

Sound and the City

A 3D Sound Visualization Scheme

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ABSTRACT

Sound and the City is a Three Dimensional (3D) visualization scheme aimed at illustrating and presenting the sounds taken from a city's location, which helps define the makeup/characteristics of that location. My goal is to showcase an alternative view, and possibly the narrative of specific locations at specific times within a city.

Sound is representative of that moment of time and life which streams by. People talking, dog barking, car honking, birds chirping, and the crunching of leaves are all instances of life that surround the urban dweller. Most people "tune out" most sounds around them. We are often overwhelmed with the preoccupation of other stimulus, sometimes masked by iPods, for example, or subordinated by the selective nature of human hearing, which filters out seemingly irrelevant information. The complexity of urban sound is pervasive, and often taken for granted. *Sound and the City* seeks to capture, transform and present those sonic moments time-over-time in a new, perceptive and beautiful way.

Audio is one of my passions, harnessed through a Bachelor in Audio Engineering and refined by my work and travels. It is the sum of many parts. I've traveled to many cities around the world and have always been mesmerized by the differences and similarities of cities. For me, they are a combination of visuals, smells, textures, and of-course multitude of sounds. These include the different languages and accents, the engines of small and sometimes un-maintained vehicles or the metal clatter of the underground tubes (subways), and rhythms of human flow as people go about their daily tasks. At first, I wanted to capture these elements. Maybe I would find something later in the clips that I missed with my ears. Maybe I'd discover more information about a city beyond my initial, passive scope. Then I thought, maybe I should try to bring out these subtleties in a visual way.

The initial test location for *Sound and the City* research was Union Square Park, near the East Village in New York City. I recorded ("sampled") 10 minutes of sound,

every hour on the hour during a period of 17 hours (covering the hours of 6:00 pm to 11:10 am starting Wednesday March 26, 2008). I chose Union Square because it's a small hub. This lively spot, the gateway to the lower part of Manhattan, adjoins the Village, East Village and Gramercy and is traversed by locals and many visitors who frequent the shops around the square. Union Square reflects life in that part of the city.

Brief history - A few years ago I had the privilege of spending a late evening into the early morning at Union Square with a friend one summer. We were hanging out and wanted to stay out all night. We were mesmerized by the transitions of all forms of traffic, vehicles, people and animals - dogs, squirrels, birds, and rats – over time. We were fascinated. Fascinated by how the rats come out at night to rule the grounds, prompting everyone to hike up their feet onto the benches as they scurried around making their squeaky rat calls. Fascinated by the different caliber of skaters who come out at night versus during the day. Fascinated by all the local news vans as they stopped at the Square, to corroborate stories for the morning broadcasts - at least that's what I thought. The scene of workers, residents, hipsters and students slowly evolved into one of lovers and the homeless seeking privacy or refuge on the night park benches. It was a transformation right in front of our eyes, which most would have missed.

Bringing this transformation to the fore hangs on my command of data visualization, which proved to be a very challenging / frustrating, and yet ultimately rewarding task.

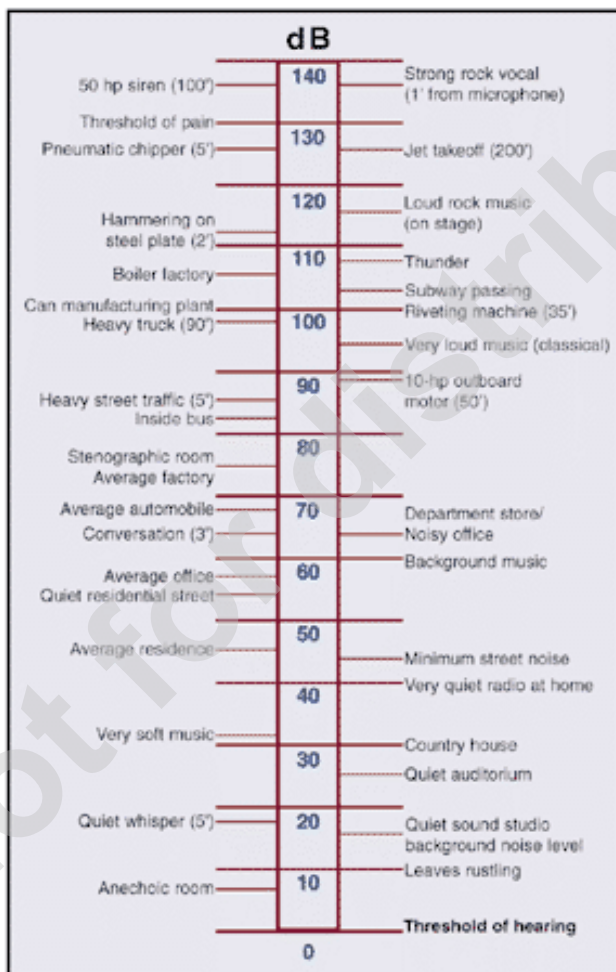
DESCRIPTION

I started developing *Sound and the City* by listening to sounds around me. I have traveled the world extensively. Listening for me is an art form if not the path to sanity. I've been listening for many years now and have probably caught glimpses of sonic details most would ignore.

One thing I noticed while listening to the sounds over time is how important they are to the make up of a city, even though the city is the source of the sounds. I refer to

it as a harmonious loop needed to maintain our familiarity and safety and comfort as we meander throughout our paths towards our destinations.

These sonic glimpses would be the loud subtle differences between the new brakes verses the worn brakes of the NYC subway and buses, verses those of say, Berlin and Barcelona. The language pockets of groups of people who gather for whatever reason. I often try to figure out in my own mind where they are from. Do they provide clues to of that place at that moment and beyond? I listen to the bird calls, or lack there of. The bells struck at the churches and or temples, the singing cries from the local Mosques. The frenzy chipping of children at play during school, or when they are on their way home. I've found that groups of children who take public transportation are louder on their way home verses the mornings – this is universal! I've actually measured this with my portable Sound Pressure Level (SPL) meter I purchased at Radio Shack a few years ago. The decibel level is around 70 - 80 dB in the morning and 80 - 95 dB after school. I've also measured other city sound levels, but that's not my thesis focus. For more information on sound pressure levels please refer to: The Engineering Toolbox (http://www.engineeringtoolbox.com/sound-pressure-d_711.html).



RATIONALE

Most sound is relative to the listener. The big question I asked myself is "was it possible to harness the sound and extract the elements I see as a necessity in our daily lives which can provoke an emotion? And if so how?" The first approach required the gathering of sounds from select sources and try to analyze them. For this process I researched the best and quickest micing techniques, a technique a curious novice can employ with ease to gather their own sounds and mics to use. I settled on using Binaural Microphones embedded into headphones. Then I practiced the DIY (Do It Yourself). I also wanted to use this method because I wanted to mimic the aural perspective of the human ears with width and height in mind.

Goals

I'm a trained sound engineer. For me most sounds have extreme "depth" and "perspective". But I know that most people selectively tune out these attributes of the sound in their environment, which I can hear and almost *feel*. I want to bring to light this experience with others in some way. But short of giving the world a crash course in sound, I figured the easier way to bring strangers into my perception range was to interpret the depth and quality of sound that I hear into something others can sense, appreciate, and ultimately share. The visualization of *Sound and the City* is a sort of sonic sculpture. I want others to see what I hear. This sonic sculpture moves and undulates, changing colors and shape and mass influenced by sound. I wanted to express the complexity of everyday sound.

Audience

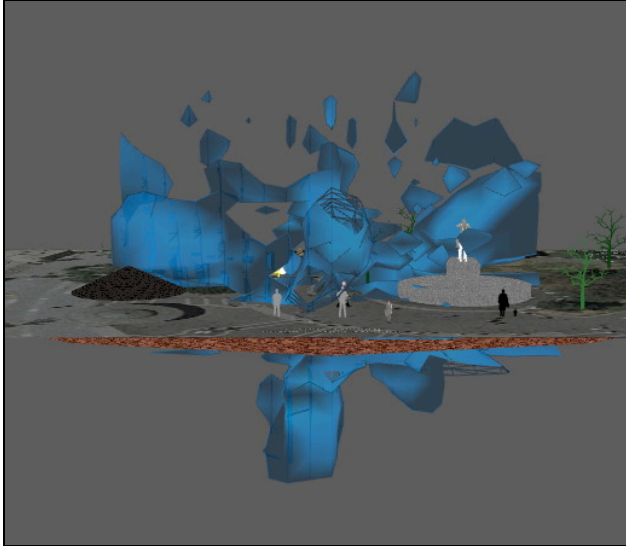
Sound and the City is targeted to persons open to the notion of sound dictating our environment. Some qualities needed are good hearing, or at least acute sonic awareness, and the open-minded nature to experiencing their environment in a new way. This sonic sculpture is a lesson in awareness. Participants are presented with a complex layering of everyday sounds and see how those sounds can be accompanied by a changing and visually engaging representation. They will have a new way to experience their own environment. This experience hopefully may last beyond their interaction with the project, because *Sound and the City* may heighten their sense of *listening*.

Location

This project is currently Screen-based and employs pre-recorded sounds. This first iteration communicates the concept in a controlled computer-enabled environment. Future models will include physical sonic installations where one can go into and experience the sounds of different pre-selected cities in a sensory visual and auditory setting.

Core Features and Functionality

Sound and the City is an aural-visual experience. High quality sound is sampled, embedded into a software tool - here I am using the lower-level software Max/MSP/Jitter (<http://www.cycling74.com>), and interpreted visually for viewer-listeners to see/hear in a high quality screening environment.



The visualization plays the sound in stereo and presents the viewer-listeners with (A) a 3D representation of the location where the sound was sampled (in this case, Union Square Park), and (B) a 3D visualization overlay of a morphing matrix that grows larger with amplitude and changes color based on sound frequency – more attributes to come.

Above the 3D visualization is the title of the work and the location and time of the sound sampling. Sound sampling changes over time, which changes the 3D visualization. To help viewer-listeners see the visualization in context, I added the element of a stylized clock dial just below the title. I did this to help people connect when sounds were sampled and to encourage them to listen more intently to the subtle changes occurring in the sound samples during those times.

User Scenario

Viewer-listeners enter the environment (in this case, the screening room) approach the large screen and hear the sounds of the cityscape from the point source speakers situated in the room. For more info see: **Sound Lab** (http://www.soundlab-speakers.com/tech_geom.htm).

BACKGROUND

I did some pre testing before to get the hang of the unit and to monitor any glitches during recording. I find it a good idea to always test a new and / or unfamiliar device before committing to the final task needed. This could save everyone time and helps prepare one for troubleshooting if needed. Of course this isn't always a

realistic outcome in this day. I also researched other sources of recording enthusiasts and specialist and adopted their findings and challenges to help with my process. It was a long journey. I then set out with the tools I acquired to get the job done.

About microphones

Binaural microphones are miniature **Omni-directional** microphones used in pairs and placed on either side of a human (or artificial) head. They should be placed as near as possible to the ears. Omni directional mics pick up sound in all directional fairly equally, so when they are used in this manner, they capture up sound very much like the human ear does minus the Auricles (outer ear). These same microphones, when paired, are also capable of delivering stereo recordings.

See: (<http://www.soundprofessionals.com>) for details.

About bit rates

Bit Rate refers to the resolution of a sound sample. Think of how the word *pixilation* relates to a digital image. The lower the resolution of the image, the more pixilated it looks, the harder to differentiate the different details of that image. Sometimes pixilation is so bad that it can distract from the main attribute of that image. Pixilation results in loss of detail, or “information” to professionals. It's the same with Digital Audio. The lower the resolution of a sound, the lower (more “pixilated”) the sound quality. It has less information. That's why professional recording studios record at higher bit rates and higher frequencies. The heightened sound quality is not for our ears. At least initially. Higher sample rates and bit rates use more memory on storage devices. For my recordings, I chose the 16-bit setting. This choice gave me more information without using too much memory. It provided a good balance for the needs of this project.

About Sample Rates

Another facet of recording technique is its sample rate. Kilohertz or *kHz* (*kilohertz*) is the number of cycles or frequency per second. One kilohertz equals 1000 *hertz*, thus (example: 96 kHz is 96000 hertz). Some standard cycles used in everyday sampling stages include: Standard Audio for CD and other electronics (44.1 kHz), NTSC video (48 kHz) and studio recording (88.2 kHz and above). I chose *96 kHz* for this project because I wanted a high enough frequency range at a nominal file size.

So in conclusion I ended up using as sample rate of 16-bit at 96kHz.

I would like to encourage interested folks to employ this process and lead them to the tools easily and readily accessible.

Date/Time-stamp

Why the need for date/time-stamp? I thought it might be irrelevant for a visual project, but I did it for archival purposes. I have always seen the need to monitor the

time-of-day and location when possible. If I create many visualizations from the sonic samples, I may see a visual pattern change emerge over time. Like weather patterns over a virtual map, viewers may be able to see movement of sound over time according to changing elements in the environment or events happening moment-to-moment. Visually, the samples may allow viewers to discover something new. It's also good for archival and metadata purposes when one needs to find specific samples based on criteria.

WORKING METHOD

I wanted to gather the sounds in Union Square Park without allowing my presence to disturb the natural rhythm of the environment. My first task was to create a recording setup that was both high quality and visually masking to the casual observer.

The Headset

I purchased microphone-capsules from Radio Shack for under \$3 each. You can also purchase the capsules cheaper and at larger quantities from electronic retailers like SparkFun (<http://www.sparkfun.com/>) or DigiKey (<http://digikey.com/>). I needed a pair for this setup.

I then acquired old headphones and hacked a few pairs drilling holes and embedding the microphone-capsules into the outer wells of the phones. I used the existing headphone wires to connect the microphones making for a seemingly stealth recording approach.



Most people just assumed I was listening to music. If one was to look closely at my headphones they would see the embedded microphones. To finish I used clear plastic glue to firmly secure the capsules to the wells and, using the existing fastening components, resealed the headphones. It's a clean design. Because it was so easy I made two other pairs so far.

The Recorder

Next, I needed a device to record the sounds to. I wanted something light, flexible and with quality and ease of use and price worthy. During my research of devices I came across the Zoom H2 handy recorder. My engineer friends in other parts of the world have been using it for field recording and they had many praises.



It was light and small. In terms of flexibility, it supports 16 & 24 bit rates, 44.1 - 48 - 96 kHz (*kilohertz*) frequency responses, Stereo and 4 channel micing options, external stereo mic input, hand switch selectable levels, phantom power needed for condenser mics, which the mic capsules were, and a robust menu selection for further refining the audio and output options for the MAC / PC. It also accommodated AA batteries. I used Nickel Metal Hydride - NiMh rechargeable batteries. And the price was right at around \$200, minus the rechargeable batteries set and extra memory cards.

All set to go out and gather my sonic samples. All-and-all this setup provided me with a non obtrusive, very stealth approach to recording in public. It was quick and easy, I could monitor levels without having to change the mic position, and I am also able to time-stamp each recording and store up to two hours on one of the two 2 gig SD card I purchased. And downloading the files to my computer was very fast and easy. Just connect and drag files onto destination.

The Recording Experience

At Union Square, the focal location for my thesis, I started in the evening when it was bustling with all sorts of activity. I sat on a park bench, and even though it was still cold out I was committed to staying the course. Fortunately the headphones doubled as ear covers keeping my ears warm. The recorder was in my pocket out of sight. The orientation in the park provided me with two different sound levels in each microphone. I also had a camera to reinforce my documentation of those moments. After rechecking my settings and the time I was ready to start. At about a five of six I started. Next are highlights of my time every hour rounded up to the hour.

Union Square Park, New York City Wednesday March 26, 2008

[5:55 - 6:11 PM]

- It's still light out
- Church bell rings from a distance. Orientation and distance hard to decipher
- Girl passes by on phone - walk by right to left
- Rush hour traffic to my right at a distance - approx 13 meters
- Street brass-band playing in a distance to my front right - approx 20 meters away
- Skateboarders to my right about - approx 6 meters
- Dogs running on gravel in doggy park behind me - right close to left far
- Dog chain rattling behind me
- Helicopter in sky - height undetermined
- People chatting all around walking by

[6:55 - 7:11 PM]

- Still light out
- Church bell rings...
- Skateboarder still practicing
- Friends talking bench to my left telling recipes into phone - approx 1 meter
- Echo of ambulance siren. Moving so orientation is hard to decipher
- Group of guys practice fighting
- Traffic is getting quieter

[7:55 - 8:11 PM]

- Starting to get a bit dark
- Church bell rings...
- Street brass band playing in a distance to my front right...
- Less people walking by, less activity

[8:55 - 9:11 PM]

- Church bell rings...
- Men talking on bench to my right - approx 1.5 meters
- Plane overhead...
- Guy to my left talking on phone - approx 1 meter
- Plane overhead...
- Higher frequencies more prevalent

[9:55 - 10:11 PM]

- No church bell!
- Two people on bench having business meeting on phone to my left on bench - 1 meter
- Lots of horns honking
- More lively than pas hour with people walking by
- Plane overhead

[10:55 - 11:11 PM]

- Sounds of garbage trucks
- Helicopter high up
- Park ranger is putting chains in position for park closure
- Police are walking/patrolling the park
- Homeless guy sits to my right - 1.5 meters
- Same traffic from two hours away

[11:55 PM - 12:11 AM]

- Mid Traffic at midnight - 13 meters away
- Less people walking by due to park closure
- Getting colder sitting on bench

[12:55 - 1:11 AM]

- Getting Quieter
- Dark barking in park behind me - apparently its owner left it alone in the doggy park
- Saw one rat - vast difference from last time I spent in the park

[11:55 - 2:11 AM]

- Changed location - was asked by park anger to leave park bench area
- MTA cleaning crew on scene - loud generator sound to my right but sound is traveling omni directional
- Dog still barking - now attracting several police officers and park ranger
- Police pulls over minivan at a distance in from of me - 13 meters away
- Police shoots dog with tranquilizer gun - very tragic but I guess necessary.

[2:55 - 3:11 AM]

- Much quieter and colder now.
- Very little activity with people.
- Still few cars on street - city is resting but not sleeping
- MTA cleaning crew still on the job

[3:55 - 4:11 AM]

- Much quieter and colder now.
- Very little activity with people.
- Still few cars on street - city is resting but not sleeping
- MTA cleaning crew still on the job

[4:55 - 5:11 AM]

- Birds chirping indicating dawn
- Light traffic flowing freely
- Morning Busses in the background

[5:55 - 6:11 AM]

- Getting lighter out
- Birds still chirping...
- Light traffic flowing freely
- Morning Busses in the background

[6:55 - 7:11 AM]

- Getting brighter
- Birds still chirping...
- Traffic is slightly lighter than before
- Morning Busses in the background

[7:55 - 8:11 AM]

- Much lighter now
- More birds chirping
- Traffic still light
- Busses in the background
- Man performing Tai-Chi
- Park cleaning crew picking up garbage
- Doggy park open and visitors arriving
- Dogs barking
- Sounds of traffic getting a little louder

[8:55 - 9:11 AM]

- Church bell rings
- Birds chirping
- Squirrel running around
- Construction behind me begins - approx 10 meters
- Park garbage van in area

[9:55 - 10:11 AM]

- Church bell rings
- Traffic slightly milder
- More construction emanating form far
- Over cast

[10:55 - 11:11 AM]

- Church bell rings
- Traffic slightly milder
- More people activity
- Gloomy and grey day
- Starting to drizzle

Side note: Surprises

This was a tough task given that it was a bit cold at times, and the on-set of loneliness set it. Good thing a friend came stopped by at 3 am and we went over to Coffee Shop - a bar near by - to have some drinks. In conclusion of my sonic gatherings it was surprising how the early morning traffic did not build up, at least by 11:00 am. Nor did the heavy influx of people migrated through the park or at least in visual scope as I had expected. Maybe it was the gloomy day, the cold weather, that time of year, that particular day, or all previously mentioned, or just that things have changed. Ideally consistent observations need to be made over a much longer period of time to at least come up with a weighted theory, if not fact. For instance, I saw only one rat verses the summer where there are hundreds that roam in the darkness of the parks. I would attribute this to the cold weather for rodents seek warm areas in the winter.



CAPTION: Rodent populations are at their lowest and breeding is minimal. - Rodents prefer warm places in or near buildings. — Bureau of Community Hygiene

Also, the park seemed to have a greater Police presence than a few years back. This is consistent with the overall police presence in NYC post Mayor Rudolf Giuliani.

Now I have my recordings, photos, and time-stamped highlights. The next task at hand is how to extract the information and then express it visually with some recognizable meaning.

RESEARCH

Earlier this I did some research related to Sound Analysis, Audio Visualization and Sound Expression. I looked at some works and tools used to accomplish one or both. Works I came across include:

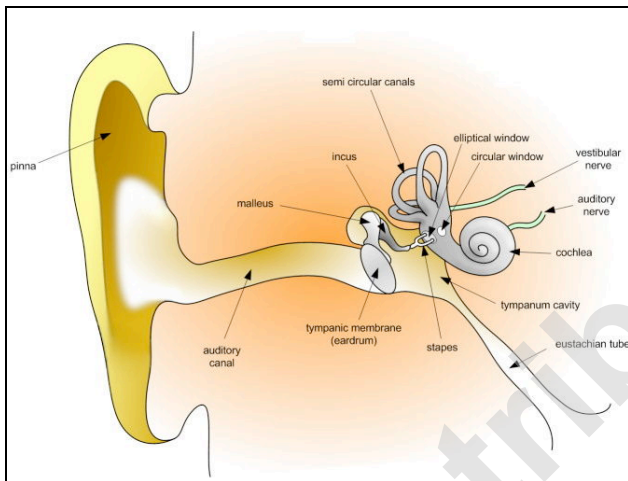
Jonathan Pettingil: Theories and Futures of Audio Visualization who explored various forms of Audio Visualization at UCSD. One of his introductory points, which stuck out for me was that his work resulted in more theory than understanding, something I feared for in my own research for my thesis.

Lawrence Harvey: Hey had an installation called Sound Site (1999) at Span Galleries in Melbourne Australia. His work was a series of sonic frames - acoustic moments that have been developed over eight months through research, consultation and interviews with individuals and groups from the blind community. This concept resonates well with me because it also involves the development of sounds of everyday life and I hope to provoke more thought into what's seen and heard in relation to the participants' perception.

John Whitney Sr: Referred to the father of Computer Graphics John Whitney successfully linked music composition with experimental film and computer imaging, one major work being Arabesque in 1975. His earlier works involved computer generated prints on paper set to a flipbook, primitive by today's standards but revolutionary and mesmerizing at that time. I hope to also set a trend in environment sonic visualization.

In my research summary I realized that visualizing sound with technical and artistic meaning will be a near to impossible task. This is given to my lack of experience with the tools I have – hardware and software, inexperience in visualization, and the point where technology is still not at the stage where it can process information like the human brain. For instance one large problem with this processing method, and many others, is that I need to factor in many variables to facilitate any highly intelligible yet easy to interpolate result.

One such variable is the human perception of sound. The sound we hear is influenced by many factors. First the location of sound relative to our ears is calculated in our brains after it's received by each of our Auricles (Pinna) or the outer ear. This sound (vibration) is trapped & funneled to the inner ear. This sound vibration is then converted into information filtered by the inner ear (Incus, Malleus, Semi-Circular Canals, Stapes, Cochlea) and then transferred electrically to the brain via the auditory and vestibular nerves.



But other factors help determine the localization (direction) of sound.

The distance between each ear affects the perceived arrival of the sound. Does it get to the left ear first or right ear? Does it sound far away or very close?

Also, familiarity to sounds and visual cues help determine if the sound lives in one's relative space or is projected. What I mean is that if we hear a dog barking and it sounds really close in proximity, but your visual scope reveals there's nothing within the space to verify that there is a dog in the immediate space then it's probably reproduced by an external source - maybe a recording of some sort.

In terms of direction if we hear a plane going by and we are in the middle of the city we know due to conditioning, familiarity, and process of deduction that the sound is coming from above - somewhere. We look up... It's very difficult to perceive height sonically.

Sound can also change its tone over time reflected versus distance. For instance we are all familiar with the Doppler effect - named after Christian Doppler. This is where a

sound changes its frequency or pitch and wavelength due to changing distance relative to the listener. Think of a car horn, which indicates that the car is coming towards you, it's then at your location, then goes to the opposite direction. The original sound source, the horn, did not change. Only the conditions in which the sound has to travel relative to the listener at an inconstant distance compounded by the reflection of sound off the surface of its surroundings.

With sound we need to be constantly calculative, memorizing and recalling in order for us to go about our day with certainty and safety. At least with respect to sound for those who aren't hearing impaired. But let's add to this, the complexity of many sounds happening at once and changing rapidly. Imagine yourself in a crowded room with a friend and everyone's is talking. Think at a bar. But you are able to hear your friend with *some* clarity. This process is called selective and adaptive hearing. Selective in that we focus our hearing on what's meaningful at the time - the conversation, thus filtering out, or just turning down - masking or turning down the volume on the other sounds around. Adaptive meaning the sounds which does not add any meaning at all is ignored or filtered out. For instance, the consistent and barely audible low hum of a generator, but annoying the least if focused upon.

We constantly execute this process in order to secure our safety and quality of our everyday conduct. Of course we may not have control over very loud sounds or frequencies, which can be excessively irritating. Think of the screeching of brakes from the trains. This is very common on the NYC Subway system, particularly the E line and is very painful to my ears and mind. In such a case we either change our environment, cover our ears or find some other distraction if applicable.

Crunching the Numbers:

Since we have to process all this information it became evident that to extract at least the localized information is a difficult task - especially from a binaural recording source. If we are using computer programs to interpret what we hear one would find it an impossible task. A computer only processes data with no bias. Its reference is a database. Its logic resides in binary and is static to a point. If you introduce artificial intelligence this still functions on the ever-updating command line, swapping and muxing variables to achieve the perceived right outcome. Right for the computer but not always for the user. For humans poses a forever developing character influenced by our changing environments and experiences - good and bad. And the same instance is different to many based on those factors. Computers are a tool but people are the ones who effectively or not utilize this tool. But our everyday cerebral logic, even though may be questionable, contains many databanks of information, constantly being updated and modified, refreshed, erased, on such a high computational system wide level, we need

a super computer to perform those task and many future iterations of programming and development to meet the same standards. Can the computer process replace the human while maintaining the quality and zeal of life? Can a computer convey emotion to the likeness of humans? My point here is that when we hear sounds in our environment we attach meaning localized to ones-self.

Future Plans

I see *Sound and the City* evolving to become an installation in an art space consisting of microphones positioned in strategic spots gathering dynamic sounds in real time, point source speakers to deliver directional sounds and a large display. There would be very user-friendly navigation controls to select and direct scenes from cities. A user can choose a 3D model of a city, the day segment (morning, afternoon, evening or night), time of year, any special occasion like New Years Eve, and many more conditions if applicable. On the back end I am still working on a web portal (<http://soundandthecity.com>) where a sound enthusiast can register and upload sounds populating the database with information from around the world. Will hopefully have a web presence for this application.

Conclusion

I've embarked on a near impossible yet rewarding venture. In my research I've learned more about what's possible and where things can be in the future. *Sound and the City* serves to remind people of their location existence within a wider city scheme. I hope to trigger nostalgia, provoke the base emotions, influence interactivity and adaptively at the next level - adding to the everyday sounds while analyzing its outcome. *Sound and the City* aims to provoke listening, not just hearing. I urge you after reading this paper to listen to your environment for about 20 minutes. Write down what you hear. Make note of the time and visual stimulus. After doing this review your list and ask yourself if you found something new, different that you may have not noticed or taken for granted. Do this once a week at the same time for as many consecutive weeks if possible. After 10 or more listening sessions review your list again and see if there's a pattern. I would like to hear about your findings or just your research. You can email this info to sound@omorphy.com.

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2. Eric Rosenthal – NYU Tisch ITP adjunct professor, President of Creative Technologies LLC, and Digital Imaging Specialist.

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