

**I/O: input / output**  
**Design Strategies: An inquiry into thinking / making**

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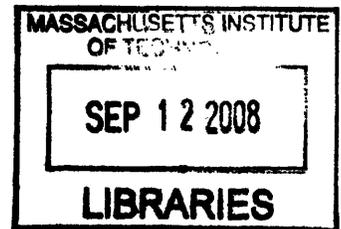
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*Para Mariana Ibanez, mi partner infinito.*

# **I/O: Paradigms in Architectural Design Strategies**

Simon Y. Kim

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*"But I don't want to go among mad people," Alice remarked.*

*"Oh, you can't help that," said the Cat: "We're all mad here. I'm mad. You're mad."*

*"How do you know I'm mad?" said Alice.*

*"You must be," said the Cat, "otherwise you wouldn't have come here."*

Lewis Carroll, *Alice's Adventures in Wonderland*, 1865.

"...beautiful as the chance meeting on a dissecting-table of a sewing-machine and an umbrella!"

Comte de Lautréamont, *Les Chants de Maldoror*, 1868.

## 1. Introduction

At present, there are no formalized design strategies for architects that address the growing field of interactivity evident in physical computing, and new media. This presents a critical position for architecture. As this new field is gaining its own powerful academic and professional agenda as witnessed in the Media Lab, the architectural academies' continuing reticence to explore its implications will soon manifest a distance that is too great to bridge. Without understanding and participating in the discourse surrounding this emergent field, architecture will have little access to it outside the use of a specialist consultant, much like the services of engineers. The missed opportunity will more likely continue to grow as the dreams of pioneer architects – of moving and living buildings – will be implemented by professionals outside of architecture. Should this come to pass, the identity and role of architects will change, and not necessarily by their choice or privilege.

The current state of the architectural profession has already been said to trail behind other design trades. Young practitioners have been the noted the advances of aerospace, automotive, and naval industries in counterpoint to the slower design and construction techniques of architecture[1]. This arena of contention is primarily in the housing industry, where the means and methods of builders have largely remained unchanged for over a century[2]. Quickly erected wood-frame housing has yet to respond to not only new materials but new communication and new representation. Balloon and platform framing became popular in the nineteenth century in North America with the abundant supply of timber, which is problematic in its present condition as a limited resource. New communications and increasingly smaller sensors have brought intelligence to many homes

whose potential is not being utilized as architectural criteria. Finally, it is telling that three-dimensional models, painstakingly created by architects in computer software, are not the primary vehicle of representing and describing the building geometry – planimetric, two-dimensional drawings are still required as the construction documents binding the contract[3].

The most widely accessible applications of physical computing is in product design and especially in cellular communications. It is here that we will find technologies that are not only at the forefront of innovation, but also at the control of market forces. In this, development, prototyping and manufacture – as well as disposal - are at such a rapid pace that challenges the notion of solidity and permanence of buildings. To conjecture, the rapid deployment of a wide range of industries and implementation witnessed in a new cellular phone, oftentimes equaled by the development of a new vehicle, staggers the classical model of design/build for the architecture, engineering, construction (AEC) industry. This rapidity promises to accelerate, and become customizable to the individual consumer, as do-it-yourself attitudes are enabled by printers and fabrication machines to soon fulfill the promise of Universal Assemblers[4].

Architects are not strangers to these new technologies. Many are interested in the broad range of services to assist in their design processes. However, a dilemma arrives in the training of an architect. Many curricula are biased toward the implementation and honing of design skills, not in the varied aspects of construction technology. Most schools of architectural education give brief introductions to these as a supply of ideas to be considered within the pursuit of a separate design excellence. The working knowledge of the construction services is to be furthered in professional practice after graduation. These support fields are therefore considered part of, but not primary to, the architectural design. These are fields of data that are therefore to be managed and implemented in service to the architectural design of a building. There is some validity to this statement when considering the schema of designing to simply making. The construction of a very deep-plan floor slab for example, where the edges of slab are of sufficient distance to deprive natural sun and air to the human occupants at the centre of the slab, is generally considered, by practitioners and occupant alike, to be a poor office or living scenario. This value judgment would

not be necessarily relevant in the problem-solving nature of the engineering services or in computer software. Structural, mechanical, and electrical efforts could produce working methods to ensure the constructability and safety of this type of building. Put in other terms, the great work of architecture is more than a sum of its parts[5].

What then is the best or relevant manner to use the new media and physical computing technologies. The role of these fields is marginalized to consider them as a support service, as they are of greater use than that. The physicality of architecture, as well as the physicality of cities is now moving towards an impermanence and dynamics, into something that is more closely associated with fields that architects are ill-prepared to understand. As architects, they are more than able to utilize physical computing and new media to inform their work, but that information must be examined.

### **Terminologies and Definitions**

In an effort to gain a shared platform for the thesis discussion, specific terms are identified, to be held separate from definitions in other professions.

The works of machine intelligence and computer science have a tendency to reduce words or ideas into easily understandable units. The benefit of this is to build up the units into a system of logic from which patterns can be made. The logic becomes a rational and bounded net that can be quantified and predicted.

Architects and designers are reticent in this approach to meaning as it denies a play of change or indeterminacy. Ideas are placeholders or tokens that can carry multiple meanings as necessary or required. This simultaneity in values affords each piece to have a unique relationship with the other peices, whether they are programmatic spaces at one level but at a different, simultaneous level, they represent another aspect altogether - stage sets for exterior views, for example.

However, the disconnect between Architectural and the real technological advancements is on par with something akin to voyeurism.

An Architect - in the scope of this paper - is a trained professional who is interested in the controlled outcome of a host of construction techniques that yields

a mediated environment. The realization of a mediated environment may be of separate scales and outcomes - which may not always yield a Building - but is always of specific use and of cultural value.

In this respect, Architecture will always refer to the intentionality and control of constructing a physical human environment, its expression through form and material[6]. The physicality of the architecture, and its noumenous ideas, work together to produce an idea beyond the artefact of the Building itself.

A Building is the resultant of the design and construction. A Building lies within the domain of Architecture, but is not the entire field. Architecture has cultural values and performances whose judgments go beyond satisfaction of a stated problem.

Design has very different connotations and it seems the best way to know its original intention is to determine its final outcome. Design is the process, through mental and physical manipulations of criteria, intentions, typologies or patterns, where a *satisficing* of all possible outcomes is achieved[7]. However, if the design criteria does not include a social or cultural aspect, the resulting design will be a pragmatic solution to varying problems.

The Designer is a trained professional who understands which of the designs noted above is required, and works within a milieu of history, recent innovations, and intuition based on years of training at a liminal manner. Knowledge based on experience may lead the designer to choose some iterations over another. The domain of a designer shares some qualities with the domain of an architect, but does not completely overlap.

Theory is a discipline that, although related, exists outside of practice. The two domains of theory and practice may share an adjacency but each has its own agendas and interior processes. This is opposed to the process of Architecture and one of its products, the Building. The process of the Architecture and its many decisions are imprinted onto the Building. Theory may discuss a record of change and development in practice but it also responds to itself, or in reference to other theories, other practices. Moreover, there is a craft and design to theory that is similar to but gives autonomy from practice.

## **2. Architecture Practice Differing Methodologies**

### **References**

In the enquiry into the current state of practice, this thesis will address two offices at the forefront of the profession: Office of Zaha Hadid and Gehry Technologies[8]. This is not to give privilege to celebrity, but to examine the processes they employ to achieve their unique results, in many materials, and in many building types. Otherwise the attempt to reconcile the use of physical computing with traditional architecture will remain limited in scope and result. Because of the scope to identify and determine processes and protocols, the owners of these eponymous offices are not being discussed.

### **Office of Zaha Hadid**

In this respect, Office of Zaha Hadid (OZH) works within an expanded border of formal generation and theory. This office utilizes not the one means but the very many in its efforts to arrive to a design, and to its fabrication.

### **Painting**

Somewhat uniquely, OZH first gained attention with large, multi-perspectival paintings. The representation of space depicted on canvas is dynamic and non-figural. The use of concatenated vanishing points denies a singular reading, further attenuated by a constant mental activity in locating continuity among common architectural elements (lines, planes, surfaces) in an effort to create a whole. This act of painting is an act of polyvalent enquiry rather than a linear depiction or a simple mapping of object to a pictorial plane. The challenge is to then find a transform, a pattern, to remap that kinetic scene to an architectural object. It is this process that sets this office apart. The building is not the primary target but becomes the vehicle for the affect.

### **Study Models**

The office uses varying means to do this. Study models are used in similar manner to the paint. Cuts and pleats are made in different materials such as paper or sheet metal to graphically demonstrate movement from the picture plane to the three dimensional.

### **Software**

At the same time multiple software packages are interrogated for their means to rapidly create a number of iterations. should none of these be able to approach the

desired affect, scripting or programming is employed to create situations in a much faster way than a cad operator is able to do by hand/mouse.

### **Concurrent vectors**

The classical idea of CAD as a mapping of digital objects - rooms, circulation, building envelope - is not at all valid at this particular stage of design. The digital is a pursuit of finding the function of an architectural spatial quality, and mapping it to the required elements that make the building material. The point to be made is that this is a concurrent and non-repeatable process. The transform function mentioned earlier in this translation from conceptual idea to realized design can be considered open and non-optimal. It will never yield the same result twice. This is not because the process is flawed, but the multiplicities apparent in the paint and model are too great to be defined.

### **Fabrication**

The test of any architect in a traditional sense is not in the design of the building, but in its final inhabitation and presence in the world. The inverse of this is to be deemed impossible to build, visionary, naïve. Once OZH is approaching the best outcome of all possible design scenarios, the CAM process becomes exceedingly exacting and precise. There is a direct relationship between the design and the construction where the material treatment, arrangement and properties become narrow in tolerance and definition. Just as in the design process, this does not mean that the same construction technique is always utilized.

### **Prototypes/Mockups**

For example, a few of the designs of OZH employ large double curvature surfaces, which presents difficulty in construction as the panels are non-repeating and their locations in space in relation to the framework are difficult to find. Nevertheless, these difficult surfaces have been made in varying materials and types. Smaller furniture pieces have been cnc milled from foam, coated in a hard polyurethane resin and finished with high-gloss metallic paint. In larger concrete shells, complex formwork of bent plywood and milled foam provide the molds for cast concrete. This type of concrete has an admixture of plasticizers to ensure full workability of the liquid concrete into the smaller folds. OZH has also utilized CAM technology to create molds for slumping sheet glass into curvatures, as well as thermo-forming solid-surface materials normally specified for countertops. Most recently OZH has been able to reproduce this curvature through fabric, making

temporary pavilions. The strategy of such varied output processes is a methodical testing of the construction choices, and the material ability to carry types of formal resolution. There are few architects who interrogate the distribution of many forms - planar, tessellated, doubly-curved - and their realizations in unlikely construction methods.

### **Outcomes**

These final buildings are determined by successive testing and development through material test and mockups. Each one of these CAM methods outlined is rigorously tested to check its fidelity with the prepared digital file(s), its material properties in texture, strength, colour, and more importantly, its intended application to the design - its interior/exterior haptics and perceptions[9].

Because of the inverted scheme of materials serving design, a catalogue of different construction methods and means can be developed. While this may present a difference in how a specific material can be a feedback into the design. The diagram of this schema – different design outcomes coupled with different construction types – is best illustrated by the accompanying figure. The best choices may be determined by purpose/affect/truth to conceptual clarity.

### **Gehry Technologies**

The offices of Gehry and Partners (GP) have produced buildings of high public recognition, and of new production methods. The recent creation of its research and development group, Gehry Technologies (GT), is dedicated to the redefinition of CAD/CAM in a singular manner.

### **Industry Alternatives**

Having developed a highly specific and successful process in the construction of his architectural designs, GT was launched as a PLM (Product LifeCycle Management) partner with Dassault Systemes, a French software company whose products range from BIM (Building Information Management) tools for industrial design to the aerospace industry. The use of its software (CATIA), originally for aircraft and automobile design, marks the first and most successful attempt by an architect to think of architecture and construction as a design challenge best met by means outside of its milieu[10].

This process was repeated until a strong pattern developed from which a version for the architecture, engineer-

ing and construction industries was launched by both Dassault Systemes, and GT, called Digital Projects.

### **Design Methodology**

Digital Projects (DP) is new software that is aimed at providing a stable, robust digital modeling environment in which BIM is implemented. What normally happens is for design decisions be made in physical study models. These models begin in rough manner with arrangements of blocks to which greater detail and at larger scales are applied. Early in these physical studies, material choices and structural decisions are made in relation to the form. Thin sheet material is a scalar proxy for sheet metal cladding and thick wood or card is used for brick or rectilinear building systems, always with a clear structural idea in place. The design of the model in this fashion is the linear mapping to the design of the building.

### **Analog to Digital Conversion**

During this time each surface of the models are scanned or translated into digital space by varying techniques of gathering point-cloud data. This technique is used again at the construction phase to test the final building, at all stages, with the digital building. The imported geometry is then cleaned and rationalized into surfaces and solids that can be parametrically controlled and defined by the GT team. The thin sheets of material that represented titanium panels, for example, are now a digital model that is given exact thickness according to real-world material gauge, and that can fold or curve with the same tolerances as the real-world material. Any changes to the curvature can be studied in this parametric model to demonstrate a variety of small changes faster than can be iterated by model makers. This variation is of finite limits as higher-order decisions of global arrangements have been made and now smaller changes are being investigated for speed.

### **Physical Constraints and BIM**

These digital models are the extension of the scale models as they show the response and action of the digital panels to the real materials in the analog, full scale building. There is no conceptual framework inside this linear sequence of physical model, digital model, full-scale building. Each piece of geometry has attributes that identify it as a specific building element, in accordance to the manufacturer or builders specifications. In fact, the clarity and rigour of this method is its strength during the construction phase. All geometry is controlled and queried for collisions, tolerances and adjacencies, as well as shared with

other consultants for structural calculations, mechanical services, and scheduling of work. The 'master model', as it is called, is a full representation of all of its parts, structure, ducting, piping and also their schedules. What would be overkill in cost per work-hour is mitigated by the complexity of the building. There are other software packages available that provide full metadata attributing of building components as well as ID for scheduling. However, two factors that set DP apart is its robustness in dealing with highly articulated form, and its core service to, and development by, practicing architects, not software engineers.

### **Full Scale Demonstrations**

Because the digital and physical models have a relationship to the material in its behaviour and qualities, quantitative assessments of degrees of curvature and maximal span are well calibrated. However, full-scale mock-ups are sometimes still required. The mock-ups are not investigative or design experiments in nature; the performance of each material component is already predicted. The primary nature of these constructs is to determine the shortest path in fabrication, on site arrangements, and installation.

### **Business model**

The importance of GT is in the technical support of the design offices of GP as described above, and also in continual development of DP as a software package to sell to others. At present, DP has sold licenses to not only academies of architecture, other architects, but also to engineers, construction managers, and developer/clients.

### **3. Current Academies The Education of Architects**

#### **Core courses**

Design Studio is the core course in the training of an architect. Every school of architecture that offers a professional degree will have design studio as the course with the most credits and time required; a student may not advance without fulfilling the requirements of studio. Such is the importance that all other courses may be considered as auxiliary or in support to the studio.

Design studio is where the student develops and hones an awareness and criticality of design and space. This design framework is put in service to various examples ranging from abstract exercises to the making of specific programmatic types (housing, museum, office) with specific site conditions.

#### **Corollary coursework**

There are other core courses that supplement the design studio. Students are required to know and understand the histories and theories of architectural traditions in relation to their own context in the discipline. Basic building systems must be known to demonstrate structural and mechanical awareness or possibilities. But to learn about electronics or sensor technologies the student will need to take an elective course outside of their program. There are certain problems with this – the elective will most likely be part of the department of robotics or electrical engineering and therefore ill-designed for the particular application to architecture. Furthermore, the student will need to perform at the same level with students from that program, placing them at a particular disadvantage.

#### **Towards electronics**

It can be argued that architectural study is an already independently full curriculum, and that this case for physical computing is unnecessary. While it is true that architecture from the time of Alberti has managed to cope without recent technological advancements, the range of necessary criteria was historically bounded by what was available. It is not for this thesis to hypothesize on what the Tempietto would be if furnished with other criteria[11]. Furthermore, if building technology, with its structural and mechanical components, are required courses then new media has its rightful place.

Furthermore, the study of architecture as described by Vitruvius (who codified the properties of Architecture when he made the tripartite issues of utilitas, venustas,

firmitas in *De Architectura* for Caesar Augustus, 15BC) was also a study on war machines, time pieces, and astronomy as well as town planning[12]. War machines, or *siege engines* in that time, were the epitome of machine technology and the responsibility of the architect. This wasn't the province for the singular polymath/geniuses – it was considered mandatory training for all architects.

### **Division of Design and Construction**

As there was a schism discriminating the trivium in favour of the quadrivium, there is a similar break between architect and builder[13]. This is popularly ascribed to the work of Leon Battista Alberti although he is not the first architect to separate construction technology from the pursuit of architecture as a theory and discipline[14]. Brunelleschi, in contrast, had designed the implementation of machines in the construction of Santa Maria del Fiore. Galileo was determinedly against the use of abstract or scaled models in the description of the full-scale object. This schism continues to this day in the schools. The need for building technology courses proceeds with the following logic: although professional architects will never be responsible for the calculations or specifications of structural members (for example), nevertheless some knowledge of this is beneficial in order to make informed decisions in the design of a building. Hence, students of architecture will have structural courses provided where they will learn to diagram, calculate the different loads along a beam, and select the appropriate profile of steel or wood, so that their design will be controlled and further nuanced with that knowledge. Therefore, further knowledge of related disciplines results in better decision-making in design. The inverse of this would be that ignorance of structure will yield designs that are naïve and unbuildable.

### **Electronics and Architectural Education**

This supplies more traction to the argument for electronics and physical computing as the growth and development of this field will accelerate. Some training in this will yield better ideas of architecture that move past the physical into the responsive, and the intelligent. Like the services of professional engineers, architects may not provide the final responsibility for this but knowledge of its design potentials, as any another material system in their repertoire, will strengthen the idea of a meaningful interface between human and machine.



*...this report has been written for the Architect assuming that he knows nothing about computers, little about the psychology of perception, and only basic mathematics.*

Nicholas Negroponte doctoral thesis 'The Computer Simulation of Perception During Motion in the Urban Environment', 1965.

#### **4. Architecture and Responsive Environments I/O and the design process: orders and decisions**

For the introduction to this section of technology, I will use a statement by Joseph Paradiso, a professor at the Media Lab, with greater clarity and far better insight[15].

*As microelectronics has escalated in capability via Moore's Law, electronic sensors have similarly advanced. Rather than dedicate a small number of sensors to hardwired designs that expressly measure parameters of interest, we can begin to envision a near future with sensors as commodity where dense, multimodal sensing is the rule rather than the exception, and where features relevant to many applications are dynamically extracted from a rich data stream... that explore various embodiments of such agile sensing structures.*

#### **Historical Context**

##### **The Media Lab**

Describing the benefits of digital technology, especially for the use of architects, involves a brief history of the Media Lab at MIT. Nicholas Negroponte first conceived the Architecture Machine Group in 1967 and continued as co-founder and director when the Media Lab opened in 1985[16]. During this time the AMG investigated the interface between humans and computers (HCI), as well as define the edges or boundaries of what these fields occupied. Marvin Minsky, Seymour Papert, and various MIT School of Architecture faculty were involved as well as the British cyberneticist Gordon Pask. Pask and Negroponte had first been published in a special issue of *Architectural Design* in September 1969 along with Karl Popper, Cedric Price, Stanford Anderson, and others[17]. Many research papers and theses were published under the aegis of the Architecture Machine Group, although an official curriculum cannot be found outside the publications of *The Architecture Machine*, and *Soft*

*Architecture Machines*. In the present Media Lab, there are separate research groups under the guidance of one faculty member who oversees and directs that research. Each group has some responsibility for its own industry partnership, promotion, and funding. There are specific goals for each group and the small numbers of graduate and doctoral students are funded by, and dedicated to the work of their group. Much like any professional degree, this is the central core of their education from which they can pursue elective courses.

### **The Architectural Association**

There is an overlapping element that introduces the Architectural Association. As well as continental cybernetic theory and work with Negroponte, Gordon Pask was also involved in the discipline of architecture at another institution in the UK. This independent school of architecture in London is based on a traditional master-pupil instruction[18]. Unit masters are given liberties to propose a field of study or endeavour at the beginning of the academic year, and attract students to its agenda. The unit system is roughly equivalent to the U.S. design studio. Over the course of a year the students will work within the guidelines of the agenda and their work is scrutinized at periodic intervals in private discussion with the unit master and in public presentations. Another, and more critical, scrutiny is the end of year Table Jury where several unit masters will discuss the merit of the student's work and evaluate its pass or fail status. Gordon Pask was a noted cyberneticist who was also active in the discipline of architecture. The connection of Gordon Pask to both schools has created an unexpected parallelism in both research output, and publications.

### **Soft Architecture Machines and Evolutionary Architecture**

A collection or a compendium of research initiatives of the Architecture Machine Group was published in 1975. Mostly written by Nicholas Negroponte, one of the introductions to *Soft Architecture Machines* is by Gordon Pask who presented an argument for Machine Intelligence[19]. The book is a quarto of roughly 20 cm square, written in large sans-serif font and accompanied by many diagrams and photographs. The overall effect is a series of related essays supported by graphics meant to galvanize its provocative writing.

The culminating idea of the 'soft' comes halfway into the book in the article *On Materials and Memory*. A division of

new types of responses is made – softs and cyclics – in the consideration of a responsive building. Soft, here, is not meant to imply occupancy of bubbles or balloons, but the temporal changes that can cause shifts[20].

Twenty years later an Architectural Association Publication was released with the work of Diploma Unit 11 under the tutelage of unit master John Frazer. The book was titled *Evolutionary Architecture* and the introduction was again furnished by Gordon Pask. This book coincided with an exhibition of the same name showcasing the unit's work, notably the use of electronics for design and its use in the Universal Constructor. This machine was designed to be representative of cellular automata and neural networks[21]. It was made of cubes packed with sensors that could plug into each other and create an awareness of its overall configuration, and the sensed environment of each cell.

Having the books side-by-side, interesting similarities are immediate. In the design of the books, the sizes and format are similar. Stylistically, there is a manipulation of the text body to create a rhythmic break; some pages go from a pattern of two columns at smaller font size to suddenly having text at full bleed in much larger font. Many images and illustrations are used as punctuation: full pages may contain diagrams that seem to merit another thought – a counterpoint. In content, elaborate and long text is generally avoided for shorter points of encyclopedic-type entries.

If the history of technology being absorbed into the discipline of architecture is one that is marked by slow adaptation, then the annealing of digital technology to architectural design is surely arriving after initial, furtive efforts.

*If the seventeenth and early eighteenth centuries are the age of clocks, and the later eighteenth and the nineteenth centuries constitute the age of steam engines, the present time is the age of communication and control.*

Norbert Weiner, *Cybernetics*, 1948

### **The Visionaries: Past Futures**

There have been a few architectural events that bring together technology and architecture in a certain vision of projected desires. The ones selected here are most relevant to the discussion on present work:

- 1909 The Futurist Manifesto
- 1919 L'Esprit Nouveau
- 1933 Chicago World's Fair
- 1948 Cybernetics
- 1960 Fun Palace
- 1964 Plug-in City
- 1966 Architecture Principe
- 1977 The Pompidou Centre

The Italian poet Marinetti wrote *The Futurist Manifesto*, by his account, after an automotive wreck in which he and his car were the new instance of human and machine fusion, described somewhat as unleashed on a new nature[22]. While insanely amplified, it did find a receptive audience in many artists and architects such as Sant'Elia who published and exhibited a series of drawings in 1914 that blended civic architecture with a magnitude and scale of civil engineering works.

The journal, *L'Esprit Nouveau*, was launched in 1919 Paris by Ozenfant and Le Corbusier with a series of articles challenging architects to see the new industrial reality in machines such as the ocean-liner, automobile, and airplanes as architectural references[23].

In the Depression-era U.S.A. of 1933, the World Fair in Chicago had many pavilions and buildings constructed by automobile and industrial appliance companies to show the products of the present as well the future. These declarative exhibitions were housed in architecture of similar expression. The common theme was a future of devices and systems to enrich society, and benefit human life[24].

Post-war England had a realignment of their traditional values, and architect Cedric Price was the pioneer in fusing architecture with technology as a kinetic, intelligent machine[25]. His Fun Palace proposal of 1960 was not built but it was an influential project. On the team was the British cyberneticist Gordon Pask. Cybernetics began as a synthesis of many branches of science and engineering, and was introduced in 1948 by Norbert Wiener in discussing signals, its communication, and its control[26].

The Fun Palace had direct descendants in Archigram's Plug-in City proposal, and a successfully realized building in Piano and Rogers' Pompidou Centre in Beaubourg, Paris. This building with its services exposed and its machine aesthetic was to become typical of a new high-tech building type from Britain whose practitioners continue its practice today. The Tower of 30 St. Mary Axe by Foster and Partners is a recent example of a technocratic shell or cladding system around which the building is organized.

The French group, Architecture Principe, of Virilio and Parent is an interesting addition to this list. They present a uniquely dystopic view in the use of technology but from its advancements in war machines[27].

### **The Next Wave**

As in the brief from Paradiso above, we are experiencing an acceleration in the capacity of integrated circuits that is changing the way we live as a society. The challenge becomes finding use for these incoming waves of circuitry in meaningful ways.

Neil Gershenfeld, Center for Bits and Atoms  
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Carlo Ratti, Senseable Cities  
Federico Casalegno, Mobile Experience Lab

The Center for Bits and Atoms as directed by Neil Gershenfeld has a project called FabLabs with locations around the world in both developing and developed nations. The mission statement of these labs is in taking technology from corporate, private interest and into the hands of the individual. Parallel research is being done in the dissemination of fabrication techniques such as flat-pack assembly for housing and antennae as well as circuit-board design and production[28].

Another research initiative is in ubiquitous networked devices called internet 0. This has widespread application in the control and cost of intelligent building systems not only for the scale of a single building but potentially networked across the planet[29].

William Mitchell is an architect and educator, past Director, and most aware of the lineage of the architect-technologist hybrid condition traced out in the section above. His research in Smart Cities is the discrete and global inversion of infrastructure as it exists in any city, be it Boston or Milan. The use of the word pervasive is often applied to increasingly smaller devices but in this application the devices are both static and active, embedded in buildings and also mobile as vehicles. This radicality is more evident as it reconnects and redistributes the information and morphology of a city without a wholesale wipeout and rebuild as suggested by the architects above. This is an approach of sophistication and maturity to maintain the urban artefacts yet allow for the introduction of new technologies[30].

Mitchell's other involvements are in the Mobile Experience Lab and Senseable Cities group. Each research team has their own agendas with projects in mapping of communications, and in ambient/interactive environments. These groups are multi-disciplinary by choice and multi-modal, with affiliations in international schools and industries. Each group is dedicated to increasing knowledge in a new field. The Senseable Cities group is working with cell-phone data in providing GIS data for communications local and abroad.

*By continuously embracing technologies, we relate ourselves to them as servomechanisms. That is why we must, to use them all, serve these objects, these extensions of ourselves... A [native-American] is the servomechanism of his canoe, as the cowboy of his horse or the executive of his clock.*

Marshall McLuhan, *The Gadget Lover*, 1964

### **Terminologies/Definitions**

Like the definitions made for the discipline of Architecture, clear terminologies are required for the terms Ambience, Intelligence, Responsive, and Environments, These terms have clear boundaries and its best use would be found in the work of the Responsive Environments Group at the Media Lab. This is a selective frame as the same term is also used by architects projecting a visionary scope beyond static or inert physical buildings.

This paper defines the term as the method of augmenting user experience by sensor technologies to bring about responsive changes. This term will then be expanded into Activated Architecture whereby physical computing becomes integrated into architecture as a specific design criterion.

The Responsive Environment for Paradiso is based on how sensor networks augment and mediate human experience, interaction and perception. This is an adequate operational definition to make clear an agenda[31].

For Negroponte, response is proposed in two classes: reflexive and simulated. The reflexive response is one that takes place as a part of that space, reflecting a purpose. Negroponte is at pains to stake this separately from examples of sliding doors as these are simply binary as the switch of a lamp or the process of a thermostat[32]. The second type of simulated response which he relegates to a secondary operation of entertainment. These simulations are meant as a secondary response system, or as a diversion.

Intelligence has been used fairly generously with sensor systems deployed in buildings[33]. As Pask wrote in his

introduction to Negroponte's Soft Architecture Machines, "The contention is as follows: intelligence is a property that is ascribed by an *external observer* to a *conversation* between *participants* if, and only if, their dialogue manifests *understanding*." [34]

Environments are also defined by Pask: "The term environment is specifically reserved for entities that can be described or prescribed in the manner of mechanical individuals: that is, in terms of states and state transitions (whether in the sense of automation theory or the very different sense of physical states)."[35]

To return to the meaningfulness of this enterprise, Negroponte provides a warning. "We must experiment with more caution in responsive architecture than is necessary with mechanical partner that have relatively singular purposes... it is a complicated set on nonlinear trade-offs that will vary from person to person... resting, for the most part, on the feasibility and advisability of a machine intelligence. The question will arise: Can a machine learn without a body? A house has a body of its own; will I be able to laugh at its jokes?"[36]

### **Popular Fiction**

There have been many representation of the future society in popular culture - some idyllic, and others skeptical. An early film from Fritz Lang, *Metropolis*, does not depict an improved society at all, but a polarized scenario of the proletariat and bourgeoisie, heightened by the oppression of machines that require maintenance at incredible human effort. One robot doppelganger for a young woman incites a workers riot and destroys the city.

A certain lure and uneasiness remains to this day in the specific rules of anthropomorphizing humanoid robots to be diminutive in stature and child-like. The rationale is that it minimizes the threat of danger or harm.

Of the many science fiction of reconfiguring/responsive houses, the British novelist J. G. Ballard had the most congruent view of what Pask and Negroponte were describing. In his short story of *The Thousand Dreams of Stellavista*, Ballard writes of a psychotropic house - a machine entity that responds and learns from its occupants, but not without some difficulties[37]. These houses are entities - fully interactive with machine intelligence and learning.

J.G. Ballard, *The Thousand Dreams of Stellavista*, 1971

*...it consisted of six huge aluminum-shelled spheres suspended like the elements of a mobile from an enormous concrete davit. The largest sphere contained the lounge, the others successively smaller and spiraling upward into the air, the bedrooms and kitchen...*

*Stamers, the agent, left us sitting in the car... and switched the place on (all the houses in Vermillion Sands, it goes without saying, were psychotropic). There was a dim whirring, and the spheres tipped and began to rotate, brushing against the undergrowth.*

*...I got out and walked over to the entrance, the main sphere slowing as I approached, uncertainly steering a course toward me, the smaller ones following.*

*...As I stepped forward, it jerked away, almost in alarm, the entrance retracting and sending a low shudder through the rest of the spheres.*

*It's always interesting to watch a psychotropic house try to adjust itself to strangers, particularly those at all guarded or suspicious. The responses vary, a blend of past reactions to negative emotions, the hostility of the previous tenants...*

*...Stamers was fiddling desperately with the control console recessed into the wall behind the door, damping the volume down as low as possible...*

*He smiled thinly at me. "Circuits are a little worn. Nothing serious..."*

*...The first PT [psychotropic] houses had so many senso-cells distributed over them, echoing every shift of mood and position of the occupants, that living in one was like inhabiting someone else's brain.*



## **5. Mediated Environments: Activated Architecture**

### **Gordon Pask**

As an instructor at the Architectural Association in London during the years 1986 to 1994 and as a collaborator with the Architecture Machine Group at MIT (now the Media Lab), Gordon Pask was interested in the dynamics of an interactive environment.

### **Activated Assemblies**

Meaning in architecture has isotropic instances of realization, one that can unfold during the design process and one that can be layered onto the artifact of the building; its components and forms constitute a communication flow that emerges from an abstract form of description to its physicality. The internal cognition of this condition situates the subject as the third element, one that identifies the meaning from the extant building to its proxy meaning. In this manner, narrative and aesthetics perform the actualizations (the spatial and physical sequences) so that the occupant may understand its implications[38]. Architecture is thus a one-directional flow of information (the building is an inert object from which meaning is derived, its physicality is static). Even in process-driven design, the synthesis of the many and the ordered, is evident in the materiality of the architectural manifestation; the building, although presented as a result of process cannot be separated from the reading of the generative operations[39].

Rather than continue in this manner of constructing meaning from an extensive coding (joining a concept to an object) or the instantiation (producing one from a larger field of possibilities) from a version, we suggest a dialectic that is bi-directional, or even multi-nodal, that is, continually self-renewing in meaning and material configuration with the active participation of the occupant. This representation is one that is time-based.

### **Architecture and physical computing**

Physical computing is defined here as a designed environment that responds to input. This input can be analog - input from the physical world of human occupation or of atmosphere - or it can be digital - input from other computers, networks, or signals.

Through the integration of physical computing in the conception of the design process, the work of architects in manipulating space with tectonic logic and material

affect not only expands, but new territories are found. Architecture gains another medium in computation that is not only critical in the making of digital form or information modeling but in the reassembly of spatial logic. As physical computing and cybernetics becomes increasingly ubiquitous in the practice of building, architecture - as a design discipline - must become a participant in its deployment. For physical computing, disciplinary tools must be applied for it to become an Activated Architecture in which we can shape and assess the polemic of its results.

### **Transitions**

The onset of ubiquitous computing and what we determine as Activated Architecture is not linked or archived only in the work of prior generations of architects. It is the purview of the physicists, the engineers and the cyberneticists alongside with architects and designers: those who increase design in their respective fields. Here the argument may move into the re-alignment of a critical discourse of architecture applied to physical computing, or into the dissolution of this outmoded field of architecture into one of networked collaborations. We are interested in trying to find an architectural polemic, a scenario where the efforts are focused at achieving an architecturally meaningful format exchange.

For Pask, digital simulation is the domain of a new reality, as it no longer needs justification from an external source; the simulation has its own set of rules and patterns making it independent. Rather than a linear, one to one mapping of an stimulus and a predetermined response, there is now a first order and second order, a system aware of being observed and of the other observer system, derived from feedback loops. This is the teleology of an observed system to the cognition of the observing system.

### **Conversation Theory**

This evolved into the use of language, of communication called Conversation Theory- one level has a set of goals, the other a set of actions. The response mechanism is not a direct, anticipatory mapping; instead the system has a higher order goal. This Paskian Environment had a capacity for boredom, a feedback loop to establish a level of interaction, rather than a simple reaction enforced upon the system[40]. This idea of system participation, and not a regulated manner of information and control is what differentiates Pask when applied to his architecture studio.

...  
*Between the idea*  
*And the reality*  
*Between the motion*  
*And the act*  
*Falls the Shadow*  
...

T.S. Eliot, *The Hollow Men*, 1925

### **Ordering and organization**

For Pask there was a need for new criteria to describe existing information. Pask's Interactions of Actor Theory continues his work on second order environments[41]. In his attempts to discard the notion of user and machine, Pask introduces process as "Concepts persist minimally as stable dynamic resonating triples linked in the Borromean manner." It can be determined in the interdependence of process and product in the continual maintenance of a dynamic stability so that a tripartite borromean knot topology is maintained. Any product or process has a simultaneous switching impact on all other products and processes. For his Paskian environments, this can have an impact on architecture that is truly participative beyond simplistic behaviours[42].

### **Architectural implications**

Pask's work in architecture, particularly as a collaborator with Cedric Price's Fun Palace, and in his own Colloquy of Mobiles art installations for the ICA in 1968, was carefully defined in definitions and behaviours[43]. The use of control, information, and feedback were vigilantly maintained but Pask was interested in the new meaningful relationships to be explored by this self-organizing system itself; he was interested in carefully specifying the initial start of the system but then allowing it to manufacture its own logic of connections, even proposing that the system grow new wire connections over time in response to its own impulses[44].

What can be concluded here is that architectural discourse can be maintained within the device of representation that is made of indivisible elements made meaningful in social action. For Pask, those elements are inextricably linked, and in a dynamic equilibrium represented in participative behaviour. The validity of the system is in the mutability of predetermined responses for an adaptive collective experience.

*"... The role of the architect here, I think, is not so much to design a building or city as to catalyze them; to act that they may evolve." Gordon Pask*

### **a new design method**

Applying this criticality, physical computing is currently defined as a designed environment that responds to input. Brought into the designed environment, which we instantiate as Activated Architecture, there is a transformation of the input that creates a dynamic response back to the occupant. This information is organized by the microprocessor into an exchange with an output device. In fact, this information is without value until linked with an agent of expression that is made meaningful to the other. It is this application of motive and its conveyance that is potentially troubled. The issue of what is perceived or interpreted is a historical one that can be addressed by the intention without ambiguity - electronics having no dominant or privileged viewpoint.

The interesting aspect of this is the nature of what input and what output creates a meaningful relationship with the occupants. The observer as the passive recipient of the building output is now wholly active in initializing the response designed into the building. Buildings now have a narrative structure that can be construed as inbuilt. In electronics, bits are organized to represent a mediated reality. Messages sent in bits to the microprocessor from the sensors, are represented/translated in programming as an output that in turn can be sent back into the system.

This is an architectural environment that is embedded and responsive. Its design and its execution are linked to become cyclical. What is generative is equally generated within its constant and dynamic feedback. The critical issues in conformal computing are those of representation and meaning as not only applied to space but to time. The sequence of actions within the system, the delay and patterning of information transfer for legible visualization, and the extensibility from local system to global networks are isotropic in the communication of meaning.

### **Continuous present – feedback as cyclical design**

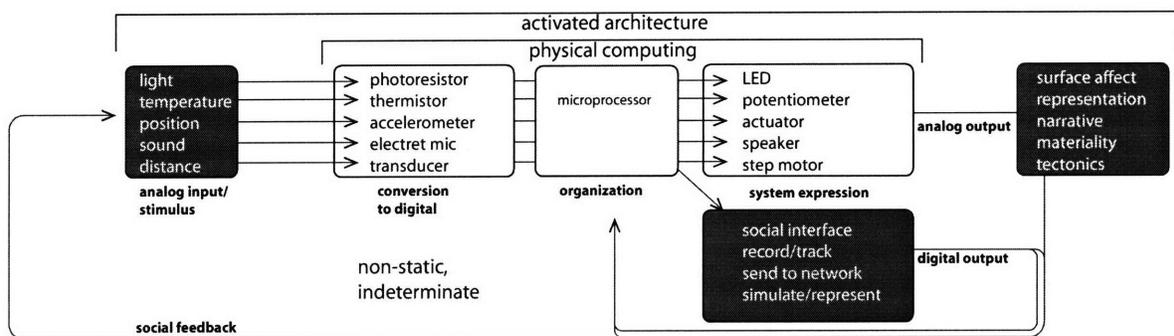
Activated architecture therefore surpasses traditional built form because of its constant negotiation of inputs and designed outcomes, an architecture that is charged and renewing. It continuously maintains a connection from the initial design phases to its materialization. The design

input is still accessible through the output via the feedback loop. Inhabitable space becomes an indeterminate design experience, not a fixed, designed environment – the process remains active.

In this context, we are facing a scenario where the efforts are focused at achieving a format exchange: a reality that occurs in digital format, and a virtuality that occurs as a physical condition. The interesting aspect of this framework is that contrary to the traditional model, one cannot occur without the other. This interaction is characterized by the fact that our physical virtuality requires processing capabilities; and it can only exist in tandem with computational intelligence. Therefore, the separation between mediums as discrete or isolated instances is replaced by a multi-nodal model; one that places physical computing at the core of architectural design.



this diagram shows the chaining of ideas or concepts so that the target and source are tied together in a cycle, and not a linear transfer.



this diagram shows the feedback loops into the system to constantly negotiate user input and maintain a dynamic system. Varying inputs can be matched with various outputs but the connections chosen should be based on a meaningful purpose or use.



## **Case Studies**

These are two current projects that utilize the thoughts and ideas developed here. They represent a certain aspect of activated architecture that use similar sensor technologies, but operate on different scales and with different goals.

These projects are commissions and belong to Ibanez | Kim studio (the author is a co-founder, along with Mariana Ibanez ); they are presented here for demonstration purposes. The electronic design and implementation were developed with Sigurdour Orn Adalgeirsson, a member of the Personal Robotics Group at the Media Lab.

Both projects were developed as experiments for the author's research and although unfinished at the time of writing (the exhibition opens in September, the house will begin construction in spring 2009), they have become patterns in which to establish future protocols.

## 6. Case Study One

### Light Boxes

Harvard University Graduate School of Design

Invited by Assistant Professor Mariana Ibanez and the Graduate School of Design Exhibition and Publications Committee

Curated and designed by Assistant Professor Mariana Ibanez

In June 2008, I|K studio was asked to design and install a field of interactive displays for an upcoming exhibition titled *New Trajectories: Contemporary Architecture in Croatia and Slovenia*.

Located at the ground floor of the Graduate School of Design, the exhibition would have to be of sufficient size to transform the large lobby space. The projected opening of September would make this the opening exhibition of the new academic year of fall 2008. The exhibition would also last six weeks, and host a conference.

Working with the designers of the exhibition, the initial idea was to create a series of display cases within which LED arrays would not only provide illumination to its contents, but also demonstrate behaviours that suggest a curatorial path for the viewer. These resultant **LightBoxes** would be suspended in a larger environment - a taut, stretched fabric shell with text and images and also lit from behind.

The design intent would be an otherwise dark gallery space encompassed by a softly lit shell. Within this wrapped environment would be a field of display cases interacting with the patrons.

For the single LightBox, proximity sensing with ultrasonic transducers was used so that the passing of a patron would activate the LED display, and become brighter as the viewer approached to view its contents.

For the collection of LightBoxes, a higher-order intelligence was needed to suggest connections with other LightBoxes, and therefore generate interest in the viewer to a prescribed, but non-explicit, trajectory. The curator would have several displays share similar qualities but have them in a linear sequence, or have them in another configuration, like a spiral. The viewer may even enter a sequence mid-stream, or one that bifurcates. This requires the LightBoxes to demonstrate a group intelligence, where neighbours and their contents are known.

## Case study: Light Boxes

### Brief:

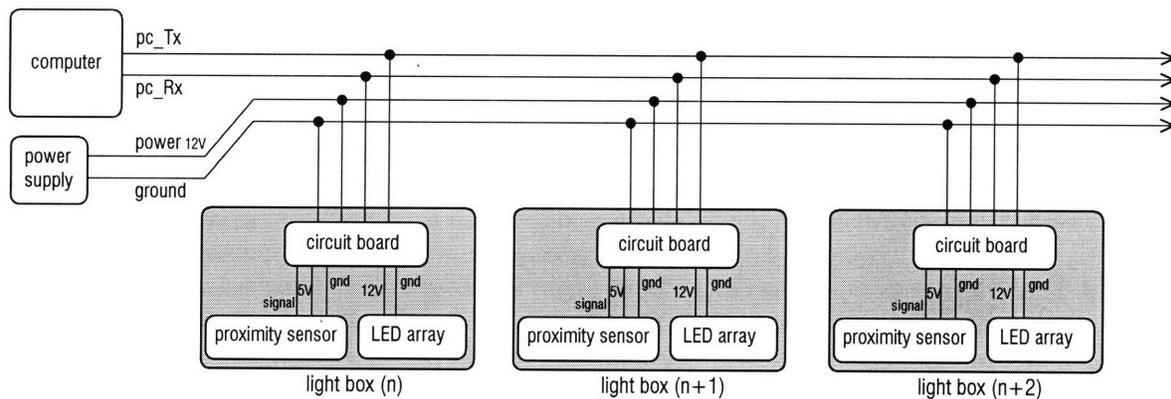
The use of LED arrays was optimal for the display of architectural drawings and physical models. Within a box of acrylic these materials would be illuminated by the LED array positioned at regular intervals for distributed lighting. The LED's would activate by proximity sensing using ultrasonic sensors.

### Goals:

The LightBoxes are set up to not only illuminate their own particular contents for the viewer, but are also able to suggest contextual paths, or the next display, by the lighting of their neighbouring LightBoxes.

### Method:

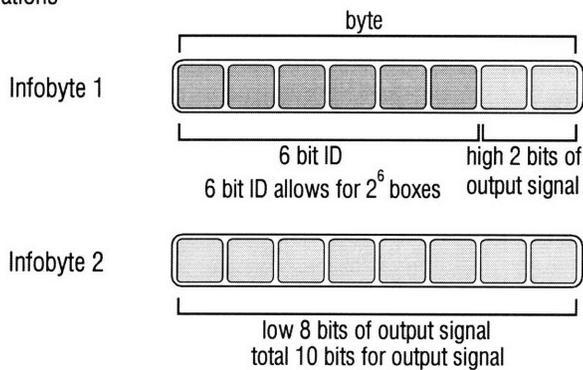
All the LightBoxes (at a number of 15) are controlled by a local microprocessor. These microprocessors are linked serially to a central computer.



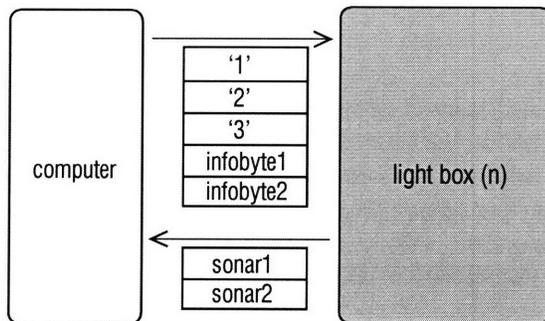
Communication:

The PC sends out a header of bytes (1,2,3) for correct synchronization of all pcb's. Each microprocessor is listening so that when they see 1,2,3 they know to listen to the next 2 values in the infobytes. The light output requires 10 bits, although one byte has 8 bits. Therefore, because each infobyte has 8 bits we use the first 6 to insert the ID of each microprocessor. When the corresponding microprocessor recognizes itself, the remaining 2 bits, plus the following 8 bits, is the Pulse Width Modulation

Communications

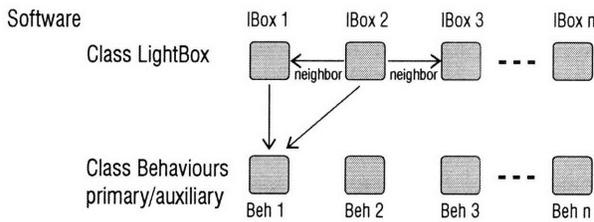


Sequence

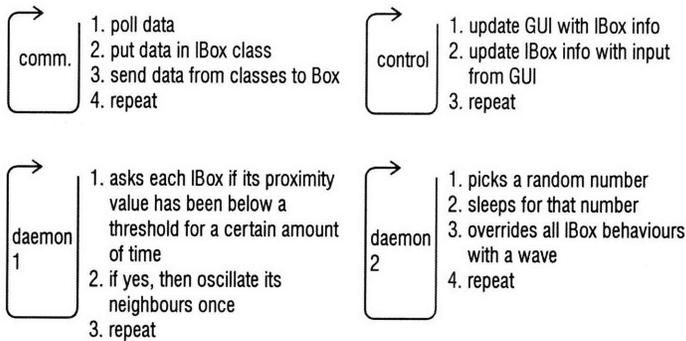


(PWM) signal for that microprocessor to send to its LED array LightBox. The microprocessor then acquires the line and sends back its sonar reading which is 2 bytes (16 bits) and then relinquishes the line. In this way the line is only occupied by data from one box at a time. The PC registers that response for that particular LightBox and sends again the 1,2,3, for the next microprocessor. This is how the system sets the light intensity of the LEDs, and reads the sonar signals.





Threading



The daemon thread picks a random number and sleeps for that length of time. Afterwards, it will override all behaviours of the lightboxes with an auxiliary behaviour such as a wave. It asks each lightbox if its proximity value has been below a certain threshold for a certain amount of time. If so, oscillate its neighbours once.

Filtering:

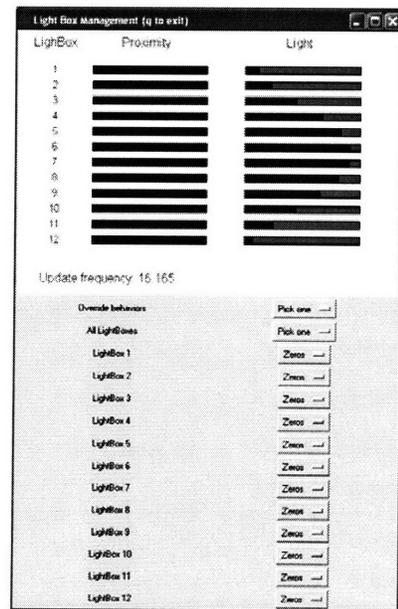
Filtering is used to 'soften' the light output as the sonar data is noisy. Both the incoming sonar values and the outgoing PWM values are filtered. Whenever a new sonar reading appears, it is median filtered and then filtered using a running-average filter. Both are of an order heuristically chosen to have the best performance. The PWM values are filtered by the lightbox class; it asks for a next PWM value from the behaviour and then it filters the value using a running-average filter. The benefits of filtering the PWM is visually nice fading and the fact that it removes abrupt changes in current.

Non-linear LED output:

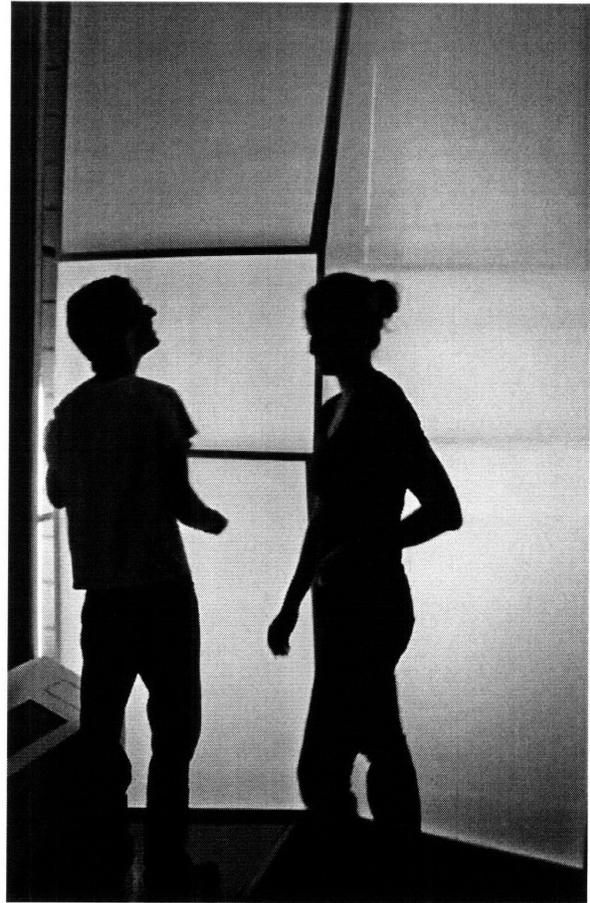
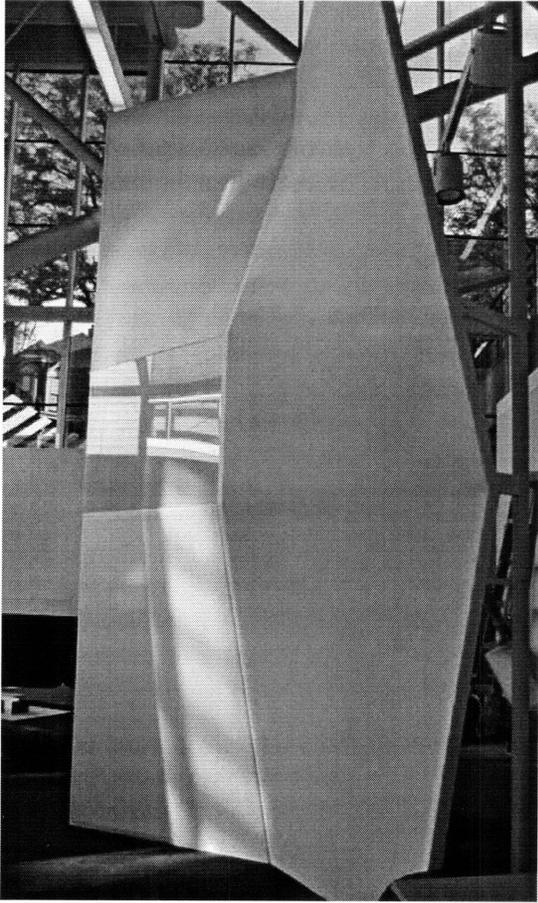
Because the light output does not match the voltage in a linear fashion, a transform function is used to equally distribute the light intensity as the voltage changes. The function used is an exponential one, visible in figure YY, to linearize the relationship between the input and the output light intensity.

The behaviours are what give a higher order to the interaction of the Light-Box. Rather than a linear mapping of human detection to light output, the primary behaviours link each LightBox to its neighbours and to the entire system in auxiliary behaviours. These auxiliary behaviours are an attempt to replicate a tedium or what Pask described as boredom in the machine when he wrote of the Conversation Theory. This is what elevates the machine from a responsive automata to a truly interactive entity that is more than simply linear or predictive.

The graphic user interface below is demonstrating a wave simulation where all the arrays in the LightBoxes are cycling through their light output at timed increments. The wave is behaviour among others that can be called by this menu, or triggered by an auxiliary behaviour.



GUI of behaviours



prototype of overall structure

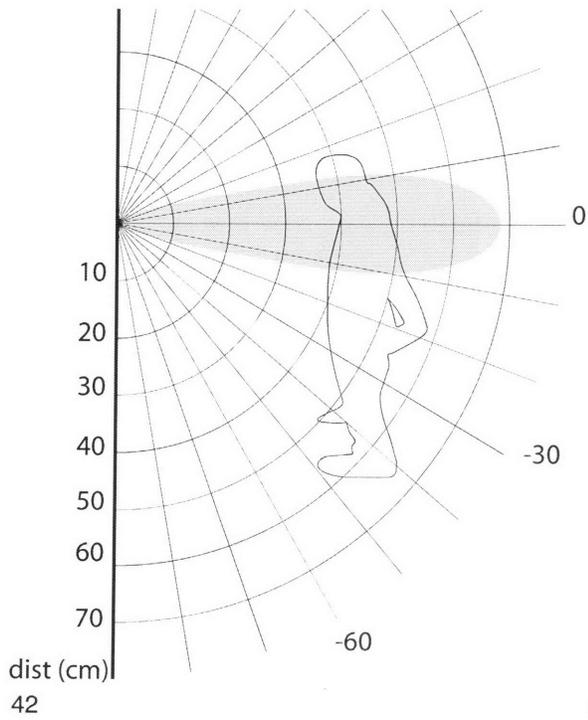
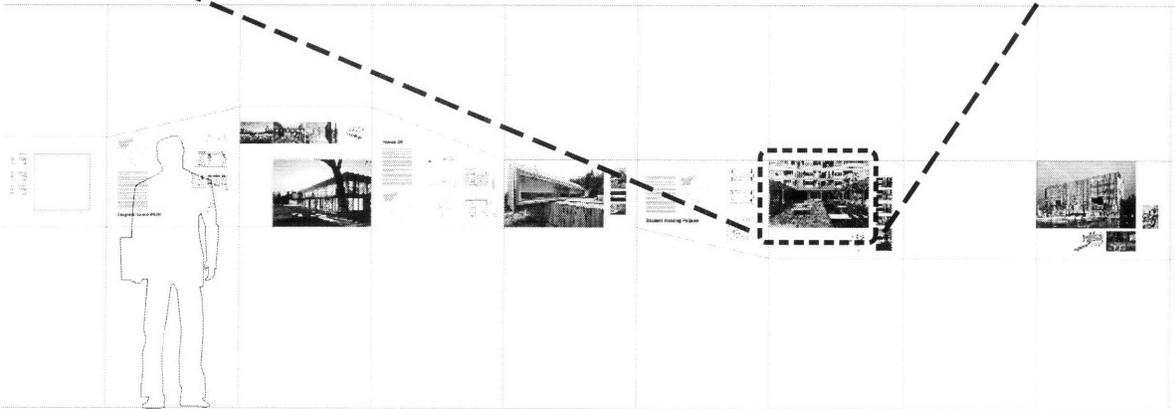
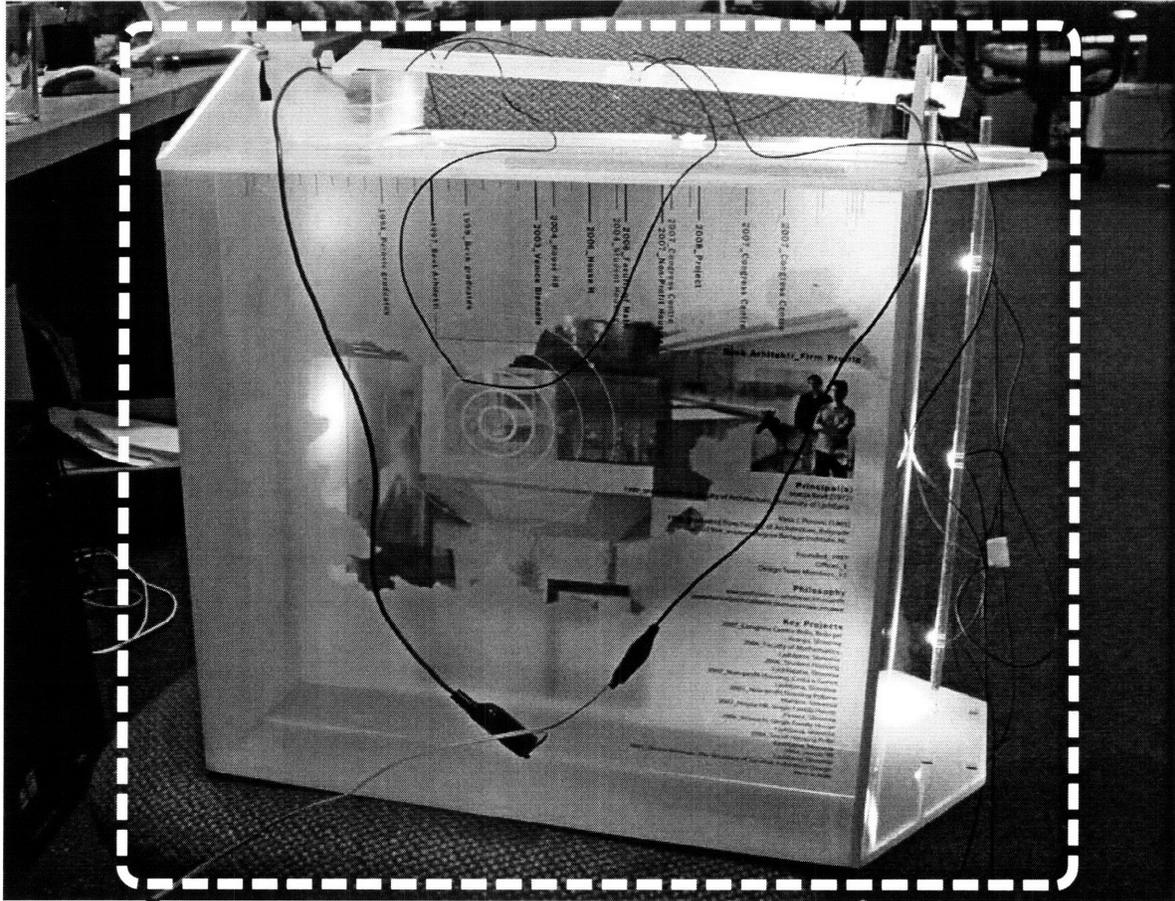
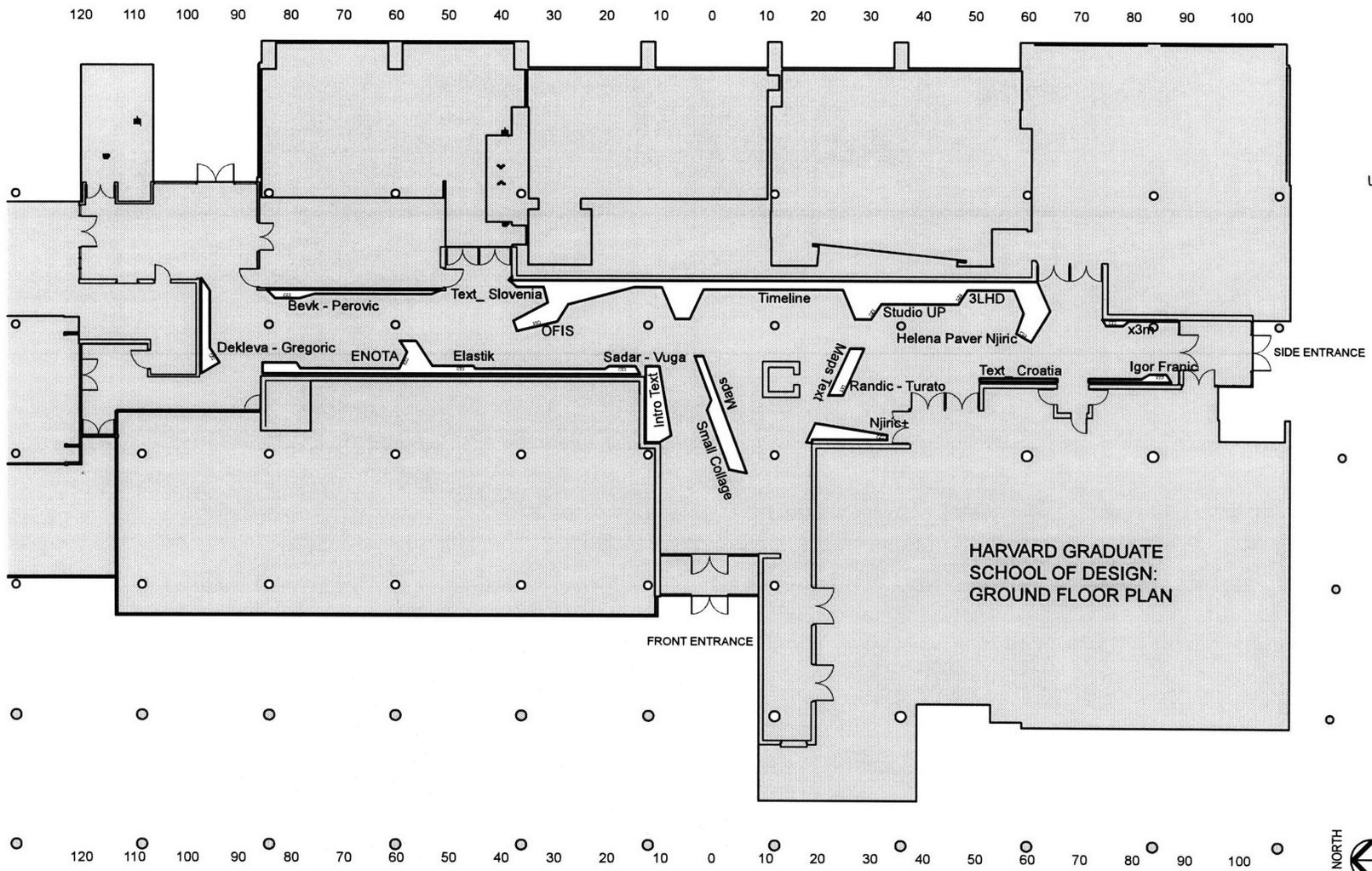
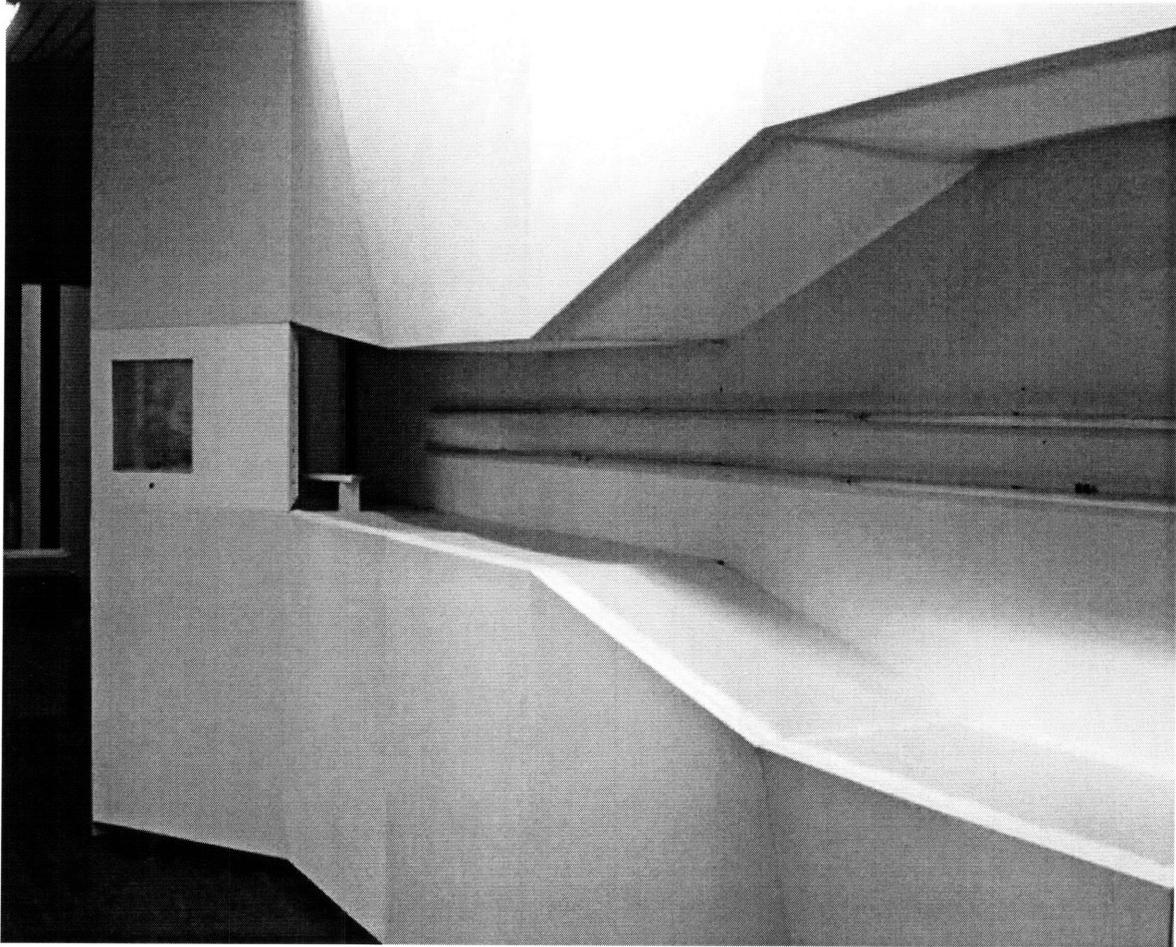


diagram placing proximity sensors at useful distances



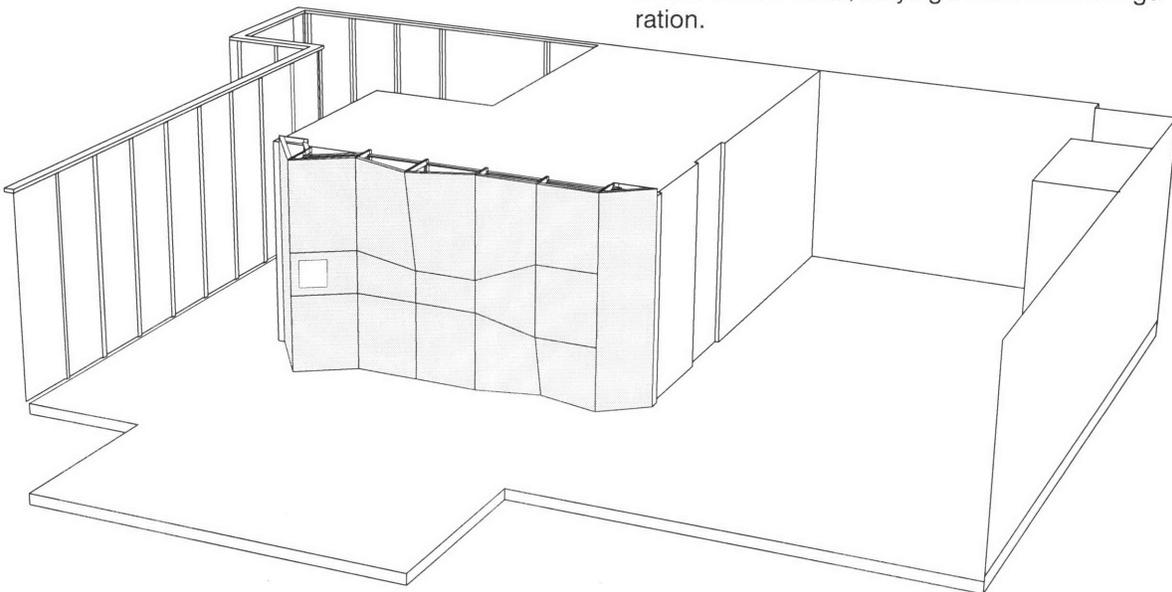
lightbox prototype and test images





above: one of the units without the lightBoxes installed

below: a depiction of the same unit. There are twelve units in total, varying in size and configuration.



## 7. Case Study 2

Ordos 100 project  
Ordos, Inner Mongolia  
Invited by Herzog and de Meuron  
Curated by Ai Wei Wei and FAKE Design

In late November 2007, I|K studio (the author is a co-founder, along with Mariana Ibanez) received a Request For Qualifications to participate in a housing development in Inner Mongolia, an autonomous region of China.

The client and developer had set aside several hundred hectares of land from a larger masterplan in which to cultivate a precinct to benefit the arts. Contracting the artist Ai Wei Wei and his office FAKE Design in Beijing, the idea of hiring 100 foreign offices to design 100 villas was established, where FAKE would be the masterplanner and curator. The architecture office of Herzog and De Meuron, with whom Ai Wei Wei had collaborated on what was to become the National Stadium of the 2008 Olympic Games, was instrumental in the recommendation and collection of an international group of offices from which 100 were chosen.

In February 2008, I|K studio was informed of their placement in what was named Ordos100 and invited to Beijing, then Ordos, to meet the client and attend conference on the urbanism and cultural implications of this non-consensus, plurality-driven undertaking. Afterwards, a lottery was held to distribute the parcel of land to each architect. Following the introductions, presentations, and site visits, the participating one hundred offices returned to their homes to satisfy the brief of a thousand square metre home.

Taken as a test case for the culmination of research and work at MIT, the architectural implications of physical computing was applied to specific aspects of this villa. Two parallel strategies were established:

1. Interaction was given to not only the occupants inside the house, but this interaction would be shared with outside/foreign agents on the site.
2. This interaction would be not only a dynamic environment, but it would also be a formal generator of the geometry of the villa.

With the promising work of the case study done for the exhibition at Harvard, proximity sensing was again used but with expanded behaviours and more elements. There were now fifty-four sensors in the landscape surrounding the villa.

As of this thesis submission, I|K studio is completing the technical drawings for the construction of the villa and the field of cross-products. This work is ongoing and construction is scheduled to begin in spring 2009.

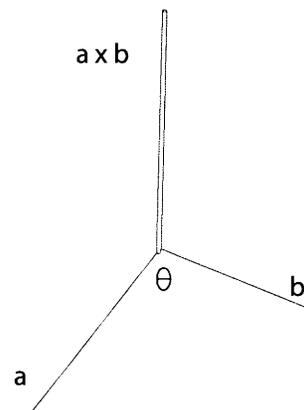
The project departs from the LightBox as another criteria comes into play. With the much larger field of fifty-four cross-product-lightpoles, agencies and activation become something like neural nets, where enough information is gathered from each element to create a mapping of the site. Conversely, if the brief would have allowed for it, the activity in the house would also be mapped. The internal/external would be examined as house and site become an interactive game.

Each crossproduct is generated by the multiplication of two vectors with the sin of theta separating the vectors:

$$\mathbf{a} \times \mathbf{b} = ab \sin \theta$$

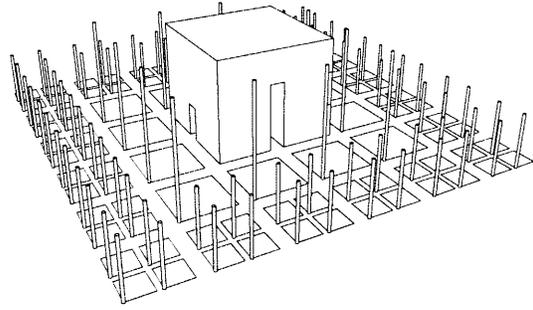
The two vectors  $a$  and  $b$  originate at a shared point and move away at their own magnitude and direction. That bounded region can be seen as a plateau, or a planar, 2 dimensional surface. In this case, each of these  $a \times b$  surfaces is a horizontal terrace that cascades down nearly 4 meters. This is a significant elevation change in the landscape. The most interesting way to make use of this kind of site is to create horizontal fields in which various activities can occur. If each field is parallelepiped, the cross product can be derived.

Vector cross products have no inherent architectural meaning. However, vertical vectors are plentiful in structural diagrams as structural supports.

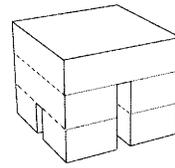


DIAGRAMMATIC PROCEDURE

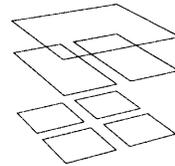
E. final



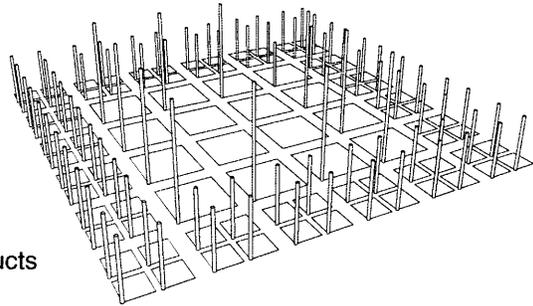
D. resulting scheme



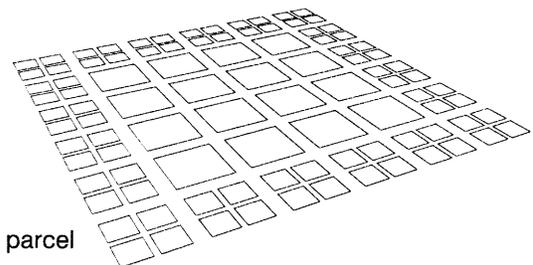
C. bifurcate 4-2-1



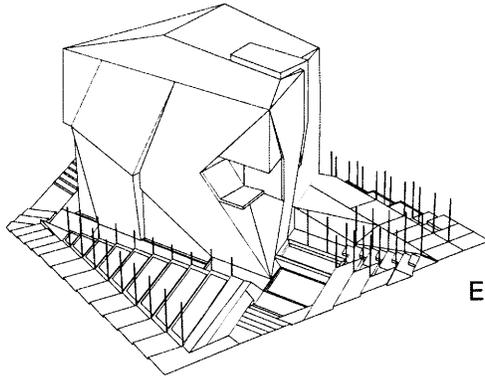
B. find cross products



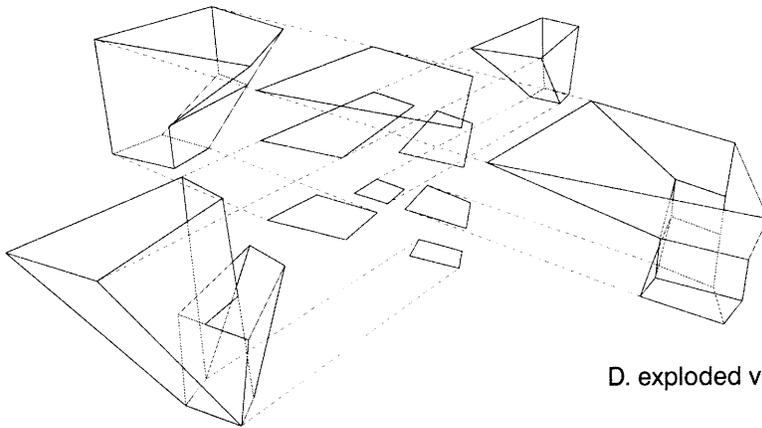
A. subdivide abstract parcel



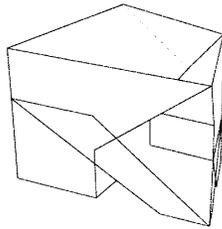
FINAL PROCEDURE



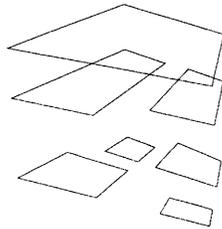
E. final composition with cross products



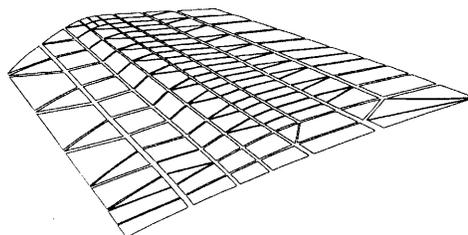
D. exploded view showing pieces



C. resulting house



B. loft from 4-2-1

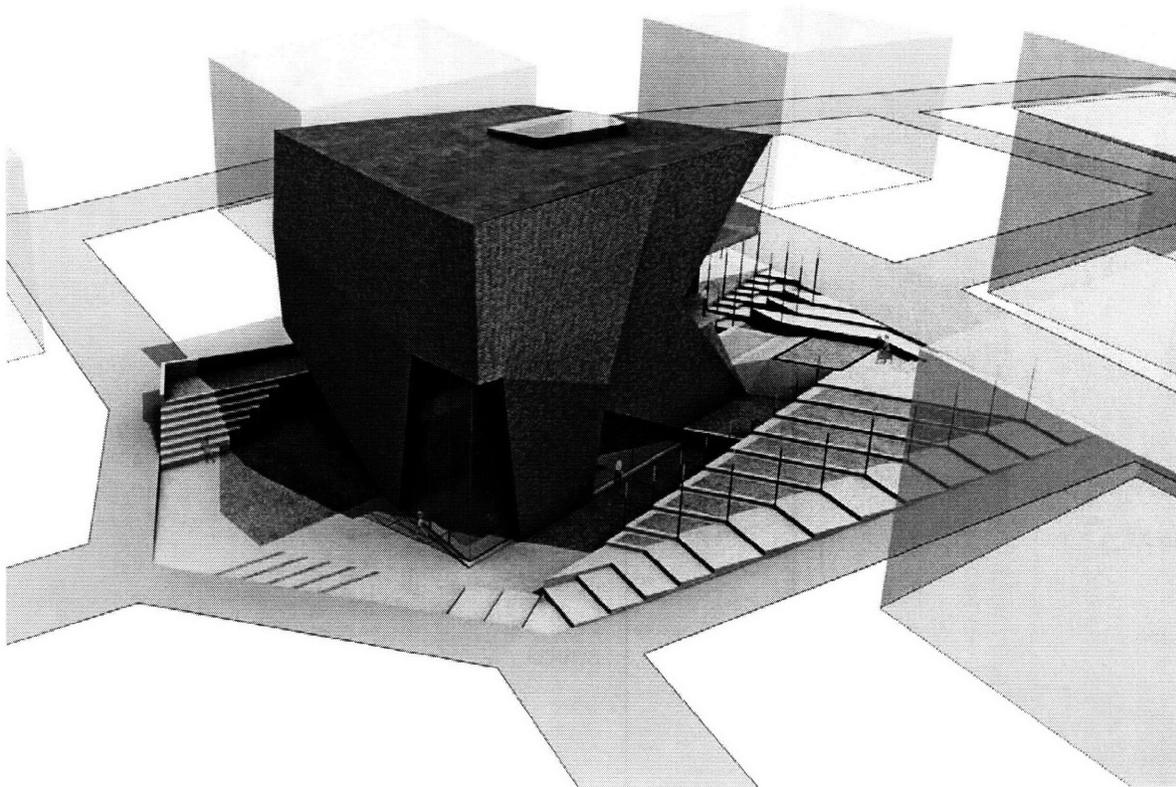


A. subdivide real parcel

## Case study: House, Inner Mongolia

### Brief:

The office of the author was invited to design a house in Inner Mongolia. 100 architects were chosen internationally to design 100 villas for a new development. For the landscaping around the house, a system of proximity sensing and lighting was employed. Rather than a classical scheme of sensor and display, the project in Inner Mongolia would be better served through an interactive outside/inside. This results in a control where the readings of the sensors in the site and the manner in which they react is controlled by the occupants within the house..

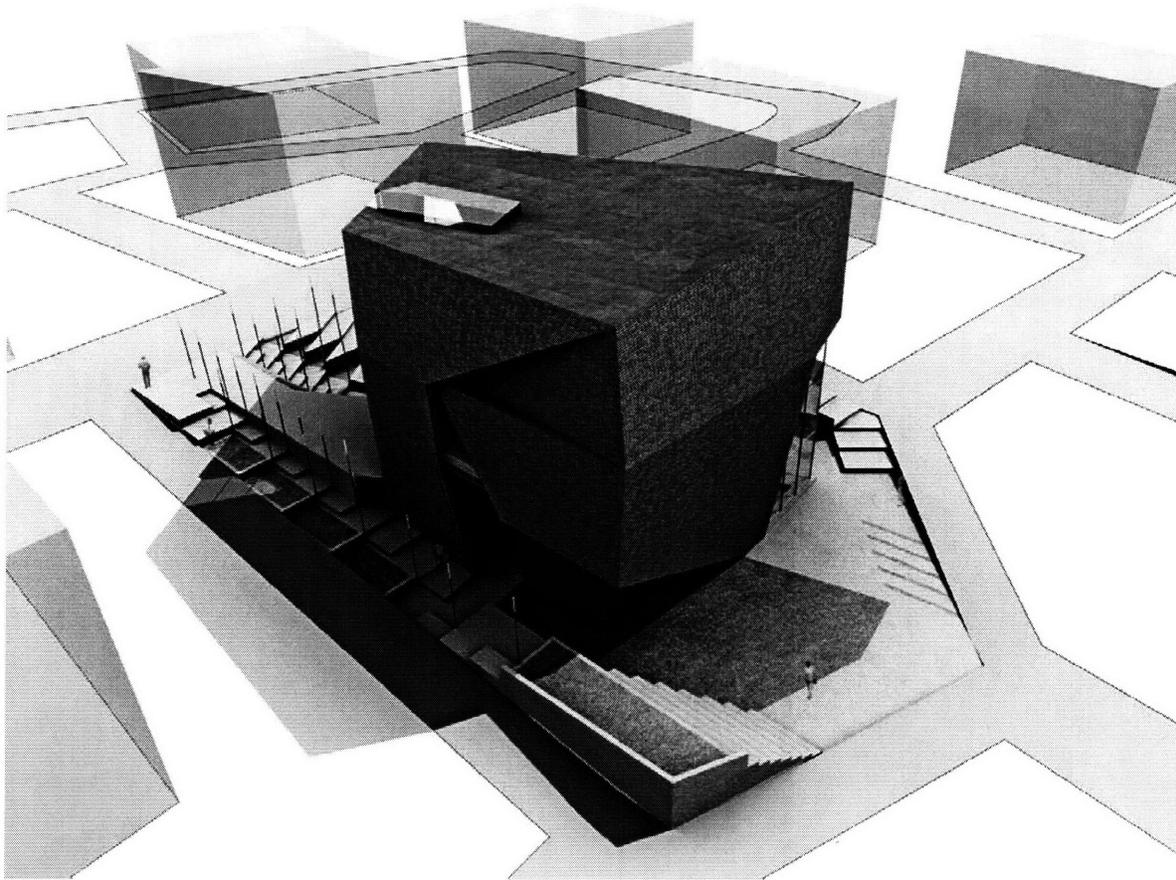


south-west aerial view

### Site Strategy

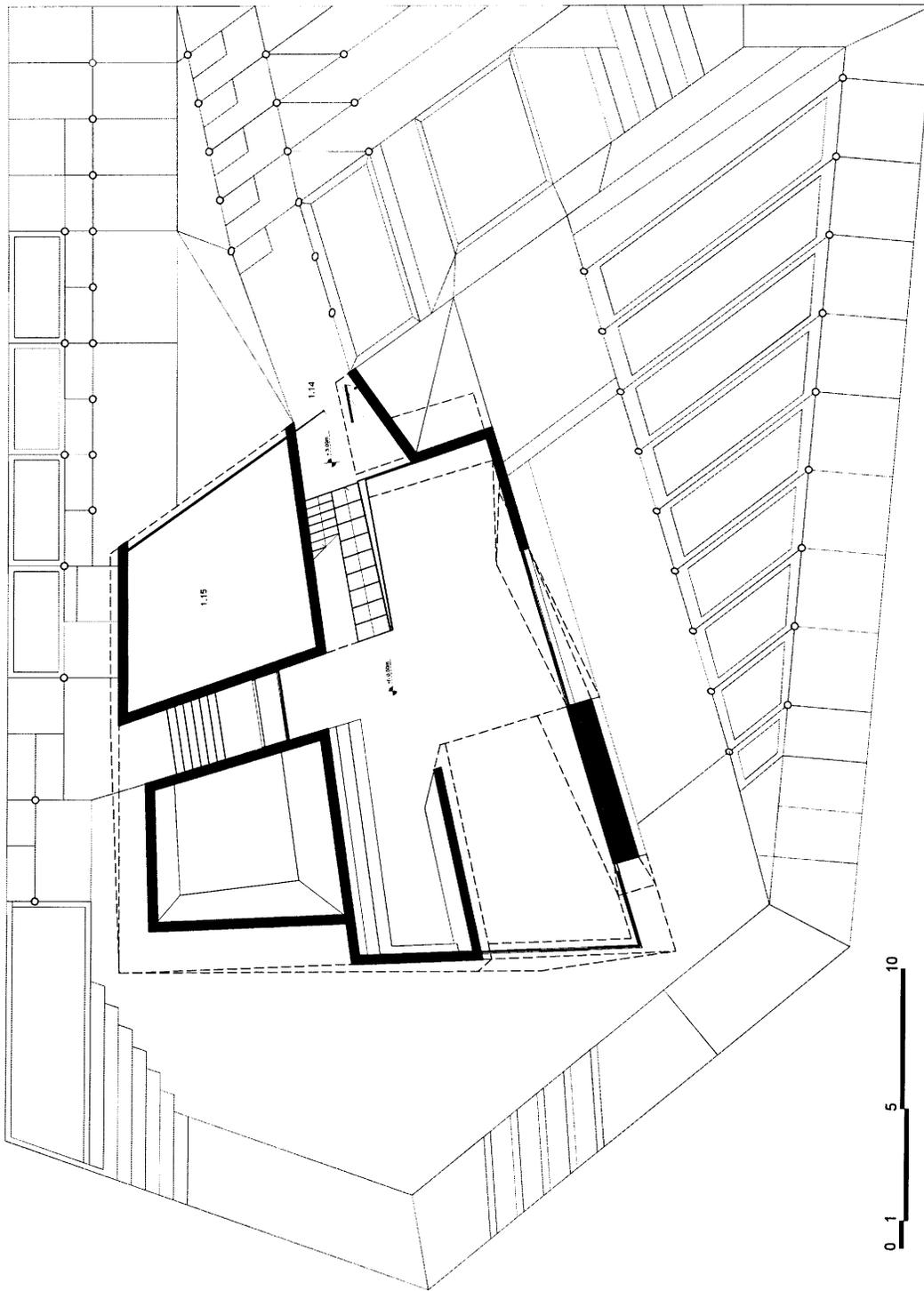
For the design of the site component of the project, we implemented the same sensor technology developed for the LightBox exhibition at Harvard with a relatively scalar shift. Instead of 15 boxes there are 54 poles, each with their microprocessor and proximity sensing.

The idea of the poles is that they are representations of vector cross products yielded from two vectors that derive an individual terrace on the landscaping that surrounds the house. Architecturally, this pole is a materialization of

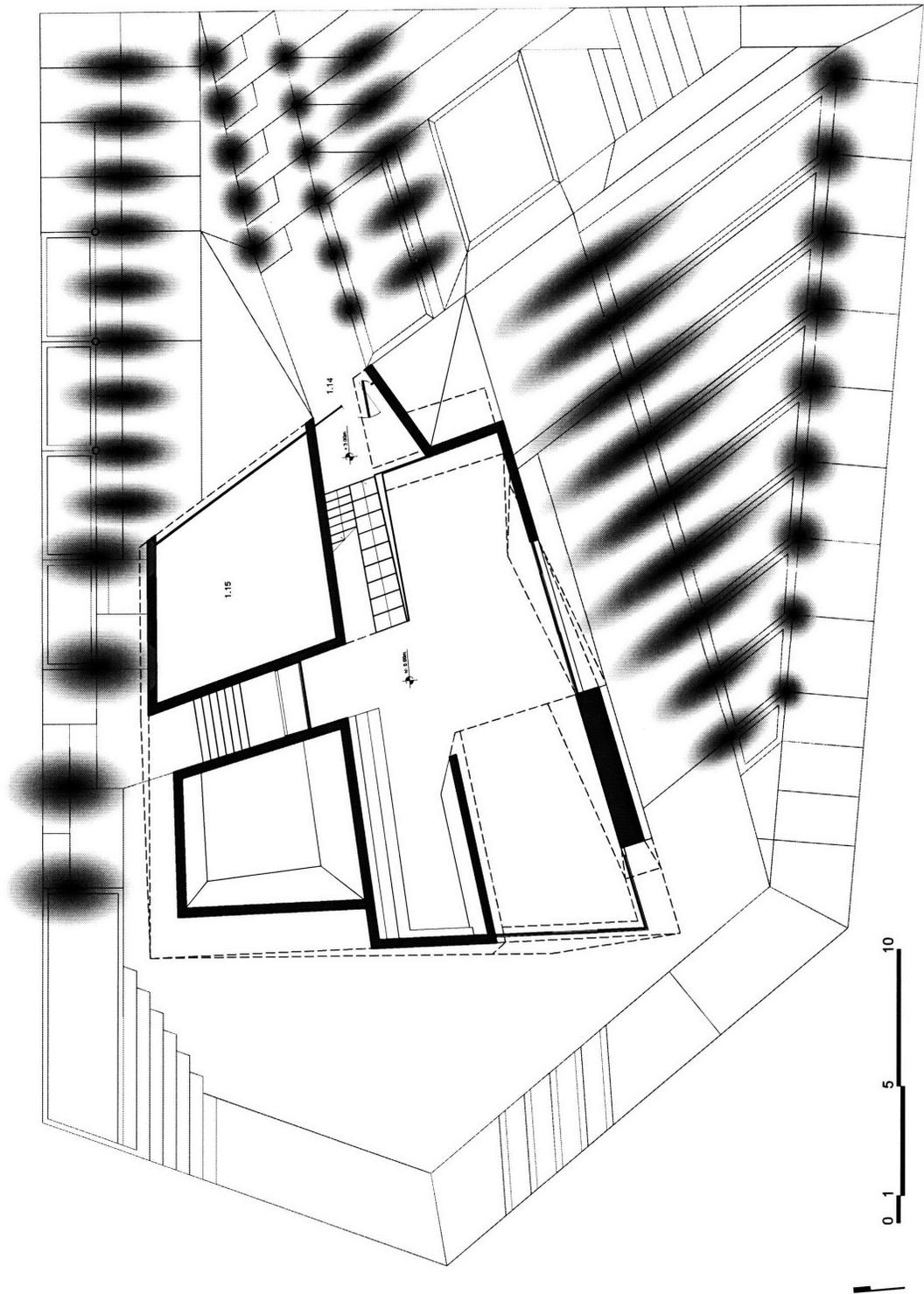


north-east aerial view

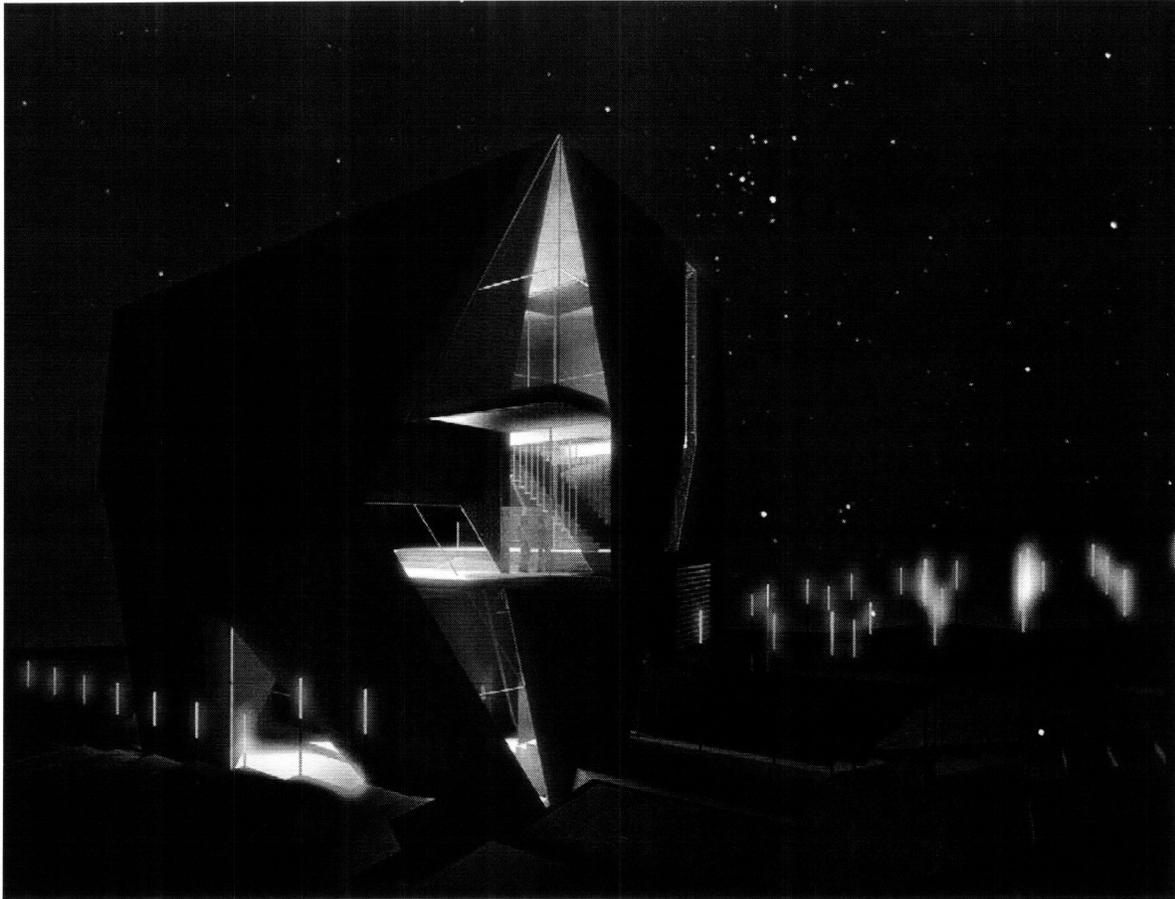
an abstract mathematical principle. The use of the cross product was twofold: it allowed for the regulation of a horizontal terracing of a relatively steep terrain as well as serve as placeholders for vertical light poles. These light poles carry ultrasonic transducers which have a range of detection dependant in which direction the sensor is pointed. These sensors are arrayed around each cross product and calibrated to have different ranges of detection and in different directions.



arrangement of cross-product/light poles on landscape. Each dark circle shows a cross-product at the intersection of their parcel. The parcel is two vectors at their bounding edge. The lightpoles are deployed as passive sensors in the private parcel, rather than use walls or other invasive security features. This 'soft' border allows for a sense of community while providing safety.



arrangement of cross-product/light poles on landscape. The light poles are sensor devices and this diagram shows each proximity sensor's range of detection. Using more than one proximity sensor for each lightpole, different calibrations can be used to limit some sensors and to maximize others. This elliptical pattern has some distortion but it shows the intent of creating non-overlapping tributaries.



night view

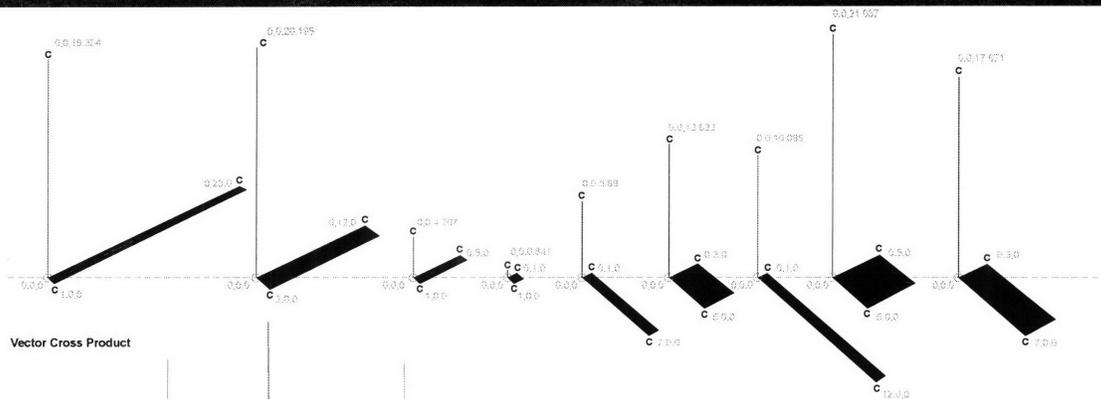
### **Organizations**

#### **Domestic Scenarios**

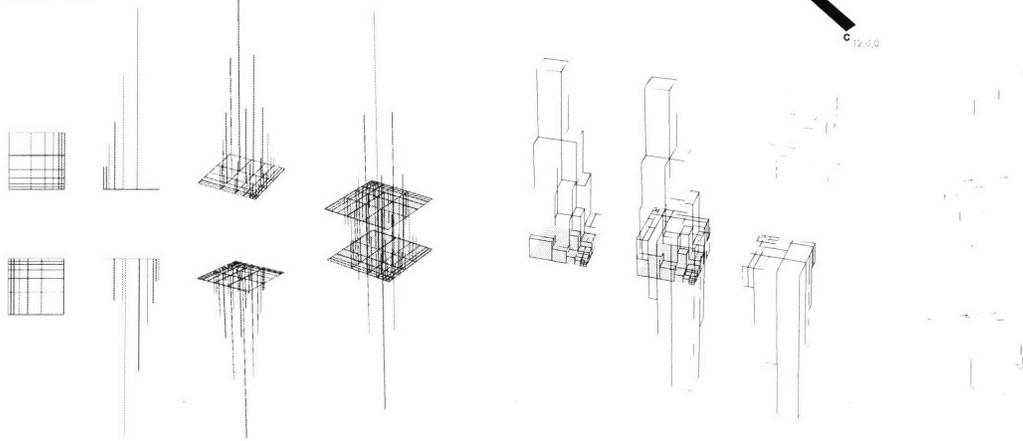
Inside the house, the participants can choose to use the sensor field in what way they choose. All the lightpoles can be turned on for illumination or off. They can also choose to activate the sensor field and give precise information in which crossproduct was activated and at what proximity. In this way the direction of passage of the outside and their speed can be displayed.

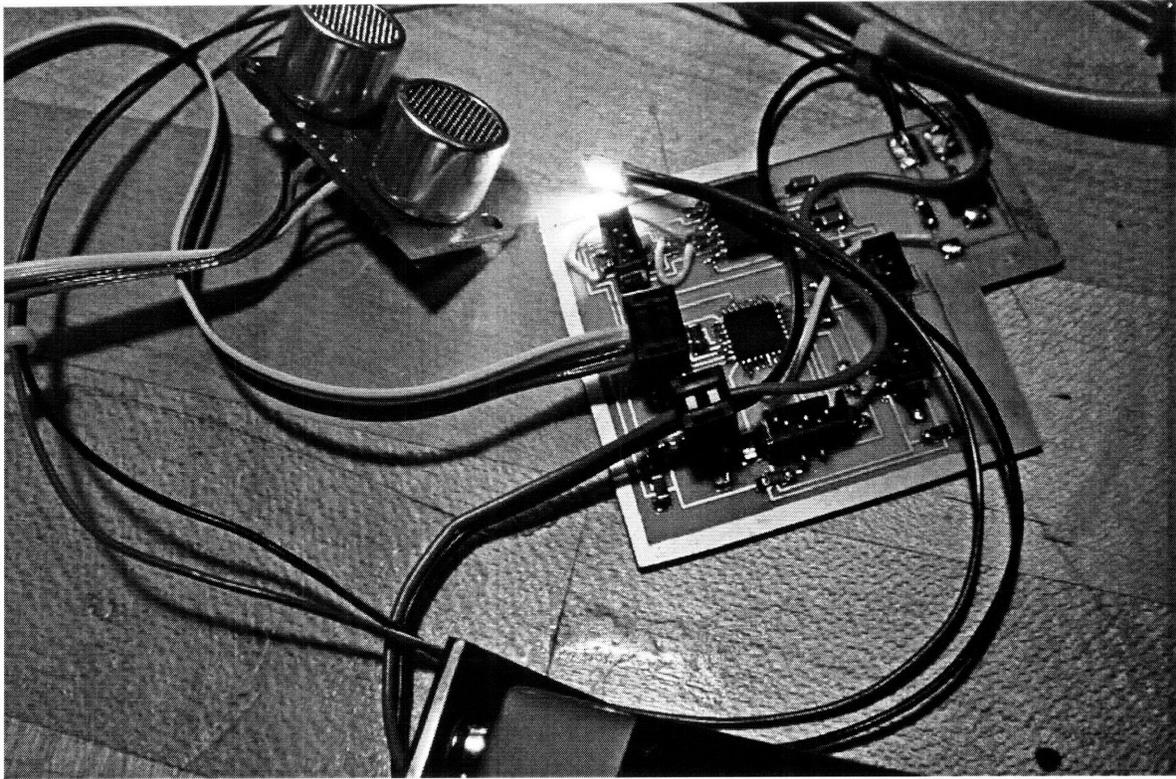
#### **Urban Scenarios**

As a passive and indirect sensor field, some measure of security can be gained without having to enclose the private property with walls or other deterrants. These sensor fields could also become more sophisticated to measure ambient temperature/wind.

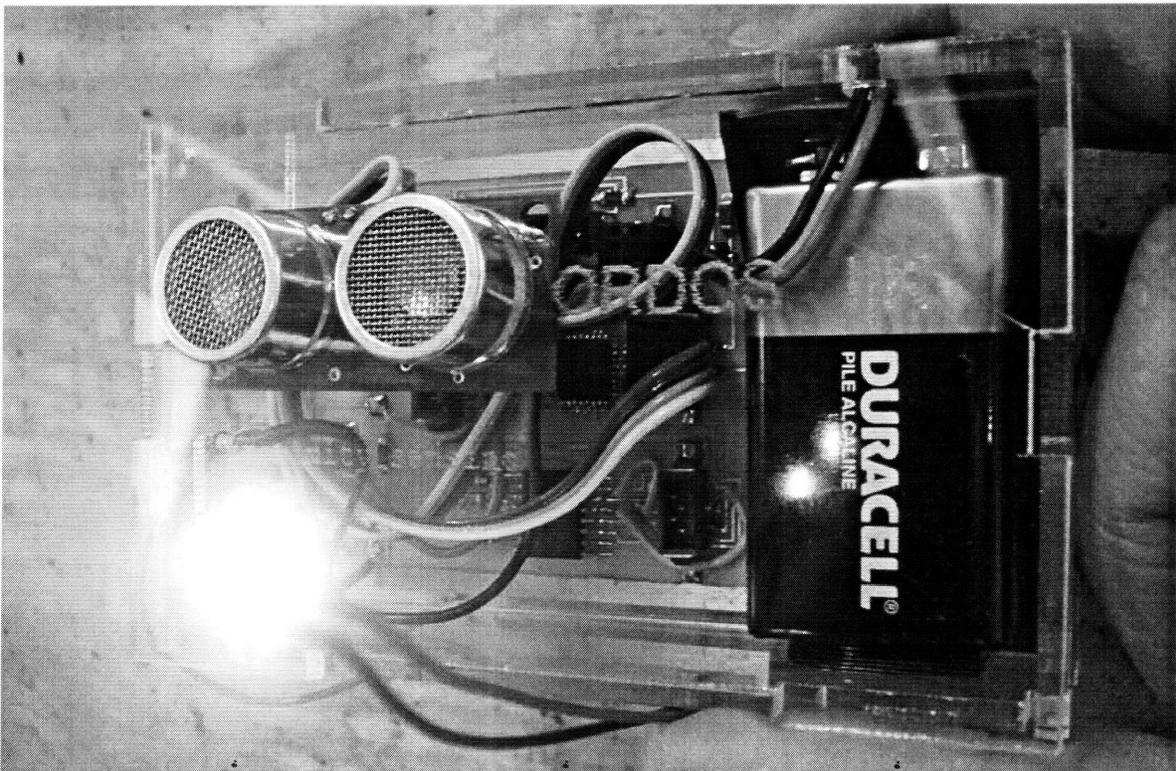


Vector Cross Product





working prototype of proximity sensor and led





## 8. Conclusions

### Experiments

These projects are unfinished at the time of writing. They are works with clients, contractual obligations and public exposure. Furthermore, as all projects, they are bound by constraints of time and budget. However, the investigations into I/O are not the primary deliverable or goal of the project. As such, the inclusion of this research was introduced in stealth. The necessity for the affect, or *its value*, had to be manufactured in both client presentations - to create a desire for the responsive as well as the architectural product. If presented as a separate element, the electronics, would be in danger of becoming a line item, exposed to the budgetary constraint on the budget. However, since the interactivity was completely integrated with the architectural project, and could not be removed without danger to the success of the projects, its costs were a justified expense.

### Strategy: Provocation

Therefore, one strategy for the implementation of the responsive environment is to merge it with Architectural expectations - to make it part of the experience. This tactic has the affect and the experience intertwined with the architecture so that one cannot be easily removed from the other. The newness and provocation of the design creates its own justification as a commodity. This highlights the present dangers to the discipline as the viability to clients becomes suspect. While most of the population is aware of the advancements that electronics have made, few would see the necessity of it in the built environment. Citizens and occupants of cities and its architecture, presented now as consumers, would resort to the overly graphic imagery of Picadilly Circus or Times Square - a hyper-textual commercial environment that is simply layered onto existing buildings. New handheld portable devices such as phones or personal data assistants, are enjoyed with a pleasure of its systems that is not transferred to buildings or urban environments. Even automobiles enjoy a better reception of features such as motorized windows or other extra features that would be available for purchase for a house.

### **Commodity/Desire**

Architecture, on the other hand, is not given the same considerations to smart industrial design objects. The reasons are many - buildings are generally far more expensive. They are not easily interchangeable in new features and upgrades. Most importantly, they are not made in series, and therefore cannot be understood as product, especially those that are easily disposable for another model. By extension, one building over another cannot have its value established in the same way as products. The value of a building comes from external factors such as value based on its property, and the local economy. Value added to a home of such design merit that it is well-regard by the architectural community may have little to do with its selling price.

### **Strategy: Innovation**

Another strategy to promote electronic interactivity is to continue a discussion that had its beginnings over three decades ago: to innovate in 'intelligent buildings'. If the previous strategy was in underpinning the value of responsiveness with consumer desire, this one is to co-opt an existing argument that is culturally accepted. This act of subversion is to take what is deemed responsible in ecology and environment, and introduce an element of architectural design.

In doing so, what is essentially an engineering purview becomes an entry point for the architect to participate. The benefit of this addition is for an outside view. At the same time, as the architect becomes familiar with the materials and processes they become a design material for architectural ends.

Future goals are to finish these case studies, and continue doing the same, but with better control and quality.

## 9. Notes

[1] Greg Lynn. *Architecture for an Embryologic Housing (IT Revolution in Architecture)*, Introduction.

[2] The Engineered Wood Association, *Engineered Wood Journal*, 2008.

[3] American Institute of Architects, *B727 Standard Form of Agreement Between Owner and Architect*.

The requirement of reducing 3d digital information to 2d flat drawings is a critical problem facing any practitioner working in any geometry that is not orthogonal. It is an antiquated portrayal of data and representation that needs addressing.

[4] Neil Gershenfeld, *FAB: The Coming Revolution on Your Desktop - From Personal Computers to Personal Fabrication*, p. 5.

[5] Vitruvius, *De Architectura*, Book III

[6] The author is a registered architect, joining the AIA in 1999. This doesn't confer authority, but allows some speculation based on experience.

[7] Herbert Simon, *Sciences of the Artificial*, pp. 28 - 30.

[8] The author provides the references from experience at both offices. The observations made here are from direct experience and from that particular time of collaboration. There are other architecture practices of similar nature but without first-hand knowledge, an accurate description from written and verbal accounts is difficult to ascertain.

[9] It may be noted that due to the cachet of OZH in the construction and design industries, opportunities and availabilities to do this level of testing and development is readily accessible. Furthermore, wealthy clients and patrons, willing to entertain out-of-ordinary designs, creates an environment for the pleasure of the innovative. However, the author verifies that the production and testing is done with extreme rigour and care. The building trade as well as their individual material suppliers are contacted, and asked of their willingness to discuss options. This may also yield an optimization in efforts. Much larger offices, of greater international and financial holdings have done much less in looking outside of stock assemblies.

[10] Aruna D'Souza, Tom McDonough "Sculpture in the Space of Architecture", *Art in America*, Feb, 2000. The article traces the use of collaborations of sculptor Richard Serra, and Frank Gehry, both using CATIA. Architects have been progressively looking for better ways to construct

buildings of complex geometry without loss of accuracy, and without increase to cost and time. GP has been a pioneer in pushing the established limits. Jim Glymph, a former partner, is credited with the idea of using the aerospace industry as a model for construction and control.

[11] The Tempietto, a small project in Rome by Bramante in 1508, is considered a masterpiece of Renaissance architecture. Its merit comes from the harmonic proportions of its parts to whole, to its placement in the courtyard of San Pietro in Montorio. The argument for introducing a new criterion would result in a completely different building.

[12] Vitruvius, *ibid.*

[13] Martianus Capellum, *Satyricon, De Nuptiis Philologiae et Mercurii et de septem Artibus liberalibus libri novem*

[14] Joseph Rykwert, Robert Tavernor, *Body and Building: Essays on the Changing Relation of Body and Architecture* pp 80-92

[15] Joseph Paradiso, "Sensor Architectures for Interactive Environments", Deleaney, K. (ed), *Augmented Materials & Smart Objects: Building Ambient Intelligence Through Microsystems Technologies*. Abstract.

[16] The history of the Architecture Machine Group and the Media Lab at MIT is outlined in Negroponte, *Soft Architecture Machines*, p 1.

[17] John Frazer, "The Cybernetics of Architecture: A Tribute to the Contribution of Gordon Pask", p. 642. The particular Architectural Design issue was a one-off dedicated to the new technologies.

[18] Observations are made from studies and instruction at both institutions. The differences between European and American models of architectural education is not only the length of study but the tradition of pupilage or training. European students have an entire year, or longer (such as *die Angewandte* in Vienna), with their teachers under a master-disciple schema.

The Media Lab is distinct from the American architecture system although it is considered part of the Department of Architecture at MIT. Conversely, it does not resemble an European architecture school so much as a Lab environment with principal researchers, and assistants. Bruno Latour, *Laboratory Life: The Construction of Scientific Facts*, could easily move his inquiry from the Salk Institute to the Media Lab, with similar findings.

[19] Nicholas Negroponte, *Soft Architecture Machines*, pp. 64 - 91.

[20] *Ibid*, pp. 143 - 151.

## 9. Notes continued

[21] John Frazer, *Evolutionary Architecture*, pp. 49. The Universal Constructor is originally a name of a self-reproducing machine given by John Von Neumann.

[22] <http://www.cscs.umich.edu/~crshalizi/T4PM/futurist-manifesto.html>  
It was first published in the French newspaper *Le Figaro* and is one of many propaganda-style call-for-actions of industrial Europe. Its influence on painting and sculpture was even greater, with Duchamp and Boccioni producing entirely new methods of production and perception.

[23] *L'Esprit Nouveau* was a self-published journal from 1919 to 1925 of Amédée Ozenfant, Le Corbusier (Charles-Edouard Jeanneret), his brother Albert Jeanneret, and Franz Léger. They fabricated different identities to give the impression of a larger staff, as well as construct advertisements that weren't ordered, and in one issue, depicted a global map with arrows to a fictitious readership. The seminal article by Adolf Loos, *Ornament and Crime*, was first translated into French from its original German by Le Corbusier. This translation was not commissioned. The author researched the original journals at the RIBA special collections library.

[24] <http://century.lib.uchicago.edu/> The library of the University of Chicago has many documents of the World's Fair digitized. It is this Fair and its architecture that Frank Lloyd Wright famously criticized for losing its American style.

[25] Frazer, "The Cybernetics of Architecture: A Tribute to the Contribution of Gordon Pask", p. 642.

[27] Mohsen Mostafavi, Interview with Claude Parent, *The Function of the Oblique*, p. 51 "Virilio was anti-militarist, but he did have a certain respect for the power of a collective organization to achieve extraordinary, almost magical results that are beyond the power of an individual."

[28] Gershenfeld, *FAB*, pp 149 - 160.

[29] Neil Gershenfeld, Danny Cohen, *Internet 0: Interdevice Internetworking*, *IEEE Circuits and Devices Magazine*, September, 2006.

The following quote is of particular sobering thought:

"In the United States, the construction industry is a trillion-dollar-per-year business... The cost of drawing, following, checking, and later revising wiring diagrams could be replaced by simply servicing the building's infrastructure with energy and information if its configuration could be determined by the occupants, but the benefit in cost and convenience would be lost if the installation must be done by a skilled network engineer and supported by an IT department. Likewise, the architecture of a conventional industrial control system is fixed by a controller that

must be expensively modified to add a new component; in a networked peer-to-peer system, a sensor could be directly read by a local display, a control processor, and a remote server. Embedded networks also have significant energy implications; residential and commercial buildings were responsible for roughly 40% of the source energy use in the United States in 2004. More efficient buildings have been observed to recover at least 40% of that, but the cost and complexity of installing the required sensors and control systems has been an obstacle to their widespread adoption.”

[30] William Mitchell, <http://cities.media.mit.edu/>  
<http://archrecord.construction.com/features/critique/0708critique-1.asp>  
The radicality of the mobile agent as power and revenue sources is here: “Large-scale implementation of this concept would be a significant step toward transforming cities into distributed, virtual power plants—an Internetlike arrangement that promises many sustainability and security advantages. Buildings would not only consume electricity, but also produce it through various combinations of solar, wind, and hydrogen-fuel-cell technologies. Vehicles, and perhaps some buildings, would provide battery-storage capacity. The system would be coordinated through ubiquitously embedded intelligence and networking. Vehicles, appliances, and the mechanical and electrical systems of buildings would become intelligent economic agents, trading in energy markets with knowledge of demand and price patterns and the capacity to compute optimal buying and selling strategies.”

The Smart Cities group has several scenarios of the City Car ready in cities such as Manhattan and Los Angeles, and the relatively recent scooter for SanYang had its debut in Milan. <http://www.sciencedaily.com/releases/2007/11/071127181356.htm>

[31] The website of the Responsive Environments group is here as well as links to their publications and theses:  
<http://www.media.mit.edu/resenv/motto.html>

[32] Negroponte, *Soft Architecture Machine*, p. 131.

[32] Stephen McClelland, *Towards the Intelligent Building, Intelligent Buildings: An IFS Executive Briefing*. ed Stephen McClelland, IFS Publications, London, 1988.

In the Foreword of this report to the British government, McClelland reports on an emerging building typology:

“Intelligent buildings are also presenting themselves under the aliases of ‘smart’ buildings, ‘high-tech’ buildings, and even ‘integrated’ buildings. Generically, ‘intelligent’ buildings seems to be the name given to buildings which have been purposely designed to employ – and coordinate – process control and data communications technology to best advantage in order to make the most of the resources and facilities available to run the services. One obvious attribute of the intelligent building would therefore

## 9. Notes continued

be environmental control, in which the entire building would be maintained at temperature and humidity conditions appropriate for its occupants....

...[there is] the emergence of user-intelligent buildings, where users are indeed given a greater degree of selective control over their environments. The design skill for such buildings cannot come from one person; these buildings look like needing substantial multi-disciplinary design teams who can provide the correct skills, correctly balanced.”

[34] Negroponte, *Soft Architecture Machines*, p. 9.

[35] Ibid, p. 10.

[36] Ibid, p. 151.

[37] J. G. Ballard, “The Thousand Dreams of Stellavista”, *Vermillion Sands*. With a fantastical material called ‘plastex’ activated by ‘senso-cells’, the particular psychotropic house in the short story displayed emotional and cognitive instabilities learned from a previous owner.

[38] Robin Evans, *The Projective Cast: Architecture and its Three Geometries*, pp. 3 - 14.

This is expanded in the legibility of pure geometry in the centralized church as described by Wölfflin and Wittkower. The encoding of form to be removed from the historical motivation of earlier pagan structure is resolved within symbolic meaning of the circle.

[39] Patrik Schumacher describes it well as the multi-valent possibilities of complex relationships in “Business-Research-Architecture: Projects from the Design Research Lab”, *The Need of Research*, p. 43.

“A decoded architecture might offer itself to inhabitation as an aleatoric field. The late sixties “soft rooms” and toy-like environments may have been the moment architecture got closest to such an ambition.

[40] see Pask, Gordon. “Cybernetics”, <http://www.cybsoc.org/gcyb.htm>

[41] see Pask, Gordon. Interactions of Actors (IA), Theory and Some Applications, unpublished but available here:

<http://www.scribd.com/doc/2947261/Interactions-of-Actors-Theory-and-Some-Applications-Pask>

[42] Op. Cit.

[43] Cedric Price, “Gordon Pask” Systems Research, Volume 10, Issue 3, 1993, pp.165 – 166.

[44] Peter Cariani, "To evolve an ear. Epistemological Implications of Gordon Pask's Electrochemical Devices" *Systems Research*, Volume 10, Issue 3, 1993, pp. 19-33.

Pask had instituted an idea of chemical computation whereby the system could adaptively change its circuitry in a process of bio-technology to grow metal filaments. The devices and associated control equipment enable the programming of many inputs and outputs. This is done with charged electrodes being introduced to a solution of copper sulphate; the resulting growth of new connectivity can be used to not only construct new sensors but to reorganize its own logic of circuitry. The implication is that engaging the system would never be the same way twice.

[45] Frazer, *Evolutionary Architecture*, p. 6 - 7.

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