# The Peculiar Nodal Generator: a speculation

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Economically abandoned cities as well as urban cores depopulated because of catastrophic events have spawned urban renewal projects of all varieties. Often these projects promote civic programs such as arenas, theaters, museums, and aquariums as replacements for what was once an interactive public realm. Unfortunately the realization of these large programs promotes a disconnected series of sequestered activities rather than the prospect of a lively and potentially frenetic urban center governed by chance interactions. As an intervening strategy, this paper considers the possibility of implementing Nodal Generators, responsive systems that sense and adapt to environmental fluctuations to create localized microclimates capable of providing unscripted public space in the discarded and interstitial regions of the modern city. Inspired biotically and explored digitally, the Nodal Generators provide a linkage between community and technology using smart materials and adaptive assemblies. This paper details several speculations on the nature and form of these nodes and proposes their implementation into urban arid situations.

We can postulate that while the nodal generators speculated upon in this paper might at first draw attention to themselves through spectacle, they will ultimately create a shared community experience through eventual inhabitation of that public space.

## 1. RE-INHABITATION

The strategizing for the repopulation of the inner city is certainly one of the great challenges for American designers. Advances in material science, manufacturing processes and computational technology make available to the designer novel configurations that suggest a repopulation stratagem. In this paper, parametric modeling environments, use of responsive materials and careful study of natural systems have become incubators for design methodologies and inventive classifications of temporal performative structures. These structures become automatons, which by the nature of processes that created them are ephemeral figures responsive to site specific phenomena, light, heat, shade and water. The automatons activate abandoned, overlooked, discarded or otherwise incoherent urban space. The kinetics of the activated machines are visual cues that connect the viewer to the processes of creating newly habitable space. This proposal postulates that these structures and concomitant spaces, once activated, serve as nodal generators that elicit strings of chance interactions. Acting as instigators they are part of a system that generates a collective experience.

## 2. AN INDUCEMENT TOWARDS ACTIVITY

In order to further discuss the proposition that automatons can create meaningful temporal public interactions, it is necessary to distinguish that which is public from that which is civic. During the past century urban public experience has been replaced by the civic function. Aquariums, stadiums, and similar civic venues encourage visitation to the city in only the most peripheral ways: we drive to the event, experience the event, and drive out: the car is a private lot, and we are invisible inside it. The civic function is largely a directed response consisting of social scripts. Alternatively, active pubic space provides a protocol. The public space operates as an inducement towards activity, whereas the civic functions present activities in the form of societal and cultural programs. The multiplicity and variability of the layers of interaction encouraged by public spaces add richness to our communal experience. Although humans search for groupings, patterns, sets, rhythms and harmonies, it is frequently the interruption in the field that causes hesitation [1]. This disruption amplifies our senses and demands our attention. To use Martin Gottlieb's term, the nodal generators are intended to create 'friction' in the often monotonous flow of pedestrian traffic. It is here, in the under or misused urban space, that the peculiar nodal generator, once initiated, becomes more of an urban public asset. This is pertinent in desert cities like Tucson and Phoenix where space extends as the temperature rises and the distance between park and coffee shop unfolds. There is a need to form temporal and moderate interstitial zones that reinvigorate existing public space. The automatons that provide shade and filter water create temporal bioclimatic zones: wet cool spots in the urban heat sink.

Robert Sommer, psychology professor at the University of California at Davis, has shown that people are 4.5 times more likely to sociably engage in an outdoor market versus the controlled corporate atmosphere of a supermarket [2]. There is something in the design, display of goods, knowledge of the goods' origin and the elicited social interaction. Cities like Tucson and Phoenix are largely devoid of interactive public space: the automatons are positioned to reinvigorate the public program.

Automatons are intended to provide a partial solution to Richard Sennett's observation that the contemporary design of public space augments movement rather than defines place. Among many notable examples is La Defense in Paris, where the real purpose of the public space is to serve as human corridors ferrying people from auto or bus to office building: this type of public space invites avoidance. Sennett observes that Westerners are culturally impoverished due to our isolation from environment and fellow citizen, largely a result of the notion that we perceive that our surroundings cease to have meaning 'save as an end of one's own motion' [3]. As a redirection to the passive opportunities already provided by the existing city fabric, the automaton provides a locus, a temporal impediment to flow, and transforms the human corridors into momentary territories of unscripted events.

## 3. COLLECTIVE EXPERIENCE: BORDER CITIES, FIESTAS, DEMOCRACY AND PING PONG TABLES

Southern border cities like Tucson or Phoenix may have an advantage in overcoming this lack of communal experience. The fiesta is intrinsic to the culture of these cities. Both the fiesta and the automaton are temporal events whose peculiarity wakes us from our daily regiment. The fiesta becomes an interruption in our daily routine that temporarily engages a less structured reality. The poet, Octavio Paz described the fiesta as a ritual that stops the flow of time and enriches both the imagination and the sensibilities; a condition where pasts and futures are reconciled and fuse with the present. He describes a situation where color is alive, the soul is unleashed, hats fly and the dust never settles [4]. In the fiesta of El Grito, celebrating Padre Hidalgo's call to arms against Spain, the populace masses and shouts for a full hour in every plaza and square in the Republic of Mexico. This action of communal yelling recalls the spirit of the Greek etymological root of public, 'publicus' meaning 'of the people'. Being aware that the entire populous of a country is in concert infers that shared experience is attained when communities gather to commit the same act collectively. The fiesta generates an impromptu 'third place.' Ray Oldenburg, in his discussion of 'third places,' notes that 'they are the heart of a community's social vitality, the grassroots of democracy, but sadly, they constitute a diminishing aspect of the American social landscape [5]. Modern examples of successful and temporal 'third places' include Chicago's 'Anyone

Can Play!' and The Cage in New York City. Lois Weisberg, Cultural Affairs Commissioner for the City of Chicago, distributed 500 ping-pong tables across the city in 2000 to entice chance public interaction. The West Side basketball courts of New York City, affectionately known as The Cage, sit atop the 6th Avenue and West 4th Street subway station. Famous for intense competition and rough play, the courts are always full and draw passing pedestrians who hang on the chain link to watch the game as spectacle. The automatons, as ephemeral third places, seek to remedy disconnected and underused urban space by generating the spirit and substance of the fiesta.

## 4. NODAL GENERATORS: AUTOMATONS

The value of the automatons, as the civic signifiers of public space, is in their intrinsic propensity to initiate compound social interactions. The automatons suggest an approach that describes a city based on sets of relationships involving access & linkage rather than singular statements. Christopher Alexander uses the semilattice as a model of a successful city: there is a complex network of relationships and potential relationships possible for the inhabitant. He notes that 'artificial' cities, in contrast to 'natural' cities which have 'arisen more or less spontaneously over many, many years', are developed quickly and intentionally. They lack the integrated complexity necessary for both the diversity and continuity of events that enrich our everyday experience [6]. This artificial city is deliberately partitioned where place and cumulative experience are impoverished and pre-scripted. In modern American cities, the placement of public spaces is prescribed by city planners. By comparison, in medieval cities, centers of communal activity emerge in plazas created by the intersection of streets. The nodal generator is assembled to create conditions for active space through performative structures. This strategy promotes the living city not through delineation but rather through articulate insertive moments. These moments activate and rejuvenate ignored and discarded spaces. As these nodal generators re-awaken the city, community has the opportunity to re-inform, centering on meaningful signifiers. Impromptu and informal gathering places are crucial to community vitality and solidarity. A primary role of the automatons is to alleviate social isolation and facilitate the exchange of ideas. Simultaneously they are mitigating: respite from the extreme solar radiation and the aridity of the desert.

Steven Carr and the other authors of Public Space provide a comprehensive definition of pure public space as democratic places that 'protect the rights of user groups. They are accessible to all groups and provide for freedom of action but also for temporary claim and ownership. A public space can be a place to act more freely [8]. The chess players and street performers at Washington Square Park in New York City are members of such a group. These successful public spaces are accessible to

all groups and provide for freedom of action but also for temporary claim and ownership. Public space is ultimately formed by public interaction.

## 5. PHENOMENAL/FIGURAL ACTIVATION

The automatons generate local temperate conditions and invite diverse public programs. The structures produce habitable space and provide temporal programming for newspaper stands, coffee carts, benches, impromptu stages and so forth. Formerly empty lots, discarded spaces, and fractures between buildings become animated, first by the automaton, and then by the inhabitants of the new public space. In Nicholas Tobier's description of the Burning Man festival, an ephemeral experimental city of approximately 30,000 people that forms each year in the barren Nevada landscape, 'there are no spectators only participants who define this temporarily appropriated autonomous zone as the festival progresses.'[8] In this instance, the Burning Man functions as the automaton. The nodal generators have another similarity to the Burning Man: they contain the figural tone of the church bell that calls people to gather.

## 6. INVESTIGATIVE MATERIALS AND METHODS

Mechanisms of biological homeostasis are a model for how smart materials can be utilized in adaptive assemblies. These assemblies have the ability to tune themselves in response to environmental variations, a quality inherent in every automaton. Skin systems and adaptable assemblies using smart materials detailed in this speculation utilize ecological models to establish material parameters. We developed the automaton prototypes within a parametric modeling environment by investigating haptic qualities and the definition of kinetic and geometric limitations.

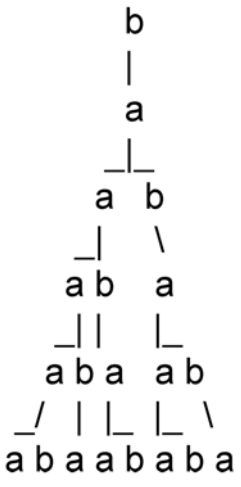
A digital investigation and subsequent morphological development was initiated from observations of biotic systems that naturally mitigate phenomena. These biotic systems inspired computational models that analyzed, evaluated and replicated the behavior of the observed systems. To generate the automatons, a binary rule set, one strut length and one pin connection, was assembled with parametric constraints in multiple iterations.

Considering the pair as a unit of multiple aggregated assemblies, a complex arrangement of simple parts emerged. This arrangement recalls the observed biotic system. The assembly was developed, refined and verified by immersing it in a digital heliodon. The heliodon models local solar conditions over the course of one year. The dialogue between digital and physical models helped develop specialization of both individual components and multiple assemblies. The physical constraints of the prototype produced from the first digital inquiries were entered into the successive iterations of digital models as parametric constraints. The automatons emerged as forms whose local constraints define algorithms used for assembly. Binary models

are particularly well suited to managing the complexity of biotic systems. As a language based on a string of affirmations and denials, a binary model makes complexities more manageable and fluid. The use of the parametric modeling in developing this inquiry helps us understand the binary systems. This experience requires us to absorb feedback directly, as a comprehensive logic, as well as through a software interface.

The automatons demonstrate that complex movement can be achieved through an algorithmic arrangement of components and articulations. Mathematical botanist Aristid Lindemayer identified algorithms as a way to describe the growth of plants [9]. The sympodial array and related formula in Figure 1 is an example of this algorithmic equation. The nodal generator detailed in Figure 4 is a 3-dimensional sympodial array derived from the same expression.

$$A \rightarrow I\left[B\right]^{n}\left[X\right]^{m}X,$$




► Figure 1. In sympodial branching the axis is terminated at every iteration, denoted in this algorithmic expression of figure (x) by the vaiable X. Lateral branching is denoted by variables A and B, I denotes the iteration.

To become an automaton the assembly requires the introduction of self-regulating actuators. A combination of temperature and light sensors coupled to servo motors were initially considered as the primary means to drive the kinetic components of the system. These first models were quite mechanical and cumbersome. The shape memory alloy nitinol was proposed as a relatively low cost alternative. The main benefit of this material is that it can be used as a temperature sensitive and non-mechanical actuator to animate the automatons. This material choice significantly reduces the mass, moving parts and energy consumption of the system while increasing the reliability of the mechanism. Nitinol, composed predominately of nickel and titanium, was developed in the early 1970's by William Buehler, a metallurgist at the Naval Ordnance Laboratory. The alloy undergoes a solid-state transformation between two phases: austenite and martensite. When heated

above a target temperature the nitinol contracts up to 4% while exerting significant pulling power. The target temperature varies with nickel/titanium ratio and in the case of the shading automatons, the alloy is set to activate in the range of 80-90 degrees Fahrenheit, generating precise figural response in the automatons to ambient changes in temperature.

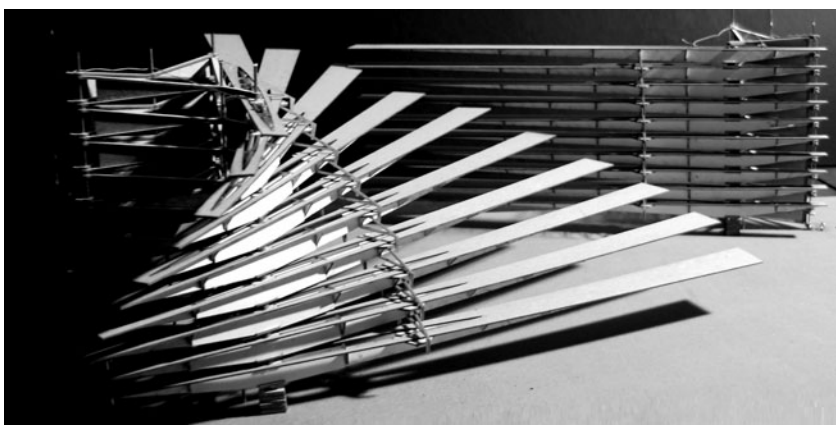
Smart materials and adaptive assemblies offer many opportunities for the design of dynamic, self-regulating systems. Because dynamic systems depend on the predictable performance of responsive materials, having a physical understanding of the parameters and behavior of specific new materials is fundamental. While we will continue to investigate both emerging materials and technologies as they develop, this performance-based process may be unique to contemporary architectural research and education [10].

The following projects present possibilities for nodal generators. Considered primarily as self-sufficient kinetic structures, they are well suited to the task of independent urban inhabitance. Localized microclimate conditions are created during activation. Distinct figurations, both at rest and in activation provide a peculiar calling for public interactions.

## 7. SPECULATIONS: 4 NODAL GENERATORS

### 7.1. Spiral Heliotrope

The Phycomyces is a fungus that reproduces via spores released from single celled phototropic stalks, sporangiophores. Formed as a translucent water filled tube which terminates in the spherical sporangium, the sporangiophore tracks any far-UV, near-UV or white light. The Spiral Heliotrope emulates the sporangiophore's ability to map spiral movement via an integrated series of shape memory alloy actuators



◀ Figure 2. Spiral Heliotrope prototype model, iteration 3: stacked and splayed configurations. Responsive to solar conditions this automaton is indicia for community gathering. The splaying of the blades creates shade and defines a temporal urban space while generating power for the local community. Credit: Robert Leyen.

The final prototype is an array of ten cantilevered solar collection/shading blades. Activation begins at sunrise when the top photovoltaic blade collects solar radiation and triggers the coupled actuator. The first blade rotates laterally 10 degrees exposing 90% of the second

blade, which is subsequently activated by the increasing solar exposure. As the sun reaches the apex of the solar arc, the blades are completely splayed, providing a shaded space ten times the footprint of the heliotrope at rest. Designed to anticipate human interaction and scales, the heliotrope is constructed from a steel frame and photovoltaic panels. The blades of the heliotrope cantilever 10 meters from the mast and the lower blade is padded with high-density memory foam, serving as a seating element.

This nodal generator, intended as both urban and arid, is particularly appropriate for desert dwelling. The activated figure of the heliotrope is an indicator of an environmental condition, the spatial reprieve from solar radiation, and functions as a call to gather [11].

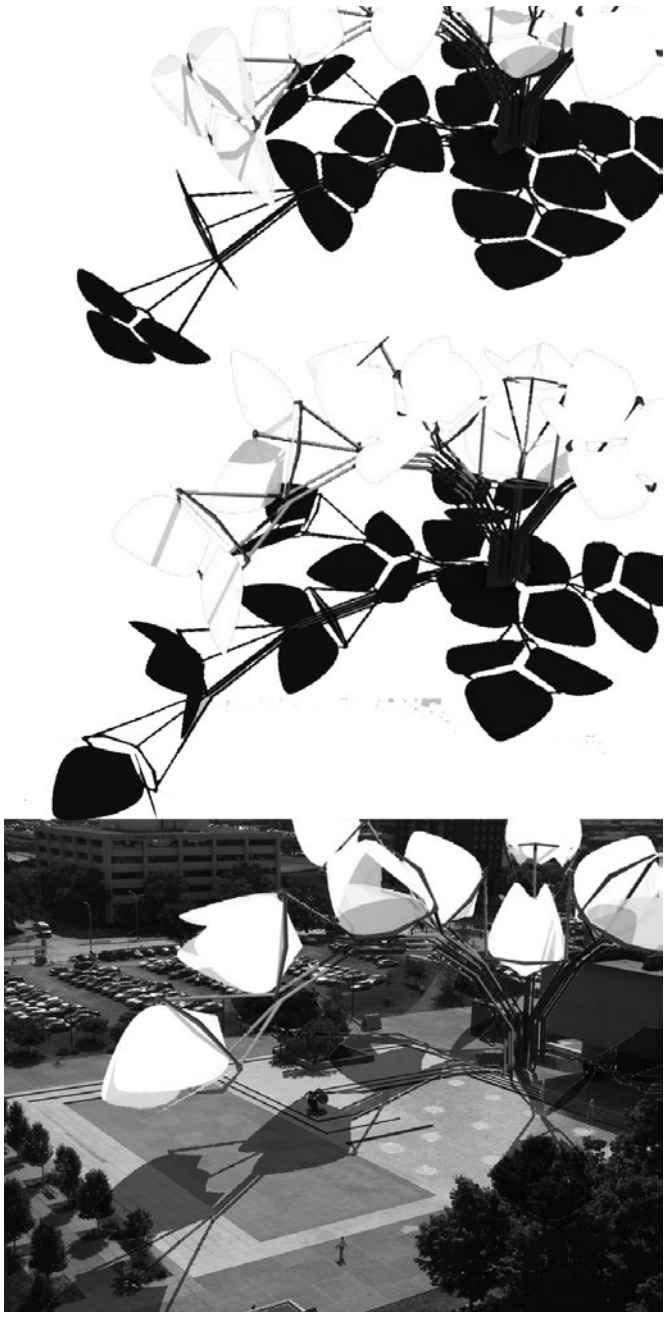
## 7.2. Water Harvester

Inspired by water harvesting techniques in native plants, the Water Harvester draws groundwater to the shelter through capillary action providing drinking water and creating a temperate microclimate (Figure 3). The harvester was investigated digitally and intended as a prototype to mitigate the extreme heat island effect of desert cities. Directional nitinol actuated valves assist the capillary action by creating negative pressure in the water storage cells. The shelter mediates diurnal temperature swings by using photo chromatic film laminated to a recycled plastic substrate. The envelope shades the interior during the day and makes use of phase change material to store heat for release at night. The Harvester is composed of modular cells and the scale can change to adapt to a given environment. These structures function as humid bio-climatic 'islands' encouraging a localized ecosystem simulating the conditions of an oasis. The Water Harvester helps negotiate an extreme environment, promoting community and relief from exposure.

► Figure 3. Water Harvester showing phenomenal principles and urban configurations: nitinol-actuated valves assist capillary action of artificial roots for water collection and regulate the resultant humid microclimate. Credit: Matan Mayer.

## 7.3. Branching Heliotrope

Inspired by cellular automata as a form generator, the Branching Heliotrope (Figure 4) captures the qualities of the heliotropic flower, Alpine Buttercup, through the clustering of petal assemblies. The spaces between the branches are filled with freely rotating petals. Through simple rotation the structure self-assembles into spatial forms providing shade.



◀ Figure 4. Branching Heliotrope showing shade configurations: responsive to light for actuation, this trifurcating system allows multiple assemblies able to adjust to a variety of urban spaces generating a diversity shading patterns. Credit: Ryan Meeks.

Based on a trifurcated branching system extending into multiple tetrahedral petal clusters, this heliotrope offers substantial shading variations. This prototype is composed with two assemblies, the trifurcated tubular steel branching sequence and the photovoltaic petal cluster. These assemblies are arranged as multiples, with the petal clusters attached to the diaphragms between the trifurcated branches. This allows indefinite extension and is capable of accommodating various site and size parameters. Although the branching takes place at regular intervals along the lengths of the structure at small diaphragm connectors, the branches may reorient in asymmetrical alignments creating variable coverage conditions. Solar energy is collected and focused on a nitinol actuator causing the petals to rotate open allowing for more surface absorption of solar radiation and increased pedestrian shading. Each petal cluster shades at least two people. As petal clusters accumulate the shade space becomes more intricate emulating a forest canopy rather than a bouquet of buttercups.

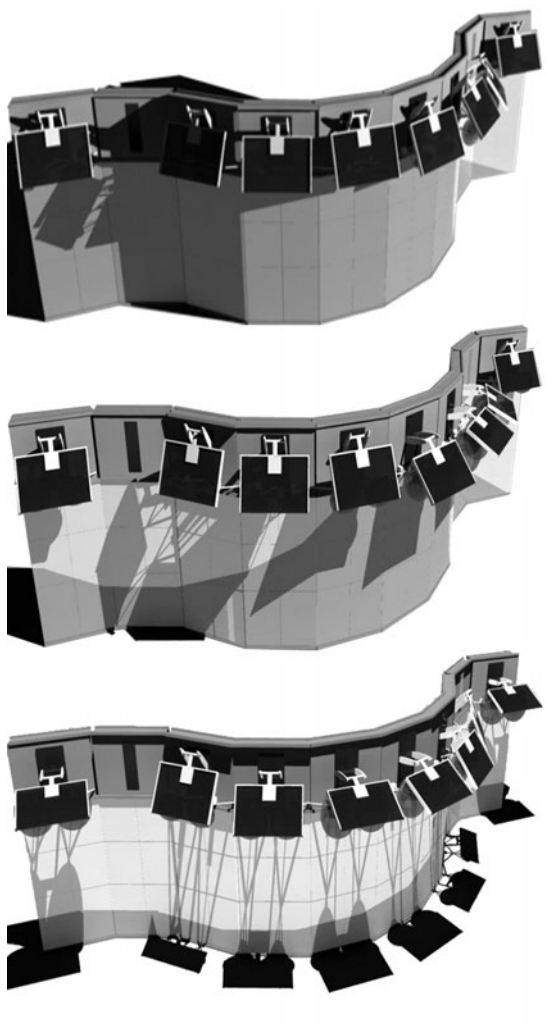
Energy collected by the array is stored in battery banks placed in multiple areas throughout the canopy protecting against catastrophic failure. Shade created by the act of energy collection provides shelter in urban arid zones. This shelter creates infrastructure based on sustainable practices that in turn encourages community participation. The heliotrope's, kinetic response to the sun announces gathering possibilities. Simultaneously, solar energy is being collected passively in preparation for future need.

## 7.4. Heliotropic Wall Assembly

The heliotropic movement of the Alpine Buttercup marks the passage of time. As the flower responds to the sun, the stomata are activated and create pressure on the base of the petals forcing them open. Each plant marks this passage individually, relative to the duration and intensity of localized solar exposure. Similarly, as seen in this digital model, the Heliotropic Wall is composed of a series of contiguous elements that become activated locally in response to ambient temperature changes (Figure 5). A pneumatic bladder controlled by heat or light programmable sensors, activates a mechanical shade petal. This bladder construction is similar to devices currently used by emergency personal for rescue operations in construction collapses and auto accidents. During inflation, the bladder membrane applies pressure to the shading petal, positioning it to provide shade in response to the angle of solar exposure.

This system enhances sustainability, as it is entirely powered by solar electricity and passive thermal reactions. Further, the Heliotropic Wall reduces internal cooling costs by shading the building at times when the solar radiation is incident upon the building envelope. Based on our empirical research, this may reduce the surface temperature of the building by up to 30 degrees, affecting a notable energy savings. During times when the angle of solar radiation is more oblique to the building skin, the shading

petals cast shadows on the ground along the periphery of the wall. These shadows form a shaded exterior passage and promote pedestrian traffic in an otherwise intolerable area.



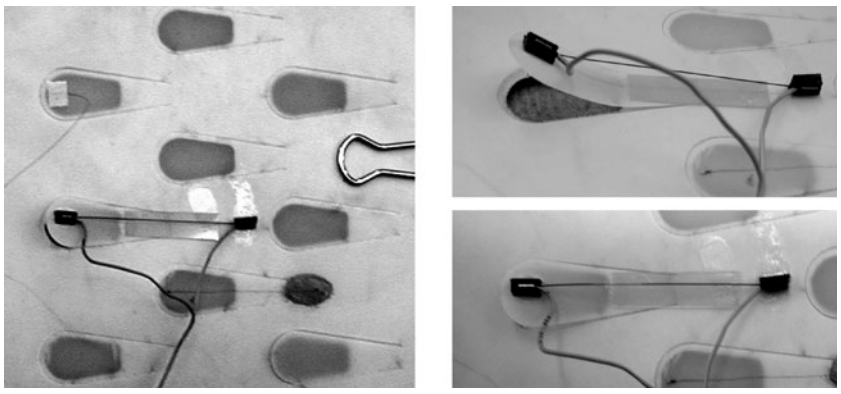
◀ Figure 5. Shade sequence for Heliotropic wall: in respone to shifting solar conditions the photvoltaic shading petals protect the building envelope and form a shaded pedestrian pathway along the edge of the structure. Credit: Shane Ida Smith.

## 7.5. Adaptation: smart filtering

This prototype is the first of a series of experiments intended to develop a variably porous envelope actuated with nitinol.

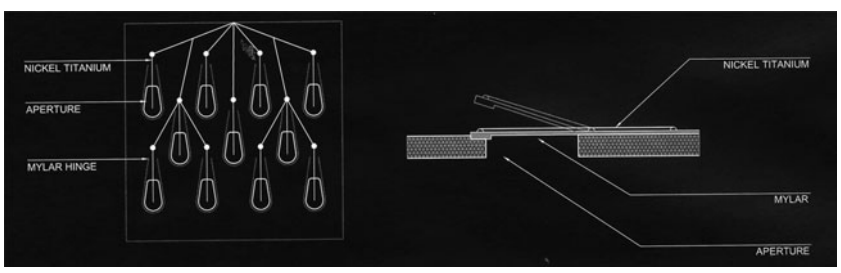
Because of their potential for reactive transformation, smart materials are appropriate materials for envelope systems designed to tune themselves to fluctuating environmental conditions. To develop prototypes of adaptive building skins, ecological homeostasis was studied on a variety of scales, from cellular filtering processes such as osmosis, to organism adaptation like the tropic behavior of plants as they move their leaves to adjust intake of heat and light. These examples guided the nature of the design of responsive or adaptive systems.

The leaf stoma was used as a biological analogue to develop a responsive envelope that adjusts its porosity according to temperature fluctuations. Stomata, in most plant species, act as valves to permit the exchange of gases between the plant and its environment. The valves are responsive to environmental conditions, including variations in light, wind, carbon dioxide and temperature. The shape of the cells and so the porosity of the leaf surface shifts in response to variation in these conditions.



► Figure 6. Photograph of the initial Smart Filter prototype in open, 4% contraction, and closed positions: the filter is an array of thermally activated valves to maintain thermal, psychometric, and lighting equilibrium.

The initial prototype (Figures 6 and 7) serves to illustrate the potential of the design where the envelope operates as an array of thermally activated valves triggered at targeted temperatures that control the surface porosity. Each pore measures approximately 1 cm x 2 cm and the entire array is designed to be installed as a responsive blanket over an existing frame. The skin is Mylar laminated to a porous substrate and fitted with a 30 mm x .15 mm diameter nitinol wire that can exert a maximum pull of 330 grams. The Mylar serves as a non-mechanical hinge. Through a calibrated series of simple and incremental contractions, the envelope adapts its form and porosity to maintain thermal, psychometric, and lighting equilibrium.




► Figure 7. Plan of the aperture array and section of the initial prototype of the operable filter.

When designing with smart materials, the variation in the site conditions activates and changes the building. What might have been an attempt to impose stability on a place becomes an opportunity for reciprocal transformation between site and installation. Drawings of buildings and site represent a moment in time rather than an outcome. They are diagrams of the relationships and interactions of the building with the temporal site conditions. This embodies a kind of technological regionalism in which the building is in continual response to local climatic fluctuations.

## 8. DISCUSSION

The 'planned' city often lacks the organic sensibility that provides spaces that induce public interaction. This prescribed plan directs traffic, people and experience, creating a place assembled almost solely from path, and removes the possibilities of chance encounters, spontaneous gatherings, and active, unscripted social experience. We realize that there is a need for spontaneous public spaces, which will lead to the maturation of inhabitant and the city by generating loci for social interactions. A return to public interaction occurs when the rigid city/perceptive structure is challenged by the unexpected as created by a nodal generator. Sennett's "purified self" re-emerges as the anarchic self, both curious and skeptical of the prior beliefs and the surrounding world. In this way, Sennett suggests that social intersection and maturation are inseparable from successful urban design strategy [12].

When considering the question of new natures and thus new urbanism, the recent trend in urban renewal strategies deserves a harsh critique. The civic program, intended to draw the populous back into the urban situation, instead partitions further the possibilities of unscripted social interactions from prescribed functions. A recent study of urban areas by Melissa Means and Charlie Tims found that successful public spaces 'left room for self-organization, encouraged a broad range of users by encouraging diverse activities, and made spaces accessible at all times of the day [13]. We hope that the chance encounter created by nodal generators helps makes space uniquely public, and that the resulting events and peculiar experiences result in a stronger community, reconnected to the urban fabric. The automatons are an experimental insertion intended to provide havens from the extreme environmental and concrete expanses prevalent in arid cities like Tucson and Phoenix. In the simplest sense, the automatons gather people by generating microclimates as they continually respond to local variations in light, temperature and humidity.

The automatons provide shared public experience, like the spectacle of street performances and public art, while simultaneously providing needed relief from current uncomfortable urban dwelling conditions. Through the activation of new nodes within the city, the public is allowed to congregate in spaces formerly considered inhospitable.

As articulate as these speculations may become, the public must test their effectiveness in the city. The future of this work is directed at full-scale fabrication and insertion into city space.

In the city the common ground is found in the rudimentary mediation of basic conditions: light, heat, water, waste. Chance encounters can exist at nodal generators and help rebuild the community at a core level. Autonomous filters act as agents of sustainability. Considering sustainable practices and utilizing emerging materials and design processes, it is possible to project the viability of the Peculiar Nodal Generator as a new nature

that inhabits the city, creating a renewed urbanism. In devastated areas that are moving towards recovery the ultimate strength in the community comes from the collective desire to rebuild and re-inhabit.

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