AN INTERFACE
FOR THE URBAN SOUNDSCAPE

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INTERFACE TO THE URBAN SOUNDSCAPE

ABSTRACT

This is an interface to the soundscape of New York City. Sonifying the urban environment with infrasonic noise concealed behind our perception, the interface is transformed into a radar translated as an instrument by performing with the ambiance and a browser by exploring the space.

Thesis supervisors:

Golan Levin, Christopher Kirwan, Karen Nourse

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1. INTRODUCTION

1.1 INTRODUCTION

1.1.1 Motivation

In the summer of 2000, I was at the office of an architecture firm called *Sonic Architecture* to discuss their new website which I was developing. After we finished a conversation about the design we were chatting about my thesis project and I told them that I wanted to do something interesting with sound found in New York City. Then, they kindly showed me a proposal they wrote to make an installation translating the urban soundscape of the city. They were excited and described to me the main core of the proposal: urban infrastructures as sound generators. One example was that World Trade Center Buildings produce a low frequency sound like a tuning fork because of the power of the wind. Similarly, the Brooklyn Bridge and the Manhattan Bridge both generate sounds because the suspension cables vibrate by traffic movements. Also, the Lincoln and Holland tunnels resonate with the sounds of traffic like how a trumpet works. I was intrigued by the subtlety of the sounds of the city and felt a passion towards discovering more analogous possibilities. On the way home I was convinced that my interest would be fulfilled through my creative expression related to the soundscape in New York City.

1.1.2 Thesis statement

We do not as a society pay attention to ambient sounds. We are much more focused on the visual over the auditory. My goal is to articulate the ambient sounds as an instrument and a sonic geographical browser so that people can perform and explore the infrasonic soundscape. Because of the physical behavior of sound, my investigation also includes the focus on the notion of space by using New York City as a stage for my thesis project. I chose New York City for its unique architectural nature to use the city's space as a potential sonic platform which clearly frames the design of the project's interface. We tend to ignore what we hear in our typical life because we have learned not to acknowledge them. Therefore, the sampled sounds from the city are a series of low frequency sounds that we do not normally perceive, so that by experiencing the interface the users are able to actively involved with an unusual sonorous interaction.

1.2 OVERVIEW OF THE THESIS

This thesis is constructed into 5 major chapters, *Introduction*, *Premise*, *Design and Implementation*, *Evaluation*, and *Conclusion*. Each of the chapters contains related passages illuminating the details of the section. In this way, my thesis brings forward the ideas that I have for what I am interested in regards to sound and the city.

Chapter 1, *Introduction*, simply shows a snapshot of my interests and how I came to the idea for the thesis itself. This chapter invites the reader inside my though process and prepares a base for them to embark into the core of the thesis.

Chapter 2, *Premise*, provides background materials that support the thesis. It covers physics of sound, a history of the soundscape, an architectural model of New York City, a concept behind hidden sounds, and an investigation based on the methodology of instrument/browser. For the research concerning the physics and the historical background for the soundscape, I primarily used *The Soundscape* by R. Murray Schafer, and I explored *City of Glass, The New York Trilogy* by Paul Auster to strengthen the concept of this unique city's urbanism. Also, I studied John Cage and Tom Johnson, both known as composers, in order to fortify the project's two cores, instrument and browser.

Chapter 3, *Design and Implementation*, explains in greater detail the actual production process. It includes stories of the on-site recordings in the city, decisions for designing the interface, and how all the functionalities in the interface were implemented, with drawings illustrating the sound interactions. I have a specific personal experience for each of the sounds I collected and share the stories with my readers. And, I describe the metaphors used for designing the interface in detail and how they graphically and technically function.

Chapter 4, *Evaluation*, investigates the thesis from various points of perspective that characterizes analytical comparisons. For example, if we have an Apple's one-button mouse and a Logitech's MouseMan ® Wheel, we can analyze the two mice by learnability scaled between *easy* and *difficult*. The Apple's mouse would be place close to *easy* and the Logitech's mouse would be situated near *difficult*. By following the same format and raising three analytical aspects, I investigate the thesis.

Chapter 5, *Conclusion*, summarizes the thesis and gives several directions that I am interested in pursuing in the future.

2. PREMISE

2.1 SOUND AND NOISE

2.1.1 Overview of sound

Sound is a physical fluctuation in any substance which can be air, water, wood, metal or any type of other material except a space in a vacuum where sound is not able to travel. When the molecules forming these substances are moved or vibrated in an organized way, the materials produce sound. The generated recurrent waves are radiated and increased at definite velocity determined by the elements of the medium that the sound moves through. This propagation of the acoustical energy is transferred and reaches our ears. Although our ears are not sensitive to the total acoustical energy, they are delicate to the rate at which the sound wave is transmitted. The rate defines the loudness. If we continuously hear sounds which are over 85 decibels for a long period of time, our perception of hearing is seriously threatened.

2.1.2 Our soundscape and its history

2.1.2.1 Pre-industrial era

We were born in the ocean. Living things on earth were born from the chemical reaction in water in billions of years ago. Similar recreations can be seen inside the watery womb of our mothers. We are at rest and protected in her warm liquid and hear submerged resonance with our first sonar ears. What kind of sound was it? On the seashore with my eyes closed and with only the sound of waves lapping, I can relax like I was sleeping in utero. I do not remember what the first sound I heard was; however, I believe that it was the sound of water or our Mother's Ocean.

WYSWYB: What you see is what you believe. We live in a visual world, ignoring the significance of hearing. The appreciation for our sense of hearing in western culture has been remarkably lost in the history of soundscape. In contrast to the western perspective of hearing, people in prehistoric times lived much more in a world of sound. Their sense of hearing was much more critical than their sense of sight and their activities of communication were based solely on voice or spoken language. Their ceremonial dances are the activities for listening divine messages from God. For example, the priest Srosh represented as a brilliance of hearing in the Zoroastrian religion listens to the religious messages that he carries to the humanity.

Our soundscape has been changed through the history of civilization. Religious sites such as churches and mosques were notable sound sources shaping the soundscape of the medieval period. The sound produced from a church bell in Christianity or the call to prayer in Islamic society is called a soundmark which is a term associated with "landmark." Soundmarks define community. A church bell in the Christian community unifies the society in a social sense. The call to prayer also functions in a similar way in Islamic culture. A soundmark does not only unify the society, but it also indicates the sense of time for the community.

2.1.2.2 Industrial Revolution

The amount of sound was extremely increased by the Industrial Revolution. Industrialized society brought a multitude of new sounds to the urban environment. The Industrial Revolution took place in England approximately between 1760 and 1840. The technological shift delivered new uses of materials like cast iron and steel and energy source like coal and steam, as well as the new schizophonical sounds. These schizophonical sounds were mostly repeated artificial noises produced from the machinenaries. All kinds of industry took place during the revolution and following the revolution. This is a brief list of the inventions.

1711: Sewing machine
1714: Typewriter
1738: Cast-iron rail trumway (at Whitehaven, England)
1740: Cast steel
1755: Iron wheels for coal cars
1756: Cement manufacture
1761: Air cylinders; piston worked by water wheel; more than tripled production of blast furnace
1765 - 69: Improved steam pumping engine with separate condenser
1767: Cat-iron rails (at Coalbrookdale)
1774: Boring machine
1775: Reciprocative engine with wheel
1776: Reverberatory furnace
1781 - 86: Steam engine as prime mover
1781: Steamboat
1785: First steam spinning mill (at Papplewick)
1785: Power loom
1785: Screw propeller
1787: Iron steamship
1788: Threshing machine
1790: Sewing machine first patented
1791: Gas engine
1793: Signal telegraph
1795 - 1809: Food canning
1796: Hydraulic press
1797: Screw-cutting lathe

Figure 1. A list of the inventions in the Industrial Revolution [Schafer 1977]

As you can see, the soundscape in England was populated by a mass of artificial sounds brought by these gadgets during the 17th century. People began to acknowledge the major appearance of noise and were annoyed. Although the origin is vague, etymologically the word "noise" can be traced back to Old French "noyse" and to eleventh-century Provençal "noysa, nosa, nausa." This generation of the concept was used again during the Electric Revolution.

2.1.2.3 Electrical Revolution

During the 19th century, the Electrical Revolution contributed the invention of the electric cell, the storage cell, the dynamo, and the electric arc light. The result of the electric power station, the telephone, the radio telegraph, the photograph, and the moving picture, added still more noise to the environment. Because of the increased transmission speed of electricity, our soundscape was harmonized on center frequencies of 25 and 40, then 50 and 60 cycles per second.

The major revolutionary creations in the period were the telephone and the radio which released the sound from its original position in space. Now people from all over could hear broadcasts from stations, spreading words and music to wide arena. The telephone eliminated the physical awareness of distance between a speaker and a listener. Also, the radio extended the audible areas and surprised people with the fact that sound disappears across space to reappear again at a distance. However, it took time for them to accustom themselves to the idea because it was unnatural to be intimate at a distance.

2.1.2.4 Present

In this way, our soundscape is occupied with numerous noises including the sound that we do not want to hear. What kinds of noise exist in our current soundscape? The most popular one is traffic. It produces enormous amounts of noise composed of the mechanical sound of the engine, the movement of tires, and the horn. Transportation means is a principle source of ambient sound. Trains, subways, and airplanes are other popular noise resources. Moreover, it is easy to notice audio disturbances such as construction, factories, street repairs, voices, sirens, office machinery, air conditioners, telephones, doors, loud speakers, loud music and quarrels from neighbors, and even riots.

Any type of sound can be noise if we regard it as the sound we do not want to hear. The definition of the term, noise, is an unwanted sound. Your favorite classical music could be noise for your neighbor. This point of view makes the word a subjective term. And, in relation to the thesis, the roaring sound coming from a truck cleaning garbage at 6 o'clock in the morning can be a form of music if we like to hear it, or listen to it. The word "hear" is not used as a verb to convey the action of listening. When we are driving a car, walking on a sidewalk, or drinking coffee at a cafe, we hear the ambient sounds around us, but potentially are not conscious of them. However, what if we listened to the noise and became aware of its ambient nature? This question establishes the backbone of this thesis.

2.2 CITY'S SOUNDSCAPE

2.2.1 Instrument

2.2.1.1 John Cage

> *"Wherever we are, what we hear is mostly noise. When we ignore it, it disturbs us. When we listen to it, we find it fascinating. The sound of a truck at fifty miles per hour. Static between the stations. Rain. We*

want to capture and control these sounds, to use them not as sound effects but as musical instruments". (*Silence*, John Cage)

John Cage is a composer, a visual artist, a writer, and a Zen Buddhist. He is mostly identified as a genius who redefined a meaning of composer. One of his most enthusiastic pursuits was ambient noise in terms of a creation of a new form of music. Based on his interpretation toward noise we cannot live without noise. I often hear that people hear a ringing in their ears when being in a place such as a suburb where is in closer silence. According to his experience in anechoic chamber, a facility constructed for a certain engineering purposes at Harvard University, we hear sound for all time. In the room with six walls made of special material, there is no echoes and are only two sounds we can hear, one high and the other low. The high one is the sound of our nerve system operating and the low one is our blood in circulation. As his experience signifies, we live with sound. It always stays with us until we die. The perception of sound is the last sense to close when we go to sleep and it is the first one to open when we awaken.

His idea translating the noise into a material to compose music deeply ties into the theme of my project. One of the major goals is to create an interface as an instrument orchestrating a composition of an urban symphony. By carefully listening to noise that we hear everyday, we realize there are certain tempo, rhythm, pattern, attack, duration, channel shift, proximity, birth, growth, and decay. A richness of these characteristics is able to give the interface a compelling quality as an instrumental tool.

2.2.1.2 Score as a graphical representation of sound

Figure 2. Traditional music score, *Waltz in Db Op. 64 No. 1*, F. [Chopin 1810 - 1849]

Music score is a method of representing sound into a form of a 2-dimensional graphic which contains a structure of leaner timeline. A score communicates with performers to synchronize the pitch and amplitude of each sound along the score path and functions as a record of sound as well. The design of the score has not dramatically changed since it was invented in the medieval period. However, a new design of music score, *Soundscapes*, was proposed at the Interval Research Corporation in a project by Joy Mountford in 1995. The concept was transforming the linear timeline into a circle form that integrates an arm rotating in cycles, and each time the arm travels over the notations represented as sounds and placed in the circle the MIDI events are triggered. Particularly, what I was interested in was the potential to use the instrumental manner that they created and superimpose it onto the notion of hidden sound.

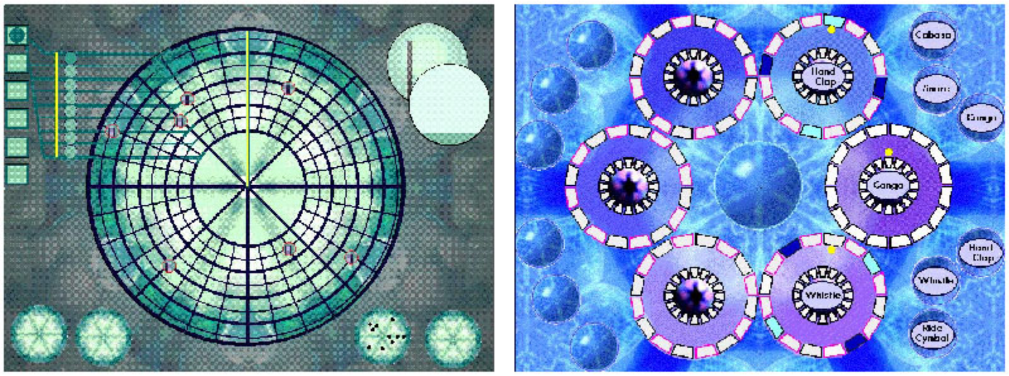


Figure 3. *Soundscapes* [Interval Research Corporation 1995]

2.2.2 Browser

2.2.2.1 Tom Johnson

Tom Johnson, a composer, describes "Documentary music" as music which translates facts into sounds and allows "details of a composition to be dictated by something other than the composer's imagination." "Documentary music" reflects some truth and some content to create distance between the composers and their music. He explains about *The Sinking of the Titanic* by Gavin Bryars in his essay section of *Breaking the Sound Barrier* as an example of "documentary music." Bryars's live presentation which included live piano music and projections related to the *Titanic* is a sound collage running about 25 minutes. This sonic and visual piece is actually a detailed reconstruction of the incident of the sinking of the Titanic because of the use of sustained string music, which consists of the specific hymns reported to have been played by the Titanic's musicians, and barely audible speaking voices, which are actual statements of observers as the ship was sinking. The notion of documentary music is projected onto the process of developing the project in order to use the actual noise as evidence.

As opposed to the mode of instrument, the interface also carries a browsing mode. It can be used as a tool that we manage a database of the urban sounds. By experiencing an ambient mix of the urban soundscape that we can communicate through the sounds and their geographical and background information, the tool conveys a meaning of browsing soundscape in specific space. What Tom Johnson describes for the documentary aspect with sound articulates the uses of the actual recorded sounds for the project and strengthens to specify the sonic truth of chosen site.

2.2.3 Space

New York City is mostly urbanized in a grid fashion which makes the city architecturally unique. I picked the city as a target soundscape for the thesis because of this interesting spatial nature and considered that the project could eloquently frames the city's spacious identity and the "space" of the soundscape.

The island of Manhattan, which is used to be a rocky mountainous wild island, is now covered with the rows and rows of unvaried straight streets and the piles of elevated buildings in the 2028 blocks of grid. In the novel, *City of Glass, New York Trilogy*, by Paul Auster, the nature of New York City is beautifully visualized in terms of the urban space in relation to the architectural navigation. The spatiality of the city is clarified through the geometry drawn by pedestrians. The path of the pedestrians is always formulated in the space because of the rule of the grid. One of the characters in the story walks in the city once a day to draws a letter, and creates a sentence in days by using the nature of the city. The artificial organization of the urban geometry is the essence of the city. A spatial metaphor is, therefore, binds the two methods of sonifying the city together and also articulates the relationship between the use of the hidden sounds and the design of the interface.

2.2.4 Hidden sounds

As I described my interest toward the sounds that are difficult for us to notice in the 1st chapter, the interface utilizes the diverse infrasonic sounds collected from the distinct locations in the city. Each of these sources is a specific individual object and carefully chosen in a manner that we do not consider as an object noticeably making sound. High-rise skyscrapers such as the World Trade Center Buildings is vibrated in a gradual speed which we cannot recognize because of the building system stabilizing the structure. We spend years and years with our soundscape in life; however, most of us are not conscious to the rich symphony of the noise. The objective is to have the users like us interested in the possibility for noise turning into meaningful sounds and how our soundscape is sonified by the various sounds.

3. DESIGN AND EXPERIMENTS

3.1 MATERIAL

3.1.1 Reason for the hidden sounds

The modern soundscape is overpopulated by the numerous sounds which are in general regarded as noise. Because of the massive scale of the sounds, we have no idea which is listened to. Moreover, most of us do not even notice the existence of the sounds indicated as noise pollution and make any efforts to listen to them. The environment easily accustoms our senses such as hearing and smelling. When I moved to New York City from Newbedford, a small town near the Cape Cod in Massachusetts, I used to be disturbed by the noise of a garbage cleaning truck on every morning. But, in a month later, I got used to the noise and could sleep well until a moment my classes started.

In order to emphasize the importance of the soundscape for the vision oriented people, I tried to reveal the various infrasonic sounds which are further difficult to be noticed. Fabricated with an interactive organization, the composition of the sounds gives the people a sonic experience that is never heard of. They must sound interesting. Consequently, the users are assumed to be actively involved with the soundscape and gain an opportunity to connect to the sounds, not noise, by listening to them.

3.1.2 Field recordings

I report some of the infrasonic sounds, which I sampled from the sites, based on the detail including my thought or feeling, method of recording, location, and material of objects in this section. All of the sounds were recorded by using a contact microphone called *Woodpecker* from Simba Products, Tennessee, with TASCAM DAT recorder except the sound sampled from a radio wave interference described later in this section. The microphone is equipped with a simple mechanism, a round firm wooden contact part and a quarter-inch output. The contact portion picks up any vibrations inside objects and sends the audio input signal to recorders. The purpose of this item is usually to record the sound of drums and guitars by attaching itself to them.

3.1.2.1 The Brooklyn Bridge

The Brooklyn Bridge and the World Trade Center Buildings have been the most interesting targets for me since the beginning of the thesis. These famous urban landmarks of the city were chosen for my first mark of sampling. It was a sunny day in early May of 2001 when I visited the Brooklyn Bridge located on the East River and connecting Brooklyn and the east side of Downtown, Manhattan. I walked on the public promenade constructed on top of the traffic way from the Brooklyn side toward the middle of the bridge and picked one of the suspension cables that I could reach in order to attach the microphone. The sound that I monitored through my headphone was like a fricative sound I had never heard of. Although the sound indicating some physical movement in metal was continuos, I was able to catch the randomness of the traffic flow. Then, I touched the cable which I was sampling and sensed the actual vibration. I looked at the huge urban infrastructure as if it was playing a tune like a harp.

Figure 4. Brooklyn Bridge [Brooklyn Bridge Gallery 1999] 3.1.2.2 World Trade Center

The first recording for the bridge was successful. However, I was skeptical to the completion of the sampling for the vibration of the WTC Buildings. There were two reasons; one was that the tower's movement was too subtle to be picked by the recorder, and the other was the security issue if they did not allow me to bring the quite big recorder kit that I was carrying. I purchased a ticket to the south tower's observation deck and waited for my turn to the metal detector gate and bag check. I successfully passed through the gate and one of the guards checked inside of my bag. I tried not to make any eye contacts on him. The recorder in the bag was very obvious. However, fortunately, he let me through. Many tourists and I took one of the elevators and looked for a cozy spot surrounded by a few people at the observation floor. I found a spot facing to the north along the window and attached the microphone onto the window surface. I reached my hand to the recorder which I was hiding in the bag and turned it on for recording mode. It was quite difficult to monitor, because of the other ambient noise in the room, except a conviction that there is no distinct fluctuation of the skyscraper. I was unsatisfied and left the site. In two days later, I was examining the tape I recorded at the observation deck and I discovered something exciting behind the static noise. Surprisingly, it was a piece of music. Throughout the section of the tape, the music and some narration of a DJ were recorded. I realized that the microphone had been capturing the radio wave on top of the building. The disappointment was suddenly and unexpectedly reformed into an accomplished recording of "hidden sound."

Figure 5. World Trade Center [Minami 2000]

3.1.2.3 Radio wave interference

When I was describing the notion of hidden sounds in the city to an instructor, Karen Nourse, at MFA Department of Parsons School of Design, New York, she introduced me her discovery at the rooftop of her apartment. I made an appointment with her and visited her apartment in Chelsea, Manhattan, at the end of the year 2000. I set up the recorder and went up to the rooftop. There were a couple of professional antennas installed on the parapet of the building. I could not listen to anything from the antennas. However, once I monitored them through the recorder a low-pitched static noise came into my ears. She previously uncovered this sound when she was shooting with her digital video camcorder by accident. This is absolutely one of the interesting concealed sounds which can performs the urban composition, although the recording method is different.

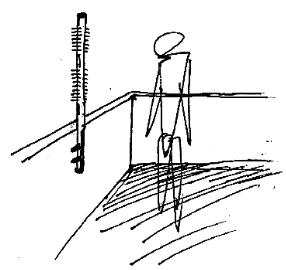


Figure 6. Antenna

3.1.2.4 Grand Central Station

The Grand Central Station is also a NYC's historical and architectural landmark. What I was attracted was the circulation of the population. In order to use the transportation connected to the station, the people migrate back and forth in the space. To record the sound of this man power I took a position on the floor of the Main Concourse and placed the microphone on top of its surface. The floor covered with marble tiles was firm enough to transmit the vibration of their footsteps.

Figure 7. Grand central Station [Heller]

3.1.2.5 Paley Park

In the middle of the high-elevated skyscrapers in Midtown, Manhattan, there is a resting pocket park. This small rectangular park was designed by architects, Zion and Breen, and well known for a waterfall featured in the back of the park. The waterfall functions removing the noise coming from outside the park, so that it creates a relaxing space with the greens of the trees and the only sound from the water fall. This is why I was fascinated as a sound source. I put the microphone onto a landing in front of the waterfall drop and recorded the sound through the granite stone.

Figure 8. Paley Park [Martin 1993]

3.1.2.6 Pier

I was walking on the public concourse along the riverside in Esplanade, a central residential area in the Battery Park City, in a cloudy day after a rainstorm. A wooden pier projected into the river caught my eyes. It was a small pier, approximately 20 feet long and 3 feet wide, with waves rolled in. How do the waves sound like from inside the lumber? I got interested in this question and passed under the yellow tape, which restricted people entering because of the high sea level brought by the storm, to get in the pier. And, I succeeded recording the sound that I want in the same method with the contact microphone. It sounded smooth or a bit blurry in contrast to the actual sound of the waves against the pier without the microphone.

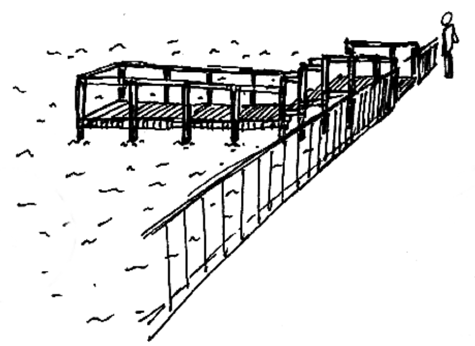


Figure 9. Pier at Esplanade

3.2 INTERFACE

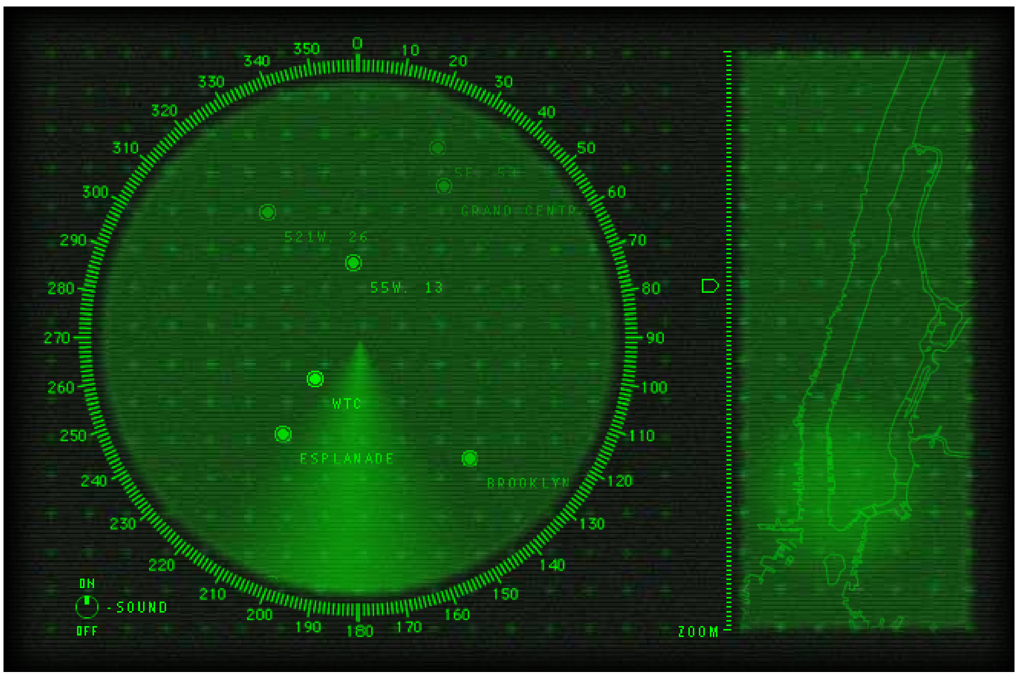


Figure 10. Interface for the urban soundscape]

3.2.1 Design and implementation

3.2.1.1 Map

When the research process was mostly completed in early February of 2001 I was struggling with finalizing the design for the main interface that articulates the conception of both instrument and browser in the soundscape. One design element that was clear to me was, however, a map of Manhattan Island and surrounding areas, such as Brooklyn, Queens, and New Jersey. This approach combining the city's geographical profile as a sub component and used within a navigational tool was a common task for the two different functions, so that I decided to advance to the final design from this foundation.

3.2.1.2 Radar scope

I considered things related to the space, the architecture, the direction, and so forth. One day I was pondering about airports, then the J.F.K. Airport, then a control tower, and then the interface of air traffic control. And, I conceived a radar interface and how it works. The development was quickly proceeded after this enlightenment. Everything made sense by acquiring the radar metaphor. Each of the notations showing the hidden sounds are visualized in space and this visualization process convinced me since the function of a radar is also detecting the coordination of physical things in space and visualizing them. Additionally, I realized that the radar is transformed into a circular score for the instrumental identity like *Soundscapes* at the Interval Research Corporation. This radar simulation works for both; the arm in the radar scope plays a role of a playhead to play each notation in the space and browses the sounds in the environment viewed through the scope. In this way, I came up with a fundamental skin for the interface embedding the navigational geographical component on the right and the main radar scope unmasking the soundscape on the left.

The framework shared by the two roles is spaciousness as I mentioned. I chose Macromedia Flash technology as a platform to implement the interface, and I was interested in an online experience brought by Flash as well as their new action scripts that control sound. Macromedia introduced the new set of scripts that developers can manipulate the sound by volume and pan in the version 5 of Flash. By implementing the engine that dynamically changes the volume and the pan of each sound produced from the notations, the interface got the simulation of the soundscape worked. The basic blueprint is that the arm and the registration point of the radar detect the distance between the sound objects and themselves when the interface is running.

The registration point or the user position in the environment represented as the map of New York City is able to be moved by navigating the draggable hollow indicating the scope's view in the map as an input from a mouse is established. In a situation for one particular object, if the position of a user gets closer to the sound object, the sound becomes louder. In the same way, if where she or he is gets farther away from the object, the sound gets softer. The pan of the sound is also simultaneously defined by the object located in the right or left to the registration point. The channel shift is dynamically transformed between the two channels as the user moves. Until I was completed the coding up to this level, the dynamic modulation of the volume and the pan was very much linear. What I achieved from here was a more organic mechanism that allows a nonlinear dynamism with sound. The closer the registration point is to the object, the more the amount of the increase is. This is true to the other way when it gets farther. This nonlinear shift is fundamentally implemented by the equation, *pow(base, exponent).*

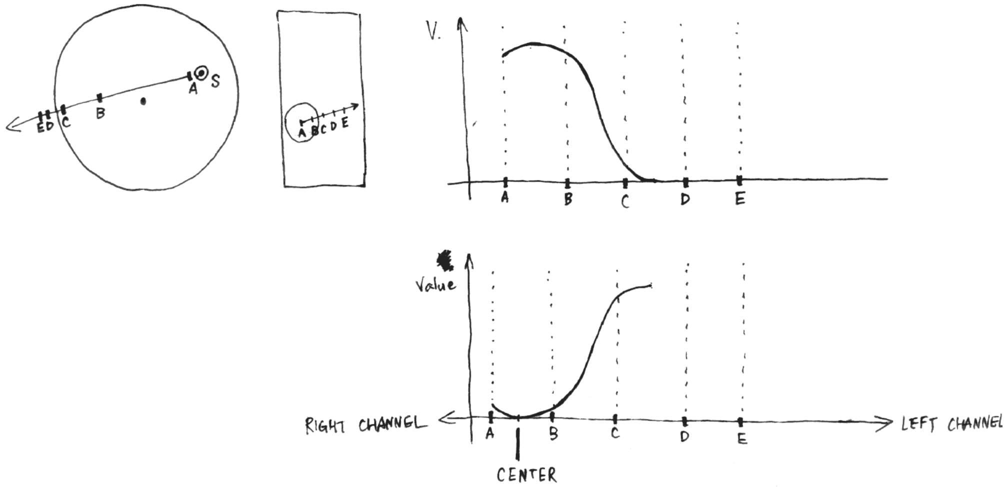


Figure 11. A diagram showing the volume and the pan determined by the location of the scope navigated by the viewer

The sweeper also functions in the same principle except the fact that it constantly rotates in the scope. This clockwise revolving movement pivots on the registration point, so that the circular area the arm sweeps also changes based upon the user's gestures. The sweeper calculates the distance by the angle between the object and itself to fix the volume and the pan. The angle is given by the equation, *atan2 (y, x)*. As a result, when the arm enters into one of the objects, the volume gets louder and loudest at the point when the difference of the gap is zero and it decays as the arm leaves. The pan also is continuously modified as the XY coordinate of the object against the current arm as a symmetrical axis. There are two basic steps to determine the volume and the pan. The first is the proximity in-between the registration point and the objects. Then, this distance is amplified by the proximity examined by the radar's arm in the second step.

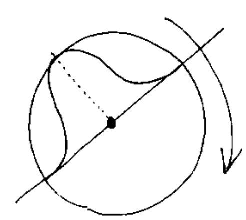


Figure 12. A diagram showing the relationship between the arm's sweeping movement and the volume shift

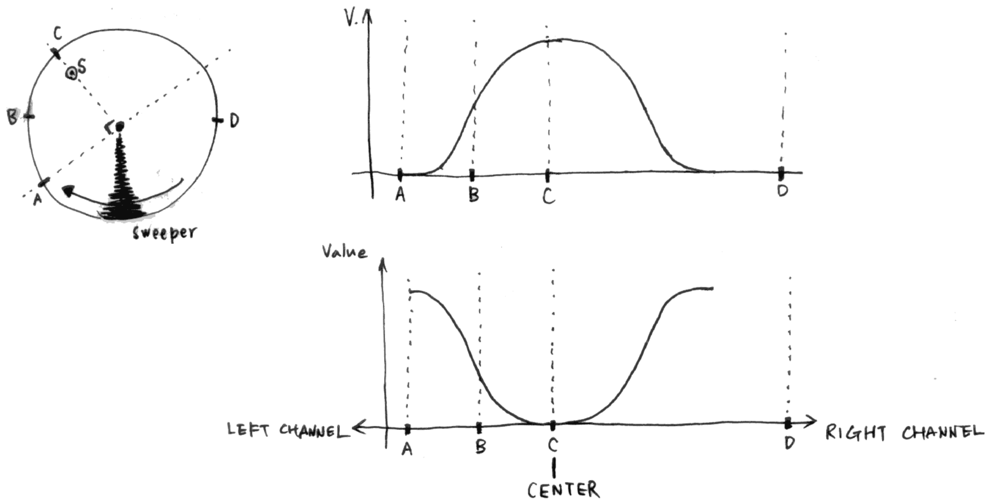


Figure 13. A diagram showing the volume and the pan determined by the arm's movement

3.2.1.3 Sound objects

The sound objects are the indication of the sounds sampled in the city. According to the actual location that the recordings took place, they are placed in the space that the users can navigate. The design of the icons for the objects is originated from traditional radio buttons used for Macintosh and Window computer environment because the objects can be turned on/off in relation to the original functions of the radio buttons that can also be switched in the same way. Accordingly, the users can channel the single or multiple sounds by clicking on the objects.

Figure 14. Traditional radio buttons (left: off / right: on) on Macintosh

As a sequence of the mouse action, the users, who want to browse the fabrication of the collected sounds, can address the information by moving the cursor on top of the objects. The users get the texts showing the detail such as the sources of the sounds, the locations of sampling, the dates, and the material. Therefore, the urban music is composed by any combination with the sound objects that the players desire and their performance manipulating the location of the active score. Also, the users manage the organization of the urban sounds by the radar browsing the soundscape and retrieving the textual information exposing the background of the sounds.

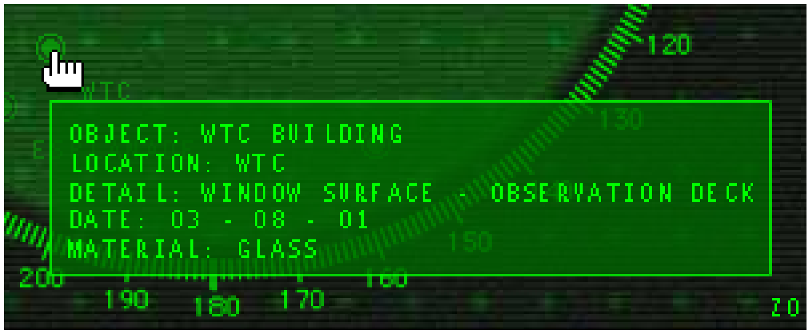


Figure 15. A close-up of the textual information

3.2.1.4 Global sound switch

A switch that the users can globally toggle the whole sound on/off state is implemented in the interface. Once the button is clicked, all the sounds in the interface are turned off and the buttons for the sound objects are changed to the off state. And the switch is clicked again, the users can activate the sounds back.

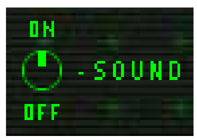


Figure 16. A close-up of the global sound switch

3.2.1.5 Zoom slider

A zoom slider is a functionality that the users can scale the map as well as the environment reflected in the same zooming value. If the map is scaled down, the viewing area through the radar is also scale down, so that the arm could sweep all of the sound objects. Therefore, the popularity of the objects inside the scope becomes denser. On the other hand, if the map is scaled up, the area is also magnified, so that the number of the objects that the users can observe through the scope is decreased.

3.2.1.6 Font

The font used in the interface is Letter Gothic MT which I was influenced by an interface for air traffic control. A common style of the fonts used for any ATC simulators and interfaces for airplanes' dashboards is that all the letters are uppercase. I noticed this fact and borrowed the style into the typographical design of my interface.

Figure 17. An interface for ATC Simulator ™ [Microsoft 1999]

3.2.1.7 Background

The interface contains an image of a grid in background This is also a subtle element which I was directed from the design of the ATC interfaces. I was not only interested in the graphical association toward the industry aviation interfaces, but also the function organizing the space in order as if it were the grid of the New York City.

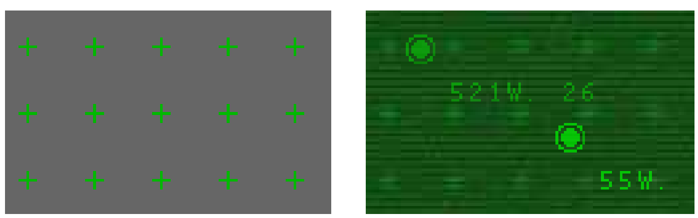


Figure 18. A grid image (left) used as the background (right) for the interface

3.3 SUMMARY

The two domains, instrument and browser, are simultaneously expressed while the interface is running. As a result, a duality is brought by this fact. Although, I was implementing a functionality that the users can toggle the two conditions by clicking on an instrument/browser button in early stage of the programming, I conceived the experience of the fine zone where the two domains are irregularly merged altogether was more convincing in terms of the solidity of framing multiple different things within a single major foundation.

4. EVALUATION

4.1 ANALYTICAL COMPARISON

I investigate the project by using different sets of two elements representing a subjective balance in this section. These analytic programs that I use are *method, spatiality,* and *expandability.* The interface is represented as the following icon.

Figure 19. Icon for the interface

4.1.1 Method

The interface is constructed into an instrument and a browser as I explained the heart of the thesis. These two manners create a program framing both techniques as a container representing a methodology. We can examine where in-between the two different states can be applied. For example, a flute would be regarded as a pure instrument, so that it is placed on *instrument* in the diagram shown below. What about a mail box on street? This is typical urban furniture and not made for a sound producing purpose. However, I have seen a person using a mailbox as a drum and making different pitched sounds. In the case like this, it is determined one's subjective mind as an example that a loud classical music can be noise shows. Based on the arguments that I articulate in the thesis, my interface to the urban soundscape is located in the middle of the diagram. It simultaneously functions as an instrument and a browser.

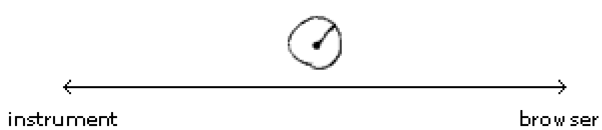


Figure 20. Method

4.1.2 Spatiality

The second analytical measurement is the spatiality that studies the interface from the *2-dimensional* and *3-dimensional* aspects. The soundscape is exhibited within a simulated urban space representing New York City. Although this is achieved by the sounds interacted in a way that sound is heard in space, the interface only displays the interaction in a planemetric view. The sense of depth or Z coordinate is not expressed in the representation. The city is not horizontally spatialized, but also it is vertically formed. The sounds recorded on the observation deck of the World Trade

Center Building and the subway in underground must differently influence the soundscape. Therefore, the interface is placed closer to *3-dimensional*, but does not reach all the way to *3-dimensional*.

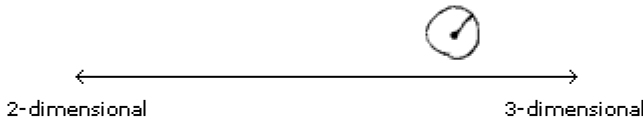


Figure 21. Spatiality

4.1.3 Expandability

As one of the future intentions, I want to record more infrasonic sounds in the city and add the new sounds into the interface. All the sounds the interface currently carries are constructed as external SWF files residing in the same file directory. If I want to put a new sound into the interface, I only need to attach the same code, which is intended as an object oriented script allowing the sound object to sonify in the space, onto the new sound and assemble the Flash movie as another external SWF file. There is no requirement to modify the code to make it work. Also, if I have a sound that I do not want, the external sound file is just required to be removed from the directory. In terms of the expandability for the sound objects, the interface can very much be located at *easy*.

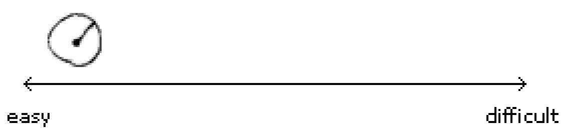


Figure 22. Expandability

4.2 PERSONAL FEELING

In the beginning of this thesis project, when I had a vague idea to do something cool with noise, I had an opportunity to listen to noise music by *Merzbow*, a Japanese noise musician. I only listened to the first tune for a minute and gave it up. I could not stand to keep listening to the repetitive scratching sound. I was endangered to lose the interest. The turning point was, however, the time in last fall when the film, *The Dancer in the Dark* directed by Lars von Trier, was opened in US. The film is about a woman, acted by Björk, gets blind and loves singing. A musical component is a core of the film and the formal storytelling is turned into the musical when she daydreams singing. The most intriguing part is the transition in-between the two different types of sequence. For instance, the crushing sounds produced from the machinery that she does her routine work are transformed into the drum-like sounds for the song she sings. And, the repeated sounds of a rail track gradually become the rhythm of the song that she sings. I experienced a very valuable moment in these fine lines in-between the two states and I was motivated once again.

I imagine that it is very tough for everyone to listen to the music comprised of only noise intensely manipulated by machine or computer like the one I listened to for a certain period. However, what I encountered in the film was an enjoyable and impressive involvement into a realm of sound. Does my interface have a similar quality? There is at least a duality of an instrument and a browser. A difference from the film is that there is an interactive freedom for the users to situate themselves anywhere in-between the two domains. While the interface is played or browsed by the users, it is possible to think where they want to be. I believe it is a beauty in this specific case.

5. CONCLUSION

5.1 CONCLUSION

When I was writing this section, I paid attention to my surrounding by chance. I heard people talking at the courtyard my room is facing to and a piece of music from the room next door. Then, I further concentrated my sense of hearing and heard a sound of a fan operating inside my computer, an electrical sound from my refrigerator, a subtle traffic sound, and my dog talking in his sleep. Then, I came to myself and pondered about my thesis. I realized I was LISTENING to those sounds, not HEARING those noises. If my thesis had no relationships to noise or sound, I did not perform this type of behavior and appreciate my sensitivity. I learned a significance of soundscape and a rich potential of noise as well as my sense of hearing.

However, it is true that most of us are unfortunately not conscious of the soundscape and do not even know what is heard. I excavated the infrasonic sounds and amalgamated them with an interaction within a simulated urban space. The interface targets an interaction between the urban soundscape and the users. It serves as an instrument taking advantage of a radar manner as its score whose playhead generates the sounds and a tool managing the structure whose radar system sweeps the sounds objects sonifying the urban environment. I raised a supposition that the users are actively able to commit to the interactive experience and be given a chance to pay more attention to our soundscape as a contribution of the thesis to the society. Moreover, I want to appeal to the users how precious and rare an experience living in the soundscape is by presenting my thesis project.

5.2 FUTURE DIRECTION

I used a contact microphone in order to capture the sounds we do not notice in everyday life. This was achieved by a simple device that did not require a complex engineering system. However, I was considering another method to transform similar kinds of infrasonic activity in the city to audio signals. This approach was a system using an optoelectrical device or a photoresistor for interpreting the amount of light and sending the light intensity to an audio recorder. It was aimed that the device would record the movements of light found in the city, such as the motions of shadow cast by buildings and vehicles, by translating the activities as recordable frequencies. This different method could be integrated with the thesis in near future.

At the field recording process, I sampled 15 sounds. As I described the development of our soundscape in the history, the number of the noise has extremely increased since 18th century. The number is increased further more if the soundscape in the cities such as New York, London, and Tokyo is looked at. I am certain that I am able to discover more situations carrying the sounds we do not perceive in living. However, the total sounds I collected from the city are only 15. Although there was a technical difficulty to implement many sounds, I want to foresee a possibility to populate the environment in the interface with hundreds of sounds which are recorded throughout the city in the same method. The ambiance of all the sounds must be more diverse and unique by the millions of combinations of the sounds. The more sounds I have, the more the scale of the soundscape and the orchestra is.

Another possible system that must deliver an interesting sonic experience is network. Currently, I have prerecorded sounds for the objects in the interface. By wiring sound inputs installed on each of the actual objects in the city to the interface with some sort of a system or a server that streams the sounds from the inputs, I can build a networked infrasonic interface which outputs the real-time sounds. The users would be ultimately able to browse a live infra-sonicscape of New York City and become a conductor for a live performance playing the urban composition.

APPENDIX A

A LIST OF THE SOUNDS RECORDED IN THE CITY

1. Brooklyn Bridge (Object)
   Brooklyn Bridge (Location)
   Suspension cable (Detail)
   03/05/01 (Date, MM/DD/YY)
   Steel (Material for the contact area)
   http://b.parsons.edu/~minami/thesis/diary/hidden_sound/bbridge.mov (URL)

2. World Trade Center Building
   World Trade Center
   Window surface, Observation deck
   03/08/01
   Glass
   http://b.parsons.edu/~minami/thesis/diary/hidden_sound/wtc.mov

3. Air duct
   55W. 13th st. KU Computer Lab, 8th fl. New School University
   Filter cover
   03/08/01
   Metal
   http://b.parsons.edu/~minami/thesis/diary/hidden_sound/duct.mov

4. Pier
   Esplanade, Battery Park City
   Wooden surface
   03/08/01
   Wood
   http://b.parsons.edu/~minami/thesis/diary/hidden_sound/bpc_water.mov

5. Electrical room
   26E. 13th st., 2nd fl.
   Door surface
   02/25/01
   Metal
   http://b.parsons.edu/~minami/thesis/diary/hidden_sound/electric_steam.mov

6. Elevator
   310 5th Ave.
   Elevator floor surface
   03/08/01
   Rubber
   http://b.parsons.edu/~minami/thesis/diary/hidden_sound/elevator.mov

7. Escalator
   Path WTC Station
   Handrail
   03/05/01
   Rubber
   http://b.parsons.edu/~minami/thesis/diary/hidden_sound/escalator.mov

8. Grand Central Terminal
   Grand Central Terminal
   Floor surface of the Main Concourse

03/08/01
Marble
http://b.parsons.edu/~minami/thesis/diary/hidden_sound/gcentral01.mov

9. Paley Park
5E. 53rd st.
Waterfall landing surface
03/08/01
Granite
http://b.parsons.edu/~minami/thesis/diary/hidden_sound/paley.mov

10. Network server
55W. 13 st., 9th fl.
Aberdeen Server
03/08/01
Plastic
http://b.parsons.edu/~minami/thesis/diary/hidden_sound/server.mov

11. Staten Island Ferry
Staten Island Ferry
Deck surface
03/08/01
Metal
http://b.parsons.edu/~minami/thesis/diary/hidden_sound/siferry.mov

12. Radiator
123W. 3rd st., 3rd fl.
Metal cover
03/08/01
Metal
http://b.parsons.edu/~minami/thesis/diary/hidden_sound/radiator.mov

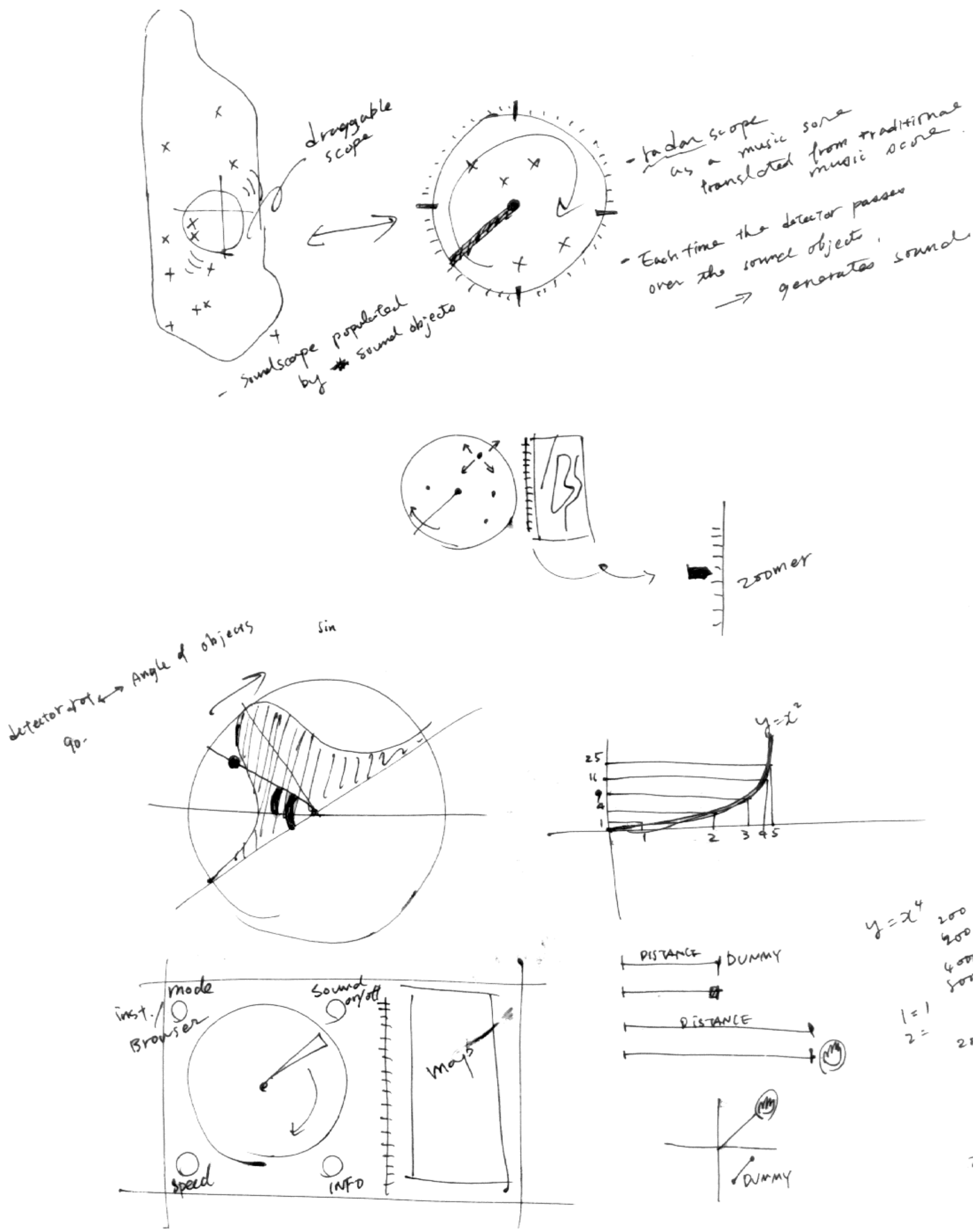
13. Subway
F Line betw. W.4th and Broadway-Lafeyette
Door surface
03/08/01
Metal
http://b.parsons.edu/~minami/thesis/diary/hidden_sound/subway.mov

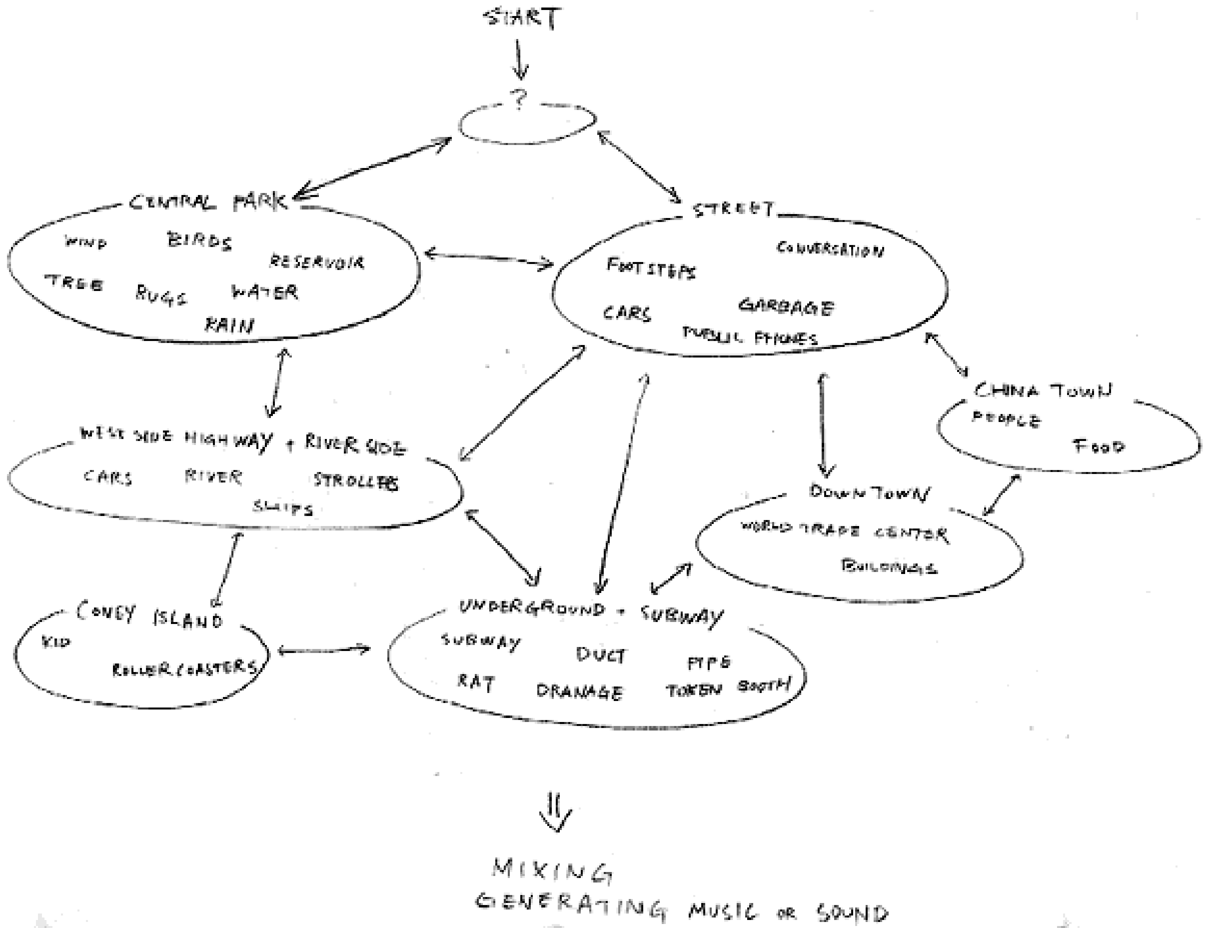
14. Traffic
6th Ave.
Interior window of a vehicle
03/08/01
Glass
http://b.parsons.edu/~minami/thesis/diary/hidden_sound/car01.mov

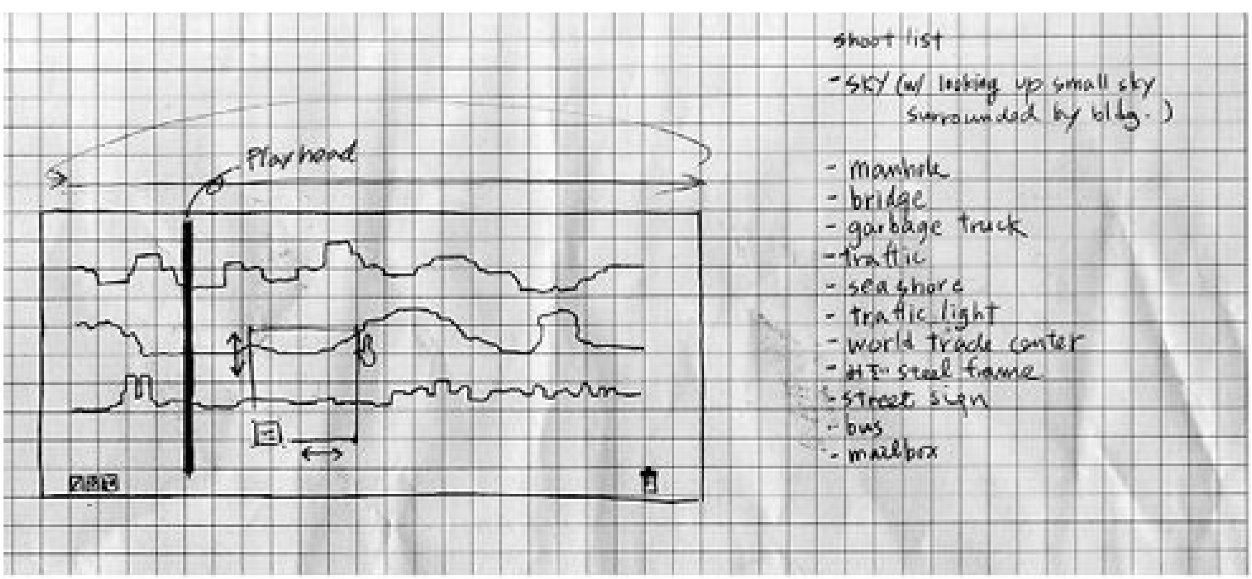
15. Antenna
521W. 26th st., Rooftop
Radio wave interference
11/20/00
N/A
http://b.parsons.edu/~minami/thesis/diary/hidden_sound/tvwave.mov

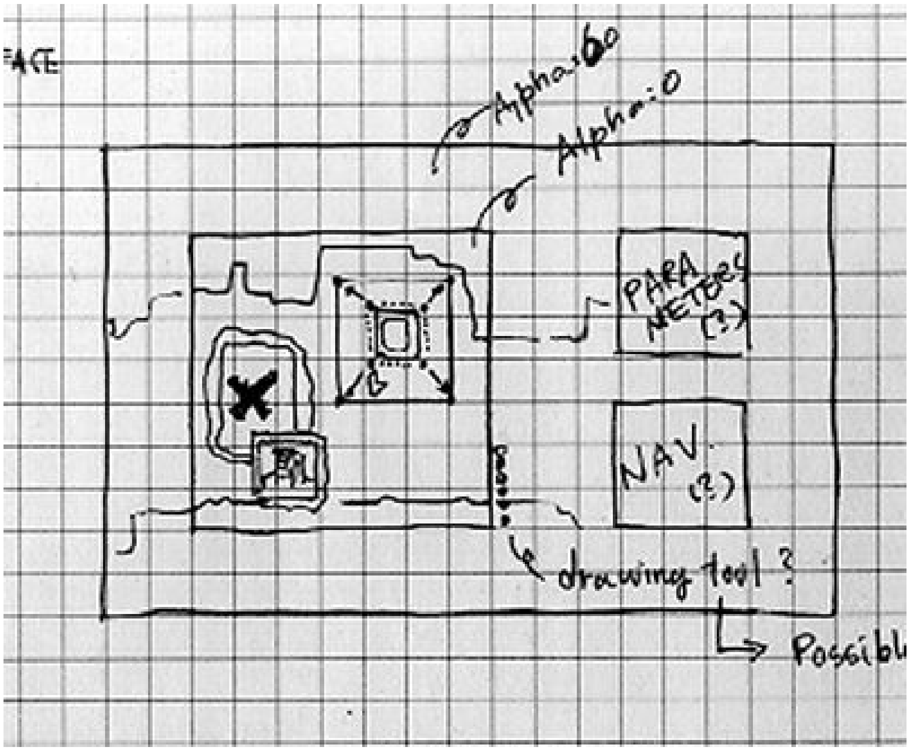
APPENDIX B

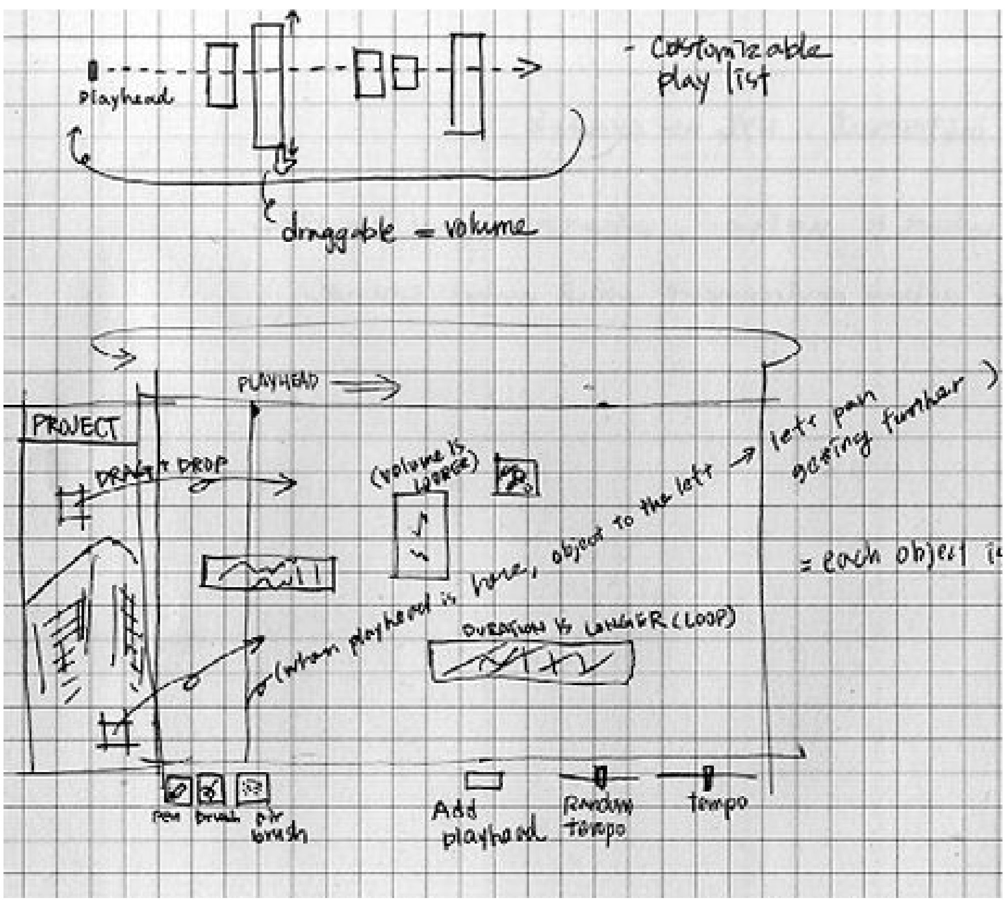
SUPPLEMENTARY SKETCHES




START
?
CENTRAL PARK
WIND
BIRDS
RESERVOIR
TREE
WATER
RAIN
STREET
CONVERSATION
FOOT STEPS
CARS
GARBAGE
PUBLIC PHONES
CHINA TOWN
PEOPLE
FOOD
WEST SIDE HIGHWAY + RIVER
CARS
RIVER
SHIPS
DOWN TOWN
WORLD TRADE CENTER
BUILDINGS
CONEY ISLAND
KID
ROLLER COASTERS
UNDERGROUND + SUBWAY
SUBWAY
DUCT
PIPE
RAT
DRANAGE
TOKEN BOOTH
MIXING
GENERATING MUSIC OR SOUND


shoot list
- SKY (w/ looking up small sky surrounded by bldg.)
- manhole
- bridge
- garbage truck
- traffic
- seashore
- traffic light
- world trade center
- street sign
- bus


ACE
Alpha:60
Alpha:0
PARAMETERS (?)
NAV. (?)
drawing tool ?
Possibl


playhead
- Customizable play list
draggable = volume
PLAYHEAD
PROJECT
DRAG + DROP
(volume is lower)
(when playhead is here, object to the left → let's pan going further)
= each object i
DURATION IS LONGER (LOOP)
Pen
brush
air brush
Add playhead
Random tempo
tempo

APPENDIX C

A CORE FOR THE SOUND OBJECTS

```
onClipEvent (load) {
	nBbridge = new Sound(this);
	mySound = nBbridge;
	mySound.attachSound("nBbridge");
	mySound.start(0, 50000);
	mySound.setVolume(0);
	iniMyLocX = this._x;
	iniMyLocY = this._y;		// initial position of this object
}
onClipEvent (enterFrame) {
	//
	// :::::::::::::::::::::::::::: LOGARITHMIC COMPONENT::::::::::::::::::::::::::::
	//
	var checkerX = this._x-_level0.dummy._x;
	var checkerY = this._y-_level0.dummy._y;
	var distanceX = (this._x-_level0.dummy._x)*_level0.logValue;
	var distanceY = (this._y-_level0.dummy._y)*_level0.logValue;
	if (distanceX<0) {
		distanceX = distanceX*-1;
	}
	if (distanceY<0) {
		distanceY = distanceY*-1;
	}
	// logarithmic calculation (math.pow doesn't take negative value, so "checkerX & Y" are needed)
	var logDistanceX = Math.pow(distanceX, _level0.exponent);
	var logDistanceY = Math.pow(distanceY, _level0.exponent);
	if (checkerX<0) {
		logDistanceX = -1*(Math.pow(distanceX, _level0.exponent));
	}
	if (checkerY<0) {
		logDistanceY = -1*(Math.pow(distanceY, _level0.exponent));
	}
	this._x = iniMyLocX+logDistanceX;
	this._y = iniMyLocY+logDistanceY;
	// dynamic alpha control
	_parent._alpha = 100-((Math.pow(distanceX, _level0.exponent)+Math.pow(distanceY,
_level0.exponent))/2)*_level0.fogValue;
	//
	// :::::::::::::::::::::::::::: SOUND COMPONENT::::::::::::::::::::::::::::
	//
	var locX = this._x;
	var locY = this._y;
	var dX = locX-_level0.centerX;
	var dY = locY-_level0.centerY;	// distance betw. self and center point of scope
	if (dX<0) {
		dX = dX*-1;
	}
	if (dY<0) {
		dY = dY*-1;
	}
```

```
        var avgdistance = (dX+dY)/2;
        // getting the angle of this object to the radar centerX's x-axis
        var myAngle = Math.floor(Math.atan2(_level0.centerY-locY, _level0.centerX-
locX)*(360/(Math.PI*2)));
        if (myAngle<0) {
                var myAngle = 360-Math.floor((Math.atan2(_level0.centerY-locY, _level0.centerX-
locX)*(360/(Math.PI*2)))*-1);
        }
        // checking this object's coordinates with the sweeper coming angle and leaving angle
        if (myAngle<=90) {
                if (_level0.detecterBar.rot>0 && _level0.detecterBar.rot<=180) {
                        var dAngle = _level0.detecterBar.rot-myAngle;
                        if (dAngle<0) {
                                var dAngle = myAngle-_level0.detecterBar.rot;
                        }
                        var dPanAngle = _level0.detecterBar.rot-myAngle;
                } else if (_level0.detecterBar.rot>180 && _level0.detecterBar.rot<=360) {
                        var dAngle = (360-_level0.detecterBar.rot)+(myAngle);
                        var dPanAngle = ((360-_level0.detecterBar.rot)+(myAngle))*-1;
                }
        }
        if (myAngle>90 && myAngle<=270) {
                var dAngle = _level0.detecterBar.rot-myAngle;
                var dPanAngle = _level0.detecterBar.rot-myAngle;
                if (dAngle<0) {
                        var dAngle = (_level0.detecterBar.rot-myAngle)*-1;
                }
        }
        if (myAngle>270) {
                if (_level0.detecterBar.rot>180 && _level0.detecterBar.rot<=360) {
                        var dAngle = myAngle-_level0.detecterBar.rot;
                        if (dAngle<0) {
                                var dAngle = _level0.detecterBar.rot-myAngle;
                        }
                        var dPanAngle = _level0.detecterBar.rot-myAngle;
                } else if (_level0.detecterBar.rot>0 && _level0.detecterBar.rot<=180) {
                        var dAngle = _level0.detecterBar.rot+(360-myAngle);
                        var dPanAngle = _level0.detecterBar.rot+(360-myAngle);
                }
        }
        if (_parent.mute == false) {
                // < BROWSER MODE >
                if (_level0.mode == "browser") {
                        if (dAngle>=90 || dAngle<0) {
                                mySound.setVolume(0);
                                reacter._alpha = 0
                        } else {
                                // reacter
                                //this._x = this._x + random(mySound.getVolume()*0.008)
                                //this._y = this._y + random(mySound.getVolume()*0.008)
                                reacter._alpha = 216 - Math.pow(dAngle*0.043, 4)
                                // volume
                                mySound.setVolume((216-(Math.pow(dAngle*0.043, 4)))/(avgdistance*0.01));
                                // pan (Math.pow doesn't take negative value, so the if ~ *-1 needed.)
                                if (dPanAngle>0) {
                                        mySound.setPan(Math.floor(Math.pow(dPanAngle*0.12, 2)));
                                } else if (dPanAngle<0) {
                                        mySound.setPan(Math.floor((Math.pow(dPanAngle*0.12, 2)))*-1);
                                }
                        }
                }
```

```
		// < INSTRUMENT MODE >
		if (_level0.mode != "browser") {
			// be aware that the "rot" turns to 0 after 360!
			// therefore, when this object is betw 270 to 360 coordinate, needs if ~.
			if (myAngle>0 && myAngle<=270) {
				if (_level0.detecterBar.rot>myAngle &&
_level0.detecterBar.rot<=myAngle+90) {
					// volume
					mySound.setVolume((216-(Math.pow(dAngle*0.043,
4)))/(avgdistance*0.01));
				} else {
					mySound.setVolume(0);
				}
			} else if (myAngle>270) {
				if (_level0.detecterBar.rot>myAngle || _level0.detecterBar.rot<=90-(360-
myAngle)) {
					// volume
					mySound.setVolume((216-(Math.pow(dAngle*0.043,
4)))/(avgdistance*0.01));
				} else {
					mySound.setVolume(0);
				}
			}
			// pan (Math.pow doesn't take negative value, so the if ~ *-1 needed.)
			if (dPanAngle>0) {
				mySound.setPan(Math.floor(Math.pow(dPanAngle*0.12, 2)));
			} else if (dPanAngle<0) {
				mySound.setPan(Math.floor((Math.pow(dPanAngle*0.12, 2)))*-1);
			}
		}
	} else if (_parent.mute == true) {
		mySound.setVolume(0);
	}
	_parent.sign._x = this._x+10;
	_parent.sign._y = this._y+10;
}
```

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