Spatializing Invisible Matter

by

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ABSTRACT

The purpose of this paper is to present and discuss current practices of computational media and sensor technologies used for identifying, capturing, and transforming the properties of an interior space, providing customized architectural environments. It explores the challenge of properly measuring and recording invisible matter on an atomic level using a range of technologies (sensors, custom electronics, databases, networks, cloud computing), finding methods of manipulating digital representations, and developing techniques for spatializing information into the built environment. Therefore, this study demonstrates how sensor technologies and custom electronics provide methods to accomplish effective measurements in real time by scraping atomic substances and sniffing particles out of thin air, as well as using software tools to spatialize and distribute information into the environment with media elements such as lighting, imaging, or visualizations. These techniques allow us to extend architectural intelligence to habitats of awareness that enable a range of imaginative possibilities.

INTRODUCTION

For a long time, architecture has been considered to consist of physical objects made of solid materials, the purpose of which is to remain silent and static. However, over the centuries, this belief has shifted as the built environment has transformed into a sophisticated amalgam of practices and technologies. Interior spaces can facilitate further functions that establish new symbols of cultural communication. In turn, these symbols re-contextualize architectural practice and accommodate flexible and imaginative aspects, evoking a number of sensorial modes and altering one's understanding of the surrounding space. Consequently, computational systems and media technologies become ubiquitous layers within the structural complexity of built environments revealing "the emergence of post-digital architecture where ubicomp" – that is, ubiquitous computing – "and ambient intelligence dominate over spatial arrangement and design methodology." [1]

Behind this transformation, these ubiquitous layers of technology provide a range of services to inhabitants – physical, intellectual, and emotional. They thus permit architecture to become an extension of an individual's personality and psyche, and to provide not only survival possibilities, but also poetic and colorful properties, such that a building can evolve into "an organism capable of conveying messages using various media, integrating them into the building fabric." [2]

In this scenario, architecture incorporates nonobtrusive systems and devices into its design as a layered, sensory skin that has the ability to "understand" the enclosed space in greater detail by monitoring properties/substances (such as air molecules or environmental properties) and to grant auxiliary computational units access to recorded information for further analysis and universal connectivity. With the use of filtering and extraction computational techniques, raw datasets can be refined either automatically using preset calculations or set manually by the user using specialized physical or virtual interfaces. In both cases, this network of things intends to support the built environment with a higher level of understanding on the atomic level and to transmute matter and energy into reconfigurable parameters for spatiotemporal sonic and graphic design. Moreover, interactive lighting fixtures are used to permit transmutation and metamorphosis, and to expressively visualize the atom

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and micro quality/quantity into its interior space. The collective synthesis of the interior, then, intends to enhance our perception and to also allow us to experience a performative space as a playground of creativity and expression that ultimately "prolong[s] our sense of freedom and possibility." [3]

The main objectives of this paper are to discover methods for monitoring the quality of domestic environments with a set of technologies and protocols developed by the author as a physical prototype, called *DataGrid*. The information captured by the device measures various substances, transmits, and logs their representations on server databases. As an extension to this, a collaborative installation, "The Cloud," uses this information as a palette and, together with a custom-made lighting system, seeks to propose a means of creating novel designs within the interior space. It is hoped that these methods succeed in promoting sensory awareness and enabling new experiential possibilities for inhabitants. Further, they lead to the discovery of new ways of "meaningfully" representing data, visualized and embedded as spatial manifestations of the physical space, using a speculative design approach.

ALCHEMIC ARCHITECTURES

> *Alchemy is not merely similar to architecture; with our current and future technologies, the two are one and the same. The alchemic analogy is useful in pointing the way to possible spatial chemistries that just might free us from architectural deadlock. Our technologies are alchemic in their ability to reconfigure matter; the more science progresses, the more alchemically adept we become.* [4]

According to Neil Spiller, experimentation within the fields of art, science, architecture, and technology is able to generate powerful combinations for the development of dynamic interiors. However, these alchemies will not be complete or fully effective unless we look deep into the macro, the mega, the micro, and the nano. When these dynamic interiors are accomplished, our personal spaces will become modular, dynamic, poetic, and psychotropic. This transformation poses significant challenges to inhabitants by morphing awareness and perception or altering current perspectives. As Mark Goulthorpe notes, "technology as extensions of man (in Marshall McLuhan's terms) is never a simple external prosthesis, but actively infiltrates the human organism, certainly in a cognitive sense." [5]

There are many examples that demonstrate the need of architects, designers, and developers to experiment in creating buildings that offer different stimuli and that transform to provide personalization and support. Cedric Price, for example, designed the Fun Palace in 1961, an architectural space consisting of a steel structure that allows owners to insert programmatic units, or spaces of energy. These units allowed the space to shift its functions and properties according to variable conditions, and enabled the application of cybernetic characteristics to define visitors' actions and behaviors, characterizing "a house as a machine for living in." [6] Although the project was never realized, it established a good model for a kind of architecture that acts as a multifunctional and flexible object. Similarly, the *Plug-In City* (Archigram), *New Babylon* (Constant Nieuwenhuys), and the *Blur Building* (Diller Scofidio + Renfro) are all good examples of spaces whose structures embody imaginative ideas of transformation through technological means that allow inhabitants to experience architecture as a dynamic, fluid, or metastatic process.

Furthermore, scientific investigation has opened up a range of possibilities in the design and construction of spaces that are able to absorb, monitor, and sense a range of visible or invisible properties; different spectra of light and energy; or interactions and behaviors caused by organisms, systems, and processes. For example, the project *Open-Columns* [7] explores the possibilities of responsive architecture by using a series of composite urethane elastomers, actuators, and carbon dioxide sensors that monitor the air to readjust and reconfigure the structure in real time. Programmatic and computational units calculate responses, and the reactive space predicts and acts autonomously to provide better functions, readjusting itself accordingly. Similarly, Phillip Bessley's Hylozoic Soil proposes an environment that acts as a giant lung and digestive system, able to "breathe" around its occupants. The room thus becomes organic and almost lifelike, "a visceral experience exploring the nuanced relationship between the biological and the artificial." [8]

With the aforementioned multidisciplinary works, it becomes evident that diverse systems and technologies are able to speculate, explore, and suggest developmental possibilities in relation to architectural space and its invisible matter. The process of capturing information is directly linked to the supported instrumentation, which demands an exhausting investigation in formats, protocols, calibration, and compatibility issues. Following that and according to the requirements of this research, there is the question of spatialization and diffusion; that is, how data can be incorporated into hard space as media artefacts using sound, light, or image.

MEDIA NARRATIVES

Pop culture and science fiction are always important sources of inspiration that assist in better understanding the imaginative possibilities of technology, art, and science. In Andrei Tarkovsky's film *Stalker*, [9] heavy radioactive pollution creates a "magical" room able to satisfy the wishes of its visitors. The invisible matter fused in this Chernobyl-like area penetrates and defines alternative realities by using the space as a living agent that is able to express and communicate behaviors, reactions, or feelings. The "Stalker" in the film says, "The Zone is a very complicated system of traps, and they are all deadly. I don't know what's going on here in the absence of people, but the moment someone shows up, everything comes into motion." [9]

In Tarkovsky's film, the physical space (objects, rooms, buildings) autonomously creates different scenarios according to the way its visitors behave, interact, and live. The radiated environment is capable of sensing subtle differences in psycho-physiological or mental states and it manages to define spatiotemporal characteristics in a manner that reflects bizarre attitudes and motivations. The film, therefore, poses the possibility of a "room" that can become something more than a representation of a cave, such as an engine, a process, or an organism.

The transformation of architecture according to information captured from the surroundings is also portrayed successfully in the popular film The Matrix Reloaded. [10] In one scene, the Architect, which is the person/algorithm responsible for engineering the film's virtual world, is sitting in a room filled with monitors that collect and project any event that has taken place in digital time, as well as every fragment of historical information that has ever existed in the simulation. This room acts as a mediator of information, aesthetics, or even digital metaphysics; it seems that the Architect's brain is directly linked to the room's monitors, allowing for immediate responses that constantly change and shift meaning and awareness.

In the dystopian comic book series *Singularity 7*, [11] nanotechnology is presented as a dominant power

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(the "Nanites") able to directly access and shape matter and energy, interconnect everything into singularity, and multiply their own machines to gain absolute control. This terrifying scenario has also been analyzed by Eric Drexler: "Tough omnivorous "bacteria" could out-compete real bacteria: They could spread like blowing pollen, replicate swiftly, and reduce the biosphere to dust in a matter of days." [12] This relates to concerns regarding "global ecophagy" following studies on gray plankton, [13] gray dust/aerovores, [14] and gray lichens [15] that warn of the catastrophic results self-generated nanoparticles may bring about. As such, it becomes important to comprehend the existing environment on the micro and nano levels, with all its complexity, potential, and danger. In any case, it is vital that emergent systems capable of sensing and monitoring these scales and properties provide an added layer of understanding and awareness to these infinitely large microcosms.

Figure 1. System developed by the author. Concept of 6 scattered sensor devices (left), mobile phone interface screen (top middle, top right), and data visualization methods (bottom middle, and bottom right). © Stavros Didakis, 2014. Used with permission.

SEEING THE INVISIBLE

It is vital that we come to understand these nanoworlds in detail, especially where they enter our personal spaces, in which we feel more relaxed and are, therefore, more vulnerable. According to the World Health Organization, [16] air pollution is one of the greatest dangers to humans. Approximately 4.3 million people die prematurely every year due to indoor/household air pollution. This is a serious matter for both exterior and interior spaces, and inhabitants' wellbeing is directly linked to the quality and quantity of many substances that surround people at all times. As these substances are able to penetrate live tissue and be absorbed by human organs, the body is affected on multiple levels – human cells transform in time in close relation to these swarms of molecules.

For this reason, the *DataGrid* sensor system developed by the author attempts to identify and record part of this large set of properties that may dramatically affect mood, health, and performance. Some of these properties include ozone, natural gases, hydrogen, nitrogen, carbon monoxide, carbon dioxide, dust particles, and radiation. Media elements such as light or image projections within a space can be linked and communicate with codeveloped technologies. Using the middleware application for mobile devices that accompanies this system, it is possible to diffuse the real-time values of each these substances in space, raising awareness of those elements that exist in the microscale and, at the same time, provide abstract, personalized digital interiors.

Thus, six sensors (figure 1) were developed for this study to "sniff" particles, digitize their quantity representations, and share them across different platforms and protocols (local- versus wide-access networks, Bluetooth, OSC, or MQTT). Each device is programmed to transmit information either individually or collectively according to the preset levels of captured values that are calculated by the system in real time. In order to stimulate an effective understanding of the interior space, every device is implemented in a different location around the house. In combination, this grid of sensors is able to give an accurate representation of the molecular level and to provide substantial information due to a continuous process of spatial scanning. The captured data are uploaded onto the cloud, where they are stored for immediate or future reference and use. The cloud becomes necessary for the manipulation of the captured instances, providing access for any imaginable type of processing.

In order to extract and manipulate the data, software tools were developed to make the selection and configuration of these possibilities as easy and intuitive as possible. The captured instances can be viewed using any screen-based medium in real time, such as dashboards and a range of data-visualization techniques. Further, the data extracted from the cloud can be used to control media elements that may exist in the interior space, such as lights, sound systems, kinetics, image projections, and so on. This allows inhabitants to diffuse and spatialize information using a middleware (such as a mobile phone application) to gain access to the configuration of the real-time performative interiors.

DIFFUSING IN SPACE

Light is a very important property of any interior space, as it strongly defines the function, purpose, and poetics of the space. Light is able to change the usual "hardness" of architecture due to its properties that soften and morph, as supported by Sommer. [17] As Rüdiger Ganslandt and Harald Hofmann state, "you only have to enter a Baroque church with its bright and inspiring atmosphere to see and feel what effects light can have in architecture, or, to the other extreme, look at Piranesi's paintings of dungeons with their dark labyrinths, where the shadows conceal a never-ending source of horror." [18] According to John Coles and Naomi House, [19] it is important to properly understand and identify the needs of a particular space in combination with the activities and mood it is intended for, and to use "a lighting system that at one extreme may mimic the warmth and intimacy of candlelight and at the other provide the lighting levels and even distribution of a sports hall, with every conceivable variant in between." [19] Diffusing light in space becomes a never-ending exploration, allowing combinations that directly affect and define mood and cognition [20] [21] and that influence performance through the intervening variable of positive effect. [21] Different light configurations can also affect serotonin levels in the body, changing mood and social behavior, [22] and

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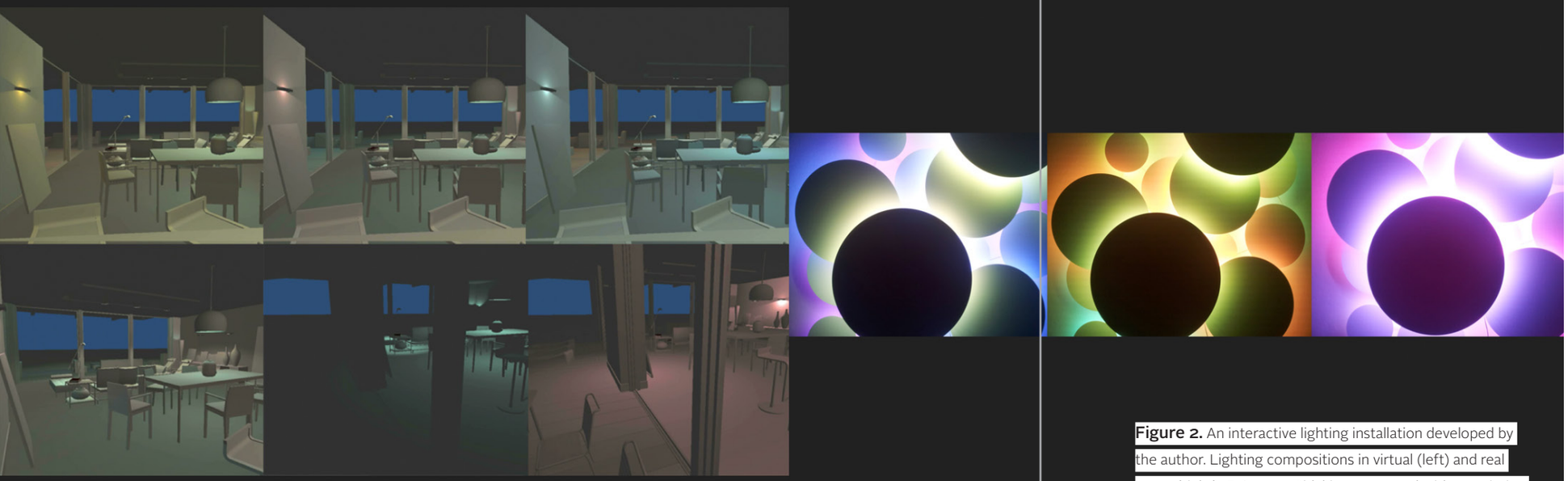

Figure 2. An interactive lighting installation developed by the author. Lighting compositions in virtual (left) and real space (right). © Stavros Didakis, 2014. Used with permission.

can also assist interpersonal communication by more general communication or encouraging intimacy. [23]

Further, diffusing light in space and creating areas of spatialized formations can have a profound effect on its inhabitatants. As in the artworks of James Turrell, light can become something more than a source of illumination. It can become a surface with volume, information, and meaning, and can be vital to perception as well as to psychological and biological needs. Changing a person's perception of space and time using light patterns can create mesmerizing and profound experiential effects, defining architecture that is able to "integrate itself with human and cultural memory" and to become "reflexive and performative – in real time or retrospectively." [24] In this research project, the *DataGrid* sensor system has been linked so that it can communicate with the lighting of an interior environment and transform the a normal lighting design into an expressional skin that empowers architectural movement such that light and color create supportive and affective interior spaces.

The Cloud

The Cloud (a collaborative project between the author and the architectural office mabarchitects – www.mabarchitects.com) is a minimalist chandelier embedded with interactive technologies, with its main function to illuminate the interior of its permanent location (an office space in Athens, Greece). *The Cloud* consists of a dozen circular panels of different sizes, levels, and positions, placed in a cloudlike formation on the main ceiling. A series of LED strips have been embedded into the panels, and are controlled remotely using different data and protocols, allowing for an exploration of styles, patterns, and visualizations. The main aim of the installation is to speculate on possible design alternatives, wherein technology, aesthetics, and architecture provide responsive, affective, and conscious spaces.

In this project, an unconventional chandelier becomes an extension of the data-cloud, allowing inhabitants to express their aesthetic preferences by engaging with a canvas that is able to oscillate from simple and dull lighting to psychedelic nebula-like formations. Using the middleware application that is part of the technology developed for this project, it is possible to connect the data emerging from the *DataGrid* and to control the lighting properties. From the middleware, the user/inhabitant can select specific data readings and link them directly to the lighting objects. This function permits interactive, realtime methods of configuring how information is going to be visualized, as well as how the interconnection between each lighting display will define the resulting overall aesthetic. Further, the oscillation between minimum and maximum readings can be adjusted to enable viewers to understand the data range or to discover whether a specific threshold has been exceeded. As there seems to be a demand "for objects with potent sensory and emotional resonance," as well as a widespread desire for systems that embody "traits of consciousness, eccentricity and an increased responsiveness to emotional input," [25] this installation – using the *DataGrid*, the accompanied middleware application, and the *Cloud* lighting system – intends to allow users to spatialize and create their own environments using a color palette that they feel connected with, and to experience their environments as engaging landscapes of endlessly shifting light.

CONCLUSION

This paper, in combination with the system and installation described, seeks to identify, discuss, and develop speculative designs for systems and technologies applied to architectural and interior spaces in order to provide fluid environments of awareness. Wireless sensor interfaces implemented on the surfaces of buildings serve as a method for monitoring, observing, and diffusing properties, which postulates the creation of novel "intelligent" interiors. We require technology capable of assisting inhabitants in perceiving all extant matter – even in nanoscale – in order to understand the environment in which they exist and to promote a sense of security, comfort, and wellbeing. Using digital tools and systems (such as the prototypes discussed in this paper), representations of the captured information within the cloud can be transformed into tools for visualization or sonification, much like middleware applications assist in the transmutation between dissimilar media and can thus create immersive ambiences. This synesthetic proliferation within our built spaces, using a large amount of tracked substances, should allow us to develop nano-perception, that is, a perception of all things of the nano-scale. Having the option to sense these properties as spatialized information diffused into the interior space may lead to alternative experiences of multidimensional existence, both in time and scale.

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