REACTIVE VOID: SOCIALIZING SPACE THROUGH REPONSIVE TECHNOLOGY

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ReactiveVOID is a research and design project which capitalizes on new technologies to influence the public perception of the built environment through the activation of interior spaces. The research critically examines the possibilities of responsive space given recent developments in responsive material technology, namely that of muscle wire Shape Memory Alloys (SMAs), metals that change shape according to temperature. This technology offers the possibility of fluid and subtle movement without the mechanized motion of earlier technologies. Operating at a molecular level, this motion parallels that of plants and lower-level organisms that could be called responsive but not conscious. A field of sunflowers or a reef covered with sea anemones offers an image of the type of responsive motion this technology affords. Its use in practical applications has been limited to the medical and aerospace fields, as well as novelty toys - the super exclusive vs. the trite. Despite the potential of this technology, there have been few serious attempts to test its effects at the scale of responsive environments.

ReactiveVOID aims to imbue space with personality more than intelligence. Although motion and architecture have been consciously linked since the beginning of the 20th Century, not until recently has the notion of responsive movement been critically addressed. This research aims to shift the argument from intelligence to responsiveness and from movement to transformation.

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Introduction

How can furniture scale objects move beyond the functional and instead operate as an interface between humans and their larger spatial environment? How can technology move beyond intelligent gadgetry and socialize space? The relationship between the functional and the social inherent within these discussions has driven the line of inquiry of this research.

As a design project, ReactiveVOID establishes a clear responsive link between humans and their environment. By filling the exhibition space with a field of operable fins, which react to the presence of human inhabitants, the space becomes animated with a sense of personality. The human body becomes aware of its behavior in relation to its surroundings, creating a dialogue between body and space that is in sharp contrast to our default understanding of space as static and impersonal context.

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Mating SMA technology with a simple panel material creates a module that can alter its shape according to local activities. Modulating this field through incremental transformation in each panel begins to create a space that can respond to various inhabitants and passersby. A field of operable fins is oriented to striate the space into a series of hallways. The effects of combined fin movement can redistribute circulation, create visual transparency or opacity, and dramatically alter the perceived scale of the space. The behaviors exhibited as the fins respond to various activities imbue the space with an identifiable personality, simultaneously affecting social and movement patterns.

History

This type of responsive environment forces an investigation into the larger role of technology in architecture and ultimately in society. This investigation must look at not only the advancements, but also the perceptions of technology.

Technology: Big and Societal

Technology's role in society has been in flux over the decades. Historically, technological advancements in the building trades have always been understood to be serving some form of functional need. The development of structural cast iron, float glass, structural steel, the elevator, and air conditioning all clearly solved some functional dilemma of the time. The criteria for success or failure of any of these advancements were based on how well any particular advancement could quantitatively improve some functional requirement such as increase in production speed, structural strength, or precise control of the environment. In this teleological understanding of the role of technology, the greater good of humankind is improved upon by the continual optimization of already existent functions. In this view, technology is seen as both the benefactor and servant of humankind in the largest sense of the word. The nature of the world's fairs and expositions indicate that although different cities or cultures might compete to make technological advancements, regardless of where the advancements were made, they were seen to carry benefits at a global scale.

The experiments of the 60's such as Archigram were delirious conglomerations orchestrated by technological monstrosities which paralleled the utopian directives of the current technological trends. Ron Herron's *Walking City* easily relates to a scale of construction and ambition made possible by the public initiatives of the Space Program (see Figures 1 & 2). While these experiments added in a social component that had not been evident prior, in the case of Archigram, this was often stylized imagery which emphasized lifestyle over any critical attempt to address the social implications of technology.[1]

Figure 1. NASA Space Shuttle 'Crawler.'

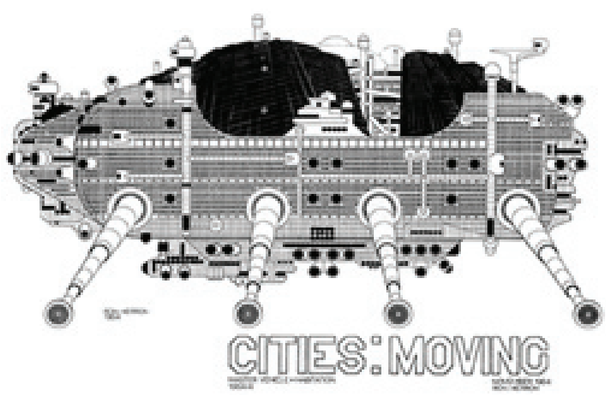

Figure 2. Ron Heron, Walking City, 1964.

Figure 3. Santiago Calatrava, Milwaukee Art Museum, 2001.

Figure 4. NBBJ, Miller Park, Milwaukee, WI, 2001.

The introduction of motion into a discipline with fundamental tenets including fixed permanence clearly has significant implications. In the past, non-static architecture was heroic in its functionality and this was the only purpose that could justify the energy necessary to create motion. Moving architecture at the scale of infrastructure is seen as inventive. Drawbridges would allow for car traffic and boat traffic to negotiate each other through the use of motion.

This grand scale of the functional can be seen in two recent constructions in Milwaukee, Wisconsin – Santiago Calatrava's addition to the Milwaukee Art Museum and NBBJ's recent Miller Park baseball stadium (see Figures 3 & 4). Calatrava's design of gently unfolding "wings" has resonated with the public as an architecture which is seemingly alive and captivating. Although few care to track exactly what factors motivate the wings – or perhaps because no one can precisely predict when it will be open or closed – it holds a sense of mystery in the public's eye. However, its public rationalization as a functional brise-soleil places it in the same realm as the ballpark where environmental factors are held up as necessitating advanced technological solutions. The roof of the Miller Park baseball stadium opens and closes in response to climate as appropriate for the sporting event, generating a different responsiveness than Calatrava's project. In both cases these projects are publicized as justifiable investments of incredible energy for the sake of a larger society.

In these cases technology is seen as an enabler of a certain scale of complexity. The current fascination with machine intelligence grows out of this tendency as well, but draws into the discussion the issue of consciousness. Over the years, technology has come to offer the possibly of not only increased speed and complexity of operation, but of a capability of (super) human intelligence as well. The relationship between technology and intelligence has followed a similar path of development as technology and motion. While there are many examples of machine intelligence prior to the 1920's, it is at this point where we see a host of anthropomorphized robot characters (such as in Fritz Lang's 1927 *Metropolis*) which only increases with the trend of science fiction movies. However, despite their human intelligence these robots are understood to be servants first and foremost. If technology was seen as the servant of humanity, the robots and automatons of the early 20th century were the literal anthropomorphized embodiment of this understanding. While the goal for motion in architecture tends to be heroic efficiency, the goal for consciousness in architecture tends towards intelligent efficiency.

Technology: Small and (Inter)Personal

A look at a parallel trend in technology offers a different potential for the role of intelligence, motion, and responsiveness in architecture. The miniaturization of technology has begun to produce opposite effects to those discussed above. The advent of cell phones, iPods, and PDAs has created a situation where the individual becomes prioritized over the collective. As technology has integrated itself into the private space it has moved from something which once affected society only at the scale of the public to something which becomes much less heroic in ambition but ever more pervasive and integral to daily life.

By tracking the evolution of popular characters which exhibit willfulness, one can place the role of responsive technology at a more personal scale within society. The robotic toys of the 80's (such as the Transformers) convey the sense of the futuristic through the level of complexity. In many cases this complexity was created by a movement of interacting parts. What was impactful was that something mechanical could approximate the motion of a human. For this to be effective, the nature of the mechanical motion needed to be evident.

Figure 5. Tiger Electronics' Furby, one of the first responsive toys - released in 1998.

Figure 6. R2D2 from Star Wars. While communicating solely through blinking lights and beeps, R2D2 proves to be one of the most likeable characters in the series.

With the advent of a series of toys which were understood to be interactive, such as Teddy Ruxpin, motion became replaced by responsiveness. These toys only needed to move enough to register the possibility of their "recognition" of their human companions. Furby and Tomogochi added to this responsiveness a form of sprightly and mischievous personality (see Figure 5). The behaviors of these toys, while scripted, increased the level of their verisimilitude by increasing their sense of unpredictability and willfulness. Could intelligence as a goal for responsive spaces be replaced by willfulness? Can the fascination with the intricacy of moving parts give way to a familiarity gained through perceived emotion of a "technological creature"?

This type of "technological creature" presents attachment as its primary purpose over intelligence. In the case of the complimentary pair of droids from George Lucas' Star Wars - C3PO and R2D2. One droid is programmed to serve in the role of translator who is therefore overly intellectual and overly polite. The other, R2D2, has no easily discernable service function, can't communicate in anything other than bleeps, but is infinitely more endearing (see Figure 6). In some ways the intelligence of robots could be seen as threatening unless they are understood as being truly subservient to their human counterparts. The appearance of intelligence dooms technological creatures to a life of indentured servitude whereas a mute and mischievous "personality" allows for our projection of even more companion-like qualities onto these characters.

Given the ability of technological creatures with nonverbal intelligence to allow for a human project of empathy, it was clear that the perceived level of intelligence should be similar to that of these early responsive toys. As is the case with these toys, some minimal form of motion was still required to create the sense of responsiveness. The nuances of this motion would become critical in terms of the type of technology selected for the design project.

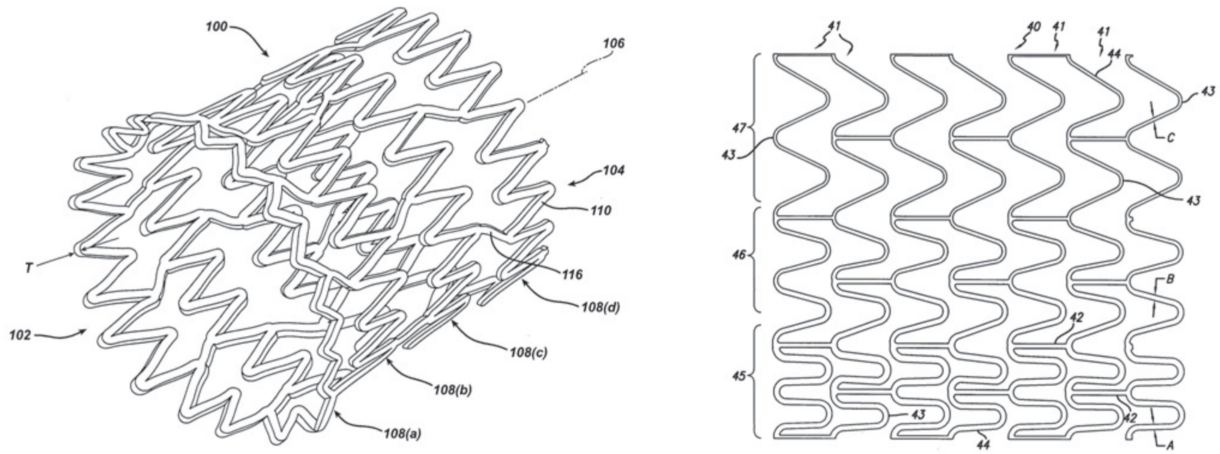

Figure 7. Nitonol arterial stints – an example of use of SMAs in medical applications.

SMA Technology

For the following design proposal, the emergence of a new material technology offers the opportunity to translate the possibility of willfulness into a spatial condition. The focus of technology could then move away from creating more intelligent spaces and instead seek to create more willful environments.

This proposal takes advantage of developments in responsive material technology, namely that of muscle wire. Muscle wire, or Nitinol, is a class of metals called Shape Memory Alloys (SMAs) or metals which change shape according to temperature. When these alloys are used in the form of wires, a simple electric current offers enough heat to change the dimensions of the material. This technology creates a form of wire which looks like any other typical wire, but whose length can be precisely varied and controlled. The Nitinol wire can contract lengthwise along its axis by about 5% of its overall length, meaning that a length of 100cm could shorten to 95cm.[2]

Nitonol was developed in the 1950's and 1960's but has only been used in practical applications over the last 20 years. Its use in practical applications has been limited to the medical and aerospace fields, as well as novelty toys - the super exclusive vs. the trite. This historical limitation is largely tied to applicable scale and limitations of market or consumerist forces. As is often the case with new technological developments, the application of a new material is first understood and deployed insofar as it can mimic a previous material or technology, though with slightly better results. SMAs, too, have thus far followed a similar trajectory. The application of this material technology has seen advances in the medical field such as in arterial stints (see Figure 7). In addition to medical applications, SMAs have largely been harnessed as replacements for electric motors in small switch and solenoid applications, due to their lightweight, reliability, and simplicity.[3] Despite the potential of this technology, there have been few serious attempts to test its effects at the scale of responsive environments.

Figure 8. The Venus Flytrap displays a type of motion which easily allows one to project a willfulness onto a plant with no quantifiable intelligence.

Impact of Technology

As the technology of Nitonol is a material advancement rather than a computational one, muscle wire is most interesting for the following proposal in that it offers the possibility of fluid and subtle movement without the mechanized motion of earlier technologies. Whereas these earlier versions of motion involved a complexity of componentry with parts following a dynamic logic of *translation*, muscle wire allows for a simple whole to engage in an act of *transformation*. Ultimately, this shift from an architecture of movement to one of transformation becomes the most radical potential of this advancement.

This motion, operating at a molecular level, parallels the motion of plants and lower-level organisms that could be called responsive but not conscious. This particular type of biomimetic motion generates the semblance of responsiveness both in terms of the physical and the emotional. It is hard to imagine that something which moves with such apparent intention as a Venus Flytrap has some sense of willfulness if not a lower form of intelligence (see Figure 8). A field of sunflowers or a reef covered with sea anemones offers an image of the type of responsive motion this technology affords.

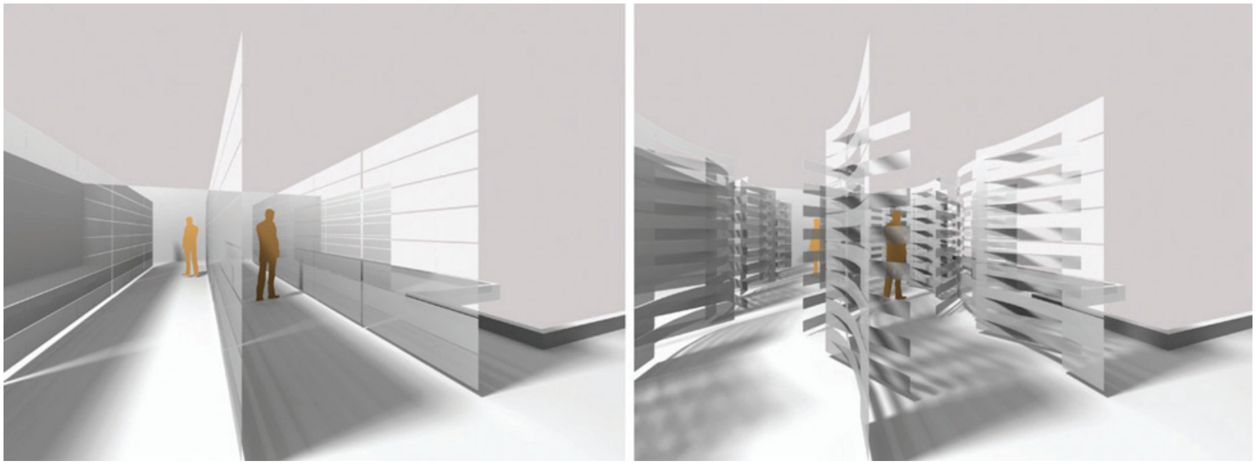

Figure 9. Rendering demonstrating the transformation from striated corridor configuration to pockets of space.

Design Proposal

In architecture's earlier flirtations with motion and technology, the emphasis tends towards justification through efficiency. This research aims to shift the argument from intelligence and motion to responsiveness and personality. Taking the analogy of the field of sunflowers, a typical Hollywood storefront was envisioned as a three dimensional field of modules which can transform (see Figure 9). When coupled with some form of input device such as infrared or RGB video, this technology can create a responsive space that exhibits traits of personality. This space becomes an active social participant, interacting with other individuals and affecting human social and movement patterns.

Volumetric articulation

While responsive technology has been used in architecture before, it has typically been used under the concept of intelligent skins. As an exterior system this might operate an environmental control system of an array of louvers which filter light and air. As an interior application this may be surface systems which deform or change in color/image according to environmental stimuli (such as the Aegis Hyposurface by dECOi). In both of these applications there is a clear impact on the quality and perception of space even while the physical parameters of the space remain constant. The raising or lowering of the brise-soleil "wings" of the Milwaukee Art Museum may greatly change the lighting of the space without changing its proportions or dimensions.

However, given the nature of this technology and its ability to effect a literal transformation of material, this research project set out to create an analogous condition at the scale of habitable space. Thus the agenda was set to literally transform space through volumetric modulations rather than to transform the perception of space through the variation of surface effects. By envisioning habitable space as a three-dimensional pixellized volume, each of these volumetric pixels or voxels can be individually controlled. While our typical understanding of pixels includes information (typically color) which is contained at each moment of space, these voxels would oscillate between solid and void. The modulation of these voxels could then effectively create infinite variations on the boundaries of habitable space.

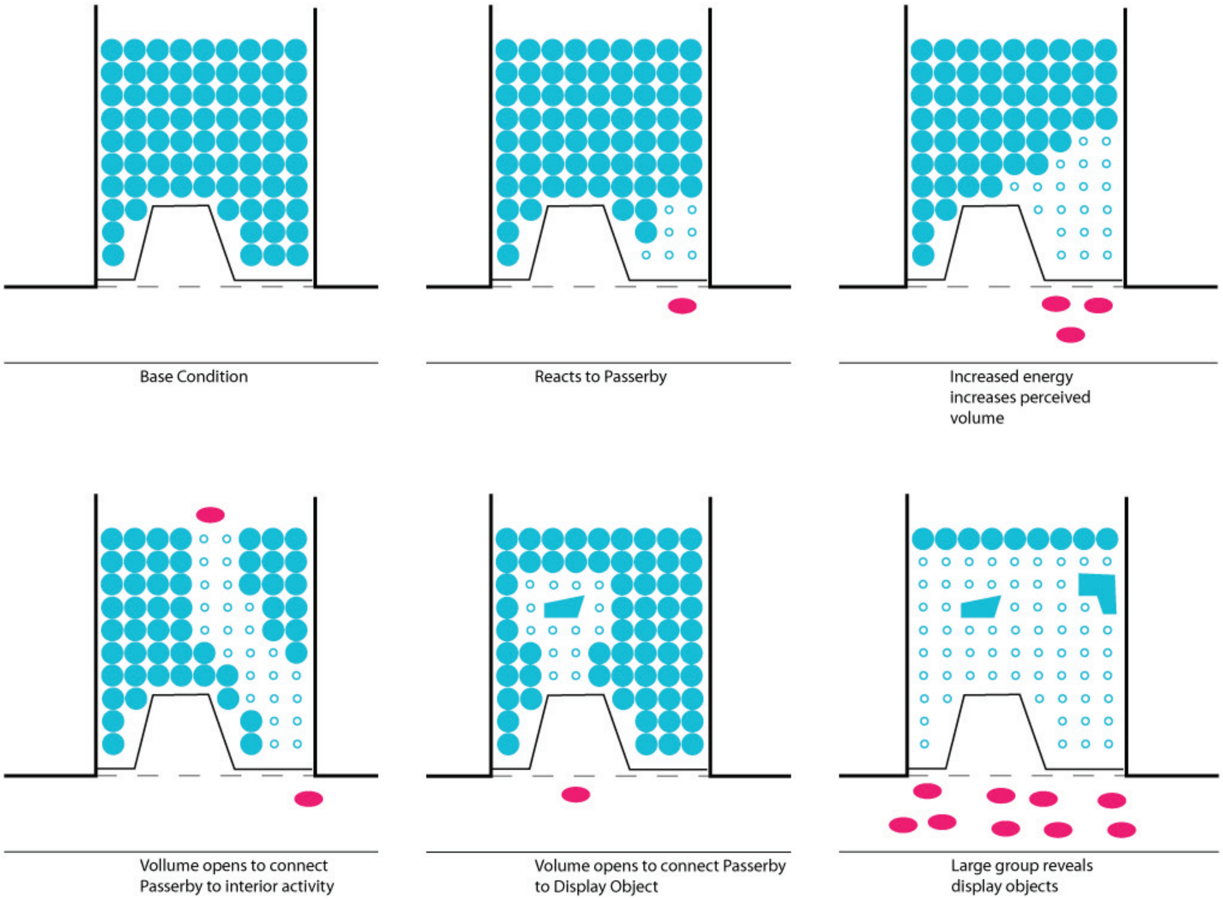

Figure 10. Plan diagrams of voxel concept. Volume is filled with expandable modules which create variable boundaries between solid and void.

Our first attempt at creating this effect of a field of variable voxels was to create a module which could expand in size like a field of balloons which could be inflated or deflated precisely to create a dynamic boundary between solid and void (see Figure 10). By modulating the field through incremental changes in each module, a space can be created which responds to the actions of both inhabitants and passersby.

While these modules were first envisioned as moments which could expand and contract in volume (such as balloons or balls), it proved difficult to couple the volumetric nature of the modules with the linear motion of the muscle wire actuators (Foxlin's Bubbles installation instead achieves this effect through pneumatic inflation of modules). Through research into origami and other folding structures, a strategy of expanded surface replaced that of the expanding volumes. Through introducing cuts along the surface, a two dimensional plane could be deformed and expanded to describe a three dimensional volume. This simple module amplified the transformational properties of the muscle wire to the scale of habitable space and proved simple and flexible enough to serve as the equivalent of the initial voxel concept.

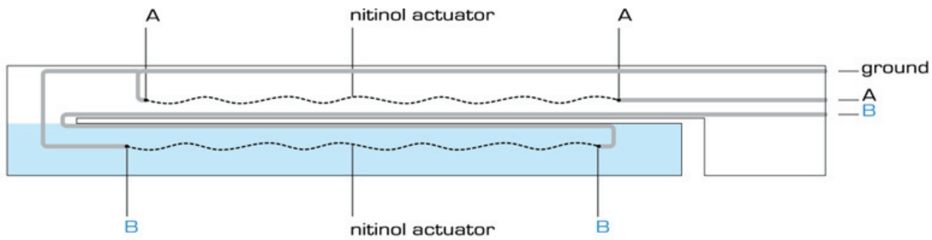

Figure 11. Fin circuitry diagram showing placement of two Nitonol wires – one on each panel of fin.

Configuration

The ReactiveVOID installation proposal capitalizes on this module by increasing the simplicity of its arrangement and deployment while maximizing its ability to generate complex responses to – and orchestrations of – social interaction in public space. Using the three-dimensional grid of the original voxel concept, the fin module was stacked sectionally to create masts which were then arrayed throughout the space, generating a striated field of deformable fins.

Fin Circuitry and Action

As the Nitonol muscle wire operates primarily in one-dimensional motion, it must work in tandem with another material in order to shape and define space. Insight was gained from the case study of the novelty butterfly toy in which a Nitonol wire acts as a linear actuator which creates motion while an attached mylar surface renders this motion visible. In the ReactiveVOID installation, the Nitonol wire is coupled with a system of fiberglass reinforced plastic fins. Each fin is divided longitudinally into two panels along which a Nitinol muscle wire is attached (see Figure 11). The wire is eccentrically attached to the opposite sides of each to the two panels. When activated, the contraction of the Nitinol wire compresses the panels, bending each in a different direction.

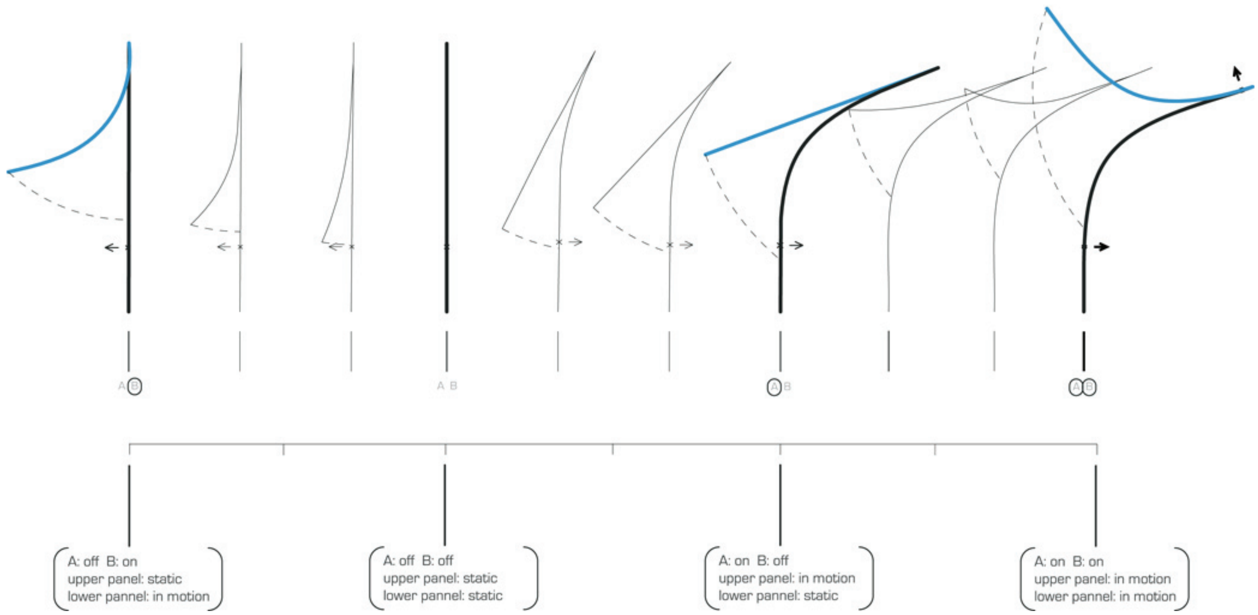

Figure 12. Possible configurations of one fin based on activation of 'A-Channel,' 'B-Channel,' or the combination of both channels.

Figure 13. View of operational model showing activation of fins and fin and mast circuitry.

Using only two channels, 'A-channel' and 'B-channel' operating within one fin, this arrangement is able to translate the linear motion of the wire into more three-dimensional spatial configurations. Activating one panel or the other can create varying degrees of deformation. When both wires are activated simultaneously, a triangular volume can be described by the two panels (see Figures 12 and 13). By supplying power to each channel using pulse width modulation, or precisely controlled pulses of electric current, the change in temperature and hence length of each Nitonol wire can be carefully controlled, allowing for configurations with the panels fully activated, or partially activated to any point along a continuum of possibilities. This fin configuration allows a maximum of variability while remaining relatively simple in its circuitry.

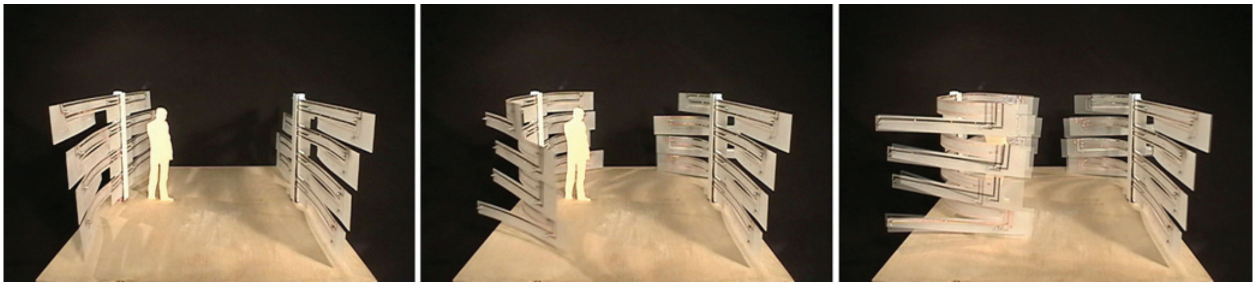

Table 14. Stills from film of operational model showing fins closing around inhabitant to create personal space.

Fin Arrangement

With vertically stacked fins cantilevering from a steel mast, the sectional configurations offer increasing variations which emerge out of a relatively simple set of operations. Responding to various activities, this configuration allows the space to selectively open to passersby. By opening entire masts the configuration can transform open corridors into more intimate pockets of space (see Figures 14 and 15). Rows of these masts are oriented to create a striation which runs parallel to the storefront, creating an opaque presence to the street in its off condition. By selectively opening certain panels within the masts, micro conditions can be created which may affect the interaction of inhabitants within the space or their relationship with the fins. The effects of combined fin movement can redistribute circulation, create visual transparency or opacity, and alter the perceived scale or energy of the space.

Personality & Social Scenarios

The design proposal for ReactiveVOID hinges on the ability of the space to exhibit a certain willfulness. This willfulness could be seen as analogous to the herding instincts developed in many breeds of dogs. While this form of willfulness could not exhibit the standard verbal intelligence, it may exhibit a social intelligence which may seem more like intuition that rationality. This notion of social intelligence is defined as an awareness of relationships developed in social relationships, whether between acquaintances or strangers.

One goal or tendency of space is to draw passive passersby into active participants in the social dynamic of the space. While the default fin configuration creates an opaque wall to the public storefront, as people pass by on the street, this wall louvers open to allow a perforated view of the space beyond (see Figure 15). This revealing of the interior activity could generate a voyeuristic curiosity for those on the street and possibly draw them in to become more physically and socially involved.

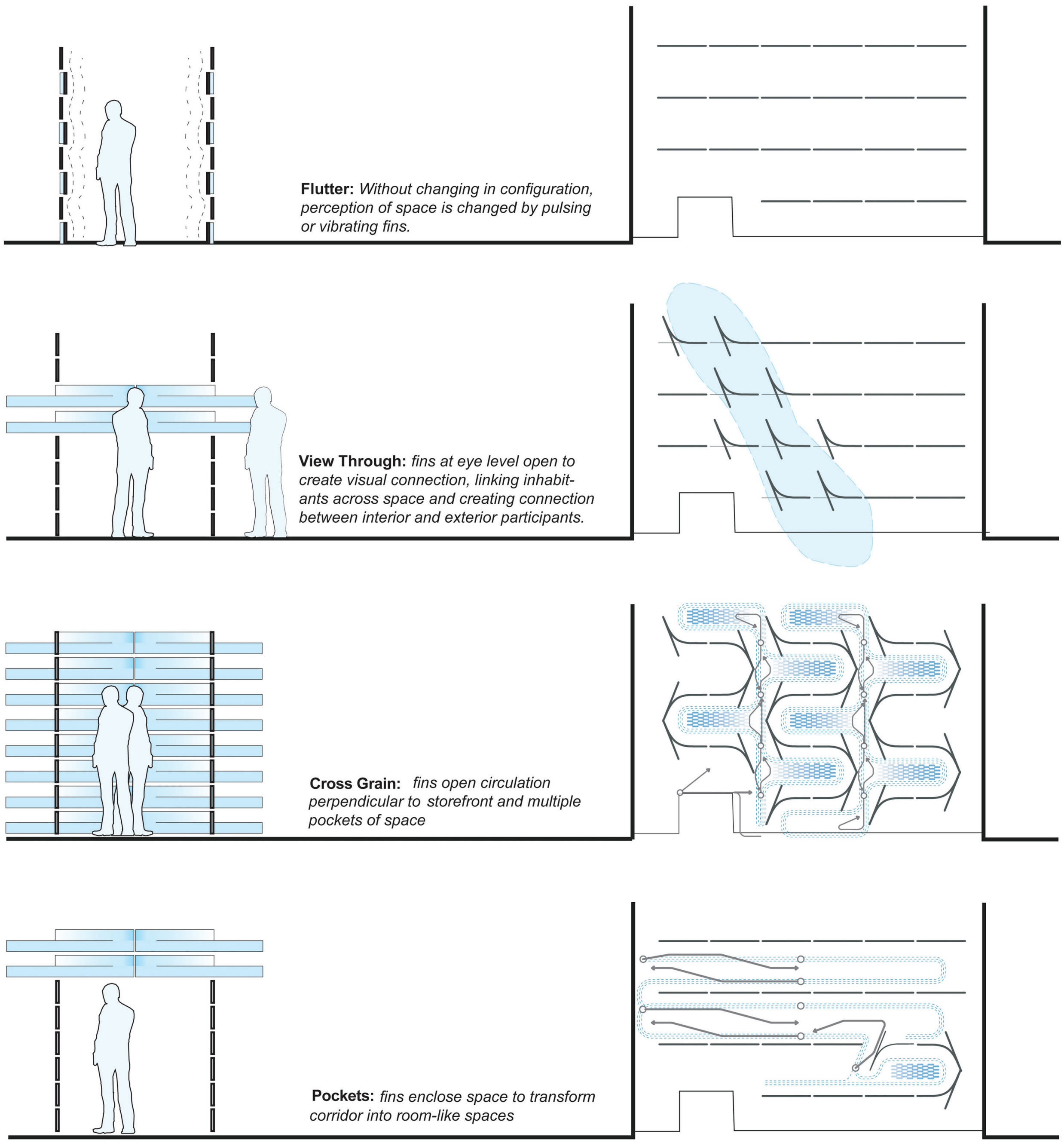

Table 15. Section and plan diagrams demonstrating various behaviors and their effects on human perception and activity.

The space also seeks to create specific relationships between its inhabitants. When a group of two or three people find themselves in close proximity to each other, the fins close around them to create a micro-sized room to clarify this moment of intimacy. This phase change from generic corridor space to specific pocket spaces for intimate conversation offers the possibility of chance proximity turning into meaningful encounter.

A variety of other behaviors could create varying perceptions of a singular space, each offering new possibilities for social interaction. The ReactiveVOID installation might begin to 'play host' to a series of scenarios. Like the responsive toys discussed above, only a minimal amount of reaction is necessary to plant the seed in the perception of the inhabitant that the space is imbued with a willfulness.

Conclusion

This research is a proposal to incorporate technology as an active socializing agent within human social space. While contemporary society has already come to understand technology as something which mediates personal interactions, the role of innovation in technology at the scale of architecture has been slow to move beyond heroic efficiency. This project moves the role of technology from one of benefiting mankind as a collective entity to the role of linking or connecting individuals to a more intimate sense of society or public.

Through the generation of different spatial configurations which respond to the social environment, Reactive-VOID operates more as a social condenser rather than a facilitator of any functional need. In Koolhaas' definition, a social condenser consists of, "Programmatic layering upon vacant terrain to encourage dynamic coexistence of activities and to generate through their interference, unprecedented events."[4]

Technology could then shed its subservient role as efficient functionality, its goal becoming the orchestration of unpredictability rather than the optimization of predictable ends. In his introduction to the catalog of experimental installations in the Gen[H]ome Project, Peter Noever states, "In these projects, technology is seen not as an opportunity for more and more efficient uses of space, but rather one that generates more and more opportunities for modes of living with the same space. The goal of infinite precision with one possibility is replaced by an investigation of negotiation of infinite variable influencing a singular space." This implies that like a series of meetings with an old friend, each conversation might be different even if the participants are identical.

The definition of "interactive technology" would then change from our current understanding of interface as a mediating device between human and machine. Instead, interface technology would be seen as interaction between humans facilitated by technology. In this scenario, the space (and therefore the technology) becomes an active participant like any other human participant. Perhaps this new participatory role for technology could counterbalance the loss of intimacy or aura that technological advances have supposedly effected on our contemporary relationship with our environment.

[1] Frampton, K. 1980 – *Modern Architecture: A Critical History*, Thames and Hudson Ltd., London, p. 281.

[2] Gilbertson, R.G. 2000 - *Muscle Wires Project Book: A Hands-on Guide to Amazing Robotic Muscles that Shorten When Electrically Powered.* Mondo-tronics, Inc., San Rafael, CA.

[3] Gilbertson, R.G. 2000 - *Muscle Wires Project Book: A Hands-on Guide to Amazing Robotic Muscles that Shorten When Electrically Powered.* Mondo-tronics, Inc., San Rafael, CA.

[4] McGetrick, B.; Koolhaas, R., Ed. 2004 - Content, Taschen, 2004, p. 73.

[5] Noever, P. 2006 – *On the Subject*, in The Gen[H]ome Project, Noever and OSA, ed., p. 2.

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