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Listening Out: Towards a New Spatial Sonic Imaginary

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Listening Out: Towards a New Spatial-sonic Imaginary

“He [sic] is always ‘listening out,’ but he does not only hear words, discourses, noises and sounds; he [sic] is capable of listening to a house, a street a town as one listens to a symphony, an opera”

- Henry Lefebvre and Catherine Regulier on the rythmanalyst, 2004 p. 87

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ABSTRACT

In the 1960s, Guy Debord proposed the *dérive*, a new way of walking, which was of course new only in name. The *dérive* was an essential part of psychogeographic practice, emphasizing observation, spirit, emotion, and experience in response to what Debord deemed a memetic society of consumption and distraction. Today, experimental and affective geographers wander down paths laid by the psychogeographers, similarly exploring the affective import of space. Cartography has served as an important medium for those interested in space; and offered a tool for geographers and artists alike to make relational sense of place and space. Still, cartographies, even those that emphasize subjectivity and abstraction, are largely visual. Soundscapes and sound mappings offer rich potential to expand sensory cartography and bridge aural and visual spatial epistemologies; but, soundmapping's emphasis on high fidelity recordings, tied directly to precise geographic coordinates leaves room for abstraction and musicality in sonic cartography. Building on decades of audio visually inspired work, this thesis examines new ways of narrating space through sonic experimentation, provides a performative protocol for data collection, and describes a resulting computational system for mapping visual to sonic spaces. The output is a site specific and autobiographical work that takes the 'daily stroll' as its central input. These daily strolls are formalized as data collection: daily video recordings were captured of Shadyside (Pittsburgh, PA, USA) over the course of a six-month period. Their visual streams are segmented and mapped to audible parameters, ultimately creating a generative composition that tells an evocative story of place over time. In so doing, the work proposes and demonstrates mapping as composition and composition as a mapping and tugs at the affective and performative potentials of sound mapping to generate new spatial imaginaries. Reflecting on the work opens further possibilities for 'hearing' visual space: from assistive wayfinding technologies to urban planning tools, there remain rich potential applications for sonifying the built environment.

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INTRODUCTION

As the last leaves drifted to the gutter, the block sounded different. The trees were bare, and the street felt hollow. It sounded cold. We stayed inside and traveled digital landscapes instead. Google Maps and the Web 2.0 have axiomatically changed the way we engage with space. Terrain, reviews, and buildings, are a mere click away, and I can arrive at the store knowing it will be ‘busier than usual.’ This wealth of geolocated data has provided new opportunities for exploration and knowledge exchange but being in a space is about much more than information retrieval; what we notice, how we notice, and how we feel in a place are often lost through the screen. In response, artistic cartographers have expanded geographic practice, embracing emotion, experience, and the deeply political import of mapping (D’Ignazio 2020, Ribeiro and Caquard 2018). This thesis hopes to do the same, embracing a multisensory approach to artistic mapping, and responding to calls to recognize the import of auditory, olfactory, and tactile senses as sites of embodied knowledge (Jones 2006).

I. Drawing Lines: Map (n.), Mapping (n.), Mapping (v.)

Map *noun*: a diagrammatic representation of an area of land or sea showing physical features, cities, roads, etc.

Mapping *noun*: an operation that associates each element of a given set (the domain) with one or more elements of the second set (the range).

Mapping *verb*: record in detail the spatial distribution of (something) ; associate (a group of elements or qualities) with an equivalent group, according to a particular formula or model; associate each element of (a set) with an element of another set

The above definitions are taken directly from the Google dictionary and while dictionary definitions may seem trite, they are wonderfully messy in the context of this thesis – a fact worth addressing at the outset. This thesis is, broadly, a map (n.) in the cartographic sense: it is a representation of a place. It employs active mapping (v.) techniques as I walk the blocks around my house. I am mapping (v.) the space as I record my videos. The videos, however, provide a mapping (n.) in and of themselves, they operate to map sonic to visual elements.

II. Finding a Place

In short, the thesis asks: *how can artistic cartographic practices incorporate sound to inspire new spatial imaginaries?* More specifically, in using the city as an instrument, what will we hear when we listen to it, and what might we find about the ways it changes over time? Inspired by experimental, affective and psychogeography (see Drifting) the thesis hypothesizes that taking a multisensory approach to cartography, using the city as an instrument, will highlight the emotional productivity of space.

Over the course of the work, I hope to braid a number of strands: part artistic cartography, part sound map, part experimental composition. I argue there is fertile ground for a computational and sonic lens to psychogeographic inquiry. Pablo Abend summarizes Walter Benjamin's work from 'The Work of Art in the Age of Mechanical Reproduction', stating, "new modes of production can lead to new modes of cultural production and introduce new modes of perception" (2018, p. 93). With new technologies come new ways of representing, displaying, telling, and therefore new ways of knowing and understanding. This case presents new modes of cartography, capable of generating new modes of spatial perception.

In framing the work, I want to emphasize it as place specific, and as way to begin thinking about temporal mapping. I also want to emphasize the deeply personal nature of the work. I motivate this choice in both 'The Hyper-local' and 'Walking with the Psychogeographers,' and further still methods section but it is an important part of the framing too. Guy Debord famously quotes to Marx (without citation) as saying, "men [sic] can see nothing around them that is not their own image; everything speaks to them as themselves. Their very landscape is alive" (Thompson et al. 2009). This thesis takes this as somewhat of a central conceit. The map is inevitability personal, inevitably subjective, and emphasizing it as such pushes against claims of cartographic objectivity.

['A word']

Briefly, I would like to take a moment to position my work, mainly through a description of omission. My description of both mapping and music begin in the 1930s, leaving behind decades of beautiful cartographies, musical notation, and experimentation with technology and music. My mapping examples are Eurocentric, as is my brief description of musicology. I do not address geographies of music, which would certainly make sense for a thesis focused on both sound art and geography. I only begin to address fascinating debates on what constitutes art, and or the range of options of labeling algorithmic, generative works as art. My research looks primarily at expanded cartographies and audiovisual experiments that danced with technological advancements. Expansion of any of the aforementioned threads would be valuable and could be appropriately placed in the 'Where To Section.'

III. The Roadmap

I begin with a Background Chapter that works to position my work among a variety of experimental practices: in geography, cartography, sound mapping, and composition. I first look at the geographic frameworks and media studies that inspire my understanding of physical space and representation, focused especially on the intersections between art and cartography. In this section, I explore three cartographic practices that I draw on throughout the thesis: *the sensory*, *the hyper-local*, and *the temporal*. I then focus on a geographic turn to the emotional and affective (Wood, Smith 2004) and explore philosophies of sound with Christoph Cox and R. Murray Schafer to position sonic mapping and sound art as a response to ocular-centricity in both cartography and philosophical thinking about perception. From here, I look more specifically at sound studies, sound art, and precedents of both placed-based and digital sound mapping. I look at a history of soundscapes, extract the merits of sonic recordings and current digital sound mappings, and identify the performative potentials in digital sound mapping. I then consider definitions of sound art and explore sonification work by Constantine Zlatev

(2012). I argue using the city as an instrument highlights its emotional productivity. I briefly describe music as an early site of computational design, following Peter Wiebel's claims that "music is the scene of perhaps the most daring artistic and technical revolution of the twentieth century" (2020, p. 489). In this section, I focus on audiovisual transcoding and experiments with graphic notation manifested sonically through technical platforms. This theoretical grounding is intended to make an argument for the merits of abstracted, temporal, and sonic cartographies, and recognize the work as following a deep history of computational sound art.

I move on to describe my methodology for this instrumental approach to the city. Broadly, the process was one of transcoding a recorded video stream into an audio composition. Transcode, as defined by media artist Kyle McDonald, is "a label for the intuition that information can be translated from one form to another" (Schedel 2018, p. 388). This definition, applied to sound, results in a sonification: a translation of visual information to audio information. On a technical level, this work is a sonification of pixel data in concert with data related to time of year and weather patterns. I describe and motivate the site and collection methods. I discuss the computer vision model I used to identify specific elements of the urban landscape that I would map to different sonic features of a composition. Next, I define sonification on a more technical level and provide a detailed case study related to emotional affect (Winters, Wanderly 2013). In 'Synthesis, Sounding,' I describe the varying processes of, and attempts at, sound generation. I detail failed experiments with sound and describe the process of arrival at a composition I felt told a compelling narrative of place. I argue this will generate a new form of sound mapping at the intersection of art and cartography: one that emphasizes play, experience, and abstraction and contributes to thinking about temporal mapping. From here, I reflect on my process – on what I learned and how both the methods and framing evolved over time. 'Where To' is a natural continuation of the reflection. It describes future work, identifying potentials both in cartographic framing, collection methods, and the reach of the project. I end with the intended contributions of the

thesis. In sum, over the course of the thesis I hope to provide a compelling case for performative, sonic cartographies as a way to think through temporal mappings, affective geographies, and sonification. I hope to propose a new way of narrating space.

Sound is not a medium particularly well suited to the written thesis document. For those interested in listening to sound precedent, audio experiments, and the final works, the documentation lies here: <https://rythmanalyst.cargo.site>. The site is intended to be used in concert with the document and progresses with the document itself. Beginning in 'V. The Sonic Surrounds, Urban Sound Exploration and Soundmapping', bracketed numbers (ie. [5]) will indicate a documented precedent that can be found at the corresponding number on the site. In the Methods section, bolded bracketed descriptions (ex. [road]) will link to an audio experiment. This site serves as a collection of audio experiments: from the historic to the contemporary to the personal, they tell a story of sound, space and experimentation and show computation as an often mediatory tool for exploring connections between the above.

BACKGROUND

I. Drifting

In 1960, Guy Debord of the Situationist International defined a new way of walking: the *dérive*, which was of course new only in name (Pinder 1996). In practice, the *dérive* is a way of ‘drifting’ through the urban landscape; it is research through observation, meant to be spirited, and closely attuned to the emotional effect of the landscape. Similarly proposed by the situationists is the definition of psychogeography which is, “the study of the precise laws and specific effects of the geographical environment, consciously organized or not, on the emotions and behavior of individuals” (Knabb 2006). In effect, the Situationist International propagated a unique way of engaging space. The contention that physical space affects emotional constitution may not be revolutionary but to call specific attention to the effective-ness of space; to actively promote wandering and observation, to uphold aimlessness and play was to critique and challenge modern day capitalism and the rise of bureaucracy (Pinder 1996). Their challenge was not to cartographic practice, rather to society fueled by consumption and mimesis (Debord 1994). Debord’s maps emphasized sensation and affect (Pinder 1996). They are personal and expansive. They are about being, about experience. The implication of their work is that mapping emotional and physical spaces need not be distinct practices (see *On Art and Cartography*).

From a contemporary standpoint, and arguably in the psychogeographic legacy, Trevor Paglen proposed Experimental Geography, defining “practices that recognize that cultural production and the production of space cannot be separated from each other, and that cultural and intellectual production is a spatial practice.” He continues, “[i]f human activities are inextricably spatial, then new forms of freedom and democracy can only emerge in dialectical relation to the production of new spaces”

(Paglen 2009). Paglen's definition pushes the production of space beyond a mutual and inevitable feedback loop, and proposes direct interventions, creation, and active world building. Similarly helpful, Di-Ann Eisnor offers a framework of neography (contested definition, see Turner 2006), as a call to reconsider geographic methodologies that tend towards the intuitive, expressive, personal, or absurd (Kvas 2014). These definitions broaden geographic practice, and highlight cultural and intellectual production as spatial and generative.

Further still, there has been a wave of geographic inquiry towards geographies of affect (Gallagher et al 2017, Doughty et al 2016, Wood 2004). Here, geographers carefully turn their attention to the emotional and affective qualities of a space. In doing so, they claim the emphasis of representation reduces the richness of being and feeling in the world. Instead, they emphasize perception and encounters within a space. Affective geographies, much like psychogeographies, "drive to conceptualize the world beyond its representation through a variety of mediatory forces, such as text, maps and photography for example, that capture and express the world" (O'Grady 2018). To further understand what is meant by affective geographies it becomes important to define and understand a variety of definitions of affect proposed in the literature. O'Grady describes affect as "the set of ever-changing processes human and non-human bodies undergo as they experience, encounter, and perform life among other bodies within material space... affect seeks to address and examine invoked states that combine what our bodies sense and perceive with our capacities for rendering life in the world intelligible" (2018). Giaccardi and Fogli use affect to mean, "the perceptions, interpretations and expectations one ascribes to a specific physical and social setting" (2018, p. 1). Finally, Gallagher et al. claims, "affect is more than feeling or emotion. It is better thought as forces that impinge on bodies which may or may not be felt. Sound, as physical vibration, is affective" (Gallagher, Kanngieser, Prior, 2017 unpaginated). Affective geographers and experimental geographers find affinity under alternative forms of representation, through creating, encountering, and engaging. They focus on the experience of

being in the world and interacting with its varying forces. They focus on that which surrounds us, and the ways that we interact with those surroundings and more than one definition explicitly calls out both physical objects and bodies and social interactions. Affect relates to how we interact with and understand the world. Working through these engagements allows for a rich depiction of space and broadens geography to explore perception and social entanglements that cannot be seen or heard in the physical world. But the question of representing and portraying affect remains essentially open for experimentation. Given Gallegher's proposition of the *affectiveness* of sound, I choose to explore affect and spatial representation through sonic renderings.

Taken together, experimental-, psycho-, and affective geographies call for alternate representations of space. They call for exploration, experimentation and affect. They call attention to new spaces, and new ways of knowing and asking. From here, I look first at artistic mapping practices as a form of experimental geographic inquiry. I then turn my attention to the psychogeographic importance of sound and investigate its current and potential applications in sensuous cartographic experimentation.

II. On Art and Cartography

"As the energy of painting has been dispersed in the past half century through the forms of earth art, conceptual art, installation art, performance art, video art, cyber art, and so it, it has dispersed the map as a subject along with it." (Wood 2006, p. 7)

For the past few decades a group of geographers have worked to emphasize the subjective, contingent nature of mapping, through a lens often termed 'critical cartography' (Harley 1989, Wood 1992, Pickles 2012). Far from an objective cartesian representation, choices of what to leave in and what to leave out of the map are fundamentally the cartographer's choice and therefore often reflect the cartographer's interests (Wood 1992). Maps are knowledge producing technologies and should be importantly understood as such, given their capacity to shape spatial and political imaginaries. More

recently, Rob Kitchin and Martin Dodge call for “rethinking maps” (2007). Their work challenges ontological security in mapping practices, instead positioning mapping as an *ontogenetic* practice: a practice that emphasizes maps as unfolding and constantly becoming. Further, their reframing expands traditional cartography, incorporating a wide range of spatial practices, including performative interpretations of space (Kitchin, Dodge 2007).



Le monde au temps des Surréalistes (The World at the Time of the Surrealists), image from p. 26-27 in special issue "Le Surréalisme en 1929" of Variétés: Revue mensuelle illustrée de l'esprit contemporain (June 1929)

Figure 1. (1929) *Le monde au temps des Surréalistes*

It follows that one such way of rethinking the map is to explore intersections between cartography and art. D. M Ribeiro and S. Caquard identify “cartography at the interface between art and place” as a tool to explore the emotional dimensions of space and cite Wood’s 2012 work *Rethinking the Power of Maps*, in which he describes map art as artist designed maps that probe the political aspects of space in a poetic way (2018). Long before these definitions were formalized and integrated, artists were exploring the political and subversive potentials in mapping. Ribeiro and Caquard present a beautiful collection of artistic cartography, as does Catherine D’Ignazio, and I draw largely from their examples, beginning my exploration in the early 21st century with the Surrealists. *Le monde au temps des Surréalistes* was

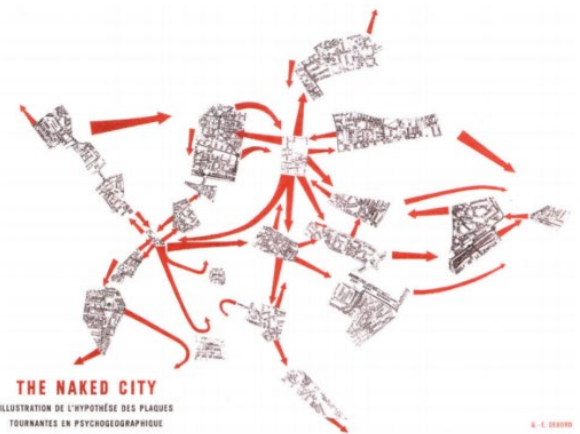


Figure 14 *The Naked City* by Guy Debord and Asger Jorn, 1957.

Figure 2. Guy Debord, Asger Jorn (1957). *The Naked City*

arguably one of the earliest critical cartographies (see Figure 1). By radically distorting landmasses and removing imperial powers from the map altogether, the map both calls into the question the reality of the map and asks what a different world might look like. Later, the Situationists take a similarly experimental approach to mapping practices. In perhaps one of the most famed examples of artistic cartography, Guy Debord and Asger Jorn map *The Naked City* (see Figure 2). Their map was a personal one and detailed their individual experience wandering and observing throughout Paris (D'Ignazio 2020). Nato Thompson describes the Debord and Jorn's practice claiming they took "the exquisite corpse of the Surrealists and applied it directly to urbanism" (2009, p. 17). Denis Wood argues these artistic cartographies are not apolitical. In mapping worlds beyond 'normative mapping institutions' art maps highlight the world-building powers of the map. He claims "what is at stake is the nature of the world we want to live in. In pointing towards the existence of other worlds – real or imagined – map artists are claiming the power of the map to achieve ends other than the social reproduction of the status quo" (Wood 2006, p. 7). As some experiment with the world building power of the map, 'deep mapping' has emerged as a practice situated between mapping and the humanities. The deep map makes use of a variety of geographic mediums, including but of course not limited to, fiction, art, and memories (Ribeiro, Caquard 2018). The deep map expands our notion of geography and adds information perhaps most pertinent to placemaking that is oft overlooked in traditional cartography. It contends that stories and memories of a place are essentially defining. While fictions, stories, films, and photographs are not new modes of production in and of themselves, their synthesis and production as a map present a new mode of producing cartographies. As such, following Benjamin above, deep mapping allows new modes of cultural production and perception of place.

Whether political or whimsical, whether calling in or leaving out, making personal, or critiquing hegemonic order, artistic mappings share in their propagation of new spatial imaginaries. I'd like to call attention to three specific cartographic practices: the sensory, the hyper-local, and the temporal.

Certainly, these are fluid categorizations but drawing distinctions helps to clarify what I consider to be three main elements of the cartography of the thesis. I briefly describe specifics of these maps, providing case studies for each. We tell stories through maps; they are rhetorical devices through which we narrate the city, they reflect, and potentially effect sensory engagements within space. Mapping the hyper-specific, or the street level calls attention to the details of urban life often lost in normative mapping practices. Temporal maps emphasize the dynamism and fluidity that so defines space.

A. THE SENSORY

Kate McLean provides an excellent example of sensory mapping in her work on smellscape.

McLean guides people on smellwalks, and weaves smellmaps through a variety of people's perceptions

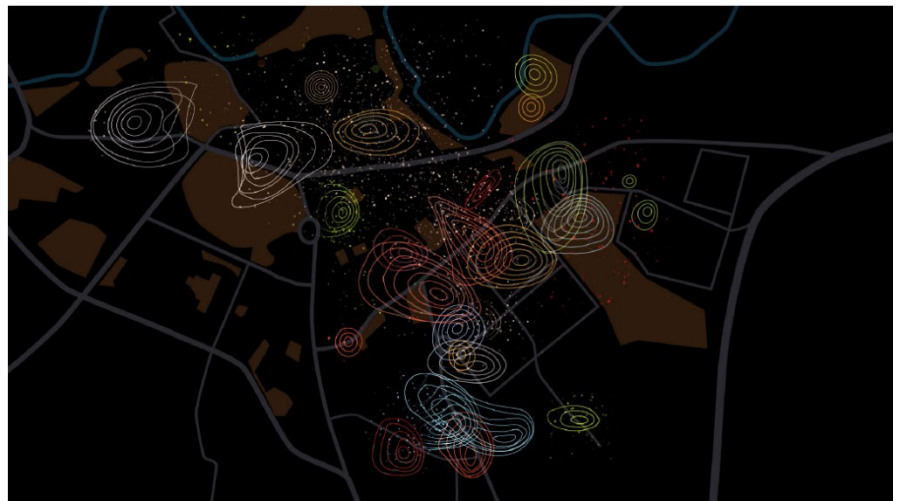


Figure 3. (Left): Screenshot of Smellscape App Interface, courtesy of Kate McLean

Figure 4. (Right): Kate McLean (2014). *Smellmap: Pamplona* [still image from movie]

throughout a smellwalk. She has conducted these walks in a variety of urban spaces, from Astor Place (2017) to Singapore (2015). Her work fits well within the temporal mapping, given the ephemerality of the smellscape; however, here I will focus on the active, sensory cartographer McLean refers to as the ‘smellwalker’ (Lammes et al., 2018). The smellwalker walks through the city, guided by their nose, and asked to record ‘smellervations,’ in which they explicitly record their perceptions of certain scents (see

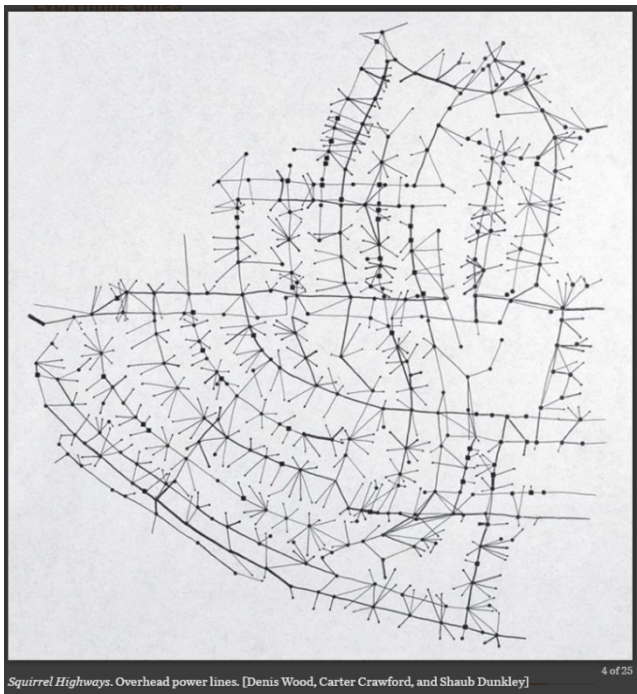
Figure 3). McLean then analyzes and visualizes these observations through abstract but clearly cartographic maps (see Figure 4). In describing her work, McLean emphasizes personal experience with the smellscape: one smellmapper's identification is likely to be entirely different than another's (Lames et al., 2018). Much like sound, smell is an affective force, whether or not it is actively recognized and felt.

I find affinity with McLean's work on a number levels: my work also involves walking as an essential act of mapping, it focuses on sensory mapping, on the phenomenological experience of place, and steps away from occularcentricity to do so. Continuing with the focus on specific elements of the landscape, while stepping away from the sensory, we turn to Wood's mappings in "Everything Sings."

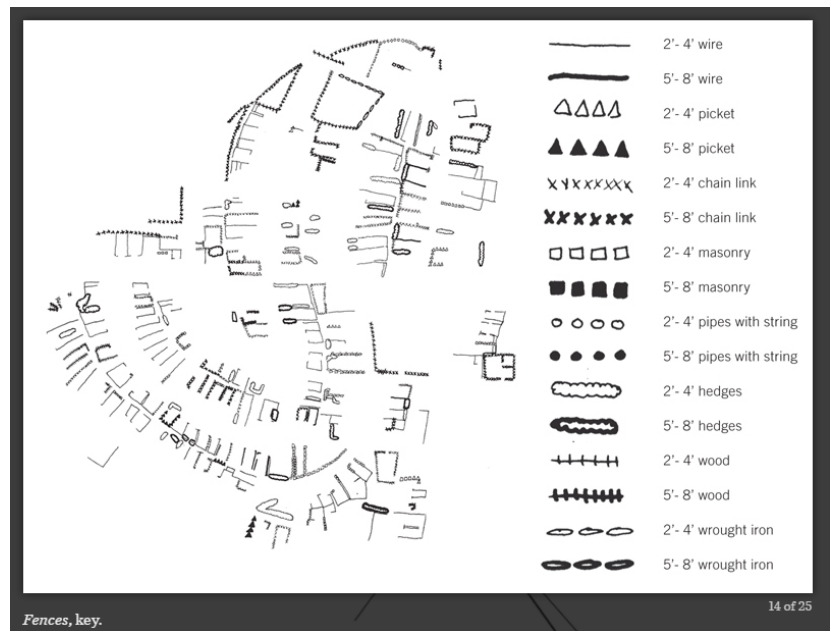
b. The View from The Street / The Hyper-Specific / The Hyper-Local

At the street level, there is an active recognition of spaces are teeming with life inaccessible through top-view cartographies. To zoom in on the hyper-local or hyper-specific aspects of urban areas is to avoid panoptic generalizations and instead embrace the subjectivity inherent in mapping. The hyper-local, defined in the case of this thesis, is used to describe the site-specificity of the work as both involving familiar spaces ('local') and a small radius of exploration ('hyper') With the recognition that cities, far from generalizable, are a fabric of stories, David Pinder claims, "the street has become cherished for offering a location that is embodied, situated, mobile with multiple and clashing viewpoints" (Pinder 2005, p. 402-403). Returning to Wood's description of the world-building power of the map, he seeks to represent specific features of urban space that may go otherwise unnoticed. Wood describes the origin of his work as part of a landscape architecture class in which he tried to call attention to that which was often overlooked, "the way the land smelled, the way it felt in their legs

when they walked it, the wound of the wind of the oaks after all the other leaves had fallen...” (Wood 2011, unpaginated). He, along with his landscape architecture class, began what I consider a bi-part investigation. The first aspect of their work is an investigation of specific elements of the urban landscape, the second is ways of abstractly representing said elements. We might recognize his original



Denis Wood (2011). *Everything Sings* Figure 5. (Left): *Squirrel Highways*, Figure 6. (Right): *Fences*



intention quoted above is similarly preoccupied with sensory experience. ‘Everything Sings’ is a collection of some of exercises that began in this course. In the end, the work is not oriented towards the senses in the way Katherine McLean’s is, instead it chooses deeply specific objects through which to convey a landscape. *Squirrel Highways* (see Figure 5) maps wires through the city, while *Fences* (see Figure 6) maps different fences throughout the city. Both maps, and the collection of work as a whole, call our attention to what we do not normally see. And in showing us what we do not normally see, they propose a shifting of attention, towards the mundane and ‘passable.’ These maps are psychogeographic in that they are about noticing the details. In focusing on the hyper-specific, and abstracting their

representations, these cartographies show us there are a nearly infinite number of stories to be told about a place, and a nearly infinite number of ways to tell these stories.

The specificity of space itself is another way of accessing new spatial narratives, and stepping away from falsely totalizing mappings. Christina Ray and Dave Mandl of Glowlab presented “One Block Radius” in 2004 as part of a public program at the New Museum (Ray et al. 2004). This work centers on one lower East Side block. The project no longer exists online but it is described at the New Museum as a “feature-rich urban record that will include personal perspectives from diverse sources such as city workers, children, street performs and architectural historians” (Ray et al. 2004). To do so, the artists used a variety of mediums to craft a fuller depiction of a place. Their specific focus allows great depth of representation and allows a variety of voices and mediums to narrate a rich ‘deep mapping.’ This specificity further allows for overlapping time frames, and avoids static, singularly dimensional representation.

c. The Temporal

Cities exist in a constant state of flux, posing a representational challenge for the cartographer. How can one effectively convey the way a space changes over time? Even further, how does one grapple with the circular nature of time suggested by researchers at the SpecLab as “the repetition of life cycles, circadian rhythms, and other apparently identical replications within temporal sequences” (Drucker 2009, p. 40)? More geographically specific, Doreen Massey asks, “how do we cope with maps as mediators of the ‘ongoing stories’ in the world” (2005, p. 107). Recognizing maps as an essentially narrative building technology, Massey’s line of inquiry starts to probe at the potential for maps as evolving over time, for maps to be alive and changeable. Pablo Abend speaks to the fixity of maps and argues that the inability of the map to address change and history has meant “the definition of time has been a neglected topic in geography” (2018, p. 92). However, he argues that the convergence of film,

cartography, and computational power might usher in a paradigm shift towards dynamic renderings of place that he considers ‘an aesthetic transformation of time-cartography in motion’ (2018, p. 96). Stuart Aitken and James Craine speak further to the harmonic affordances of film, cartography, and the computer. They claim that beyond their fixity, most contemporary GIS maps strike one flat and affectless while cinematic landscapes evoke emotional intensity (2006). New forms of visualization could be similarly affecting if they were to embrace motion, however Aietken and Craine caution against taking vision for granted, and insist on ‘problematizing’, theorizing, critiquing, and “historicalizing” the visual process (2006, unpaginated). I argue that beyond theorizing or critiquing the visual process, one can generate emotional intensity through the use of sound.

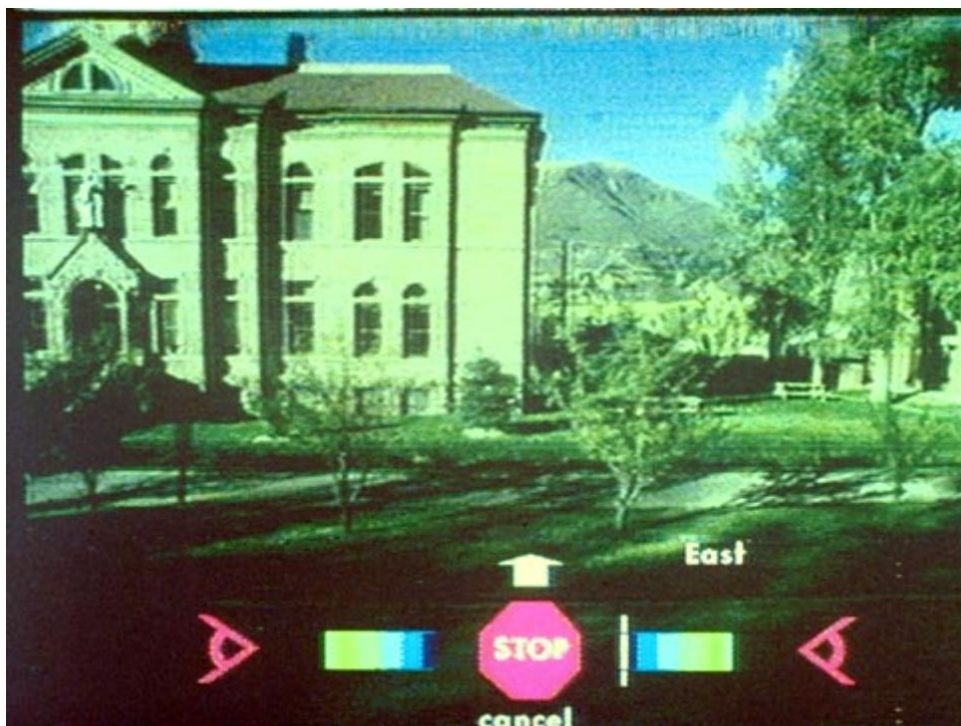


Figure 7. Screenshot of Aspen Movie Map (1978) interface

In the late 1970s, researchers at MIT created “The Aspen Movie Map,” arguably akin to an early digital map (see Figure 7). The Movie Map simulated real-time movement through Aspen and allowed the user to feel as if they were in fact exploring the area themselves (Abend 2018). Naturally as new

media have allowed for the convergence of cartography, film, and computational power, new ways of exploring space have been afforded. Google Earth, developed in 2005, allows the user to traverse the globe through the screen. The map is no longer a purely static, or one dimensional object, it is navigable and viewable at radically different scales: from outer space to the street. Abend claims, “the difference between Google Earth and the perfect panopticon is the lack of real-time imagery” (2018, p. 102). He claims that the encompassing representational layers provide a sense of raw objectivity – we seemingly have access to the entirety of the globe, rendered through real photography of the space. However, he claims this is a false perception and uses Latour’s framework of oligopticons, which he defines to be “little windows which only allow a snipped view of the social world when taken in isolation” (2018, p. 102 – 103) to emphasize that Google Earth represents mere snapshots of space. The images are taken and frozen in time, stitched together with other images produced in the same way. Space, then, can be represented and understood more fully through a temporally evolving lens. This avoids ‘snipped views’ and renders maps more able to tell ‘ongoing stories.’

James Balog’s photography provides insight into the power of the image in conveying the way a space changes over time. His work *Extreme Ice Survey* is intended to “give a ‘visual voice’ to the planet’s changing ecosystems” (Balog 2021). This project installed time-lapse cameras at a variety of sites and documented the catastrophic change of the Ice caps over time (see Figure 8). A still of an ice-cap does little to convey the nature of the problem Balog set out to represent; visualized as a time-lapse, however, one is struck by the radical change of the environment.

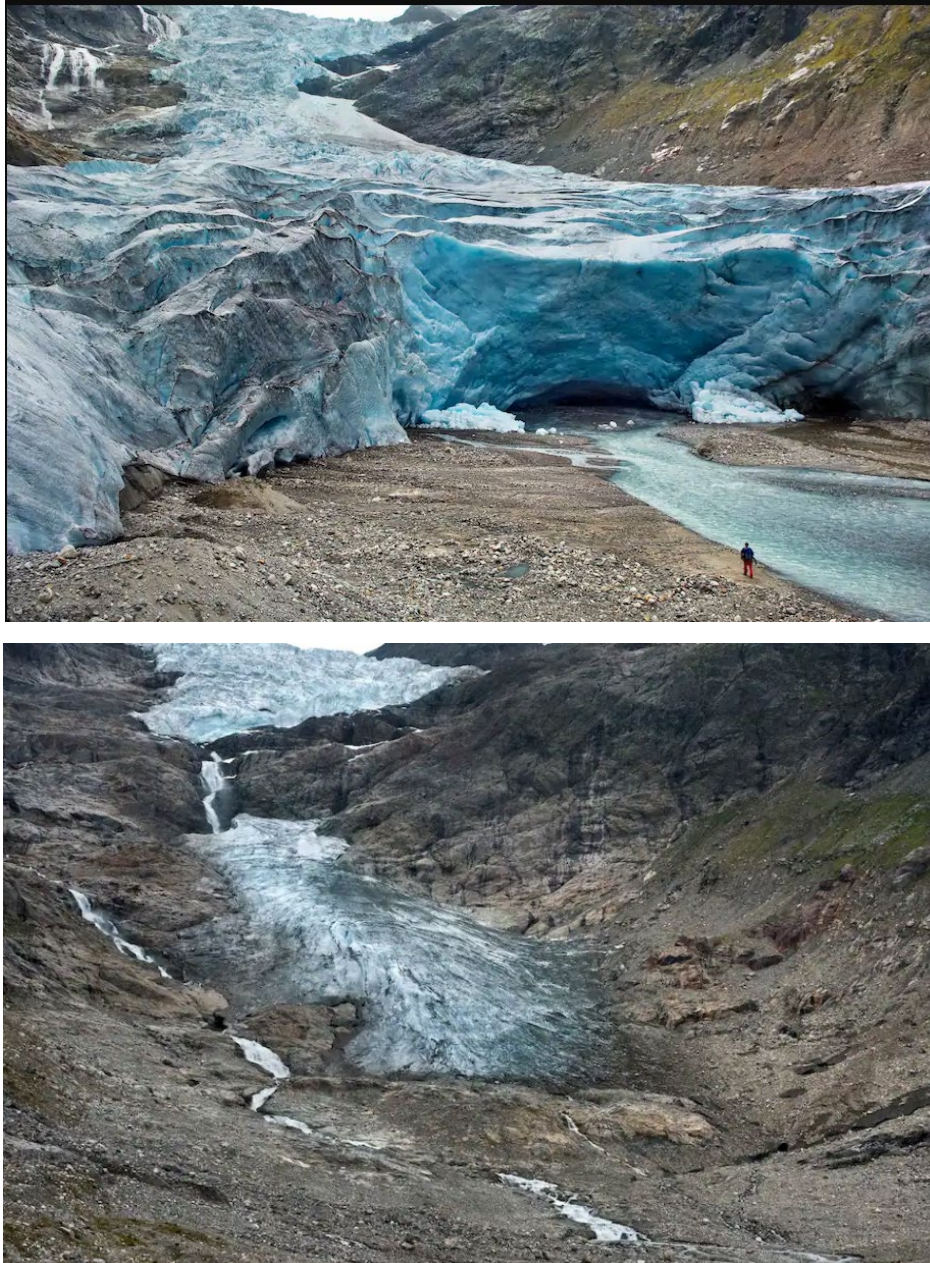


Figure 8. James Balog, Extreme Ice Survey, Stein Glacier. Top: Sept 17, 2011, Bottom: Aug. 20, 2015 screenshots from <https://www.washingtonpost.com/news/energy-environment/wp/2017/04/03/you-cant-deny-climate-change-once-you-see-these-images/>

Still, in contrast to Balog's 'visual voice' an 'audible voice' likely has powers as well. Peter Weibel extols 'music as the mother of time-based arts,' which may lead us to consider sound as useful in thinking about temporal cartography. Or, more poetically staked by Thrift, **"the frozen circumstances of space only come alive when the melody of time is played"** (1997, p. 448).

III. Walking with the Psychogeographers

“Walking is mapping with your feet,” says Lauren Elkin. Indeed, walking was a short step away from an artistic cartography for the psychogeographers and an undirected walk is likely to affect the walker – their encounters are their own, their experience self-reflexive, and their patterns of perception unique within that space and time. Countless literary masterpieces have employed the walk as an essential rhetorical device (Dostoevsky 1866, Sebald 2001, Joyce 1922, Nabokov 1925 are a very few personal favorites). It is through walks that the city is constructed alongside mental landscapes and the reader becomes intimately acquainted with city and character at once. In a book aptly titled “The Walk,” Robert Walser describes,

“With the utmost love and attention, the man [sic] who walks must study and observe every smallest living thing, be it a child, a dog, a fly, a butterfly, a sparrow, a worm, a flower, a man, a house, a tree, a hedge, a snail, a mouse, a cloud, a hill, a leaf, or no more than a poor discarded scrap of paper on which, perhaps, a dear good child at school has written his first clumsy letters. The highest and the lowest, the most serious and most hilarious things are to him equally beloved, beautiful, and valuable” – Walser 2012

Walser’s walk lyrically points to the brilliance of the details in a space, and the reader is left wondering what they might have noticed that Walser did not. Where are the cracks on the sidewalk and how many steps lead to the door? A walk can take many forms, teetering between the passive and the active, the depressive and the joyous, the political and the solipsistic. To be sure, walking is key in constructing a spatial imaginary. David Pinder describes the work of Benjamin Rossieter and Katherine Gibson. Their work claims a political dimension to walking, and they describe ‘transformative potential of walking and performing appears weak, powerless, and foolish,’ in the context of urban spaces defined under capitalism (Pinder 2005, p. 401). A prevailing rhetoric of socially polarized, inequitable and

desperately place-lessness cities can, they claim, be countered though a 'poetics of walking' that refuse to consider the city as inevitably prescribed. Pinder does not overlook the political dimensions of walking in the city, and notes that different bodies have different access, ability, and experiences while navigating the city (2005).

Walser's walk, along with Rossieter and Gibson's, focused on vision and to continue to explore the spatial imaginary I'd like to explore the range of sensory experience offered in a space, focusing specifically on the sonic surrounds.

IV. Perception, the Senses, Signals

In 1967, Marshall McLuhan published "The Medium is the Message," in which he argues, "since the Renaissance, Western art has been visually preoccupied and "[the artist's] conception of space was in terms of a perspective projection upon a plane surface consisting of formal units of spatial measurement." In this work, he calls for multidimensional "new media" methods. Considering maps as media (Mattern 2018), and recognizing their largely visual perspective, new media mappings may too incorporate a multimodal approach to representation. Sound offers rich potential to re-engage multiple perspectives, multiple senses, and capture a breadth of experience. Later, Caroline Jones proposes "in conjunction with the visibility historians have charted as characteristic of the modern, we should begin to reckon with the auditory, the olfactory, and the tactile as similarly crucial sites of embodied knowledge" (2006). Above, we saw Katherine McLean's work with the olfactory. Here, I choose to reckon with sound.

Sound is brilliantly ephemeral, it is evocative, and constant; it is everywhere, and in a state of endless flux. Without material presence but materially essential, sonic epistemologies applied to spatial imaginaries offer new ways of reading and experiencing a place.

a. THE SILENCE AROUND SOUND

Despite great experimentation with sound as a medium (see 'On Sound Art') and despite the range and depth of work in the burgeoning field of sound studies, (see 'Studying Sound') writing about sound is challenging. I have been surprised by my inability to find words to speak to the importance of sound; I have felt desperately repetitive, and as though the words I need lie out of reach. I, it turns out, am not alone. It's no mistake, according to Cox, that we don't yet seem to have the appropriate vocabulary to talk about sound: "the sonic arts are resistant to description and analysis via theories of textuality and representation, which accounts for the near silence about sound in contemporary aesthetic theory" (2014). These theories of representation, and signification, have dominated aesthetic theory over the past few decades under semiotic, deconstructive, and psychoanalytic approaches (Cox 2014). To further understand the 'silence about sound', we might also consider why the sonic and visual arts have remained distinct in art theory and criticism.

Both Cox and Jones cite Clement Greenberg, art critic and famed modernist thinker of the 50s and 60s, as paving the way for the preeminence of the visual in art theory and criticism (Jones 2006, Cox 2014). Jones argues that modernist, formalist tendencies worked to effectively 'parse' the senses, giving precedence to sight, for its sensorial engagement was considered most separable from the body itself (Jones 2006). One stands outside and looks at the painting, the sound, existing nowhere in specific, travels through and in around the mind. As such, Jones states, "the body's place, as undifferentiated corpus, was nowhere. The body's portals as separated aggregate functions, were everywhere." (2006). To reincorporate sound then is to end 'modern sensory regimes' (Jones 2006) and move closer to geographies of affect – towards non-representational, performative epistemologies. Cox and Jones' push towards an aesthetic theory of multisensory, non-representation is strikingly similar to the aims of the affective geographers. Pure representation, affective geographer Nat O'Grady claims, reduces the

richness of life experienced through space (2018). In exploring the import of emotional and figurative spaces, I open my ears to sound.

b. ON STUDYING SOUNDS AND SIGNALS

Sound studies 'students' seek to discover a language, an understanding of sound as an object, as an event, as a piece of media, through a multiplicity of overlapping, interweaving disciplines (Sterne 2012). Sound studies as a field aims to investigate, expand, and study the "*sonic imagination*," which Sterne describes as "is a deliberately synesthetic neologism – it is about sound but occupies an ambiguous space between sound culture and a space of contemplation outside it. Sonic imaginations are necessarily plural, recursive, reflexive, driven to represent, refigure, and redescribe. They are fascinated by sound but driven to fashion some new intellectual facility to make sense of some part of the sonic world" (Sterne 2012 p. 5). I'd like to put this definition alongside Trevor Paglen's definition of experimental geography, recognizing the pluralities, representations and refigurings that bubble within his definition. If we take his active approach to world building, we might take a similarly active approach to sonic creation and consider sonic creation as an act of spatial creation. Said differently, sonic and spatial imaginaries seem particularly well suited for each other. Both are independently autopoietic -- generated and generative, but they unquestionably affect and are affected by the other. I claim studying sound is in part studying space, and studying space is in part studying sound, and that experimentation in one is experimentation in both. Sound mapping, then, is a notably explicit intersection of space and sound studies. In 'Sonic Possible Worlds,' Salome Voegelin claims sound mapping may show us "the world through relationships and processes, reminding us of the ideological and aesthetic conditions that determines any sensory engagement" (2014 p. 10). It is this very potential I would like to explore and the following section investigates sound mapping practices, particularly in the digital domain.

V. THE SONIC SURROUNDS, URBAN SOUND EXPLORATION, AND SOUNDMAAPPING

Soundmapping offers rich potential to tap into to the non-visual nature of being in space. According to Raimbault and Dubois the soundscape “accounts for the relationship between the individual experience and subjectivity with a physical and sociocultural context” (2005 p. 310). Samuel Thulin proposes a five-part taxonomy of “cartonophy” -- defined as the union of sonic and cartograph practices -- sound-as-map (sounds carry distinct, place based meanings), sound-into-map (sound as a tool to visualize un-reachable space), map-into-sound (cartographic sonification), maps-of-sound, and maps-of-sound-as-interface (union of previous two categories) (Thulin 2018). Thulin equates “map-into-sound” with “cartographic sonification,” a framework particularly well aligned with this thesis. Thulin notes the majority of online sound maps tend to fall under the ‘maps-of-sound’ category, and importantly contends “online sound maps have some way to go in attending to their own potential for performance and performativity” (2018 p. 10). In conversation with Dodge, D’Ignazio, Ribeiro, and Caquard, this notion opens space for artistic sound mapping practices. This section extracts practices of exploring sound in physical space. I look at briefly at soundwalks, and then turn towards online sound mapping, highlighting its collaborative affordances, and noting imaginative limitations.

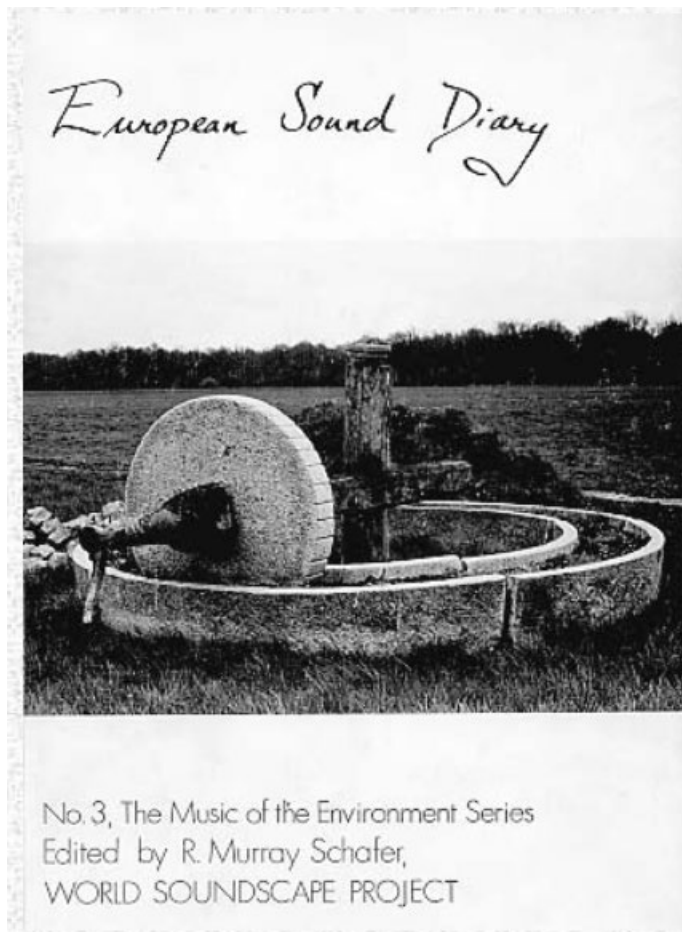


Figure 9. R. Murray Schafer (1972). *European Sound Diary* No. 3

a. THE SONIC SURROUNDS

The ambitious World Soundscape Project (WSP), established by R. Murray Schafer in the 1960s, set out to find ways to balance human communities and their sonic surrounds [1]. While the origins of the project were a practical approach to ‘noise pollution’ in Vancouver, the project’s aims were more broadly concerned with documenting sound and the effects of human activity on the soundscape. Eventually the WSP’s soundmaps became active pieces for communal engagement and

experience. According to WSP member Helegard Westerkamp, “a soundwalk is any excursion whose main purpose is listening to the environment. It is exposing our ears to every sound around us no matter where we are” (Westerkamp 1974). The maps guided users through space, suggesting things to listen for, posing questions, suggesting next stops [2]. In this way, WSP researchers were in direct communication with soundwalk participants and participants were active explorers of the city, perhaps with new knowledge, or perhaps with a new means of attention, a heightened awareness of the senses.

b. HEARING IN PLACE

A number of beautiful projects follow the legacy of the World Soundscape Project and embrace sound as a deeply meaningful way of engaging with and understanding space. The following research and projects I present are about being in a place. They move beyond taking sound for granted, away

from passive hearing, and towards active listening. Some emphasize sound as way to evoke memory, to re-remember and re-experience place. Others propose something closer to a soundwalk, letting the sounds of the space envelop and ensound.

Sandra Jasper writes beautifully about unique acoustic spaces of Western Berlin. Here, the landscape itself inspires landscape design, and in turn, the landscape produces the soundscape. Jasper looks at the work of Gerhard Beck, who used plants as materials for sonic experimentation, and as a potential balm to addressing an ever-noisier industrializing city (2018). Beck's experiments were place specific, with deep care for the affect of sound in between different plants, at different times, under different conditions and this example highlights the ways sound spaces are affected by a confluence of socioeconomic factors.

Alex Braidwood, and his 'Listening Instruments' projects focus on the relationship between people and the sounds that ensound them. He presents a series of soundwalks, one of which is "Hear Below: Listening to Chicago Underground", a journey through Chicago's pedway system, and invites listeners to shift focus from the visual to the audible (2020). [3]

These projects are sensuous and engaging; they promote new ways of being in an interacting with space, and arguably better capture the spirit of Lefebvre's *rythmanalyst* (2004). Still, as web-based mapping continues to shift and shape our understandings of place (Giaccardi, Fogli 2008), I'd like to turn my focus to the digital realm and explore representational sound mappings.

c. THE SOUNDWALK GOES DIGITAL

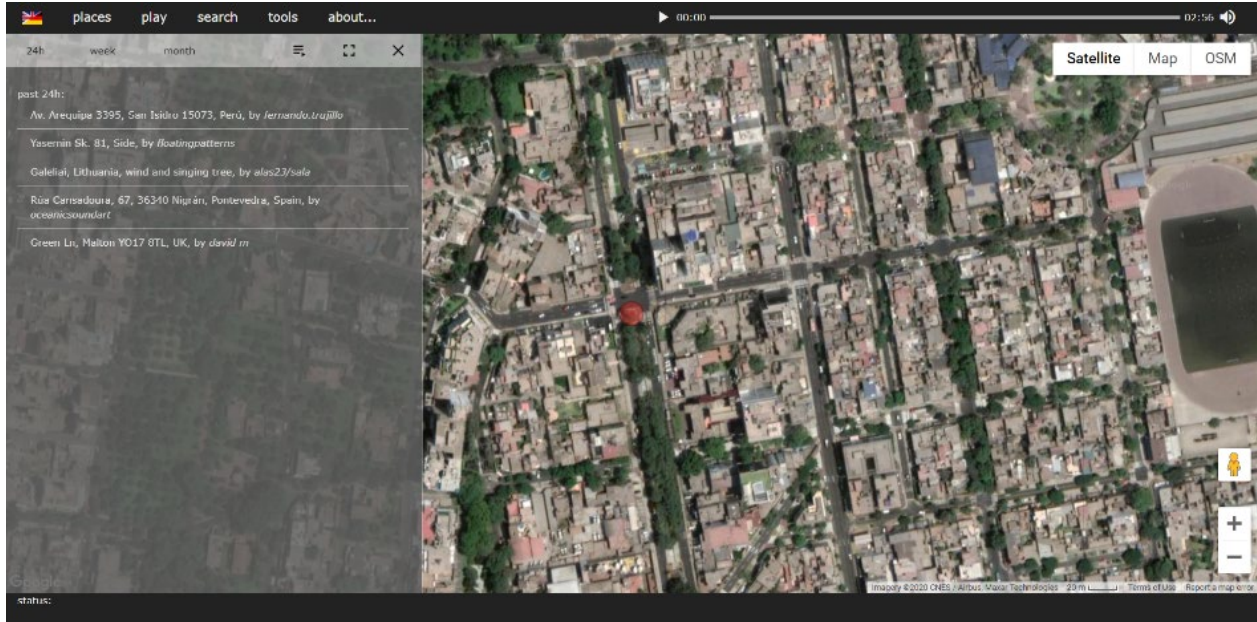


Figure 10. Screenshot of Radio Aporee Interface taken from

With the proliferation of online mapping, soundwalks have been digitized as well. Largely thanks to what is known as the “geoweb”, an infostructure through which users can navigate a variety of geotagged data, users can access and share place-based information with great ease (Fogli, Giaccardi 2008). Through the geoweb then, whether laying data of physical world, or user experiences, sound becomes another potential data overlay. Often, sound mappings take the form of communal projects in which a diverse group of users can upload data to the map, generally called Volunteered Geographic Information (VGI) (Goodchild 2007). Under this framework, users from around the world are able to record and upload sounds, generating a map¹. The geoweb is primarily representational, focused on fidelity and data driven information over the perceptual and affective qualities of a space. To be sure, these goals are entirely appropriate; the contention here is only that there is room to expand cartographic semantics. The following sound mapping projects all recognize the sensuous potentials of

¹ Still, Wen Lin notes these maps, too, fail to foster quite the degree of collaboration we may attribute them. As it stood in 2015, 70% of sound map uploads came from males between the ages of 20 and 50 (Lin 2015)).

hearing a space and recognize the import of sound in understanding a place. They poke at what Giccardi and Fogli believe to be ‘the future of the geospatial web’ – one that incorporates ‘personal meaning’ and is driven by affective geographies (2008).

Radio Aporee provides a richly cited case study in online soundmapping platforms (Thulin 2018, Waldock 2018, Lin 2015). [4] The project is effectively a crowdsourced database of field recordings. It is a profound repository of sound information from around the world and works to expand traditional cartographic practice by incorporating sound and democratizing contribution. Using Google Map’s street view interface, visitors to the site can search for places or sounds, effectively accessing soundscapes from around the world (see Figure 10). Users can also click on a place to add a recording (with some quality and content restrictions), favorite places, and choose to play a randomized collection of soundscapes.

Further, Daniela Fogli and Elisa Giaccardi’s work on the collaborative sound mapping platform TheScilence.org emphasizes the way “sound represents a personal and powerful way to remember, re-encounter, and gain new understandings of everyday space” (Fogli, Giaccardi 2008). Their work involved a pilot field study in which 20 users were asked to contribute sound recordings to a collaborative map. At the conclusion of the study, they asked users to share experiences and thoughts on acoustic maps, some of which I quote here for their direct emphasis on user experience of sounding maps. In response to traditional picture-based web sharing applications one participant notes, “sounds are more intimate... pictures feel more detached... sounds feel more like being immersed in the experience” and another responds, “sounds have more room for the imagination” (Fogli, Giaccardi 2008). Their direct engagement with participants provides insight to the affordances of sound, and the validity of engaging other senses in processing maps.

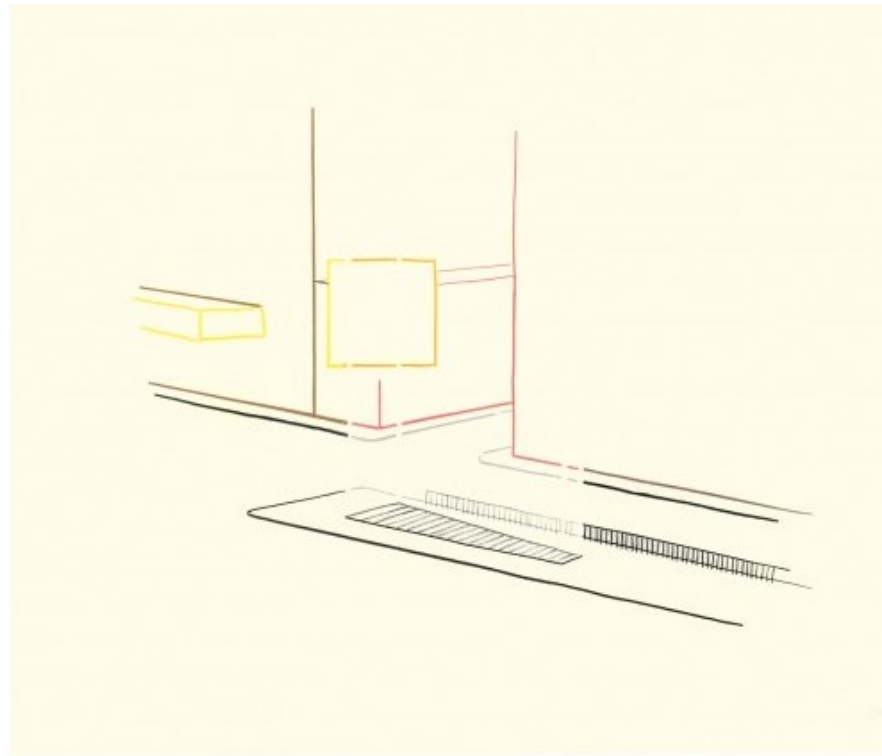
There are a host of online platforms that provide similar experiences, generally with more place-specific ties. Limerick and Toronto, along with the China Sound Map all have local versions of digital VGI sound maps (Waldock 2018, Lin 2015). While these mapping practices do work to expand traditional cartographies and broaden experience within digital mapping platforms, the emphasis is generally on high fidelity recordings, tied to precise geographic coordinates. The base layer of the map reigns and the sound is an overlay, a clickable datapoint if one so chooses. To consider the range of emotional productivity of sound and space, one may turn to sound art, and continue inquiry regarding intersections of art and cartography. From here, this work responds to Thulin's calls for performativity in sound mapping. The following section focuses on sound art as a practice from which to draw inspiration.

VII. "Sound Art", or Other

a. SOUND AS MEDIUM

The past 40 years have seen a proliferation of what has been called 'sound art', in which artists have tapped into the evocative nature of sound and its capacity to foster new ways of understanding and experience. I put "sound art" in quotes because other terms seem equally suited: 'sonic art', 'sound poetry,' 'sound sculpture,' and 'experimental music' are often used interchangeably, and the merits of departing from pure 'music' is open for debate (Dunaway 2020). "Sound art," is, in the words of Christoph Cox, "a thorny label... like any label it is clumsy and inexact" (2018 p. 20). Cox goes on to clarify sound art and music are not altogether distinct, and that it risks a certain reductivity in housing a broad heterogenic field under one roof (2018). Still, he finds merit in the term claiming, it "allows the critic, theorist, or artist to redraw the boundaries in revealing ways, to demonstrate material and conceptual connections among disparate practices and media" and considers the term not a genre but a 'conceptual device' (2018 p. 20). I follow Cox's lead and also employ the term 'sound art' throughout the

piece as a lens to tap into sound across physical and virtual, melodic and ‘noisy’, natural, manipulated, and manufactured domains.



Max Neuhaus, *Times Square*, 1992. © The Estate of Max Neuhaus

Figure 10. Max Neuhaus (1992), *Times Square*

Max Neuhaus is one of the first artists to be credited with using sound as his primary medium, and his seminal 1997 work *Times Square* places resonant sound drones underneath a grate in Times Square (see Figure 10). [5]² His work draws attention to sound in public space, jolting the passerby into a new awareness. Other early sound artists are La Monte Young, Alvin Lucier [6], and (until recently, under-cited) Connie Beckley, Maggi Payne [7], and Julia Heyward [8] (Cox 2011, Dunaway 2020).

b. THE SONG OF THE SPACE

In December of 2019, Interfaces hosted a conference, producing research titled “atlas: a sound cartography of Europe.” In this work three composers, Dimitris Kamarotos, Carmine-Emanuele Cella,

² Interestingly, Neuhaus himself later disavows the label ‘sound art’ (Neuhaus 2000)

and Vaerio Tricolo, located in Athens, Paris, and Karlsruhe, respectively, collected sounds from the public to use as part of their compositions. They worked together along with video artist Marine Gioti to produce a performance that simultaneously represented these three cities (Interfaces 2019). The work combines sound and video, and utilizes sounds both real and composed to generate an innovative narrative of space as collaborative and sounding. The result emphasizes the importance of sound in spatial storytelling and demonstrates the effectiveness of audio as part of novel cartographic practice.

c. SONIFICATION: DEFINITIONS, APPLICATIONS, FUTURES:

To ‘play’ the city is to sonify the visual in this thesis. Simply put by Winters and Wanderly, “sonification is an interdisciplinary field or research broadly interested in the use of sound to convey information” (Winters, Wanderly 2013, p.1) Similarly, Kramer et. al define: “sonification is the transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication or interpretation” (Kramer et. al 1999). These definitions are pleasantly broad and Kramer’s work importantly notes the interpretative nature of sonification. The process of sonification generally involves representation by means of matching data and parameters. In this case, the data is pixel-based – it is the landscape passed through a computational lens. As Walker and Nees point out, sonification draws from and is used within research and design processes including but certainly not limited to audio engineering, computer science, linguistics, music, psychology, and telecommunications (2012).

Further, Walker and Nees describe three domains under which auditory displays have been used: alarms and warnings, status process and monitoring, and data exploration, finally appending art and entertainment to the list of functionalities (2012). In this description they note the relationship between computational capacity and computer music, and note the potentials for events to serve as the basis for a musical score, claiming “while the composers often attempt to convey something to listener through these sonifications, it is not for the pure purpose of information delivery” (2012, p. 5). Similarly, in this work I hope to convey geographic affect through sonification – delivering a way of thinking about and experiencing a place, rather than representing specifics or relaying data. In the words of Cox “music has always been recognized to be a non-representational art, lacking the tow-tiered structure of reference characteristic of words and images... musical tones and works are not signifiers, not media for the expression of semantic content” (2011, p. 148). Along these lines, Walker and Nees lead us through a ‘semiotics of sonification,’ that exists on a spectrum ranging from analogic to symbolic (see Figure 4) (Walker, Nees 2012). At the analogic extreme, sounds are most explicitly related to their referent, on the symbolic end, mappings are arbitrary. This work positions itself firmly in the symbolic realm; thus,

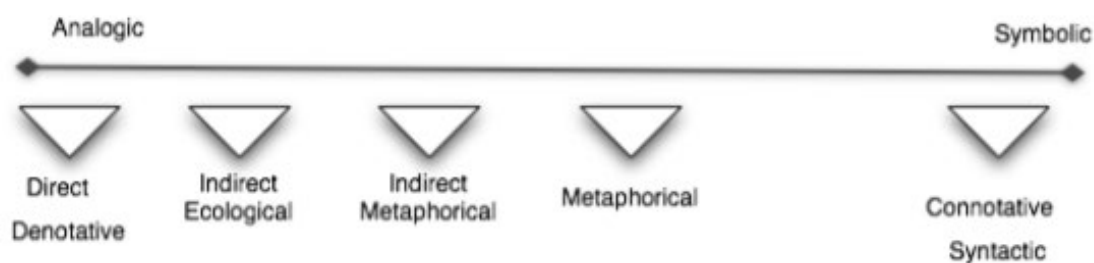


Figure 4. Semiotics of Sonification: Analogic sounds explicitly relate to their referent, symbolic sounds are arbitrary while representational, it is symbolically and performatively representational, and this abstraction, I hope, allows it space within a *non*-representational affective, psycho-geographic practice.

In exploring the potential for a sonification mapping database, Walker and Lane identify open questions in sonification research (2008). In short, there is no one way to determine what sounds are best for a given data type. Walker and Lane describe three essential elements to sonification design, all

of which highlight the deeply personal choices involved in a sonification. First, one must know the nature of the mapping, what dimensions of the data are being mapped, and what acoustic parameters (frequency, tempo, etc.) will be used to represent which data. In this case, the data is a video, and the question is what data to extract and then map from the stream. Second, one must consider polarity. Does an increase in measurement correspond to an increase in acoustic parameter (up-up polarity³) or vice-versa (up-down polarity)? The final consideration is the scale of the mapping: how much should an acoustic parameter change in response to a change in the data (Walker, Lane 2008)? These questions remain open across sonification applications and are addressed in the case of the urban environment throughout the methods section. But Walker and Nees open another, more abstract, and arguably more relevant question, stating that “questions of aesthetics and musicality remain open in the field of sonification.” In the following sections, I begin to investigate these open questions as I seek an evocative, potentially musical sonification of the environment.

d. SONIFICATION AS AN ART

Other sound artists explore Walker and Nees’ question of aesthetics and musicality, using data as medium and sonification as a tool.

Sonification provides an epistemic transfer of knowledge: as data is converted to a highly sensual domain, ways of knowing are expanded. Sonification has been applied across a variety of disciplines; in the methods section I elaborate on the

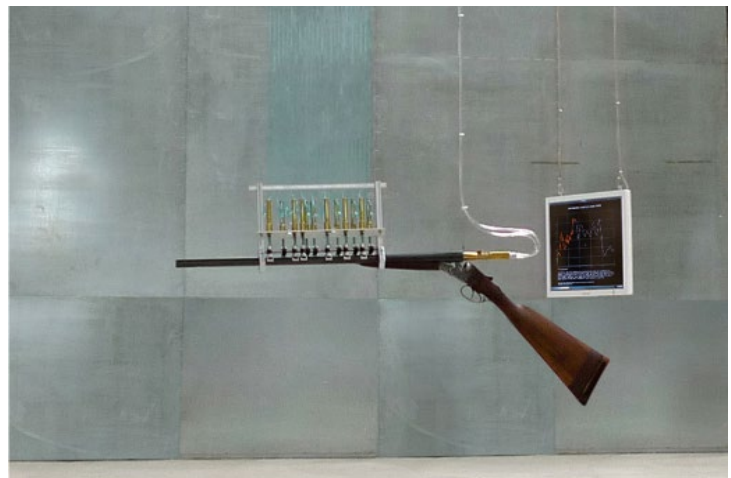


Figure 11. Constantine Zlatev (2012). *The Last Gun*

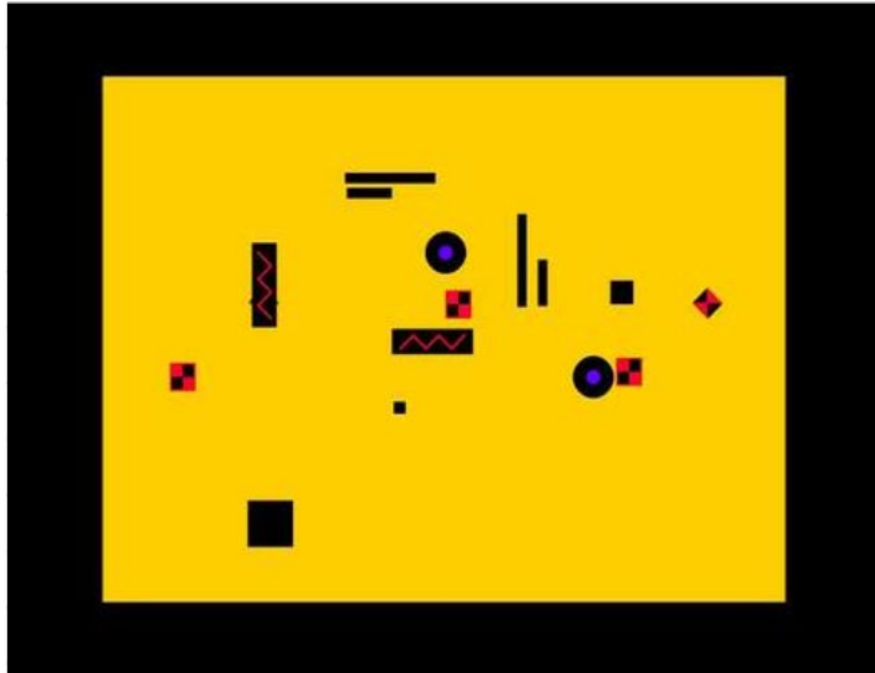
³ Up-up polarity refers to a mapping in which an increase in measurement corresponds to an increase in acoustic parameter. For example, increase in temperature increases the volume parameter. Up-down polarity, on the other hand, would mean an increase in temperature decreases the volume.

background, process, and further applications of sonification. Here, I focus more specifically art, allowing us to return to Sterne on ‘the poetics of signal processing.’ (Sterne 2011). Constantine Zlatev’s work “The Last Gun” is a suggestive sonification of weapon exports at the end of the 21st century (see Figure 11). Here, Zlatev makes a clear statement of intentionality and subjectivity in the sonification process, highlighting the protentional for provocation and emotional understanding to hearing data. Of the work, Zlatev states, “The flute’s aural response is based upon a value judgement. It is programmed to play a somber melody for every rise in arms exports and an upbeat tune for every year the arms exports drop” (Zlatev 2012) [9]. Other sonification experiments are less about sound as a medium towards new ways of understanding and more about sonification as synthetically generative. Twinthesis takes public tweets as its base and generates music by sonifying ascii characters. Here, the intent seems more purely generative – while it plays nicely with the metaphor of the ‘tweet,’ it makes no suggestion, rather uses data as an experimental process in sound production (Harman 2011). [10]

My sonification, however, takes visual, spatial information as its dataset. The collection of videos, a series of maps in and of themselves, become musical maps as well. In this process they become a form of notation, and considering them as such follows a history of experiments with audiovisual transcoding.

VIII. Sounding Pixels

“My dear musicians, my dear painters: You will see through your ears and hear with your eyes...! The electric spectrophone will obliterate your ideas of sound, color, and form” – Raoul Hausmann, (from Xenakis’s UPIC to Graphic Notation Today, 2019, p. 491)



Furukawa, Kiyoshi; Fujihata, Masaki; Münch, Wolfgang, «Small Fish», 1999

Figure 12. Kiyoshi Furukawa, Masaki Fujihata, Wolfgang Munch (1999). *Small Fish*

This is not a thesis about computer music, per se, but in this brief section I hope to situate musical composition as one of the earliest examples of computational design. The origin stories of music in Greek mythology offer fascinating insight to a divergence in thinking about music, a divergence that plays out nicely when thinking specifically about computer music. In one story, music is born from Athena’s vocal lamentations of Medusa’s death. Here, the aulos is the result of an impassioned emotional outpouring. In a different story, Hermes invents music through a physical experimentation with a turtle shell. Here, music is innate and discoverable property of nature, guided by the laws of physics, and mathematically predictable. Schafer describes the aulos as Dioysian: irrational, subjective,

and unpredictably expressive. The lyre, on the other hand is the Appolonian: ‘exact, serene, mathematical’ and ‘based on number theory’ (Schafer 1977 p. 6). Cox extends this argument and continues to theorize a divergence in thinking about sound, claiming, “Descartes (1961[1618]) could write of music that ‘its aim is to please and to arouse various emotions in us” (p.11). While Leibniz (1989[1714]) could claim that the beauty of music ‘consists only in the harmonies of numbers and in a calculation that we are not aware of, but which the soul nevertheless carries out’ (p. 212)” (2011, p. 149). These stories and varying analysis offer fascinating insight into the ways that music is considered as both a very mathematically describable and as a highly emotive, evocative medium. The computer, in this case an early example of computational design, specially allows the merging of these two notions.

The precedents detailed here fall under our broader definition of sound art; I choose to distinguish them because these examples speak more directly to the affordances of the computer in the production of sound and emphasize the legacy of the computer as a tool in the creation of sound art. This section is not a section on computer music, or broadly on experimental music. The particular focus of this section is the role of the visual in generating audio, and the ways that notation, instrument, machine, composition, composer, and musician were affected by specifically digital technologies. I do not address a beautiful history of alternate notations, of improvisational jazz scores, another site of graphic experimentation in music notation (see Cox 2018 for these). Instead, I stick to the ways that computers inspired experiments with notation, scores, and sounds. I start by looking at the relationship between sound and visuals in film in the 1930s. From here I jump to the 1970s and the development of the UPIC by architect Iannis Xenakis, concluding with a few contemporary projects that similarly work to transcode visual into auditory realms. Here we return to the more explicitly Apollonian or Leibnizian understanding of music – music as an “unconscious exercise in arithmetic.” (Found in Weibel 2019, p. 19 citing: G.W. Leibniz in a letter to Christian Goldbach, April 27 1712: “Musica est exercitium arithmeticae occultum nescientis se numerare animi,” in Oliver Sacks, *The Man Who Mistook His Wife for a Hat* (New

York: Summit Books, 1985)). These sorts of arithmetic exercises are allowed even more explicit expression in a digital environment. Peter Wiebel claims “**music is the scene of perhaps the most daring artistic and technical revolution of the twentieth century**” (Wiebel 2019, p. 23). In what follows I hope to demonstrate audiovisual works as informed by and informative for, developing technologies. Further, this section grapples with relations between composer, composition, musician, and instrument, and motivates geographic videos as a form of musical notation.

a. AN AUDIOVISUAL PREOCCUPATION

In the 1930s, Dada artist Raoul Hausmann declared “We demand electric, scientific painting!!! The waves of light different only in their length and frequency” (Weibel 2019, p. 491). With this sentiment he gets at an implicit understanding of sound as the physically representable, an effective series of sine waves. Hausmann went on to create the Optophone, which electronically translated light beams into sound waves and sound waves into light (see Figure 13). Hausmann’s vision sets away from a hierarchy of the senses and calls for a fusion of artistic forms. It embraces relationships between auditory and visual senses and sonic and graphic art forms.

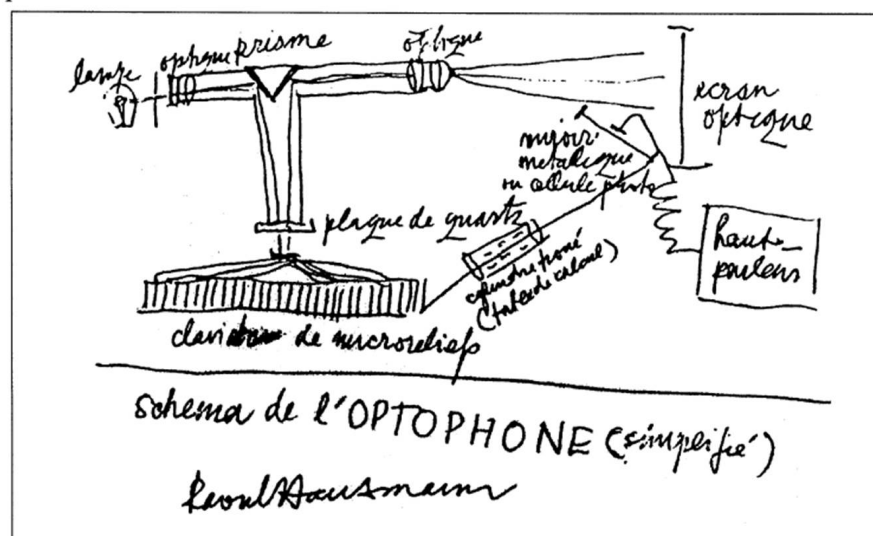


Figure 13. Raoul Hausmann (1936). Optophone

Interestingly, early film technologies necessitated audiovisual harmony. In the 1930s, optical sound was used instead of magnetic recordings meaning audio and visual information lived on the same filmstrips (see Figure 14). This, Weibel continues, allowed Fischinger to ask, “what are the sounds in the

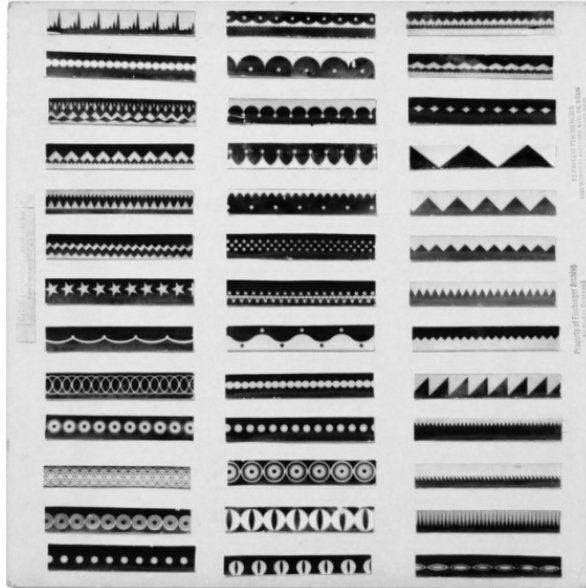


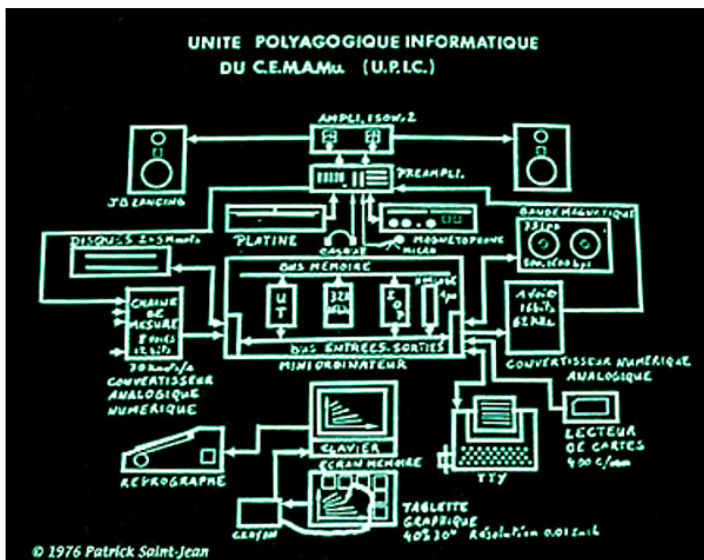
Figure 14. Oscar Fischinger (1930). *Sounding Ornaments*

objects?” He considered these shapes to be “drawn music,” which Weibel claims is another word for graphic notation (2019 p. 494). [11, 12] In 1932 Rudolph Pfenninger filmed patterns on paper to include in an optical soundtrack [13], Dapne Oram produced audio waves from scanned pencil curves [14, 15]; by 1959, Jose Reidel created the first binary electronic music composition for a documentary *Impul unserer Zeit* (The Impulsion of

our time) (Weibel 2019). These examples brought about what Weibel describes as ‘a crisis of notation’: with new tools, “conventional notation was no longer sufficient. Thus, the development of graphic notation and musical graphics began in the 1930s and burgeoned in the 1950s” (Weibel 2019, p. 506). Arguably, reading notes is a way of translating image into sound, and the works of Anthony Braxton and Cornelius Cardew in the 60s and 70s challenge the classical musical score through further abstracted symbols (Cox 2018). Without precise semantic rules, the composer leaves room for experimentation and guarantees no two such readings of the piece will be performed in the same way, allowing for an endlessly generative set of guidelines. While technicalities of definition: ‘musical graphics’ as opposed to ‘notational image’ as opposed to ‘visual music’ are contested, they all point to a frameshift in music in response to new technologies (Weibel 2019).

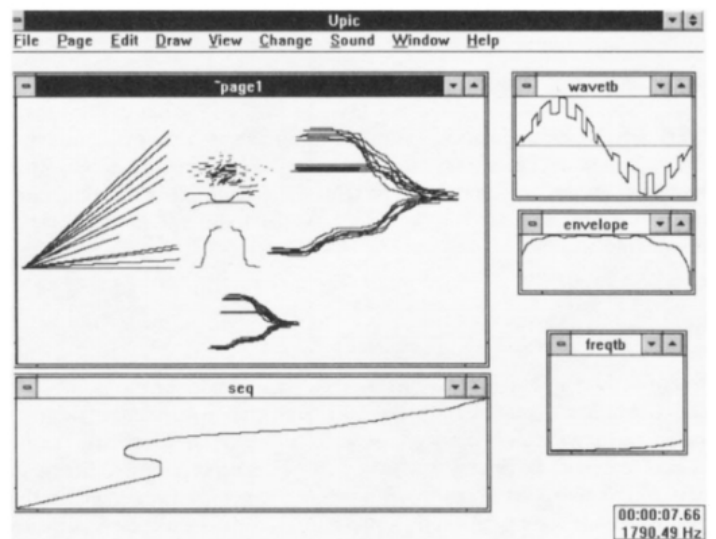
b. EXPANDING NOTATION THROUGH THE COMPUTER

The Unite Polyagogique Informatique de CEMAMu (UPIC) was conceived by Iannis Xenakis and developed by Guy Medigue in the late 1970s. It was a revolutionary instrument that essentially allowed one to draw musical compositions (see Figure 15). [16, 17] The drawings, represented on two screens: one analogue, the other digital, were sent to an analogue-to-digital (ADC) device that translated the graphic coordinate system into numeric information that was then translated to sound material. The design and object of the UPIC system can be seen above, respectively. The upper left hand panel is the drawing, and the surrounding windows show the way the image affects different sound parameters.



A screenshot showing the outline of the UPIC system. This image is taken from the documentary by Patrick Saint-Jean, the engineer who designed the UPIC together with Xenakis.

Figure 15. Screenshot of the outline of the UPIC system



EXAMPLE 2: THE UPIC OBJECTS

Figure 16. the UPIC interface

More recently, a variety of projects have worked in this domain of expanded notation. Small Fish presents a clear descent of the UPIC. Created by Kiyoshi Furukawa, Masaki Fujihata and Wolfgang Munch (2009), Small Fish was originally created as part of a ZKM digital arts series, the work is now available as an app. [18] The app's graphic user interface allows visual objects to generate musical scores (see Figure 17). The creators claim the interactive component positions the app as a musical instrument -- the user a musician who manipulates sound through image. Current instantiations of

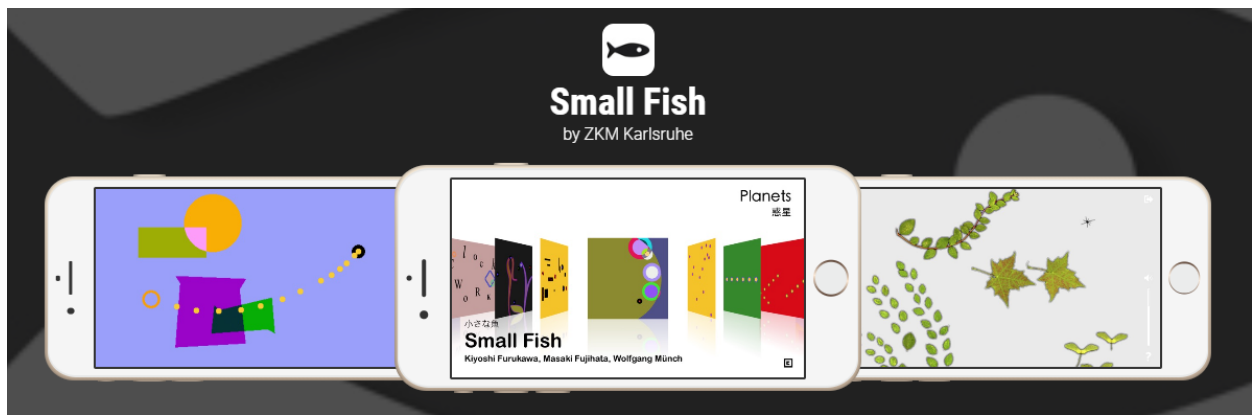


Figure 17. Screenshot of Small Fish App, taken from Apple App store

audiovisual transcoding's demonstrate a continued interest in audibility, on the relationship between seeing and hearing, and prove that computational tools work as an interesting lens through which to explore relations between these senses.

Taken together, sound art, for its recognition of the importance of sound in perception, and sonification, for its ability to translate between different ways of knowing, offer rich potential for exploring psychogeographic landscapes. My thesis lies at the intersection of the above processes: it is a sonification, a "sound art", and a highly abstracted map in which spatial information is used as notation towards a composition. It is a map in its representation of geographic space; a map allowed if one utilizes definitions of geography and cartography defined above.

Before moving on, I hope I've effectively touched on the ways that artistic cartography opens space for thinking about sensory, localized, and temporal mappings, emphasized the importance of

sound in expanding the range of sensory involvement in mappings, and highlighted the ways that visuals have served as audio maps for decades now. My work draws on all these practices, essentially proposing that mapping place is a compositional activity and compositions can be written and read as mappings. From here, I describe my technical process of weaving these practices, of creating and mapping sounds, and of crafting new forms of spatial narration.

METHODS

From here, I describe my approach to sonification and the present-day digitized mapping of the derive. The methods section will walk through the process of translation between the visual and sonic domains and clarify my approach towards a final composition. I begin by identifying the site and collection methods, describing a process of noticing that draws on ethnographic approaches to ‘doing nothing.’ From here, I move on to describe processes of data extraction and representation, elaborating on the computer vision framework I used to identify different aspects of the environment. Finally, I describe the sonification process, specifically looking at the design choices made in regard to feature mappings that drive the sonification. The sonification aspect of the thesis process is highly personal: virtually every mapping used was determined by a personal relationship to both the environmental surrounds and aspects of musical compositions. The work contributes a rigorous case study in cartographic sonification that bridges and extends experimental geography and composition by mapping segmented visual streams to audible parameters, ultimately creating a generative composition that tells an evocative story of place. My methods are intended to foster new techniques of recording and mapping ideas and experience. They begin to fill some of the performative gaps identified by Thulin (2018) and speak to the artistic and aesthetic potentials of sonification noted by Walker and Nees (2012).

I. Site, Capture, Collection: What I see

As Covid-19 devastated the globe, many took to walking as a brief respite from the relentless presence of whatever shade their wall was painted. Walking became change of scenery away from the designated four walls, and the breath of fresh air that was no longer required (arguably discouraged) to make it through the day.

There are phases of building a relationship to a space. To be new to the space is to feel stimulated and excited, a flooding of the visual senses, a hopefulness that accompanies the new. And then there is the familiarity that sets in, there is knowing where you will come across the seafoam house, the caved in porch. I have always been a walker. I have always been deeply affected by space and have always found my mental landscape to be radically influenced by my physical surroundings. I have always loved anomalies, seeing the details, the beauty in the banal. This thesis celebrates that and hopes to inspire others to find ways of representing, reflecting, and understanding their experience in place.

a. SITE:

The site was the mile radius around my apartment. It was the streets I know too well for my own good, the blocks that have served as a respite from the inside of my apartment (see Figure 1). I live in Shadyside, Pittsburgh, PA. A generally residential neighborhood, my apartment is situated around many homes and next to a commercial block with a few restaurants, a consistently busy bakery, a shop of bizarre toys, and the Gap. The streets are small, the speed limits are slow. There are generally people strolling, some shoppers, some runners. People tend to their gardens and sit on their porches. My feet have carried me down these blocks countless times, in countless weather patterns and through countless moods. They are sometimes old, dull, and predictable; sometimes teeming with impossibly

intricate details. These walks and what I captured was personal. I took notes on the anomalies while I went (See Appendix C). For me, this is what makes being in a space fun.



Figure 1. Map of Shadyside, walking radius, green dots are origin points of day's stroll

The site was temporal as well: from January to May and between the hours of 4:30 and 5:30 PM. I wanted to say something about the way the space changed over time, wanted to capture what it means to wander through gray slush or blossoming spring. In their work, 'Theory of Sonification' Walker and Nees claim "auditory displays exploit the superior ability of the human auditory system to recognize temporal changes and patterns" (Walker, Nees 2012, p.2) Part of the curiosity of the thesis is how effectively the sonification would be able to capture this change, how the composition might be able to evoke a sense of change in a way that vision could not. More explicitly, I claim that the temporality of

this work is essential in attending to affect. Speaking to the affordances of sonification, Walker and Lane claim “auditory displays exploit the superior ability of the human auditory system to recognize temporal changes and patterns” (2012, p. 2). One of the primary aims of the project is to understand affect not as constant or given within a unique place, but rather to trace affect across days, weeks, seasons. To hear certain fundamental consistencies in concert with everchanging variables, is to access affect.

Finally, the site of the final work is static and sonic. It is static in that it exists to be accessed from anywhere, it lives at one virtual address. In the spirit of the ‘GeoWeb,’ (see Soundmapping) the final piece allows one to access certain aspects of being in a place from miles away.

B. CAPTURE, COLLECTION:

As for the capture, I used my iPhone. The intention of the thesis was not to capture high fidelity recordings of the space, rather a sense of being in the place. It was intentionally a little mundane, much like the afternoon stroll. On these daily walks I would, at some point, pull out my phone to capture a 30 second clip of where I was (see Figure 2). I carried forward, my phone in front of me. These recordings are discrete blocks of the broader composition. Together, over time, I hope they capture what it was to walk around the blocks around my house over the course of a few months in quarantine.

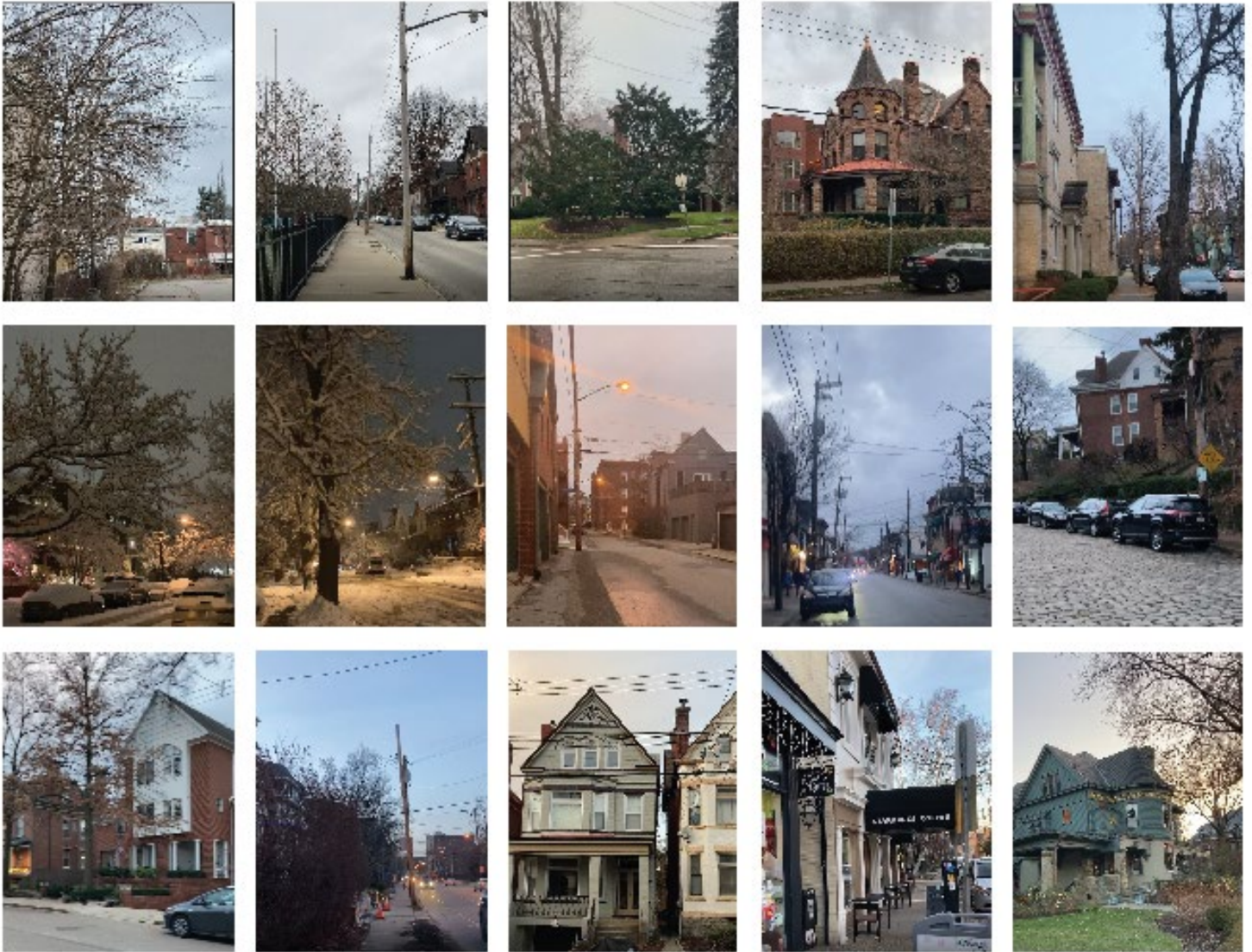


Figure 2. Stills from video recordings

The videos were not the only aspect of the collection. I took a few small notes each day on the things I noticed that I knew wouldn't be represented in any sort of computer vision model, or whose strangeness would not be captured. (It's one thing to recognize a traffic cone, it's another to recognize a traffic cone on the top of a roof). There would be a distinct lack of exactly what it is that makes being in a space visually exciting. So I wrote them down (See Appendix C). I recorded the temperature and the technical time of the sunset. I calculated the average brightness of the recording. I recorded the latitude and the longitude (See Appendix A). These aspects of the day would prove to be essential pieces of data

in the sonification – they generally set parameters that would be used across distinct elements of the composition. In order to set and map these distinct elements, I investigated a computer vision model that would help me to isolate and sonify aspects of the urban environment. What follows is a description of the model, and the mappings it inspired.

II. Object Identification: What the Computer Sees

In order to ‘play’ the landscape, there was the natural question of how to encode spatial features. Elements of the terrain from trees and poles to roads and cars were key components of the sonification input. The task in this stage was to ‘recognize’ a set of objects, and features in the scene for integration in the composition. First, I run a simple Canny Edge Detection algorithm in CV2⁴. Then I move on to a semantic segmentation model that assigns each pixel to an object class. Specifically, I used TensorFlow hosted DeepLab3+ model, “a state-of-art deep learning model for semantic image segmentation, where the goal is to assign semantic labels (e.g., person, dog, cat and so on) to every pixel in the input image” (Chen et. al 2018). The DeepLab models were trained on several datasets, including PASCAL VOC 2012, Cityscapes and AED20K. As part of the model, they provide checkpoints in the training process, available on TensorFlow as frozen graphs. This is effectively a graph that can no longer be trained; it contains the hyperparameters and constants at the given checkpoint. While a saved graph contains gradients at each point for further training, the frozen graph discards the previous gradients, making it a lightweight model, usable on a local desktop.

⁴ https://docs.opencv.org/3.4/dd/d1a/group__imgproc__feature.html#ga2a671611e104c093843d7b7fc46d24af



Figure 3. DeepLab Output

I used the `Xception_71_dpc_cityscapes_trainfine` backbone trained on the Cityscape `train_fine` set from the TensorFlow model zoo (Chen et. al 2018). The Cityscapes Dataset is set intended for use in understanding urban street scenes. (Cordts et. al 2016). This dataset draws from 50 cities over the spring, summer, and fall months and includes 5,000 finely annotated images and 20,000 coarsely annotated images. It has 30 class definitions, all related to urban space. Examples include roads, cars, poles, buildings, vegetation, and people (see Appendix A, Cityscapes Classes). Given the semi-urban nature of the site, the classes of the Cityscapes dataset seemed especially useful for encoding spatial features. I ran the model on each of the collected videos, and would later use the class identifications as mappings in the sonification (see Figure 3).

In effect, each frame became a 2D matrix in which a pixel was given an integer corresponding to one of the Cityscapes classes. I used only the first 120 frames of each video, and ultimately condensed the day's video into a nested dictionary where frame numbers were the keys, the Cityscapes classes were the nested keys, and pixel counts of each Cityscapes class were the values (See Appendix B, Day Dictionaries). This would ultimately allow for the calculation of the relative presence of the classes in the matrix.

From here I describe the process of translating these dictionaries, along with previously mentioned (see 'Collection') elements of the landscape into a sonic composition. In the following section on sonification I begin with a formal discussion of literature and use these discussions to motivate my design choices.

III. Sonification: What the Eye Hears

a. RETURN TO SCHAFER

Thinking through music as an example of computational design, one might consider music as a system, and a system of representable patterns. The briefest of introductions to music theory helps set the tone for the composition process. It is of course worth noting that what follows is a Western-centric relationship between notes; still, this formulaic underpinning rests in many musical compositions and is the fundamental of this work as well. In essence, one way of thinking about music and keys is in terms of octaves – sets of 12 notes. Each of these notes has its own key, and each of these keys have fundamental major and minor chords that are consistently structured in relation to the key note. Musical Instrument Digital Interface (MIDI, see more on MIDI protocol in 'midiUtil_exp_OLD') notes describe keys as numeric integers between 0 and 127. I.e. musical note 'middle C' is mapped to midi-note 60. This mapping is helpful when describing relations between notes. A major cord, for example,

will contain the key note, and notes 4 and 7 above the base. A minor cord, on the other hand, includes notes 3 and 7 above the base. These patterns evoke Leibniz's description of music as unconscious calculations: a clear and consistent pattern obfuscated as one experiences a piece of music.

Schafer, while describing the Soundscape, steps through ways of analyzing sound. In effect, the composition works well with Schafer's soundscape schema of keynotes, signals, and sound marks, defining "*keynote* is a musical term; it is the note that identifies the key or the tonality of the composition... it is reference to this point that everything else takes on its special meaning." (Schafer 1997, p. 9). This definition will prove to be useful in thinking about designing the ambience of the day's composition. The key sets the basis for the day; a great deal of the composition will be influenced by this parameter. Signals, on the other hand are foregrounded sounds and consciously heard, and will draw attention to specific classes of the space. From here, I describe the crafting of these aspects of the composition, and the process of turning what I had seen and felt, and what the computer had identified, into a generative composition.

IV. Design Choices

The design process was winding and involved omission as much as inclusion. I describe my early experiments, the tools used, the process of composition, the setting of global variables, and the more specific class to sound mappings. I discuss the inclusion of visuals in the work. Finally, I reflect on the output, and, in so doing, open spaces for the technical pipeline to serve as a wayfinding tool. As a brief reminder, bracketed and bolded words correspond to sound experiments that can be found and played at <https://rythmanalyst.cargo.site>

a. THE MAX ENVIRONMENT

I used the visual scripting language MaxMSP (from here referred to as 'Max') to do this work (see Figure 5). The Max environment makes it possible to work with the matrix representation of each video frame, along with the daily dictionary entries and allows me to create a continuous, sonically generative video stream. Max is composed of a series of 'patches', made up of objects and messages: messages serve as input to objects. Patches can contain sub patches, and call other patches. Within Max, 'MSP objects' are used for processing audio signals, whereas 'jitter objects' work primarily with visual signals.

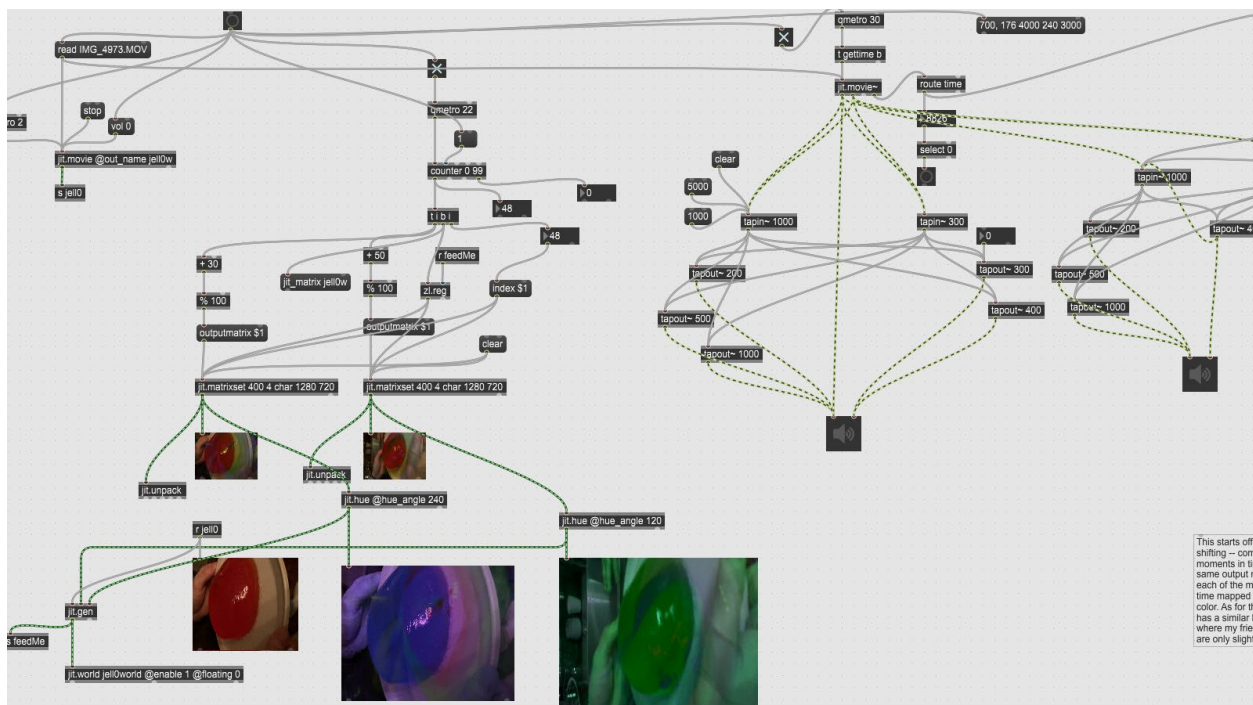


Figure 5. MaxMSP Scripting Environment

Throughout this work, Jitter objects were particularly useful in doing matrix calculations to that served as parameters to MSP objects.

b. EARLY EXPERIMENTS

My first experiment simply involved color and frequency. It was 8 seconds and worked by isolating red, green, and blue color planes, and mapping each color to a specific frequency. **[colors]** This

somewhat of a proof of concept, demonstrating a myriad of aspects of the environment that may be sonified.

From here, I sought to capture the atmosphere of the space by creating an edge-based synthesizer. **[edges]** The contention was that a crowded visual field should produce a crowded sonic landscape, a sparser visual field would yield a sparser sonic field. The process involved running the

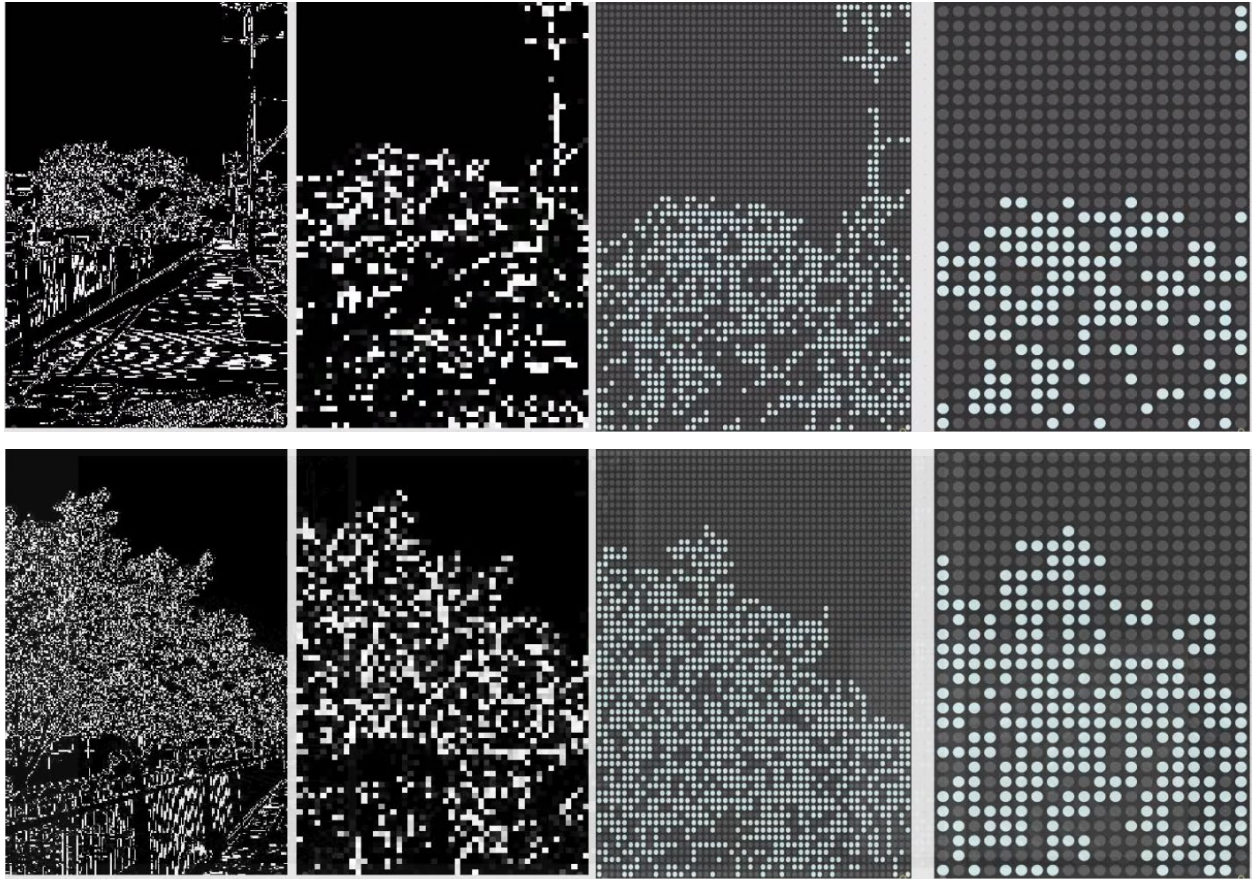


Figure 6. Edge based synthesizer. Top and bottom rows represent different frames from the same video, left to right represents the process of down sampling the matrix. The two images on the right of both the top and bottom rows represent the on/off matrix of the synthesizer. Each dot is mapped to a note, light blue dots are 'played'

videos through a simple edge detection algorithm in python and representing the output as a stream of binary matrices. In Max, then, the matrix is down sampled, to three different degrees, and mapped 1:1 to a synthesizer (see Figure 6). A one in the matrix activates the corresponding note on the synth. Each row of the matrix corresponds to a different frequency and the composition loops through matrix columns, essentially passing a series of chords through a mini synthesizer. This too, was another way of

representing the urban environment, focused not on color but on the crowding of the optic field, and the sort of sounds that may represent the saturation of the visual space.

c. SOUNDING ALIKE

Next, I moved on to sculpting analogic sounds: those intended to explicitly sound like their referent. Here I asked, how can I use musicality to represent the sound of passing cars? **[cars]** How about the sound of falling snow? **[snow]** And what, then, does the snow sound like when it has turned to grey slush? To engineer the sound of the cars, I used a long ramp time, and a resonant bandpass filter. In the end, I decided all forms of transportation (including bus, truck, and motorcycle) would be represented by this sequencer, and the volume would increase with the identification of a truck as opposed to a car. The snow fell through a poly-synthesizer that randomly selected notes in the key of the base note (more on this in ‘Piecing Together’) at the highest octave of said key. The intent of these sounds is a degree of obvious representation, but I also intended to create a composition with a degree of abstraction: the question became how to include these elements as part of a broader work.

d. PIECING TOGETHER

After engineering sounds that I felt would successfully evoke a particular element of the landscape, I turned my attention to the aspects of the composition that would unify the varying components, seeking to evoke the spirit of the day and illuminate atmospheric dynamism. The field of psychoacoustics concerns itself with the psychological import of certain aspects of musical scores. This work is fascinating, but beyond the scope of this thesis. Still, it is well documented that pitch, tempo, and timbre are essential to one’s understanding of music. In the case of experience in a place, I find brightness and temperature to be similarly essential in affecting; therefore, they map to the key and tempo that underscore each day’s composition. In other words, key and tempo are the global variables in each piece: they are the parameters that are used across the varied elements of the score.



Figure 7. Segmented image frame. Vegetation is coded as green, cars as red. This frame, then, will sound particularly of vegetation, the car sequencer will be present as well, but a comparatively lesser volume.

The brightness of the day was calculated by taking a rolling average of the LAB color space across the day. This color space is relevant in the context of this thesis because the *L* of the space refers to the luminance value of the frame, which tries to approximate human perception of lightness. (*L* = 0 is total blackness) The brightness values are responsible for both the key and the tempo, while the temperature affected the octave of the key. Luminance values ranged from 112.61 to 137.97 and were scaled to map to MIDI keys from 48 – 72 (C in the 4th octave to C in the 6th octave), (again, see `midiUtilExp_OLD` for more on MIDI) and to tempos between 200 and 2000 beats per minute. The tempo became slower as the day became darker or faster as the days lightened; the keys became brighter along with the day and were further affected by the temperature⁵. Once the base note of the key had been determined, the full

set of note values in the key were calculated, as were the major and minor cord values. These were the notes and cords to be used throughout the day's composition. The conversion between MIDI notes and

⁵ Days colder than 12 degrees Fahrenheit occur two octaves below the base note, days between temperatures 12 and 25 degrees were one octave below the base note days between 25 and 40 degrees occurred at the base note itself, the pattern continues, the octave increasing as the days grow warmer

frequency values in Hertz (Hz) (the signals used by Max MSP objects) is represented by the formula (MIDI Tuning Standard, Wikipedia):

$Frequency = 440 * \exp(0.057762265 * (x - 69))$ where x is the value of the MIDI note

Max, however, has a built-in object 'mtof' that makes the translation process automatic -- this object is used liberally across the patches. The key and tempo were set as parameters for each component of the composition, thus unifying the day's piece.

I placed the varied elements in conversation with each other by controlling their volume, and therefore their presence in the sonic space. To do so, I simply took a count of each class, divided by the size of the matrix. These values were scaled to a range from 0 – 157 dB, the general range of human hearing. If a matrix is dominated by the integer representing the 'vegetation class, the composition levels for the 'vegetation patch will maintain the greatest presence in the composition (see Figure 7).

e. midiUtil_exp_OLD

At this point, I turned my attention towards a python library called 'midiUtil.'⁶ This library makes it relatively simple to program a composition using the Musical Instrument Digital Interface (MIDI) standard which is, "a technical standard that describes a communications protocol, digital interface, and electrical connectors that connect a wide variety of electronic musical instruments, computers, and related audio devices for playing, editing, and recording music" (MIDI, Wikipedia). This library essentially allows one to compose music via a series of simple python commands: `addProgramChange()`, `addTempo()` and `addNote()`. In particular, `addNote` takes the MIDI note value, the duration of the note and the velocity (better understood as volume) as inputs. My general approach in python was similar to my approach in Max. I set a base note for the key, a base tempo, and calculated the relative

⁶ <https://github.com/MarkCWirt/MIDIUtil/releases>

presence of different classes to set the volume for that aspect of the composition. Scripting in this way had a few distinct advantages. First, it was simple to change between instruments (the MIDI protocol maps key values 1-128 to varying instruments; thus, changing the instrument with the MIDIutil library was a simple act of changing a key value, therefore creating different sounds, and working through whether a cello or harp might be better suited to represent a building, was greatly simplified. Instead of crafting sounds based on a given function's ramp time, one can simply map the channel to a number corresponding with a different instrument. Where in Max the sound of rain was carefully crafted, it is merely represented by number 97 in the MIDI environment (See Appendix A).

However, the results were discretized, and I listened feeling less like I had crafted a composition, and more like I had stacked a set of kitschy instruments on top of each other at the same speed. It didn't sound good and didn't work to capture the feeling of the day – the consistency of the note strikes didn't allow for atmospheric variation. [It is worth noting that the MIDI util library does not allow for manipulation of the full range of information available in the MIDI protocol.] In response, I decided to return to the massively manipulable environment of Max.

f. THE BEAT OF THE STREET

At this point, I considered the features that did not directly 'sound' themselves: roads, sidewalks, additional infrastructure, and buildings. One might consider the pace of the city as set in part by the transit infrastructure. A space that is primarily road, with little vegetation or few buildings might imply a faster, or urgent pace, while ample sidewalk and narrow roads may feel slower, gentler. For this reason, transportation infrastructure (roads, sidewalks, traffic signage) controls the percussive aspects of the piece. There are two primary aspects to the percussion. The first it is maintained throughout the piece, varying only in tempo and volume, based on global variables and the relative presence of infrastructure in the matrix. The sound is the result of a variety of functions (see Figure 8). Images 1 and 2 are

controlled by the presence of the road and will produce smooth and consistent sound drums, with a quick attack and slow delay. Image 3 is set to return a randomized pattern that is influenced by the relative presence of the sidewalk: uncertain rhythmic walking. **[roads]**

The second part of the percussion uses prerecorded drum samples from 'Music Radar Drum

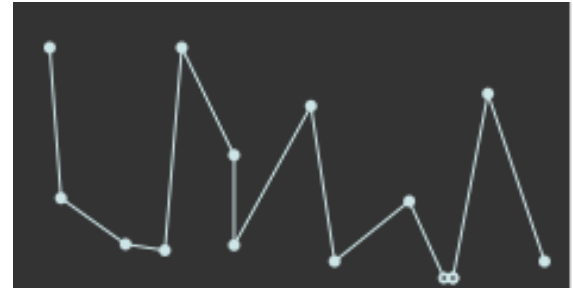
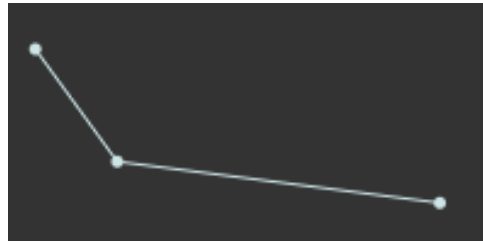
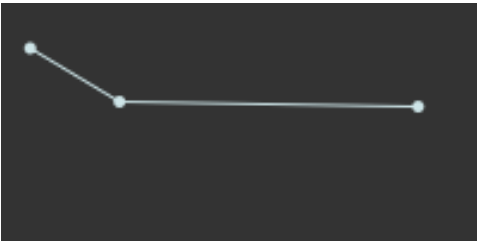


Figure 8. Left to right, Image 1 to 3, Drum Functions

Samples'. The snare, hi-hat, and kick drum are also controlled by transportation infrastructure. Here, different drum sounds are produced by manipulating the signal of the drum sample.

Buildings controlled a string section, making their presence especially notable throughout the composition. Here too, I used a prerecorded sample: one second of a cello stream included as an MSP sample in Max. In this case, the relative presence of the buildings did not only control the volume but shifted the pitch as well. This means a greater presence of buildings produces a particularly distorted and harsher sound. (Future work may involve enhancing the Deeplab model I worked with to include a variety of building types. Houses and skyscrapers surely sound different.) **[buildings]**

Still, the piece lacked an atmospheric quality essential to place. I worked with classes 'terrain' and 'vegetation,' to map to the aspects of the composition I refer to as the 'ambience'. A lushly vegetative scene should, I contend, correspond to lush sonic landscape. A visual space filled primarily with roads and cars will sound, and therefore feel, more barren, more percussive. The most basic aspect of the ambience is simple and consistent throughout the day. It is intended to be entirely background, a mere suggestion of the key. It has no tempo, but it is louder as the presence of vegetation increases, a

sense of calm ambience floating over the piece. The affect is achieved by passing pink noise through highly resonant bandpass filters with a central frequencies of the day's major key cord. **[background]**

In contrast, the second aspect of the ambience is more notable throughout. This piece involves a fair amount of randomness and a simple FM synthesizer with a spectral, tapped delay line. As with the rest of the composition, the key, tempo, and volume are the essential parameters in the mapping. In this case, the brightness also controls the amount of feedback in the system, known otherwise as the 'dry/wet' values. Darker days have more feedback – they are hazier and slower. With less feedback, brighter days sparkle. **[veg1, veg2]**

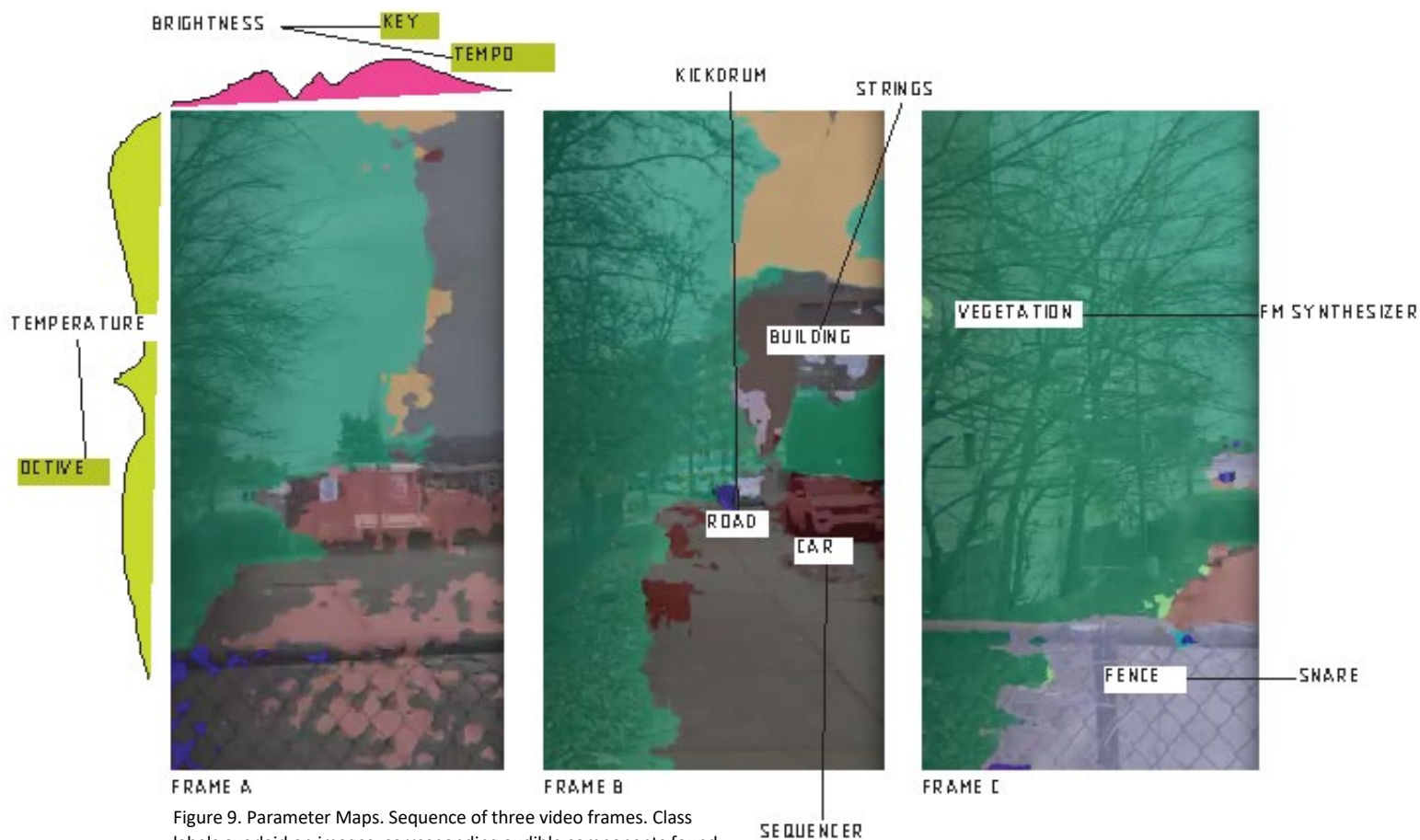


Figure 9. Parameter Maps. Sequence of three video frames. Class labels overlaid on images, corresponding audible components found around the periphery

At this point I had created a map of sorts – a map from the seen to the heard. I had found a way to put these distinct elements of the map together to tell a broader story narrating urban space (see Figure 9). I didn't spend too much time running through specific days – I spent more time crafting specific components. John Cage describes experimental composition claiming, “the word ‘experimental’ is apt, providing it is understood not as descriptive of an act to be later judged in terms of success and failure, but simply as of an act the outcome of which is unknown” (Cage 1955, p. 1) In the spirit of Cage's ‘experimentalism’ I sought to set up a generative system whose production would yield an uncertain auditory experience.

V. Findings

a. LISTENING OUT

The final output is generated continuously – the program is set to run through each day's video without any interference, yielding a singular stream. In the end, the full composition of the day ‘plays’ only the first 20 frames of the video, where each frame occupies for 10 second in the composition. The final work produced an audio stream of 10 minutes and 30 seconds, the culmination of 32 day's recordings in Shadyside from December 2020, through May 2021 (See Appendix B). This stream can be heard at **[full stream]** and the audio visuals can be experienced at **[full stream with video]**. Schafer notes the ‘incompleteness’ of sound diagrams and efforts to visualize sound (Schafer 1977 p. 126). Still, the spectrogram and sonograms provide nice visuals representations of frequency across time. Figure 10 includes the spectrograms of three different days and shows the variation in frequency at time given different days. For example, 3/29/21 has notably less variation in intensity; this is a less percussive day than its counterparts with more visually varied frequencies.

As an aside, for a more direct comparison of two days, and shorter listening experience, the output of January 2nd, 2021 and May 29th, 2021 can be found in [1.02.21] and [3.29.21]. These recordings use 120 frames from the day, rather than 20⁷. Returning, once I had produced the full audio stream, I took the recording out for a walk. I wandered the same spaces, listening now to their audio translations.

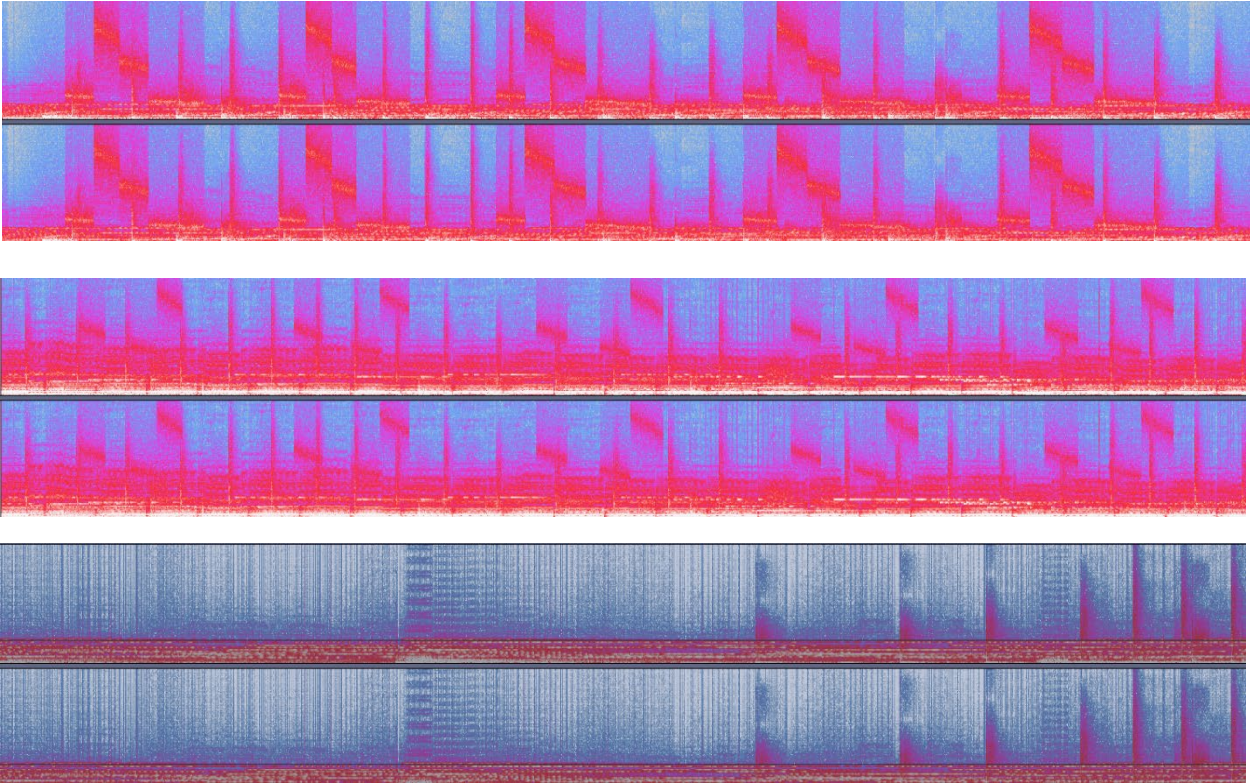


Figure 10. Spectrograms: Top to Bottom: 1/16//21, 2/21/21, 3/29.21

b. REFLECTION AS A METHOD

This walk, taken on July 2nd, was one intended for reflection. It took place at a strange time in the trajectory of Covid-19, places had reopened, masks were coming off. Vaccines were widely available in the United States and there was a tentative hope that we might be emerging on the other side of an upending year and a half. Relationships between and within space were once again being reconfigured. I continued to walk, many others continued to walk. The line for the bakery stretched down the block

⁷ The originally streamed audio recordings did the same, but I ultimately condensed them to create a shorter, more consumable composition for the listener.

once more. This walk felt like a bookend to the previous months of work, and in many ways, the previous months of life. My route did not directly mimic the places the individual recordings occurred but took place around the same blocks at the same time of day. I listened to the recording in its entirety; as I have emphasized, the evolution of the score is of particular importance. The output was not quite as expected, though logical upon reflection. The music was repetitive, many aspects of the piece are notably consistent and disappointing as they work to flatten the variation. Still, this realization was perhaps interesting in and of itself, and inspired a number of ideas for future work. The sound of the sidewalk permeates the composition. To a degree, this is insightful and speaks to the consistency of the sidewalks around the Shadyside area. From this one might understand the neighborhood as ‘walkable.’ This got me thinking about this thesis in terms more applicable and descriptive of a space – and considering future work may be less personal and abstract than the proposal of the thesis would provide (see ‘Future Directions: Practical Wayfinding’).

The composition map operated as I had asked it to and paralleled a cartographic practice perhaps even more explicitly than I had intended: a map, with keys and symbols, allows the viewer to understand through repeated visual cues. This mapping had similar consistency, the audible map was ‘legible’ for its limited classes and for the experiments I had chosen to omit.

In terms of the psychogeography, I maintain some of the days do indeed *feel* different. While there is notable consistency (to an occasionally unlistenable point) I claim that on the extremes, the audio does represent my experience with a day. To be sure, some of the days are loud and rushed, some are saturated with buildings, some are quite quiet, and some seem to be mainly cars. But at its best the mapping did produce the atmosphere of the day. In particular, a recording of a wonderfully ornate church in a grassy field sounds lush, resonant, and beautifully without rhythm. I quite clearly remember the beauty of this day: a sunny blip, a glimpse of life in the midst of a grey winter. Days later, it was grey and snowy; I walked down a busy bridge and, appropriately, the day sounds grim and foreboding, it is

almost entirely aggressively rhythmic. I listened to these days and earnestly hoped they accompanied the day and I place I was imagining. In these two cases, they did. However, I did appreciate the ability to see the day the audio represented.

I felt that without appropriate context for the project, and likely without associated memories, one might note an evocative transition through the score, but the geographic import might be lost. The emotion or memories and changes associated with this particular space may not be transferable, but of course this is true. What is also true is that everyone will encounter the work with their own spatial narratives, and everyone will have a unique experience with this work in particular. I wanted people to be able to listen to the audio exclusively, I also wanted to give people the opportunity to investigate whether their seen and heard perceptions aligned, or if the aspects of the composition they associated with aspects of the environment mapped in expected or imagined ways. For this reason, ideally one would listen to the audio exclusively before watching the video and form feelings and impressions without visual accompaniment. But there is beauty to watching the audio and the visual in concert, to a more inclusive sensory engagement. This was an interesting tension, and one I didn't feel a strong need to resolve. I think engaging with the work is valid either way, which is why you can find either on the site.

I wanted to ask a friend to listen or to watch and listen; at the same time, I didn't want to put a friend through a fairly repetitive recording of experimental composition. While on one hand this seems a critique of the reachability of the work, I contend there is merit to its autobiographical nature. This had become a personally intensive process. It allowed me to relish the small details of my locality -- an essential aspect of psychogeographic research, and one approach to experimental geography. The protocol I have developed provides a method to attend to the poetics of space, to observe and record and represent differently. My investigation was unique, but I have built a set of resources that allow others to encounter space in this way.

Reflecting further on sonic engineering in the built environment, I came to realize that in my preoccupation with affective geographies, and artistic, abstract cartography, I had missed another interesting proposition. Rather than an artistic cartography, this system might actually serve as a wayfinding tool. The process of bringing this into the world generated what I find to be an important future direction for the work. (See 'Practical Wayfinding') I discuss these opportunities below.

Discussion

Through reflecting on the final output of the work, I came to recognize that while it did work to evoke certain memories, or set a general sense of a day, the consistency from day-to-day actually illuminated more about the structure of place. In other words, the key and tempo ended up being less revealing than the specific class to instrument mappings. This opened spaces that stepped away from the artistic and temporal and further in the direction of understanding urban infrastructure and organization. Here I discuss these potentials, along with other ways to augment the Deeplab model and perhaps help increase accessibility in the city.

I. Where Next: Future Directions

a. MODEL EXPANSION, IMPROVEMENT

The segmentation model I used ended up providing less insight than I had originally imagined. This is not to say the process of object recognition has no merit, only that the range of identifiable objects might be expanded. In the future, one might choose to use a not-yet frozen graph and train a model to recognize more specific, perhaps recurring objects or details in the environment. One could also expand or break apart class definitions in the Cityscapes dataset, perhaps distinguishing 'house' from 'skyscraper.' Doing so would introduce more variation in the composition and perhaps yield more artistically interesting results. So much of what influences a psychogeography, what pulls our attention

and takes us around the contours of the environment, are the oddities of a place, the strange moments, the anomalies. It is the small hand stuck in the sidewalk, the water bottle that sits on pillar day after day, after day after day. It is the velvety flowers that call us to stop and take notice. This is what makes being in a place special. This was really the original idea. It shifted over time to become what it is now, but in the future, one might find ways to map the peculiar.

It is also worth considering moving away from object recognition in the first place, instead using computer vision to draw lines, outline contours, calculate lengths. One might consider something more along the lines of the canny edge algorithm I used to generate the 'Edgy Synth' (see methods). It is likely not the objects that affect the place, rather the details of the objects. Perhaps one thinks about sonifying the details, focusing even more specifically. Maybe the focus is exclusively on the trees and listening to their tired winter limbs muster the strength to support brilliantly pink spring blooms. Maybe the roof trimmings of houses on the block are the point of focus. A geographic justification may become trickier here but as Dennis Wood's work *Everything Sings* reminds us, there is cartographic intrigue in the hyper specific.

b. NARRATIVE EXPANSION, ENGAGEMENT

Along these lines, one might consider broadening the reach of the tool, allowing any user to translate between video and audio. Further still, one might imagine a platform that would allow for user manipulation of certain parameters. This would be quite similarly aligned with projects like Smallfish in providing an alternate, user-controlled notation. Allowing users to tune certain parameters themselves, based on their personal perception of spaces could hint at something interesting in the ways perception is shared or individually unique. A snowscape may inspire a lush, shiny composition for one user and a desolate hollowness for another, but the underlying principle of being able to translate space – both geographic and emotional – into sound has resonant possibilities. Finally, allowing one to 'hear' their

walk in real time offers interesting applications both artistically and practically. On an artistic side, this ability might encourage spatial exploration and drive a desire for narration. On a practical side, accessibility and spatial navigation could be audibly augmented.

c. PRACTICAL AND POETIC WAYFINDING

Here is where I find an especially promising direction for the work of this thesis. It lies not in artistic cartography, rather in practical wayfinding. The pipeline I have created could serve to benefit those with visual impairments⁸, or potentially urban planners looking understand the city through a currently unconventional medium. The transition from artistic cartography to wayfinding tool would involve mainly stripping away much of the abstraction; the key changes, the octave, and the tempo become undesirable here. Rather, the relative presence of highly distinct sounds directly speaks to the features. A strong presence of a sequencer and drums likely means a busy street, while drums without a sequencer suggest an empty one. To follow this road, one might consider a return to the `midUtil` python library (see: `midUtil_Exp_OLD`). In this case, the discretized output may work well to clarify and delineate varied aspects of the environment. Depending on the application of the tool the work that needs to be done might lie in real time sonification. TensorFlow Lite Task Library⁹ would be useful in building the image segmentation portion of the pipeline. However, a real-time protocol between Max

⁸ There are certainly precedents of audiovisually assistive technology operating at levels poetic and practical. Far from a comprehensive overview of precedent, I will briefly point to artist Neil Harbisson's 'eyeborg', and MIT Media Lab's 'EyeRing' as two particularly relevant examples. Neil Harbisson is a colorblind cyborg who sought to understand color. To do so, he developed what he calls the 'eyeborg': an antenna that detects light's hues and converts them to frequencies, thus allowing him to 'hear' color (Jeffries 2014). In the case of Harbisson, the eyeborg is a poetic, emotionally laden way for him to engage his surrounds and alter his perceptions. On being a cyborg he claims, "I'm treating my own body and brain as a sculpture" (Jeffries 2014). A different lens on assistive technologies is presented by EyeRing, a finger-worn device with a camera and Bluetooth computational system that allows for speech I/O (Nanayakkara et al. 2013). In one application of EyeRing, users are able to point EyeRing to a currency, and are read the monetary value.

⁹ <https://www.tensorflow.org/lite/examples/segmentation/overview>

and a live application would involve developing such a protocol from scratch. This is surely a doable task, but no simple solution currently exists.

For the planner, real time sonification may not be particularly important. Instead, the planner might be interested in understanding the walkability of the city, the presence of cars, or the height of the buildings in a neighborhood. They may augment already existing data about the city with a sonification. For the visually impaired or someone seeking to hear the city differently as they explore, the audiovisual transcoding needs to be immediate and calibrated to an appropriate distance. The algorithm would need to be refined, perhaps allowing the user greater choice in what they hear. Maybe one only cares to hear the road, at varied volumes or tempos. Perhaps one would appreciate an updated version that lets them listen to the way the building height or proximity changes through space. Exploring some of these more practically operationalizable applications is where I think the future of this thesis lies, though contributions of the work I did produce are discussed below.

Conclusion

And finally, to piece it all back together: in summarizing I'll note the conceptual contributions of the work, where the system might live in the world, what it might be used for in the future. I'll wrap up by leaving others room to explore the importance of sound and experimentation in narrating space.

I. Contributions

The contribution of this thesis is less about the final output, and more about the process of positioning and mapping. I hope I have convincingly found a way to unite an array of disciplines and practices (cartography, affective geography, soundmapping, sound art, sonification, experimental notation) that are tangentially related, but whose intersections are underexplored. These fields reference one another, wittingly or not, and I wanted to create a project that could put them in more

direct conversation. I wanted to bridge narrative cartographies and sonic affordances in affective geography and offer cartography as experimental notation. I think the work takes questions from one field and tries to answer them with another. (For example: How can we approach temporality in mapping? Sound. How can we create affective geographies? Evoke temporality.) At its core, this thesis proposes and demonstrates mapping as a composition and composition as a map.

The contribution offers a pipeline that allows for the sonification of various elements of the urban landscape. It provides a toolkit for audiovisual transcoding that may be used artistically or practically. A possible baseline for hearing the urban environment has been established and others can follow in recognizing the importance of sound in understanding space, and perhaps augmenting a sonic landscape or calling specific attention to that which goes unheard (streetlamp, building, sidewalk as opposed to road).

Further, the work responds to a number of specific questions. I first return to Wood and Pinder who emphasize narrative and subjective cartographies. I hope the work created a convincing case for a local site, and demonstrated a hyper-personal map is still a map, a map that importantly asks one to reconsider just what it is a map does. I presented one way to approach the neglect of time in geography Abend describes and reacted to Thunlin's calls for performative sound mapping considering Walker and Nees' claims of unexplored artistic potentials in sonification. I hope ultimately to inspire other people along these lines, offering the potentials of sound in narrative cartography. Finally, I hope someone might find an idea worth exploring in my discussion of future directions. Above all, I hope I have shown one way of 'listening out,' that I have shown one can listen to a street town as one listens to a symphony.

II. Muting

In sum, this work responds to the perceptual import of sound and seeks to bridge visual and sonic epistemologies in mapping by building a protocol for autobiographical geographic exploration. I find important inspiration from neogeographic practices, from calls to rethink the map, and from a legacy of imaginative, abstracted mappings. I recognize the presence of both artistic practice and sound mapping in cartography, and produce sound art that pulls at the merits of both practices. It contributes to a body of work in both sound art, artistic cartography, and experimental composition using the city as an instrument, features of the city as data, and sound as an emotive output. Despite a highly personal output, I contend a specific local offers insight to the nature of change in place, and the resulting emotional change. This thesis presents and demonstrates new way of being in place, and a new way of tracing experience through place. I'll turn the volume down here, but hope the sonic surrounds continue to ring!

APPENDIX A:: Mappings:

A.CITYSCAPES CLASSES

```
{'road': 320,  
  'sidewalk': 511,  
  'building': 210,  
  'wall': 360,  
  'fence': 496,  
  'pole': 459,  
  'traffic light': 450,  
  'traffic sign': 440,  
  'vegetation': 284,  
  'terrain': 555,  
  'sky': 380,  
  'person': 300,  
  'rider': 255,  
  'car': 142,  
  'truck': 70,  
  'bus': 160,  
  'train': 180,  
  'motorcycle': 230,  
  'bicycle': 162,  
  'nothing': 0}
```

B.MIDI-INSTRUMENT MAPPINGS: (<http://www.ccarh.org/courses/253/handout/gminstruments/>)

Piano Timbres:

- 1 Acoustic Grand Piano
- 2 Bright Acoustic Piano
- 3 Electric Grand Piano
- 4 Honky-tonk Piano
- 5 Rhodes Piano
- 6 Chorused Piano
- 7 Harpsichord
- 8 Clavinet

Chromatic Percussion:

- 9 Celesta
- 10 Glockenspiel
- 11 Music Box
- 12 Vibraphone
- 13 Marimba
- 14 Xylophone
- 15 Tubular Bells
- 16 Dulcimer

Organ Timbres:

- 17 Hammond Organ
- 18 Percussive Organ
- 19 Rock Organ
- 20 Church Organ
- 21 Reed Organ
- 22 Accordion
- 23 Harmonica
- 24 Tango Accordion

Guitar Timbres:

- 25 Acoustic Nylon Guitar
- 26 Acoustic Steel Guitar
- 27 Electric Jazz Guitar
- 28 Electric Clean Guitar
- 29 Electric Muted Guitar
- 30 Overdriven Guitar
- 31 Distortion Guitar
- 32 Guitar Harmonics

Bass Timbres:

- 33 Acoustic Bass
- 34 Fingered Electric Bass
- 35 Plucked Electric Bass
- 36 Fretless Bass
- 37 Slap Bass 1
- 38 Slap Bass 2
- 39 Synth Bass 1
- 40 Synth Bass 2

String Timbres:

- 41 Violin
- 42 Viola
- 43 Cello
- 44 Contrabass
- 45 Tremolo Strings
- 46 Pizzicato Strings
- 47 Orchestral Harp
- 48 Timpani

Ensemble Timbres:

- 49 String Ensemble 1
- 50 String Ensemble 2
- 51 Synth Strings 1
- 52 Synth Strings 2
- 53 Choir "Aah"
- 54 Choir "Ooh"

Brass Timbres:

- 57 Trumpet
- 58 Trombone
- 59 Tuba
- 60 Muted Trumpet
- 61 French Horn
- 62 Brass Section

Reed Timbres:

- 65 Soprano Sax
- 66 Alto Sax
- 67 Tenor Sax
- 68 Baritone Sax
- 69 Oboe
- 70 English Horn

55 Synth Voice
56 Orchestral Hit

63 Synth Brass 1
64 Synth Brass 2

71 Bassoon
72 Clarinet

Pipe Timbres:

73 Piccolo
74 Flute
75 Recorder
76 Pan Flute
77 Bottle Blow
78 Shakuhachi
79 Whistle
80 Ocarina

Synth Lead:

81 Square Wave Lead
82 Sawtooth Wave Lead
83 Calliope Lead
84 Chiff Lead
85 Charang Lead
86 Voice Lead
87 Fifths Lead
88 Bass Lead

Synth Pad:

89 New Age Pad
90 Warm Pad
91 Polysynth Pad
92 Choir Pad
93 Bowed Pad
94 Metallic Pad
95 Halo Pad
96 Sweep Pad

Synth Effects:

97 Rain Effect
98 Soundtrack Effect
99 Crystal Effect
100 Atmosphere Effect
101 Brightness Effect
102 Goblins Effect
103 Echoes Effect
104 Sci-Fi Effect

Ethnic Timbres:

105 Sitar
106 Banjo
107 Shamisen
108 Koto
109 Kalimba
110 Bagpipe
111 Fiddle
112 Shanai

Sound Effects:

113 Tinkle Bell
114 Agogo
115 Steel Drums
116 Woodblock
117 Taiko Drum
118 Melodic Tom
119 Synth Drum
120 Reverse Cymbal

Sound Effects:

121 Guitar Fret Noise
122 Breath Noise
123 Seashore
124 Bird Tweet

125 Telephone Ring
126 Helicopter
127 Applause
128 Gun Shot

APPENDIX B:: Day Data:

B.DAYS USED IN RECORDINGS

12/05/20

12/12/20

12/13/20

12/15/20

12/16/20

12/17/20

1/01/21

1/02/21

1/03/21

1/06/21

1/07/21

1/08/21

1/10/21

1/13/21

1/15/21

1/16/21

1/19/21

1/19/21

1/23/21

1/26/21

1/27/21

1/31/21

2/10/21

2/12/21

2/15/21

2/19/21

2/21/21

3/03/21

3/14/21

3/19/21

3/21/21

3/22/21

3/26/21

B.Day Dictionaries example days: 3/29/21, 2/03/21, 1/05/21

```
{
  "3.29.MOV":
  {
    "temp": 50,
    "brightness": 128.55,
    "sunset": 0,
    "snow": 0,
    "lat": "40 deg 27' 12.60 N",
    "long": "79 deg 55' 59.52 W"
  },
  "2.03.MOV":
  {
    "temp": 25,
    "brightness": 121.69,
    "sunset": 0,
    "snow": 2,
    "lat": "40 deg 27' 16.56 N",
    "long": "79 deg 55' 58.80 W"
  },
  "1.05.MOV":
  {
    "temp": 33,
```

```

    "brightness": 137.97,
    "sunset": 5.07,
    "snow": 2,
    "lat": "40 deg 27' 17.28 N",
    "long": "79 deg 55' 12.00 W"
  },
}

```

C.EXAMPLE FRAME MAPPING – 12/17/21, First 3 Frames

```

{"0": {"road": 30, "sidewalk": 18, "building": 0, "wall": 97, "fence": 38332, "pole": 3110, "traffic light": 0,
"traffic sign": 56, "vegetation": 252940, "terrain": 2, "sky": 0, "person": 102, "rider": 0, "car": 0, "truck":
0, "bus": 0, "train": 0, "motorcycle": 0, "bicycle": 0, "nothing": 0}, "1": {"road": 4, "sidewalk": 4,
"building": 1, "wall": 408, "fence": 35214, "pole": 3120, "traffic light": 0, "traffic sign": 298, "vegetation":
255302, "terrain": 152, "sky": 0, "person": 184, "rider": 0, "car": 0, "truck": 0, "bus": 0, "train": 0,
"motorcycle": 0, "bicycle": 0, "nothing": 0}, "2": {"road": 174, "sidewalk": 92, "building": 30, "wall": 943,
"fence": 35611, "pole": 2954, "traffic light": 10, "traffic sign": 228, "vegetation": 254107, "terrain": 10,
"sky": 0, "person": 528, "rider": 0, "car": 0, "truck": 0, "bus": 0, "train": 0, "motorcycle": 0, "bicycle": 0,
"nothing": 0}}

```

APPENDIX C:: Sample Notes:

- + Banana Republic mannequins wear masks
- + Saw not a single person
- + Church sign invites people to text ways they are 'growing love'
- + Spiked high heels still on lawn, they have rested there many months now
- + Living fern's neighbor is dead
- + Glass yard flamingos face away from each other
- + Gnome garden with an especially spotted mushroom
- + Woman and man raise voice in front of Sotheby's Real Estate
- + Lawn full of deflated Christmas blow ups
- + Tr*mp flag (Day after January 6th 2021 domestic terrorist attack)

- + Tog frog leg in the street, half a dominos pizza down the block
- + Yellow outdoor umbrella is open today, covered in snow
- + 1 gargoyle, 2 pillars
- + Cars with falling icicles
- + Party audible from down the block; Frank Ocean playing
- + Boy looks forlornly at ball rolling across the street
- + Bystanders cheer as ball is retrieved unscathed
- + Lemonade stand (pink)
- + Traffic cone at top of fire escape
- + Only half a roof
- + Door in the window
- + New crosswalk paint
- + Hand in the sidewalk

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