3]. This is deemed important due to the recognition of the social failure of much modern architecture based on machine metaphors, particularly in relation to engendering a collective cultural identity. In contrast to intelligent facades, media screens have been described by the same author as enabling a valuable form of social interaction and engagement. In a similar vein, Anders suggests the needs of contemporary society have extended beyond that of a communal physical reality [4]. Media screens can be seen as early manifestations of architecture adapting to an information rich society and adding to its sphere of practice by mediating between physical and information space.

As would be expected at these early stages the majority of such media screens take the form of large scale computer displays, utilizing data projection or video walls on the facades of buildings. More recently light-emitting diodes (LED's) have been utilized to turn whole buildings into a computer controllable image. The Chanel building in Tokyo by American architect Peter Marino is a 56 meter high tower that lights up Ginza each dusk to dawn with 700,000 embedded LED's [5]. The interactive system consists of over 6 kilometers of control cables, 3 master control computers, and 65,000 micro computers. An innovative system of canvas roll blinds and state-changing electronic privacy glass allows office workers to see out by day but provides a black background for the display at night.

A more low tech, but highly effective approach is the 'BIX', a 900 sq. m. light installation set behind the double curved acrylic surface of the Kunsthaus in Graz, Austria [6]. Made up of standard circular fluorescent lamps, these act as large scale pixels, each individually controlled by a central computer to enable the generation of low resolution imagery. Regardless of the time of day, or content, the tectonic quality of the BIX wall is engaging beyond that achieved by standard video screen technologies. This approach has subsequently been applied at a larger scale in Berlin where a façade on the Potsdamer Platz has been transformed by 1800 ordinary fluorescent lamps integrated into the ventilated glass façade [7].The external envelope is transformed into a low resolution media screen, with the large grid pattern attuned to the architectural scale of the façade and surrounding context. Rather then been perceived as applied surface or screen, the display reads as building skin integrated into the constructional logic of the whole, and has a tectonic quality over and above its display function.

The degree to which such screens can be considered interactive is debatable as they are predominately a one way media display, be it information or public art. More interactive examples of media screens can be found at smaller scales in internal environments. There have been various projects which use mobile phone technology to enable users to interact with content and more recently infra red combined with image tracking technology have enabled a literal 'hands on' approach. The New Zealand pavilion for the 2005 world expo in Japan showcased a rear projection screen system linked to an infra red camera which tracks the hands of users interacting with content [8]. Dozens of hands can be tracked at anyone time, with individual hand shapes being recorded to enable subsequent interaction. An example of interactivity operating in the urban realm and at a slower time scale, is the D-tower, an art piece commissioned by the city of Doetinchem in the Netherlands [9]. The D-tower consists of three parts: a website (accessible to everybody), a questionnaire (accessible to a hundred different people each year) and a 12 meter tower reminiscent of a jelly fish. All three parts are interactively related to each other, with the tower being internally lit with a mix of red green and blue light. Updated each night, the mix of color reflects responses to the questionnaires, which are intended to gauge the mood of the town in relation to a variety of issues. The tower is expected to stay in place for decades and has already added to a sense of social cohesiveness in this small provincial centre.

A primary problem with light based media walls is they are only marginally effective in daylight. The Agesis Hyposurface is an example of an alternate approach, in which imagery is created through physical movement of architectural surface [10]. Made up of triangulated metal plates driven by a bed of pneumatic pistons, dynamic 'terrains' are generated in real time. In this way imagery on a computer can be transferred to a three dimensional relief, the triangulated plates acting as pixels. At present the mechanical requirements of the Hyposurface are such that the prototype has yet to make its way to into architecture, but the principle of a mechanically driven surface will no doubt be adapted in time. At the other end of the technical spectrum artist Ned Kahn was commissioned to produce a wind veil for a non-descript parking building in the small town of Charlotte, USA [11]. Kahn designed an eighty by fifteen meter skin made up of thousands of 75 mm square aluminum discs, each individually pivoted in a cable grid. Any small wind eddy is picked up by the reflective disks generating an effect not unlike the quality of metallic fluid. This skin as installed is reactive only to wind, but suggests possibilities for low tech systems that have passive energy sources.

Precedent from the Kinetic and Generative Arts

Compared to existing precedent in architecture, the range of visual art works that may inform the sphere of design activity for the interactive skin is vast. The approach taken here is to use critique from within the field to map out the range of approaches: for the kinetic arts the writing of pioneering artist George Rickey analyses work before the widespread availability of computers; while Dorin provides a valuable taxonomy of physical process, which he argues underpins the generative electronic arts.

Kinetic Art before the Advent of the Computer

Aesthetic outcomes generated by movement can be traced as far back as ancient wind chimes, but the term kinetic art came into being in the twentieth century, with Duchamp's 1920 work 'Rotating Glass Plates' generally acknowledged as the first exhibited work in which the aesthetic is based on physical movement. Other early experiments include Gabo's 'Kinetic Sculpture' (1922) and Moholy Nagy's 'Light Space Modulator' (1930). Anthony Calder dominated the pre war period with a series of suspended compositions, while the most prolific period for kinetic art was during the 1950's and 1960's. In addition to the continuing popularity of Calder, prominent artists include Schoeffer, Takis, Lye and George Rickey. Rickey trained as a painter in Paris before returning to America in 1949 where he started producing steel sculpture based on a system of meticulously engineered counterweights and bearings, activated by air currents and the pull of gravity. He would continue to refine his work for the next fifty three years, while at the same time teaching and writing in various professorial appointments in the United States.

Rickey's essay 'Morphology of Movement: A study of Kinetic Art ', is one of the few attempts at a formal discussion [12]. This provides a useful overview of six general directions for the period up until 1963. These directions are: (a) experimentation with optical phenomena, such as moiré effects; (b) transformation based either on movement of the art work such as the phenomena of wheel spokes in motion, or through motion of the observer such as effected by polyphonic painting; (c) works where the surveyor physically interacts with the work; (d) machines where motorized gears and pulleys cause 'orchestrated' movement; (e) light play based on colored light, shadow and reflection; (f) ""movement itself' usually with economy of means and self effacing mechanics" [13].

Rickey's bias is towards the final category, with a particular dislike of the banal use of machinery in which repetitive motion generates for him, "a more emphatic stasis" then lack of motion. He argues true kinetic works are those where the capacity for motion is designed, and is intrinsic. Rickey continues this formal analysis of kinetic art by articulating a 'vocabulary' of movement. He describes the classic movements of a ship at sea (pitch, roll, fall, rise, yaw, shear), vibrating springs, and the non periodic movement of a pendulum, as examples of a vocabulary of 'form in motion'. These are small in number and surprisingly simple, "scarcely more" than the twelve tones of western music [14]. Continuing his analogy, this vocabulary is arranged as sequences over time in a similar manner to musical composition. Rickey differentiates kinetic art though, in terms of its openness to chance "introduced by the movement of the observer, which the artist prepares for but does not predetermine, or by incorporating in the object itself, some factor of fortuitousness" [15].

Designing Process in the Electronic Arts

A key factor in Rickey's argument for a sophisticated kinetic art was the capacity for a work to accommodate chance, either through making the work open to interaction with environmental forces and / or the anticipated but non-predetermined interaction with users. Arguably this approach requires the artist to design a process rather than an object. In a similar desire for indeterminacy the design of process underpins a contemporary form of electronic art described as genetic or evolutionary [16]. Often the artworks are an extension of computer science research into artificial life and are exhibited as screen based works in which synthetic creatures interact and evolve within a simulated environment. In some the audience interacts with the artwork thus adding to the range of evolutionary forces. An example of this approach relevant to architecture is the 'Future Garden' proposal by Jon McCormack, planned as part of Federation Square in Melbourne, Australia [17]. The work consisted of large scale planes of glass set into the square, underneath which were proposed a lattice of LED's. Patterns of light are generated by a programming technique known as cellular automata, in which simple rules form complex patterns and behaviors over time. Visitors to the square would be able to interact with the artificial garden by touching or shadowing the glass, and would notice seasonal changes on subsequent visits. Unfortunately McCormack's proposal was not realized, but suggests a precedent for the application of cellular automata (CA) to architecture that is relevant to this discussion. Control systems, for example could utilize CA to create self organizing shading and ventilation which responds to environmental and user input.

The connection between kinetic art that interacts with physical process and the simulation of such process to create electronic art works has been recognized by McCormack's colleague Alan Dorin, who has written extensively on process in the arts. Dorin distinguishes three different types of process via the example of the painter, the playwright and the gardener: the painter engages with process in terms of color mixing and application technique but the process is fixed in the final artifact; the production of a play produces a repetitive process in which the outcome follows a closed script but

is open to nuance in its performance; and the garden in which there is no script but an ongoing process according to natural laws and the 'pruning' of the gardener [18]. Dorin goes on to distinguish between physical process and abstract process: physical process are those "that depend for their path on the properties of matter" ; abstract process "involve the manipulation of symbols" [19]. While an abstract process can notate physical process, for example music notation, many electronic artists manipulate code to produce artworks which are synthetic and do not correspond to any material properties.

Where might we position the design of the interactive skin in relation to fixed, repetitive and ongoing process? Traditionally architecture has fallen between the fixity of painting and the repetitive experience of theatre. Process is used to create a fixed artifact, but the experience of a building is affected by nuances of light, moisture and occupancy. We may experience subtle changes each time we visit, but essentially the same script is played out despite our ability to wander and pause. By contrast the interactive skin may be more like the process of the garden. As environmental conditions and user needs change over the course of day / night and seasonal cycles the range of experience may be relatively dramatic. The design of the interactive skin involves the design of a process and for architecture this primarily relates to the physical properties of matter. For this reason Dorin's other writing on the classification of physical process may be valuable in relation to the aims of this paper.

Dorin proposes a taxonomy in which he classifies physical process as a "step towards understanding the relationship between physical processes and time-based art" [20].He proposes five - pulse, stream, increase, decrease, complex. These categories are more that of syntax, then the vocabulary of movement explored by Rickey. For Dorin movement is the outcome of a process, and the types of process can be described by these five types. Pulse is a "repeating sequence of events" such as the regular pumping of a heart. The spacing between events in a pulse can be of such a scale that it perceived as uniform stream. These occur at the limits of visual perception – a revolving sphere may be rotate so fast that it appears motionless or so slow that process is not apparent. Increase and decrease are relatively self evident forms of process, characterized by forever higher or lower intensity, in which the nature of the change is constant. The final category is complex process, which "forever change into new forms without reiteration". Compared to the regular beat of a pulse, or the smooth change of accelerating or de-accelerating intensity, a complex process "will be different to all future and past states of that system" [21].

Towards a Design Framework

Precedent and critique of intelligent facades and media screens suggests a more integrated approach is required for the design of what we term interactive building skins. The responsibility of architecture to utilise advances in science to construct buildings, which have better environmental performance and which can accommodate changing user needs, must of course be addressed. Ideally, these objectives can be realised in conjunction with a wider definition of performance criteria. This definition would include the recognition that architecture has a responsibility to engender social engagement and cultural identity. The transition of the traditionally static building envelope to an interactive skin, presents an opportunity for architecture to forge a new form of engagement with contemporary culture. The transformational capacity of the intelligent facade and the media screen dictate this should be undertaken in terms of the design of a process, rather an artifact. Here precedent from the kinetic arts and the process based approach of some electronic art, may be a useful precedent for the outline of taxonomy for the design of the interactive skin.

This paper concludes with an overview of where the design decisions occur when considering the design of process for interactive building skins. The objective is to identify the factors to be considered, rather then the prescription for any particular design approach.

Arguably the scope of design decisions occur around three interconnected questions: (1) choice of input or *sampling*; (2) the manner in which these samples are processed by the *control* system; (3) the *tectonic*, or constructional logic and appearance of the skin.

1. **Sampling**

(a) Cultural…….Environmental
(b) Local…….Global

What data will constitute the physical and "virtual space events" of the interactive skin and how will these be captured or sampled? Architecture has a long tradition as a form of public art and there exists an opportunity to sample a range of cultural inputs as well as environmental stimuli. Environmental input would necessarily be related to the local, while cultural input could sample both the global and the local.

2. **Control**

(a) Top-Down……..……Bottom-Up
(b) Micro (time) ..……..……Macro (time)
(c) Physical……Abstract
(Pulse, stream, increase, decrease, complex)

If there is some form of mediation between input and resultant affect, how might this meet aesthetic as well as performative criteria? There may be an opportunity for auto-poesies in which the aesthetic is to a degree, emergent. Alternatively the personal aesthetic of the designer may be embedded in a similar manner to, for example, such proportional systems as used by Palladio or Le Corbusier. Thus the control system would be

located within the spectrum of top-down, in which particular criteria are 'directed' and bottom-up approaches where parameters are set for the evolution of behavior.

Artists and architects considering the design of interactive skins need to consider foremost that the design of process is a temporal art. The temporal scale would range from the micro to the macro in relation to human visual acuity and memory. Input may be directly streamed to output at the micro level of real time response, while simultaneously be processed to create macro scale trends that emerge over a longer period. Dorin's differentiation between physical and abstract process is useful, given the sampled data could relate to physical or the abstract and the mediated output could be also be manifest via physical movement or abstract devices such as the media screen. When the control system is related to physical process Alan's taxonomy of pulse / stream / increase, decrease / complex should be considered. This classification can be interpreted as providing a type of formal syntax for the design of physical process.

3. **Tectonics**

(a) Passive……..…… Active
(b) Physical……..……..……Electronic
(Vocabulary: Move……Rotate……Scale)

What technology is available to implement an interactive skin? Typically, composition in architectural design is based on a tectonic approach in which the aesthetic is largely based on fabrication methods, articulation of joints, and materials. As evidenced by the Arab Institute façade, this attitude to engendering aesthetics can be extended to environmental control systems. Similarly the example of the BIX electronic skin indicates the tectonic design of electronic displays can in itself be important. The interactive skin can be manifest in either physical or electronic form and both require detailed design in terms of their physical appearance as well as their performance. We can make a broad distinction between passive systems with minimal 'mechanics', such as the wind walls of Ned Kahn and more complex energy dependent systems such as the Agesis Hyposurface.

Finally, if Alan's taxonomy applied to control systems can be seen as the syntax, the range of movement possible with physical systems can, as discussed in relation to Rickey's morphology of kinetic art, be considered a vocabulary of movement. Here the number of discrete actions need to be considered in relation to the chosen tectonic.

Further Work:

This paper provides a framework for the design of interactive building skins, which will be further developed and assessed through project based research by the author.

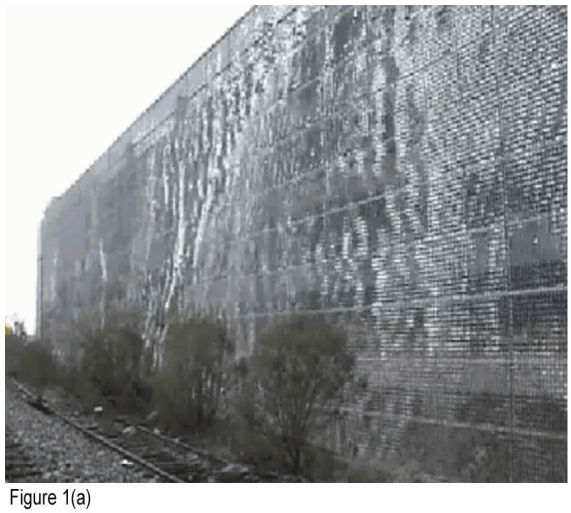
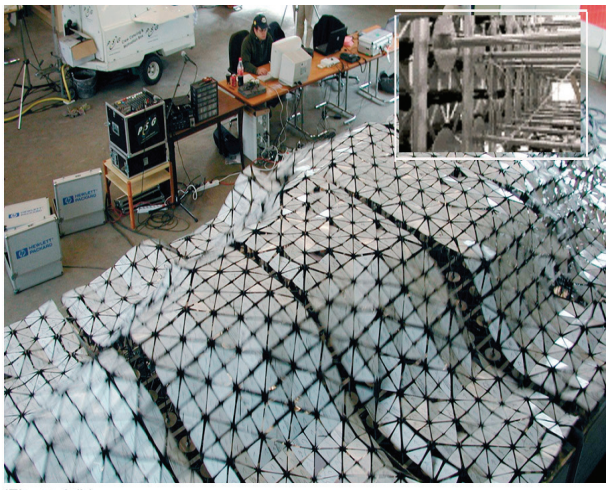


Figure 1(a)



(Figure 1 (b)

Figure 1 . Examples of passive and active systems.
(a) A wind wall by artist Ned Kahn. Reflective discs are suspended within a net, capturing wind field effects.
(b) The Agesis Hypersurface. A triangulated panel is activated by pneumatic pistons (see inset in the top-right) enabling data input from a computer.

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