The choreography of sensations: Three case studies of responsive environment interfaces

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Abstract. Architecture (i.e. the built environment) has traditionally been thought of as solid, static and permanent. Here we consider, instead, a soft, dynamic and fluid architecture created with smells, sounds and electromagnetic fields. The concept of a "spatial operating system" is introduced, with implications for virtual environment design. Suggestions are made for "soft" interfaces based on rich, suggestive outputs that counter usual efforts to increase efficiency and verisimilitude. Three projects by the author are described to illustrate how such environmental interfaces might be developed.

1. Introduction

It has been said, and many times reaffirmed, that architecture is "frozen music".[1] What a melancholic and tragic way to describe a concept so inherently vivacious! It brings to mind existence in a world of silence, beyond which float melodies that we will never hear because we are imprisoned by stasis in time... This approach to architecture traps us by forcing us to think of designing only solid, static structures.

Instead, let us consider an architecture that can *only* exist in time, an architecture that is a choreography of sensations, an architecture that both *changes* over time and *responds* to changes in time. Such a conception can never be frozen: it is responsive, dynamic and emotive. It welcomes the interactions (and interruptions) of people who occupy such spaces. Rather than employing traditional architectural materials like stone, steel and glass (which imply permanent, inert structures) this approach to architecture employs more ephemeral materials like smell, sound and electromagnetic waves.

Just as computer hardware needs software to make it useful, so too does architecture require an ephemeral materiality to animate it. It is at this point that architecture and virtual systems converge and in the process, the distinction between "real" and "virtual" becomes less clear.

2. Architecture: hardware and softare

Architecture, the original broadband interface, has traditionally been understood as the combination of physical, static elements that make up our environments and enclose us, like walls, roofs and floors. One might call these the hardware of space. An alternative approach is to think of architecture as software: the ephemeral sounds, smells, temperatures, radio waves, even social relations that surround us and program the way we interact with space. Pushing this analogy even further, we can think of architecture as a whole as an operating system, within which people write their own programmes for spatial interaction.

Virtual environments that are influenced by an architecture-as-software approach consider spatial frameworks, not as rigid, absolute structures, like the Star Trek Holodek which seeks to

recreate or represent whole physical spaces, but instead as a collection of fluid relationships. These relationships (between people and objects, objects and spaces, people and spaces) grow out of conversations in an environment. People give meaning to their environments by using them. This requires an approach that focuses not just on sensing and computation, but also on providing rich, suggestive outputs.

Just as the designers of operating systems such as Windows, Mac OS X or Unix, provide varying levels of openness within which people expand their own creativity (using programs like word processors, drawing software or movie editing suites), so too can spatial designers provide meta-systems that encourage multitudes of architectural programs. The challenge is to develop architectural systems that nourish imagination without adding further layers of prescriptive control. One model of operating system that is particularly relevant to architecture (since the design of space is always a collaborative process) is an open source system.

3. Spatial poetries

Most advanced spatial interaction research is these days produced by non-architects. Technologists at both academic and commercial research labs are developing responsive systems that allow people to interface with their spaces, working, for example, on projection walls, remote devices and 'intelligent' sensors. These developments throw into question the very role of designers, because such user- and environmentally-responsive mechanisms allow people themselves to take prime position in configuring (that is, designing) their own spaces.

As in architectural design, designing virtual systems involves developing spatial configurations that provoke interactions between people, and between people and their spaces. In enhanced environment design, where traditional architecture and virtual systems unite, users can be the designers of their own spaces — and, since spatial experience is a collaborative project, one might call these "open source" spaces.

However, in an age where we are approaching the design of what industrial design theorist Anthony Dunne has called "post-optimal objects" (i.e. objects one designs once practicality and functionality can be taken for granted) "the most difficult challenges... now lie not in technical and semiotic functionality, where optimal levels of performance are already attainable, but in the realms of metaphysics, poetry and aesthetics where little research has been carried out." [2]

Architects contribute to the discourse because their expertise lies in designing spatial and environmental "situations". However, while virtual system design has often tended to emphasise efficiency, convenience, punctuality and predictability, architecture, on the other hand, can give clues about ways to develop spatial poetries.

Contemporary computing interfaces often rely too heavily on unnatural logic systems that presume that we all see, all things, the same way. Virtual environment design, through the focus of an architecture-as-software approach, encourages us instead to find our own logics and leads us away from designing for verisimilitude and towards designing for abstraction.

If we assume that technology systems in environment design could deal with the practical and functional requirements of constructed spaces then the beauty in design comes from the poetries of those who use/implement/remake it.

4. Softspace interfaces

For this to be possible, softspace interfaces need to be developed or reinvigorated to encourage diverse interactions. These interfaces do not rely on accuracy or communicability of information. Rather, they presuppose instability and precariousness, emphasising metaphor and suggestion. A good example is the use of smell as a spatial output: "unlike the other senses, smell

needs no interpreter. The effect is immediate and undiluted by language, thought or translation". [3]

Explorations have taken two distinct approaches. The first has been to look at what might be called softspace technologies: systems that incorporate the ephemeral qualities of architecture including smell, sound, light, heat and electromagnetic fields. This approach has concentrated on the interactions that make up our experience of space and has proposed systems to affect these interactions. It has also explored the psychology of spatial perception, helping to expand the boundaries of those perceptions.

The second approach has been to investigate how people operate within such environments. Movements in art that challenge accepted dichotomies between audiences and performers have parallels in spatial investigations that challenge the distinctions beween architects and occupants. These investigations propose new models for environmental design based on systems that welcome the active participation of people operating within those systems, informed by the ways that culture provides frameworks for social interaction.

Together, these two approaches confront our relationship to designed space and enhanced environments because they encourage us to think not of static silent structures that surround us but rather of fluid, transient, dynamic systems within which we can be both consumers and contributors.

5. Some examples of an architecture-as-software approach

Below are outlined three architectural design research projects by the author that have a direct relationship to the design of enhanced environments. The first project, Scents of Space, is an interactive smell environment. The second, Sky Ear, is brought to life through interactions with electromagnetic fields. Finally, Haunt describes a work-in-progress to explore the psychology of perception through phenomena such as infrasound and electromagnetic fields that give rise to haunted sensations.

A. Scents of Space

Scents of Space (a collaboration with Josephine Pletts and Dr. Luca Turin) is an interactive smell system that allows for three-dimensional placement of fragrances without dispersion, enabling the creation of dynamic olfactory zones and boundaries.

The study of the human olfactory system has progressed rapidly in recent years. However, when architects and interactive designers use fragrance in spatial designs, they tend to do so merely for branding purposes or for suggestive advertising (e.g. pumping the smell of coffee out onto a street to attract people into a store). Such designs fail to pick up on the potentials for developing evocative and memorable experiences using the sense of smell. This project demonstrates how smell can be used spatially to create fragrance collages that form soft zones and boundaries that are configurable on-the-fly.

Scents of Space posits that if an architectural space could be precisely "tuned" with scent collages, it would be possible to create completely new ways of experiencing, controlling and interacting with space.

Visitors enter the enclosure and experience digitally controlled zones of fragrance that define areas of space without physical boundaries, encouraging them to encounter an invisible yet tangible smell environment.

The installation is a carefully orchestrated sensory environment. Smells are emitted singly or in "chords" in combination with a visual cue in the form of glowing cubes. Each of the dozen smells can be precisely and dynamically located in three-dimensional space, allowing visitors to

encounter new scent boundaries as they move along the horizontal and vertical axes of the interaction zone.

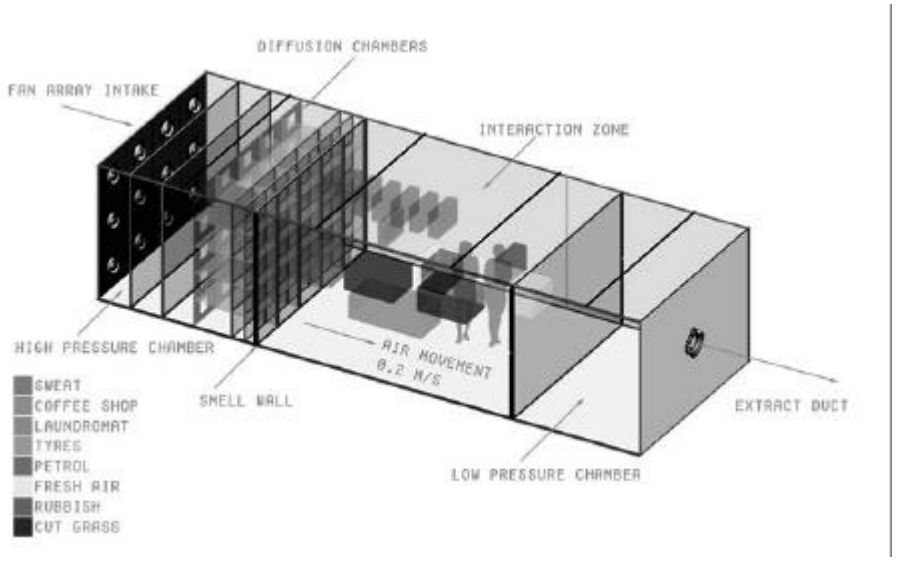

Figure 1. Diagram of interior airflow

Smells are emitted in response to people's movements and these smells travel slowly through the space in straight lines until the visitors choose to mingle the fragrances with the movement of their bodies.

The fragrances used in the project are both pleasant and unpleasant; recognisable and unfamiliar; natural and artificial. The odourants are created by dissolving single molecules (for single "notes") and multiple molecules (for "multiple tone accords") in alcohol or other appropriate solvents. These odourants are then released into air streams, where the alcohol evaporates to leave clearly discernible fragrances.

Several fragrance ensembles are employed, using fragrances that evoke a journey through a city, including: a subway, a garden, a coffee shop, a rubbish heap, a car tire, a laundromat; other implementations include the smells of a flower garden; or, following ordourant design, collages of fragrances never smelt before.

The installation is a simple translucent enclosure, 9 metres in length, that glows inwardly during the day and outwardly at night. Airflow within the space is generated by an array of fans. Moving air is then controlled by a series of diffusion screens to provide smooth and continuous laminar airflow. Computer-controlled fragrance dispensers and careful air control enable parts of the space to be selectively scented without dispersing through the entire space.

The air in the interaction space moves at a speed of 0.2 m/s - this is slow enough that visitors don't feel the movement of the air but are merely aware of the smells appearing and disappearing as they move past. As each smell is emitted from the smell wall, the zone from which it comes lights up to indicate that the smell has been activated in that area.

Figure 2. View into interaction zone

Figure 3. Scent output wall

There are two levels of interaction in the Scents of Space installation. The primary interaction occurs between the space and the visitors: scents are output in response to the position and movements of people. The system builds up a database of responses to smell, from which it develops strategies for being either "alluring" or "repelling". In this way, the installation is constantly evolving in its responses to the movement patterns of visitors.

A secondary level of interaction occurs between the visitors and the smells themselves. Visitors movements mingle conjoining smells to create turbulent "third" smells. In this way, the space is actually passively reacting to the visitors' movements. At the same time, visitors build up a pattern of associations and memories, because smell is so closely linked to the ability to recollect experiences of space.

B. Sky Ear

Electromagnetic fields exist all around us. We become aware of these phenomena as more of our devices employ electromagnetic waves daily. This abundant, invisible territory is altered in shape and intensity by both natural and human-constructed landscapes. We find ourselves walking around a room trying to find good signal on mobile phones; we set up wi-fi networks that are intricately affected by the positioning of furniture, doors and walls; we feel secure knowing that cries of a child will be heard over a baby monitor, freeing us to move to other parts

of a house; we install shielding materials because we are concerned that electronic data transmissions will leak out of our buildings.

One can imagine the undulating qualities of this invisible topography that surrounds us and affects the way we related to space in much the same way that traditional architectural elements do -- it guides us to certain parts of a building, it conditions movements we make and how we make them and, through devices like mobile phones, it has direct impact on the way we associate with other people. Apart from issues arising out of being in contact virtually anywhere, anytime, the mobile technologies through which we conduct our daily lives have made us far more aware of the electromagnetic environment that envelops us.

We are concerned about the health effects of electromagnetic radiation (from power lines or mobile phone handsets) and this has further spatial implications. Yet these waves often exist as natural phenomena in the form of radio waves emanating from distant stars, gamma rays coming from elements here on earth or even electrical waves from inside our own skulls. Humans have only recently begun contributing to the cacophony with their pagers, medical devices, televisions broadcasts and mobile phones. These devices feedback on the way we use such spaces and suggest a richly textured ethereal cartography of space that affects us but which we only know about through use of our instruments.

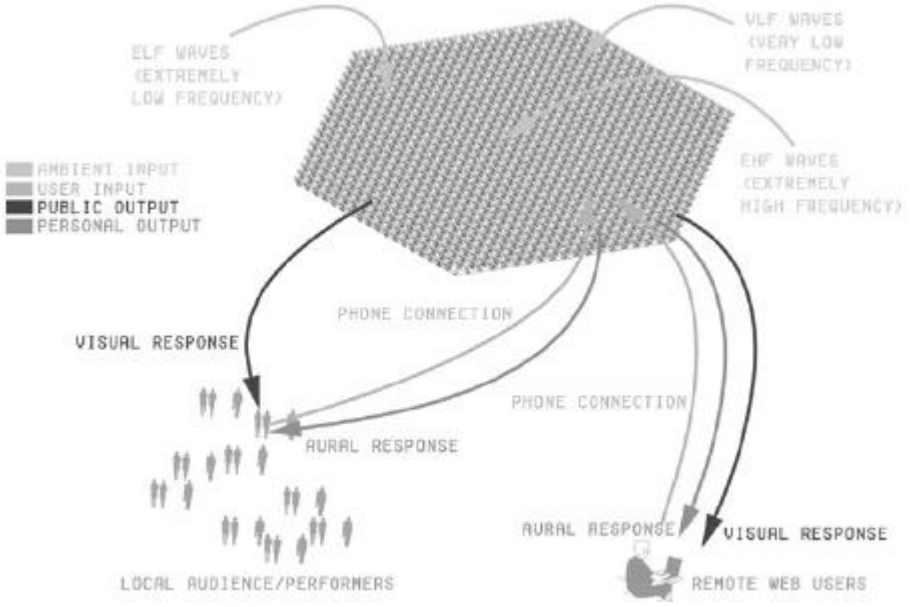

Figure 4. Sky Ear interaction diagram

Sky Ear gives form to this space, making visible the invisible richness that exists just beyond the threshold of our natural perceptions. The original concept was to create a "radar sweep" that would move through space and light up as it encountered varying intensities of EMF. The final structure consists of a 25m diameter carbon fibre framework supported by 1000 extra-large helium balloons.

The Sky Ear structure is released from its ground moorings and slowly floats up into the sky like a glowing jellyfish sampling the electromagnetic spectrum as it rises and changing colours as it encounters varying electromagnetic fields. The balloons function both as buoyancy/flotation devices and as diffusers for the 6 ultra-bright LED lights (which mix to make millions of colours) controlled by individual sensors inside each balloon. The balloons can communicate with each other via infra-red; this allows them to co-ordinated to create larger patterns across the entire Sky Ear cloud.

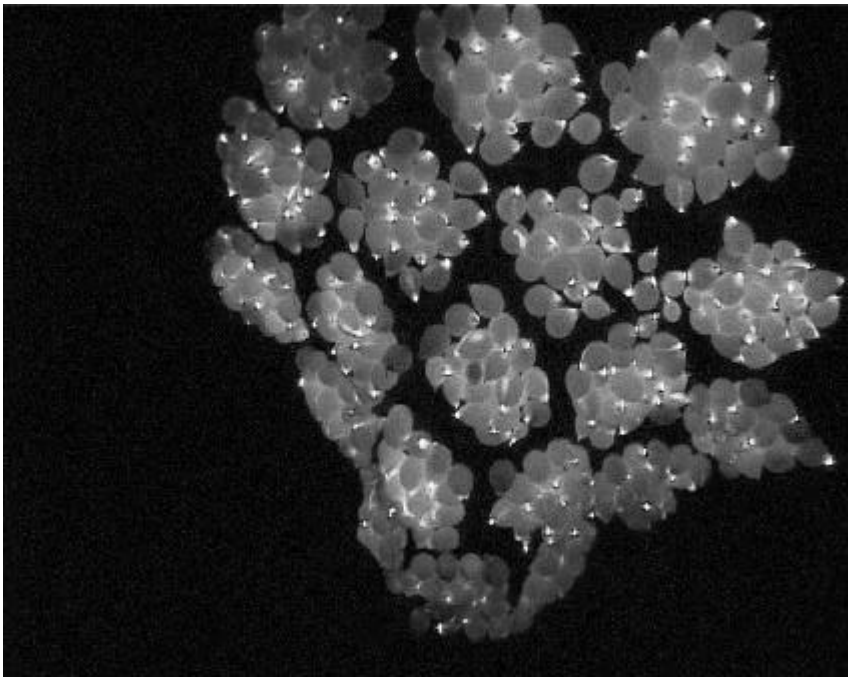

Figure 5. Sky Ear in flight

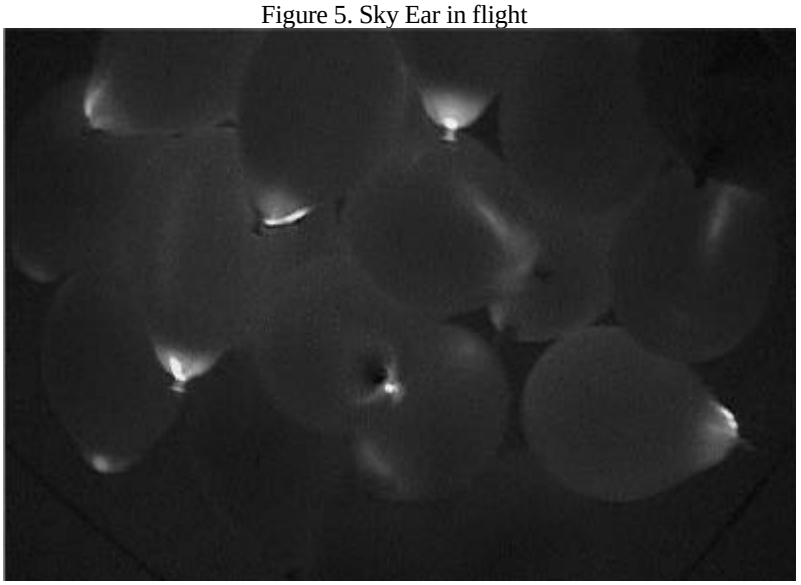

Figure 6. Balloon interactions

Embedded in the cloud are several dozen mobile phones. As people call into the different regions of the cloud, they listen to the distant electromagnetic sounds of the sky (called whistlers and spherics, which are the audible equivalent of the Aurora Borealis/Northern Lights). Their mobile phone calls change the local electromagnetic topography and cause disturbances in the EMF inside the cloud that alters the glow intensity and colour of that part of the balloon cloud. Feedback within the sensor network creates ripples of light reminiscent of flashes of lightning.

The cloud shows both how a natural invisible electromagnetism pervades our environment and also how our mobile phone calls and text messages delicately affect the new and existing electromagnetic fields. Sky Ear encourages people to become creative participants in an electromagnetic performance; as an architecture project, the experiment makes visible our daily interactions with the invisible topographies of electromagnetic space.

C. Haunt

In experiencing a space, we have a feeling that something is "out there". Are our senses playing tricks on us? Or is the space we exist in constructed by our senses? Such epistemological questions are fundamental to the design and construction of spaces, both real and virtual.

Using humidity, temperatures and particular electromagnetic and sonic frequencies that parapsychologists have associated with haunted spaces, this project, currently under development, builds an environment that feels "haunted".

Architecture is a discipline that is inherently informed by psychology; similarly the psychology of individuals is affected by the architecture that people inhabit. To talk about haunted spaces is to talk about two things that are phenomenological: the subjective sensation of haunting and the perception of space, which again depends on the particular occupant of that space. Objective analysis of these perceptions always seems to give conflicting results. Rather than attempting to measure objective phenomena, this project considers how supposedly "objective" phenomena can affect our reasoned though subjective responses to external stimuli.

These spatial qualities will be reconfigured dynamically, adapting constantly to real-time biofeedback measurements in people in order to heighten the experience and to build up a large database of response patterns.

Spatial phenomena that often correlate with "haunted" sensations include:

- *Infrasound*: humans hear sounds of approximately 20 Hz - 20,000 Hz. Frequencies of 18 or 19Hz are just outside our ability to hear – as infrasound, our bodies may perceive them subliminally, causing feelings of unease and upsetting senses of balance. A multichannel sound system creates intricate subsonic topographies while digital acoustic cancellation systems and anechoic materials minimise other noises.
- *Humidity*: air quality is fairly consistent in most spaces. However, in apparently haunted spaces, one often encounters wide fluctuations in humidity from bone dry to uncomfortably muggy.
- *Temperature*: in most spaces temperature should be fairly consistent, given good air dispersion, though large changes occur as one rises vertically. Wide fluctuations in temperature can make hair stand on end and have been associated with apparently haunted spaces.
- *Air movement*: as a substance that is fundamental to our existence and surrounds us yet cannot be seen, air is often regarded with awe. When air moves across our skin without any apparent cause it can be very "spooky". Air movement (by itself and in combination with temperature and humidity) is key to a "haunted" sensation.
- *Electromagnetism*: studies have been undertaken to gauge effects of electromagnetic fields (EMF) on people's perceptions. Some argue that electric fields from appliances, antennae or power stations create sensations of haunting. Others note cases where none exist nearby. The gaussmeter is therefore one of the main instruments of parapsychologists. A variable electromagnetic frequency generator or Helmholtz coil will create weak electromagnetic spaces that are beyond the threshold of direct senses.

In order to evaluate responses to the system's outputs, it has been necessary to develop a biofeedback system that works in real-time to track fluctuations in people's reactions. A galvanic

skin response (GSR) meter has been adapted to allow for wireless untethered monitoring of people's emotional responses as they move around the programmed spaces.

The values obtained from the GSR are used in real-time to alter the outputs of infrasound, air and electromagnetic fields on-the-fly to create a dynamic interactive system. For example, if a certain frequency of infrasound is provoking a particularly strong response, the system might either reduce that frequency, or continue it for a certain amount of time, or vary it in combination with one of the other outputs. Alternatively, if a person is not responding to a particular output combination, the system can reconfigure outputs until a response is achieved (for example, by changing the frequency of infrasound).

By modelling spatial output patterns on simulated intelligence algorithms the prototypes dynamically reconfigure themselves based on how people respond to them. The system will get "better" at what it is doing over time as more people experience the system and provide real-time biofeedback evaluations of how good the various components (infrared, air quality, electromagnetic) are at creating "haunted" sensations.

In this way, a large database of subjective responses to each type of output can be built up relatively comprehensively; a simple learning algorithm (along genetic algorithm principles) is employed to determine the most "haunted" output combination. As a constantly adapting system responding in real-time to the physiological state of visitors (with algorithms based on artificial intelligence strategies), Haunt tends to reinforce the idea of an unknown "controlling" force and touches on issues of feedback and control in enhanced environments.

6. Conclusion

The projects listed here are first steps, more experiments with colour in a palette than finished paintings. They explore ways that enhanced environments might interface between real and virtual spaces, though this distinction is becoming less important as the interfaces become more robust. The precise nature of such environments is ambiguous because people themselves interpret, appropriate, design and reuse such spaces within their own frames of logic. These spaces don't merely enable people to develop their own ways of responding, they are actually enriched by them doing so. As people become architects of their own spaces (through use of such spaces) the word "architecture" ceases to be a noun: instead it becomes a verb. Such an architecture is explicitly dynamic, a shift that opens up a wealth of poetic possibilities for designers of space.

References

[1] Attributed variously to Friedrich von Schelling and Johann Wolfgang von Goethe.

[2] Anthony Dunne, *Hertzian Tales*, Royal College of Art, London, 1999

[3] Diane Ackerman, A Natural History of the Senses, Vintage Books, 1991