ABSTRACT

By fusing sensing technology, robotics and coding in unison with architectural form designed to move and reconfigure itself, a new kind of architecture that goes through a formal transformation in interaction with the user can be imagined and devised. Aiming to merge human presence with space through technology, this new architecture defines space as an extension of the human body and consciousness rather than one that regulates and controls it. Similar to terminology in the discipline of Artificial Intelligence, where human consciousness merges with computation, such a condition can be called Architectural Singularity, where architecture becomes the body rather than the host itself.

Through historic examples, theoretical vantage points from art, architecture and media theory as well as built design experiments, this paper aims to problematize the conclusive notion of architectural form and agency. The user becomes architecture, code becomes form and robot becomes the user in continuous feedback loops.
PLACING CONSCIOUSNESS INTO MATTER: THE STORY OF THE TURK

A phantasmagorical combination of human mind and machinic automation, *The Turk* (Figure 1) was a humanoid mechanical chess player, designed and built by Wolfgang von Kempelen in the late eighteenth century. This great hoax of artificial intelligence curiously lacks a metaphysical storyline (Gottlieb von Windisch 1784). Covered with a complex veneer of fake as well as functional clockwork, providing the machine an illusion of instrumental validity and concealing its true mode of operation, *The Turk* was merely a mechanical device where a chess player hid inside and controlled it like a complex marionette. The genius of the machine was therefore not in its untimely scientific achievement of man-made consciousness, but rather its success at concealing its inner-workings with such rigor and precision meanwhile maintaining an enigma of curiosity and mystique. *The Turk* exemplifies the age-old desire to build robotic devices that are capable of interacting with and responding to the human mind autonomously.

Although the aspiration to place consciousness into objects in order to create tools that are subservient yet autonomous from humans has a long history, from the myth of Galatea to the Golem, the Turk is a significantly different cultural phenomenon where such an aspiration is contextualized as science rather than metaphysics. It also solidifies the notion that the proof of intelligence and consciousness relies heavily on interactivity and responsiveness. Architecture as a form of technology, once perceived as an extension of this cultural aspiration, has long negotiated the relationship between objects, people and the environment in directly interactive ways. More recently, our scientific exploration of nature through physics, mathematics and material sciences lead to the formation of quasi-intelligent abstract systems in the realm of simulation and computation. These contemporary influences of technological thinking affect both the “software” (as in design intent) and the “hardware” (as in formal, organizational and structural logic) of design methodologies. Current application of robotics and code into architecture both as practical and theoretical paradigms are synonymous to the Turk as both create illusions of reason through an imagery of automation and tooling, since they both hope for an emergence of consciousness through increased complexity, or a unified intelligence by displacing and de-contextualizing the tool itself. On the other hand, in order to create an architecture that is inherently responsive and symbiotic to human presence, such architecture is required to be in physical motion in synchronization to human form, and simultaneously create a continuous feedback loop between spatial design logics and human consciousness, meanwhile maintaining elements of reason and inference through rule based computational reasoning and embedded anomalies.

TRANSFIGURATION: ARCHITECTURE AS HARDWARE IN MOTION: THE SHAPE(SHIFTING) OF MATTER

The role of motion in architectural form has largely been an introverted mediation between associated proportions and intimate perception of the body as an external yet a metaphysically connected subject in the role of a perpetual observer. As the observer moves through space, his/her own motion brings architectural form to life. This kind of categorization is based on the representation of form always through a fixed vantage point; a deterministic choreography and composition historically vivid from eighteenth century English landscape design to twentieth century Modern Architecture. The invention of cinema is largely responsible for challenging this notion and has highlighted the importance of the shift in perception as the observer is in motion. Through the proliferation of cinema as the dominant media of communication, architecture addressed the notion of motion and its consequent perceptual transformations more aggressively, yet always made of point of differentiating buildings from other occupiable design objects in motion, such as cars. For architecture, it has been its lack of motion that armored it with its cultural significance and value. The user always existed in response to a fixed architectural object. Therefore architecture has never viewed itself as a tool that could be rendered as the extension of human form and activity. Although it has always made formal connections to the body as seen in Vitruvius to Le Corbusier, it was rather seen as a device that exclusively organizes and controls its flow. This is particularly prominent in the
works of architects from the 80s on, as exemplified in the works of Deconstructivist architects and their more contemporary incarnations. Greg Lynn points out this inherent problem of architecture in perpetual stasis through an analysis on cinematic representation in his seminal work Animate Form (1999). He says, “the dominant mode for discussing motion in architecture has been the cinematic model, where the multiplication and sequencing of static snapshots simulates movement. The problem with the motion-picture analogy is that architecture occupies the role of the static frame through which motion progresses. Force and motion are eliminated from form only to be reintroduced, after the fact of design, through concepts and techniques of optical procession” (Lynn 1999, 11). Lynn’s continuing research on the role of motion in space has resulted with design methods with exceedingly intricate formal strategies made possible through cinematic digital techniques and encoding of calculus based mathematical definitions as well as evolutionary scientific models (Lynn 1999).

These seemingly oppositional ontologies, the permanence of spatial invention and contemporary design methods based on evolutionary systems, both require the design process to be frozen at a particular moment in time in the fear that an architecture dependent on technology would overwhelm the design process and interrupt the efficient flow and organization of material logics, therefore damaging its credibility. As a result, architecture’s theoretical relationship with motion and transformation in response to contextual parameters, as in nature or human occupation, exists merely in allegorical and representational realms. Contemporary iterations on Lynn’s timely work from the late 90s still largely operate on his earlier premise that “the context for design becomes an active abstract space that directs form within a current of forces that can be stored as information in the shape of the form” (Lynn 1999, 14). It is important to note that the opposite of formal stasis is not temporality but perhaps a potential an architecture in literal transformation or evolution holds.

The role of the contemporary architect is defined as a consequence of this paradigm, is limited to composing the material world conclusively and continues to be as such. The principles of this organization rely heavily on social behavior and the changing paradigms of human interaction and cultural zeitgeist. Therefore the twenty-first century architect needs to re-prioritize the concerns of design, as the exactitude of geometry no longer stands as a true reflection of human intellect. Rather, architects need to search for methods to organize material behavior transformatively and reactively. Many contemporary practices of our generation are using coding, robotic fabrication and other digital/physical translation tools to infinitesimally vary methods of material organization and complexity. Since more complexity does not equate to intelligence and autonomy, how do we legibly define the behavioral aspects of architectural form? The static nature of form “encodes” movement in itself but is incapable of rearranging its material constitution in response to changing environmental factors.

As we attempt to translate the “animate” into the material and vice versa, we submit to the twentieth-century notion of modernism where the designer organizes material conclusively, which in return is expected to have definitive phenomenological outputs. This form of determinism is no longer an accurate reflection of contemporary society, and indicates that the potential of Lynn’s work is largely misunderstood. The only constant of architecture is its vis-a-vis relationship to culture and technology, not its permanence. In fact, there’s no potential of form, affect, and materiality, unless form is liberated from Form to create an architecture that becomes an interface itself, fusing the human intellect with space.

Liberation of form from Form is the liberation of architecture from its physical context and the outside forces that determine its boundaries; a space that has a silhouette but no figure. A transfigural architecture, by its ephemeral, seemingly amorphous yet programmed behavioral iterations is bound to travel between a multiplicity of contexts.

An architecture that has a transforming design boundary with its outside world continuously contextualizes its context, and content meanwhile disperses it. By allowing itself to be shaped by multiplicity of external forces, it gives form to its user and his or her environment. Form without Form is not form without context, content or intent. It is design-space that temporally re-calibrates its relationship with the outside world, repeatedly and through time, by actively transforming its physical and conceptual boundaries; meanwhile, simultaneously translating its phenomenological perception by the user. Therefore a kinetic architecture in responsive transformation is content without context par excellence, as context is not a paradigmatic constant.

SYMBIOSIS
CONTINUOUS FEEDBACK LOOPS:
SPACE SHAPING USER SHAPING SPACE

As a crude example of human-machine cohabitation, The Turk can also be viewed as a system of first-order Cybernetics. As described by twentieth-century scientist Norbert Wiener (1948), Cybernetics is the study of complex systems consisting of actors of diverse nature and origins, primarily of machines and organisms. The study of such biomechanical ecologies as complete systems
affected the organization of industrial manufacturing environments that require human-machine collaboration and led to the birth of Artificial Intelligence as a field of study. Further categorizations of Cybernetics lead to the definition of a “first order” described as observed systems, and a “second order” where the observer as well is a part of the system under observation (von Foerster 1981).

Contemporary proliferation of sensory devices allow for the control and calibration of spatial parameters in real time with the user. An architecture in literal transformation in synchronization with human sensory data operates further than merely problematizing the binary opposition between static form and simulated motion. An architectural motion that is aware of and in synchronization with the human mind and body through sensory feedback and robotic actuation might come across as an ambiguous prognosis, yet it creates a more intimate symbiosis and mutuality between the subject and architectural objects. This synchronization or singularity between space and subject as a unified system that constantly informs each other in a continuous feedback loop creates a morphological relatedness in infinitesimal yet foreseeable transformation. Therefore, if architectural form storing encoded information of motion is a “first order,” then an architecture in formal transformation can be summarized as a more elusive design intent in the “second order.”

**Inference**

**Logic of Intelligent Systems: Expert Systems vs. Procedural Code**

In the field of Artificial Intelligence, an Expert System is a computer system designed to simulate the decision making process of an expert human (Jackson 1998, 2). Such systems are created to resolve problems by computational reasoning, represented primarily as if–then rules rather than through conventional procedural code. Unlike an expert system, which has the ability to “interpret” the question at hand through a library of possible responses to a particular problem, procedural code can be described as simple code that will resolve a calculation only if the particular command is repetitively asked in the identical format that the code is designed to respond to. Most calculations rely on procedural code, and expert systems require a more robust configuration where multiple procedural codes are embedded within, as one of the main requirements of intelligence is plasticity of responses rather than deterministic repetition.

The two projects illustrated below, both designed as expert systems with multiple procedural codes that they cycle through, aim to simulate intelligent behavior. Through experimentation with robotically actuated animatronic architecture where motion is triggered by sensory devices, code acts as a mediator to create a symbiotic link between form and the user. They consist of surfaces that absorb and remember the presence of multiple users; changing their physical and phenomenological morphologies as an accumulation of user inputs, therefore creating real time continuous feedback loops between human presence and architecture cumulatively. Although there are patterns and repetition in the mode of behaviors, the response and position of each response is unique.

**Two Experiments on Architectural Singularity**

**Cerebral Hut**

*Cerebral Hut* (Figure 2) is a responsive architectural installation that explores the relationship between architecture, interactivity, motion and human thought. It debuted at the Istanbul Design Biennial 2012 and was later exhibited at the Saatchi Gallery, London, in Summer 2013 (Figure 3) as well as SXSW Festival in Austin 2014, Texas, as a part of “Bioreactive Experience” presented by Pepsi and Fast Company.

*Cerebral Hut* is a robot built as space, and it is the first prototype of architecture that goes through a formal transformation in direct correlation to brain activity. It is an environment that is calibrated and synchronized with intangible phenomena such as “thoughts.” It is dependent on human mental input to come to life. Formally, the overall geometric construct of *Cerebral Hut* is based on the rejection of simulated yet static complexity. Instead of attempting yet another representational recurrence of complexity, it uses or borrows anonymous form, such as an Archimedean solid. The input from user participation becomes
the primary agent that determines formal iteration, richness and variation. In order to create a space that is reactive to brain activity, a commercially available EEG (Electroencephalography) device was hacked, which can measure concentration levels and blinking. The helmet is wirelessly connected to a computer.

Through Processing, the computer interprets the data from the EEG helmet and runs an algorithm that translates these data thresholds into a sequence of motion. Once the concentration threshold passes 65%, the motion starts.

The Arduino microcontroller splits the signal from Processing into seven stepper motors, controlling their range and speed. The interface translates code into linear motion.

The seven stepper motors move steel pistons through the help of a custom made gear mechanism. The pistons are linked to folded paper panels on one end, and a stretch fabric panel on the other.

As a result, Cerebral Hut becomes a game-space where the user controls the physical boundaries of the environment by his/her thoughts. As the user engages in activities that increase concentration levels, the environment responds in real time and changes its formal configuration. Code acts as a mediator between the physical transformation and user input. As the environment transforms as a consequence of data from the EEG helmet, the transformation effects the user psychoactively in return, which manipulates the concentration level of the user again, therefore influencing the overall system in a continuous feedback loop. The code is designed to create predictable behavior with slight variation, where the user develops a more complex relationship to the system, in comparison to a direct response where identical behavior always yields to the same result. Although the user can influence the system that he or she is a part of, the system is designed so that the user can never fully predict the response of the system with repetitive results. The same concentration level can correspond to a different pattern that the code cycles through. The purpose of such anomalies in the system is devised to test how difference in fact affects the behavior of the user, therefore embedding variation and iteration to the formal transformation, always ensuring a novel connection between the user and the system itself. Consequently Cerebral Hut is an expert system in the second order with inherent anomalies.
Cerebral Hut is an exploration on building the foundation of a reactive architecture that directly responds to the human psyche. It creates a collective architectural form in continuous transformation, composed of the mental traces of its users embedded in its physicality. As kinetic architecture, it has no final or ideal design-form; its interior and exterior are in constant transformation triggered by user participation (Figure 5). It paves the way for a form of artificial intelligence that embodies space, human and robot simultaneously.

AETHER PROJECT

As a part of the Third Year Advanced Design Studio: Architectural Intelligence, Exploring Space as an interactive Medium, which I have taught in collaboration with Casey Reas of UCLA Design Media Arts Department, Aether Project is generated by the research team I lead, aiming to explore the hybrid boundaries between architecture, media arts and computation. Through formal and technological experiments, it aspired to contextualize contemporary debates regarding code, robotics, interactivity and artificial intelligence as spatial paradigms. The instructional process required students to use a sensory input device (motion sensor, sound sensor, brainwave EEG headset, kinect, leap motion tracker etc.) and program this device as an interactive interface that triggers an actuator (industrial robots or custom made electromechanical actuators) for spatial transformation. Through a thorough study of materials, geometry, structure and electromechanics, the students developed 1:1 scale large prototypes that are designed to go through a formal transformation, both in physical or digital space. The transformation had to be triggered by the sensory input from the chosen device and utilized industrial robots and other custom made electromechanical actuators for precise motion control. These prototypes served as “proof of concept” in order to develop a spatial scenario or an environmental application.

This particular student team (Refik Anadol, Julieta Gil, Raman Mustafa, Farzad Mirafaei) was instructed to use industrial robots as armatures to actuate motion of an external skin that
can be defined as “robotic couture” in conjunction with 3D video projection mapping content. Conceptually it explored the motion control capabilities of robots as skeleton and architectural geometry in transformation as skin, meanwhile being posed with a new technical challenge of creating a live projection mapping content on an object not only in motion but also in formal transformation, or transfiguration.

Initially students devised an interface with a static board attached to one robot and a projector to the other (Figure 6). A Leap Motion Tracker device was programmed to allow for a real time motion control of the robots as a sensory input (Figure 5), communicating with the robot through Processing as a mediating platform between the robot code and the sensory device. As a second iteration, a folded tessellated panel with moving hinges was designed in relation to the joint and axes structure of the robot (Figure 7). This new triangulated surface in motion became the canvas for a variable 3D projection mapping, which was also controlled by the Leap Motion simultaneously. The projection transforms in synchronization with the geometry attached to the first robot as well as the Processing code, creating a physical yet more ephemeral form of augmented spatiality through motion (Figure 8).
7 Real-time control of the industrial robot motion by hand gestures through Leap Motion Controller. The hinged triangulation of the final design surface interfaces with the axes of the robot and transforms as the robot moves. The 3D projection mapping onto the surface of the panel uses the same data to generate video content in real time (Refik Anadol 2013).

8 Test and calibration of real-time control of 3D-mapped video projection on robot couture through Leap Motion (Refik Anadol 2013).
Conclusively, the user can control the motion of the robotic couture real-time through hand gestures and manipulate not only the geometric configuration of the folds and orientation of the tessellated panel but also the pattern and color of the projection simultaneously through the same interface (Figure 9). The Processing code that controls the projection content updates real-time through an algorithmic system that generates unique content through a set of rules based on the projection content and physical board geometry. The experiment engages the user in a continuous feedback loop with the transforming architecture, where the user behavior is affected by the spatial configuration and is therefore influencing the content repetitively through the variation in physical transformation and digital projection. In conclusion, the user is being challenged by transforming modes of sensory information where depth, color, shadow, and geometry is constantly blurred through a combination of varying physical and digital perception.

CONCLUSION: EMERGENT INTELLIGENCE OF SYNCHRONIZED SPACE AND SENSE; A NARCISSISTIC ENGAGEMENT

Prolific media artist and theorist Roy Ascott has determined, in response to cybernetic theory, that a more holistic approach toward art objects, observers and environmental parameters can lead to an understanding where art can emerge from the ecosystem of relationships rather than the discrete occurrences of art production exclusively conducted by the artist and consumed by the observer in isolation (Ascott 1990). In this model, the distinct roles of the artist and the observer along with the objectness of art is problematized and blurred. In *Is There Love in the Telematic Embrace?* he proposes to replace the word “observer” with “participant” with the intention of rendering art as “a participatory process (as opposed to discrete object or event) defined not by formal parameters, but by behavioral relationship in which artist, observer and environment are all integrated in an emergent, interactive system of morphological relationships” (Shanken 1997, 3).
Ascott traces the genesis of this ideal back in Marcel Duchamp’s Large Glass, where the simultaneous properties of reflection and transparency creates a narcissistic engagement of the viewer as an integral part of the art piece meanwhile allowing him/her to still contextualize it through the filter of the artist and other external yet inherent parameters, such as the physical context as a backdrop (Ascott 1990).

An active engagement of the viewer and the context into an art piece as such is a productive model for re-interpreting a new relationship between space and the subject. In Duchamp’s case, a very architectural understanding of material logics, transparency and reflection becomes the vital link between the object and the subject. In architecture, such material logics are already embedded into the conception and reception of design methodology. A new kind of architecture can emerge from an enhanced human engagement, one that is equally optimistic as Ascott’s alternate scenarios where technology becomes a vehicle to imagine an augmented material world. In reality, a space as such is a robot itself that works in unison with form, motion and sensory feedback, de-contextualizing human consciousness outside the boundaries of the body through technology. Such cybernetic thinking in the second order can push beyond the spectacular elusiveness of robotic iconography, currently offering merely a seductive allusion to late-twentieth-century, post-Fordist society, a promise of an autonomous machinic future with a tantalizing connectedness and alienating distance to the material world. Contemporary research and development in the field of robotics in architecture predominantly follows this tradition of viewing the robot as a form of technology that either constructs objects with precision or moves and assembles them. Imagining architecture as a form of artificial intelligence itself, a form of interactive technology that responds and behaves, can pose an alternative to such detached conceptions of technology as external to human intellect.

REFERENCES


Gottlieb Windisch, Karl. 1784. Inanimate Reason; Or a Circumstantial Account of that Astonishing Piece of Mechanism, M. de Kempelen’s Chess-player; Now Exhibiting at No. 8, Savile-Row, Burlington-Gardens. London: Gale ECCO.


GÜVENÇ ÖZEL is an architect, artist and researcher. He is the Technology Director of IDEAS, a multidisciplinary research and development platform at UCLA Department of Architecture and Urban Design, and the principal of Ozel Office, an interdisciplinary design practice located in Los Angeles. He holds a Masters of Architecture degree from Yale University. His projects were published and exhibited worldwide, including Istanbul Museum of Modern Art and The Saatchi Gallery in London. He formerly taught at Yale University and University of Applied Arts in Vienna. His current research focuses on experimental applications of robotics, sensing devices and augmented reality as they relate to art and architecture for the creation of reactive, intelligent environments.