



Computing Atmospheres

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Abstract. Atmospheres have a considerable effect on the body and mind and the ways in which we inhabit spaces and correspond to our surroundings. Architecture contributes to the dialog between the senses and the (electronic and physical) environment. As a form of atmospheric interface, architecture augments or intimates sensible ambient human-computer interactions. This paper explores how a number of architects—Frank Lloyd Wright, Luis Barragán, Iannis Xenakis, Bernard Tschumi, Peter Zumthor—have staged, composed and modeled atmospheres to produce architectural backdrops as receptacle for sensory and emotional engagement with the ambient. These examples form a baseline for considering ways in which computational design practices can create atmospheric architecture—sensory spaces of effect and affect.

Keywords: Atmosphere · Emotion · Architecture · Atmospheric data · Sensory data · Computation · Ambient

1 Spatial Tricksters

Architects are spatial tricksters. They have developed tactics to “trick the senses”—to design and fabricate “virtual” or “mental” spaces, to use the words of Baudrillard and Nouvel [3: p. 8]. Admittedly, even if her feelings are very real, a person who experiences a built environment may not necessarily know why she relates to the space in the way she does.

Firstly, the experiencer with a particular background and life trajectory enters into a conversation with that which it is to be experienced, a spatial intention born of the mind of a designer with also a particular background and life trajectory. For example, the spaces of Mexican architect Luis Barragán exude a personal interest in local building styles and, at the same time, modern architecture, which he encountered during numerous travels abroad.

Secondly, the interplay of spatial parameters can be very complex, involving the synergistic (and, at times, unexpected) behavior of data (sensory and other) as diverse and rich as the varying degrees, levels or hues, of radiance, absorbance, color, sound transmission, or spatial amplitude. For Peter Zumthor for example, material quality (reflectivity, sound and warmth) is fundamental to the making of atmospheres, which is, as Böhme explains, the dialog between what is perceived and its audience [8].

Thirdly, spatial experience involves movement, spatial flexibility, the fluid manners in which we perceive the world, the circulation of bodies within spaces, the flow of

natural elements throughout spaces, and/or the electro-mechanical movement of smart architectural elements (the dynamism of a changing digital facade).

While architects have little control over a perceiver's entire background and life trajectory,¹ and are limited with respect to the tools available to represent atmospheres, experienced as unbounded phenomena, they can nevertheless stage, compose and model architectural backdrops as the receptacle for our sensory and emotional engagement with our environment—thereby opening up possibilities for affecting, through perceptual manipulations, the perceiver's worldview.

1.1 Fluid and Sensory Spaces

Space is experienced by means of mobility—physical, mental and digital, more so when it is designed to dialog with, time, channel, control the flow of people who traverse and (temporarily) inhabit it. Fluid spaces, modern or more contemporary, from Frank Lloyd Wright's organic architecture²—the Falling Water (1936) especially—to Peter Zumthor's Therme Vals (1996), Lars Spuybroek/Nox Architects' "HtwoOexpo" interactive water pavilion (1997), and Philippe Rahm's Interior Gulf Stream (2008) engage both our moving bodies and our senses.³

Wright's Falling Water and Nox Architects' HtwoOexpo are at the opposite end of what a fluid space can be. One building engages the exterior environment, while the other does not; one relies on the intrinsic quality of building materials while the other overlays electronic to physical surfaces; one was meant to be inhabited on a seasonal basis, the other is experienced for a shorter period of time.

The underlying reason for the incongruous juxtaposition of these different examples is to introduce the making of spaces that do not relegate atmosphere to an after-effect, or as the consequence of an architect's work addressing (more importantly) programmatic and formal concerns. These architects incorporate atmospheric and sensory parameters as foundational to conceptualization.

On one hand, Wright reconciles interior and exterior through the organic scenography of architectural and natural elements—for example the dramatic approach to the building, the stairway to the waterfall that invites its sound into the building. In addition to the sense of danger, which typically prompt humans to naturally seek refuge and that charges the building with primal emotions,⁴ Hildebrand stresses the sensory benefits of locating the house atop the waterfall: "Another advantage of this site has to do with the degree to which the sound infuses the house. It is a commonplace that the waterfall is heard throughout; it is less commonly observed that its sound is muted by the masses

¹ For some of us, the physiological phenomenon of synesthesia, which consists of experiencing a sense by the way of another, further contributes to the mystification of atmospheres.

² For Wright, "In Organic Architecture then, it is quite impossible to consider the building as one thing, its furnishing another, and its setting and environment still another. The Spirit in which these buildings are conceived sees all these together at work as one thing." [15: p. 102].

³ Fluid spaces may not necessarily involve water as an architectural element. However, the above-mentioned projects explore different states of the fluid—liquid, solid and gaseous.

⁴ Hildebrand bases his analysis of Wright's architecture on the prospect-refuge theory of Jay Appleton.

of concrete that intervene between the waterfall and the living spaces” [12: p. 104]. In Wright’s *Falling Water*, sound augments the way in which we relate to space.

Similar to Wright’s organic architecture and extending this design of fluid spaces further, Zumthor investigates, for the *Therme Vals*, the different manners in which the body meets the water—indoor, outdoor, cold, warm or hot, steamed, sprinkled (showers), and by drinking (water fountains). The architect wanted to experience bathing rituals in “Turkish baths in Budapest, Istanbul and Bursa” [10: p. 91] to be able to translate the felt sensations into his building, and via the making of large-scale models.

Nox Architects, on the other hand, immerses us in an interior of undulating surfaces that also accompany the movement of bodies in space, augmented with digital projections triggered by sensors and the sensory effects of different states of water. Nox’s pavilion operates much like the nineteenth-century panorama, in which the movement to the viewing platform, the 360° painting (necessitating technical skills for blending multiple perspective views together) and, on occasion, sensory props (using seaweed for its smell evokes the seaside [7]) were orchestrated to ensure disconnection with the outside and produce maximum enchantment. Within Nox’s interactive interior space, the use of water in the form of mist and ice participated to induce the senses and destabilize bodily perception [5: pp. 111–116]. Ensnared within, people connected to the temporary space via their individual and collective perception of visual and haptic sensations.

Finally, in the *Interior Gulf Stream*, Rahm organizes spaces associated with certain temperatures (bathroom at 22 °C and bedrooms at 16–18 °C) according to the pathway of air convection [21]. The result is an unusual distribution of spaces in the interior. It illustrates the idea that, to conceptualize space, the feelings that designers seek to precipitate can be taken into account before generating forms.

1.2 “Sensuous Correspondence” and Wayfounding

The examples above illustrate the fluid manner in which bodies and buildings can dialog and how fluid spaces can afford a “sensuous correspondence”—even if temporary. A “sensuous correspondence”, according to Neil Leach, occurs when a space allows people who experience it to “camouflage” [16] within the environment offered and as Böhme and Alberto Pérez-Gómez explain, to “attune” to spaces [8: p. 30 & 20].⁵

As Leach argues, aesthetics is key for this moment of connection to happen [16]. Furthermore, an architecture that offers sensuous correspondence is “an architecture that both invigorates and innervates” [16: p. 47]: “Such an architecture might therefore act as a lens or mechanism through which those who experience it might inscribe themselves in the world, and learn to live more productively” [16: p. 47]. Achieving this requires the architect to exhibit “sensitivity”, “openness”, responsiveness and a “sense of

⁵ Alberto Pérez-Gómez refers to Heidegger’s use of the word: “Emotions are ways of being in the world—*attunements*, as Heidegger called them—bodily transformations that operate at a reflective level. Like sleep, emotions “come over you.” One can invite them, and architecture can be instrumental in doing so, but they come from the outside, like the Greek divinities in epic literature and drama.” [20: p. 28].

empathy”. In the same sense, “wayfounding” [1], which is the capability to anchor to spaces, however fluid, further support the idea that atmospheres, as phenomena that enable us to bypass the classic dichotomy between real and virtual spaces, are essential to feel grounded and at home [1] in “the spaces of flow” [6].

Architects have refined a personal repertoire of spatial “tricks”—they have staged, composed and modeled atmospheres—to enable this sensuous correspondence to happen. This paper further investigates these tactics further, given that architecture contributes to producing a dialog between the senses and the (electronic and physical) environment. As a form of atmospheric interface, architecture can create sensory spaces of effect and affect, which, in turn, can augment or intimate sensible ambient human-computer interactions that go beyond only triggering the visual sense.

2 Staging

2.1 Architecture as a “Theater of Effects”

In his seminal 1998 essay on *The Architecture of Atmospheres*, Mark Wigley speaks of atmospheres as “some kind of sensuous emission of sound, light, smell, heat and moisture; a swirling climate of intangible effects generated by a stationary object.” [24: p. 18]. He compares architecture to a stage set, as the “thinnest layer of paint, texture or wallpaper” of a building [24: p. 19] contributes to projecting atmospheres. For example, Mies van der Rohe’s buildings are atmospheric in a particular manner as the real and the virtual coexist [2], in part because of the materials he uses (reflective glass, polished stone surfaces). His buildings, as Stan Allen writes, “produce complex optical and experiential effects that can never be simulated or predicted by drawings: the play of light, shadow and atmosphere, as well as the parallax effects produced by the movement of the spectator and the intricacies of peripheral vision” [2: p. 99]. For instance, Mies’ New National Gallery in Berlin (1968) uses the city as a background that unfolds as we walk in—and around it—by the means of reflections that glass as a material enables. The “theater of effect” operates, as Allen notes, like a nineteenth-century panorama [2], the difference being that a panorama is an immersive experience completely disconnected from the outside.

Mies’ collages further express the intangible effects of his building in staging different frames—in the foreground a rectangular painting, in the background rectangles of landscape—and, in the case of his 1942 *Museum for a Small City* collage, sometimes omitting architectural elements—mullions being represented by a blank space between the two projected planes of landscape views [2].

“The art of the stage set”, philosopher Gernot Böhme argues, is “a paradigm for an aesthetics of atmospheres [...] It is, after all, the purpose of the stage set to provide the atmospheric background to the action, to attune the spectators to the theatrical performance and to provide the actors with a sounding board for what they present” [8: p. 30]. In alignment with Wigley’s idea of “sensuous emission” and Allen description of “Mies’ theater of effects”, and following Böhme’s argument, to generate atmospheres, spatial designers must be concerned with the “outward properties” or “ekstases” of spaces, their “tone” and “emanation” [8: p. 32].

2.2 Atmospheric Repertoire

Luis Barragán, who is known to have appreciated the performing arts and to have been influenced by architect Frederick Kiesler interested in programmatic flexibility, “performance in space” as well as spatial “psychofunction” [19: pp. 99–101] creates dramatic atmospheres combining the effect of colors, light and shadow, wall dimensions and water features.

The Gilardi House, for example, employs Barragán’s full repertoire of color usage, “a culmination of tried-and-tested processes” [19: p. 190] including coloring a space through stained glass, coloring a white wall via the reflection of a colored wall, “generating softer or brighter hues through direct and indirect light”, [19] and using water reflection that deepens colors.

Barragán is not the only architect to develop a repertoire of effects. Many architects do. However, in a way that is very unique, Barragán connects and orchestrates the variety of spaces resulting from his repertoire of effects, hence offers a holistic experience of his buildings.

Scenario Writing. In addition to the specific atmospheric moments that one can develop, the transition between these “unités d’ambiances”—to use the vocabulary of the Situationists—or the “islands” or “atmospheric capsules”, as writes Bégout in his analysis of the Situationist city [4: pp. 39–40] becomes very relevant. Represented as red arrows in the famous “Naked City” 1957 Situationist map, they take another amplitude in the graphical analysis of the Garden of Versailles by landscape architect Catherine Szántó [22] or by the way in which Luis Barragán dresses a “spoken portrait” of his creations.

The “literary stage” of Luis Barragán’s design process consists, after having found a concept attuned to his understanding of clients’ needs, in “dreaming up the project design and making a spoken story out of it” [19: p. 138—quoting Raúl Ferrera, Barragán’s long-time associate] describing in great details the movement in space (up, down or right for example), the spatial features (narrowness, materiality, objects—props—encountered) and impressions conceived (the effect of water flowing). As Pauly Danièle further writes: “The “narrated account” was in essence a spatial scenario that Barragán devised as a set of sequences. [...] The “oral portrait” as Barragán termed it, was in fact a highly detailed description of the architect design view, which he would recount as if it were an imaginary tale” [19: pp. 138–139].

Narration and promenade, or “practicing the landscape” [23] are closely related. In the 17th century, the Garden of Versailles was conceived to be the “stage for international diplomacy” [9] as well as the theater of extravagant celebrations (the most famous are the ones of 1664, 1668 and 1674). The Sun King himself was involved in refining a visiting route, the *Manière de montrer les Jardins de Versailles*, for guests to appreciate his garden and his power (not everyone was given the honor), orchestrating movement within and pauses around sculptures and fountains that emphasized his majesty and France’s grandeur [9, 22].

Even though some features have disappeared or changed, visitors can still experience part of the garden’s architecture “à la manière de” or admire the clever orchestration of (and enticement to) movement by the way of architectural “tricks”: for example, level

changes, “primary” and “secondary” focal points, rhythm, water features to channel movement, curated fragrance and sound that give definition to places of rest [22]. For Szántó, “Space is thus conceived not as a backdrop that we see while in motion but as an invitation to motion, as a spatial dialogue taking the shape of a promenade.” Her comment emphasizes the fluid and connective character of atmospheres.

It also speaks to the idea that—for the power it holds to trigger emotions—the art of storytelling (also in reference to Barragán’s “literary stage”) can be an efficient tool in the making of atmospheres.

3 Composing

Composing implies the assembling, the making of a whole, and ultimately the synergy of discrete notes, parts or data. As such, a composer not only understands each part, but how each may fit with others. Composing is thus the art of the transition, of what happens between, of transformation. It is inherently dynamic and variable, much like the parameters with which it plays.

3.1 “Descriptive Drawings”

Because of the fluid and dynamic relationship between the perceiver and the perceived that enables their reification, atmospheres are challenging to represent in a comprehensive manner. As Wright says, “If one would get the essential character of an organic building, it could not be by camera, inasmuch as it is wholly a matter of experience.” [15: p. 323]. Wright did use drawings to represent his buildings—architects still need drawings as instruments of service, to communicate their concept to clients, builders, contractors and regulators. Yet, traditional architectural ambiances drawings represent the building at a moment in time, usually, as Wigley notes, the building “basks in perfect sunshine” [24: p. 19]. Wrights’ descriptive representations of Falling Water, for example, expressed the organic nature of his architecture, merging, in an effort to highlight their communion, sky and building together through the use of parallel lines, which Wigley also compares to today’s computerized representations which treats buildings like “hydrodynamic” flows [24: p. 19].

In *Practice: Architecture, Technique and Representation*, Stan Allen writes that “traditional representations presume stable objects and fixed subjects” [2: p. 60]. These traditional representations are, as Bernard Tschumi notes, “descriptive drawings [that] can be subjective (impressionist, expressionist, and so forth) or objective (“technical” or “analytical”)” [26: p. 135]. However, Allen further explain the increasing role of notation because “[...] the contemporary city is not reducible to an artefact” [2: p. 60]. The “spaces of flows” [6] call for, as Tschumi labels, “prescriptive drawings [...] intended to be operative [...] manifestoes of sorts” [26: p. 135]. Atmospheres, which are intrinsically fluid and dynamic, also call for drawings that have bring something into reality.

3.2 “Operative Drawings”

Architects that have been concerned with the indescribable aspects of architecture, the “sensuous emission” of architecture or movement within spaces, have turned to notational techniques to prescribe spaces. Allen suggests that notation, “always describes a work that is yet to be realized”, “go beyond the visual to engage the invisible aspects of architecture”, “include time as a variable”, “presume a social context, and shared conventions of interpretation” and “work digitally” in the sense that it observes technical rules—becoming a mode of representation to propose alternative scenarios for the fluid city [2: pp. 64–66].

In an interview conducted by Frederic Migayrou at the occasion of an exhibit on Tschumi’s work at the Pompidou Center, the architect explains that notation is a “question of language” as language frames the way you do things—in the same way a computer software yield a particular architectural form [17]. For Tschumi, these drawings are not only a way to document the “movement of bodies in space” something invisible that has been neglected from traditional architecture documentation, but also a mean to develop the score of possible relationships between people and building [17].

According to Tschumi, “operative drawings” are “prescriptive”. The architect devises four types: The “conceptual diagram” which are “turning a broad and heterogeneous amalgam of data into a sharp concept”; “transcripts” which visualize the “complex relationships between spaces and their use; between objects and events [...]”; “transformational sequences” which were based on “a precise set of transformational rules and discrete architectural elements”; “interchangeable scalar drawings” which attempts at combining the concept, the transcript and the transformational sequences at different scales—much like fractals operate [26: p. 135].

For Tschumi, operative drawings are “devices for developing a reading of architectural reality” and “form is never their objective” [26: p. 135]. Additionally, because of the dynamic information embedded within them, notational drawings are an entry point to the world of variability that parametric tools can offer.

Atmospheric Scores. Iannis Xenakis organizes sound in space using mathematic formulas and their visualizations [14]. He composes memorable events by the way of drawing beautiful graphical scores or maps. He was also interested in “sonic dimensionality” [14: p. 56]. The Philips pavilion for example, which he designed when employed at Le Corbusier’s office, is an example of architecture optimized—because of its shape—for acoustic performance. As he writes, “The configuration of the volume of air enclosed in the shell thus structured has a primordial influence on the acoustical quality (its own resonances) of the room [...]” [13: p. 134].

For the occasion of a seminar entitled *Enlarging theatrical activities and architectural practices*, Xenakis explored the “relationship of sound and visual sources” as “A three-fold link exists between audience-source and architecture” [13: p. 154]. He explained the infinite variability of typologies that can emerge from the relationship depending on size, spatio-temporal relationship (how are they perceived or “distinguished”), nature of sources—direct/indirect/machine-made, “type of receptacles” and their materiality and technology [13: pp. 150–155].

Xenakis' interest in music, mathematics and architecture led him to experiment with procedures of sound propagation in space, something he later explored using computer technologies. As Lovelace notes, "Xenakis once remarked that he did not composed at the piano, that instead his tools where mathematics and computer science" [14: p. 54]. Iannis Xenakis is probably the original computational composer of atmospheres and sets a precedent for using atmospheric data to generate emotionally charged space.

The Cartography of Ambiance. Described in a recent article by the author [1], the cartography of ambiance is a spatial practice⁶ that explores the process of decoding an existing ambiance and modeling it parametrically so as to generate permutations of the original ambiance investigated. It entails a five-step iterative process that includes practicing the landscape, drawing from memory (Fig. 1), gathering data, decoding and encoding parameters of ambiance.



Fig. 1. Drawing/feeling an ambiance from memory. Ecole Spéciale d'Architecture, 2015

The cartography of ambiance is the beginning of a long-term research project led by the author and that investigates ways to compute—narrate, score and prototype—spaces of effect and affect (Fig. 2).

⁶ An architectural experimentation led at the Ecole Spéciale d'Architecture (2013–2015) and the Ecole Nationale Supérieure d'Architecture de Paris-Malaquais (2016) in France and Kyoto Seika University (2015) in Japan. Further architectural experimentation is currently being led at Penn State University through the research seminar: Atmospheres: Perception, Design and Fabrication (2018).



Fig. 2. Decoding ambiances. Ecole Nationale Supérieure d'Architecture Paris-Malaquais, 2016

4 Modeling

In addition to staging/storytelling and composing/scripting atmospheres, modeling can ensure a better control of intended effects. Luis Barragán and Peter Zumthor are for instance using modes of modeling to develop the design of the effects and atmospheres they have in mind.

Berteloot and Patteeuw, observed that Zumthor's principles of atmosphere building—which incorporates “the sound of a space” and “the temperature of a space” [25]—was “embedded in the [architect's] way of making,” notably his physical models [11: pp. 83–92]. With regards to his iconic project, the Therme Vals, Zumthor indicates how critical it was to keep sight of the qualities of an early model made with local stone (A photograph of which was used to communicate the intention of the project): “[...] we had constructed a stone model out of local gneiss and filled it with water for a town meeting in Vals [...]: in architecture, stone and water can enter into a natural, and even charmed relationship. [...] stone forms a room; the room of stone contains water; light filters through in chosen places and the stone lights up; the water begins to shine, sometimes like a mirror, sometimes like a solid mass—and there it is, this ambience, this special atmosphere.” [10: p. 140] A medium for communication, the model—especially at large scale [10]—stands as a mock-up, a prototype of the intended effects to fabricate.

Barragán, as Pauly notes, was sculpting space using cardboard models, deciding of the height of walls and the volumes of courtyard and light to bring in the spaces created [19]. Yet, that was insufficient. The creation process continued as construction proceeded. The Mexican architect would visit the site regularly, observing light playing with building and re-deciding the colors to apply, grappling intuitively with the environment of the place his building was nested within, how to finesse its atmosphere, only

stopping when finally, the desired effect was reached [19]. Financial and commercial implications aside, this iterative way of crafting atmospheres brings the architect nearer to the artisan and the artist.

Modeling is, as its core, a very tactile activity. It is for Zumthor and Barragán the occasion to feel the atmospheres as they are making them. For building spaces of affect, spatial tricksters have, indeed, a hand in spatial effects.

5 Form... After Effects

As substantiated in this paper, many architects have been developing ways to produce, design and fabricate inviting atmospheres. And, as paradoxical as this may sound, it involves the finding and manipulation of atmospheric and sensory parameters of rather fluid and formless phenomena. Staging, composing and modeling atmospheres, as we have found, calls for sophisticated and dynamic techniques to tackle, not form, but effects. These techniques include storytelling, scoring atmospheric data and prototyping at large scale, or even live, buildings to feel the atmospheres before they come to existence. The goal remains the production of spaces that afford the “sensuous correspondence”, “attunement”, or “wayfounding” of their inhabitants, even temporary. As Juhani Pallasmaa writes: “The timeless task of architecture is [after all] to create lived and embodied existential metaphors that concretise and structure our being in the world” [18: p. 76].

Computational capabilities have already been used to optimize sonic environments or light conditions resulting in complex geometries of interior cladding or skin envelopes. Nevertheless, this paper wants to argue that, by recognizing the dynamic and interactive nature of atmospheres, and the role of architecture as atmospheric interface between the senses and the (electronic and physical) environment, architects can engage new modes of parametric design—one which goes beyond form-making and is built to generate sensory experiences.

Architecture—conceived and realized as computationally generated atmospheres—may also present an opportunity to reimagine computer-assisted design processes: for example, using VR technologies to not only see but also feel spaces as they are being conceived. Atmospheres can intimate a way to devise meaningful ambient computing and electronic environments by narrating the movement through space, scripting events and moments of connection and testing sensory experience in real-time and space.

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