New York City's New Noise Code and NYU's Citygram-Sound Project

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ABSTRACT

Honk – bang – whir – whiz – roar – ding – beep – chug – boom – rattle – hum – screech – boom. More than 2000 years ago, the residents of Rome, Italy complained about the disturbing noise from chariots racing through the city's cobbled streets at night. Ever since then the sound of civilization's progress and development have led to the recognizable sounds of construction and manufacturing noise, exhausts and impact noise, horns, and sirens, etc. Also with the development of musical instruments musical sounds became an issue. Some of these sounds were welcome and some were not. Civilization's "progress" can at times seem to disturb the general tranquility of everyday life. Each observer makes the determination of the difference between "sound" and "noise." For example a perennial source of tension between parent and child is the optimal level at which music or television is enjoyed. As technology advanced so did methods to measure sound and a determination of what types of sounds created a nuisance and also at which levels noise disturbed people and effected their ability to work or rest. The City of New York is the most populous city in the United States, with its metropolitan area ranking among the largest urban areas in the world. Its size and population brings with it its own set of unique and challenging noise issues. Almost everyone enjoys certain sounds of the City. The bustle of kids playing and laughing in a park is welcome. Also welcome are the happy cheers at sporting and other public events. However, blasting stereos, honking horns, un-muffled exhausts and ear-splitting jack-hammering can ruin a good night's sleep and diminishes the city's quality of life.

Keywords: Urban, Noise, Sensor Network, Cyber-Physical System

1. INTRODUCTION

In response to this issue in October of 2002, Mayor Michael Bloomberg announced Operation Silent Night, a new coordinated citywide quality of life initiative to combat loud and excessive noise. It also was announced that DEP had began to amend the City's noise code to decrease the excessive noise. This effort to revise the decades-old Noise Code, would work to limit noise throughout the City by using practical standards that are easier to enforce and easy for the general public to implement. DEP would make the code more specific adding the latest noise standards to make enforcement more effective. These standards are expressed with greater clarity whereby making it easier for the regulated community to come into compliance. Shortly thereafter in 2003, in a related endeavor a non-emergency telephone number 3-1-1 was established in New York. It provides quick, easy-to-remember telephone number to attain access to municipal services. Dialing this number allows city residents to obtain important non-emergency services through a central, all-purpose phone number quickly and effectively for issues such as for noise complaints, heating issues and parking regulations. The largest United States 3-1-1 Citizen's Service Hotline operation that exists operates in New York City (NYC). Citizen noise complaints to 3-1-1 established itself as a major quality-of-life issue. The Noise Code bill was passed by the City Council unanimously on December 21, 2005. It was signed by the Mayor on December 29, 2005. Among those present were NYCDEP Commissioner Emily Lloyd and Deputy Commissioner Robert Avaltroni. The Law had an effective date of July 1, 2007. There was universal praise for the collaboration between the City, the construction and nightlife industries, neighborhood groups and the City Council. The legislation

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protects New York's legacy as the "City that never sleeps" while making sure that New Yorkers can get some peace and quiet. The new Noise Code removed outdated code sections and replaced them with ones that use the latest acoustic standards and provided for flexible and reasonable enforcement. This paper mainly highlights and focuses on several areas of the new law including new efforts for noise mitigation in collaborative project with New York University. In particular, we will focus on the following. (a) *Reducing sound resulting from construction*: The new code through the promulgation of the Construction Noise Mitigation Rule provides updated and reasonable means of limiting noise from construction sites located near residential neighborhoods. The Rule establishes a uniform best management practices for all work sites, uses greater discretion in granting permits for night and weekend work and mandates that "*Construction Noise Mitigation Plans*" be available at each site. The Plan provides for solid perimeter noise barriers, and includes portable sound barriers, adequate mufflers for equipment at all construction sites including "noise jackets" for jackhammers. Following the uniform Plan should decrease noise pollution. If a contractor cannot meet the requirement of the Construction noise Mitigation Plan, he or she can file and Alternative Noise Mitigation to the Department for review. The topic of Construction Rules is touched on in more detail in subsequent sections of this article. (b) *More practical regulation of sound from commercial music sources*: The existing old noise code prohibited sound from commercial music establishments such as bars, clubs and cabarets, louder than 45 decibels (dB) as measured in a residence. In the new code that sound level was reduced to 42 decibels as measured in a receiving property dwelling unit utilizing the 'A' weighted network. The old standard did not effectively measure intrusive bass-level music, which cannot be captured by a conventional 'A' weighted decibel scale. A 'C' weighted decibel scale standard now also regulates commercial music with a measurement standard that captures annoying low-frequency sound. Moreover, the new code establishes a more flexible standard and enforcement schedule for music sources that includes no penalties for first offenses if compliance is achieved. Musical sound from a commercial establishment is prohibited from exceeding the following limits as measured in a nearby residence: 42dB(A), or; 45dB in any one-third octave band as measured in a residence, or; Increases by 6dB(C) scale when the ambient sound level is 62 dB(C) or greater. As long as the establishment meets certain criteria a zero civil penalty for a first violation is imposed if liability is admitted and the establishment certifies that it has been brought into compliance.

2. THE CONSTRUCTION RULES

Construction is one of the largest industries in New York City. Prior to the Noise Code revision industry representatives understood that noise complaints were the number one quality-of-life complaints that contractors face in the City. Statistically, noise is the number one complaint to DEP. Construction noise is one of the top complaints that the DEP receives. The old construction noise standard needed further clarifications to establish what is required and what can be expected. DEP worked with the industry to determine what reasonable noise mitigation requirements would be necessary so that building development and infrastructure rehabilitation could go forward, uninterrupted. To accomplish this goal the City would need to update its old and ineffective construction noise regulations and develop new guidelines specifically intended to reduce construction noise citywide. While seemingly an idea that would appeal widely, the initiative was not without its skeptics. Change is often difficult, and people can be resistant to change, even if it would be beneficial to them. These concerns can be even further magnified when there might be economic consequences associated with complying with the new laws and Rules. After reaching industry consensus with builders and many meetings and hours of deliberations the previously mentioned Construction Noise Mitigation Rules were promulgated pursuant to the authority of §24-219 of the new Code with the same effective date of July 1, 2007. The Rule provides for a generic Construction Noise Mitigation Plan that will incorporate types of equipment and mitigation methods to be utilized. Any person, corporation or business doing construction in the city must adopt a plan to mitigate noise before construction at the site begins, or within three days for emergency work. A Plan need not be filed if it conforms to the rules of the department but it must be available for view on-site. It is violation to perform work at a construction site that is not in compliance with the site's construction noise mitigation plan. This provision requires the DEP to promulgate and adopt rules that identify noise mitigation strategies for certain devices and activities. Such rules shall include additional mitigation measures for sensitive receptors. The new Rule describes and guidelines for the use of perimeter noise mitigation barriers around work sites. Solid Perimeter noise barriers can be a crucial

line of mitigation keeping site noise within the location. The new Rule describes particularly noisy construction equipment and activities and provides several examples of various methods of noise mitigation for each piece of equipment for the contractor to consider. Procedurally, upon receiving noise complaints from the public, NYCDEP noise inspectors will be dispatched to the site to review the contractor's Noise Mitigation Plan. If a violation is found the contractor will be afforded a period to achieve compliance. If the contractor does not feel that compliance is possible they can then file and seek approval of an Alternative Noise Plan within the spirit of the Code to mitigate noise in a reasonable way. The Noise Mitigation Plan: Construction between 7 a.m. and 6 p.m. is permitted on weekdays. Contractors will need to develop, and post conspicuously for inspection and review, a suitable Noise Mitigation Plan. NYCDEP will allow for Alternative Noise Mitigation Plans and Utility Noise Mitigation Plans for special purposes. Sample Plans are on DEP's Website. Contractors will certify that all the equipment used on site will comply with noise emission limits.

3. RECOGNITION AND AWARDS

3.1 Technology for a Quieter American 2010

The National Academies favorably reviewed the Noise code. In discussing the hazards of noise it stated: "Exposure to noise at home, at work, while traveling, and during leisure activities is a fact of life for all Americans. At times noise can be loud enough to damage hearing, and at lower levels it can disrupt normal living, affect sleep patterns, affect our ability to concentrate at work, interfere with outdoor recreational activities, and, in some cases, interfere with communications and even cause accidents. Clearly, exposure to excessive noise can affect our quality of life. As the population of the United States and, indeed, the world increases and developing countries become more industrialized, problems of noise are likely to become more pervasive and lower the quality-of-life for everyone. Efforts to manage noise exposures, to design quieter buildings, products, equipment, and transportation vehicles, and to provide a regulatory environment that facilitates adequate, cost-effective, sustainable noise controls require our immediate attention. Technology for a Quieter America looks at the most commonly identified sources of noise, how they are characterized, and efforts that have been made to reduce noise emissions and experiences. The book also reviews the standards and regulations that govern noise levels and the federal, state, and local agencies that regulate noise for the benefit, safety, and wellness of society at large. Noise emissions are an issue in industry, in communities, in buildings, and during leisure activities. As such, Technology for a Quieter America will appeal to a wide range of stakeholders: the engineering community; the public; government at the federal, state, and local levels; private industry; labor unions; and nonprofit organizations. Implementation of the recommendations in Technology for a Quieter America will result in reduction of the noise levels to which Americans are exposed and will improve the ability of American industry to compete in world markets paying increasing attention to the noise emissions of products." Important citations are listed that discuss the 2007 NYC Noise Code were highlighted in Technology for a Quieter America. The most relevant pages of the book published by the Academy of Engineering and Science in Washington that favorably reviewed the new NYC Noise Code.51[i]. On page 118 of "Technology for a Quieter America" it says the New York City Noise Code is a modern noise code and "a good starting point for upgrading existing noise laws or creating new ones [in the USA]." On page 13 the "Construction Noise" section it cites the presentation on NYC construction noise that Thalheimer and Shamoon wrote regarding the NYCDEP construction noise law in 2007. I recommended Thalheimer to DEP when Shamoon read about his work in Boston. There were efforts from many people at DEP.

3.2 NoNoise.org Award 4/17/2007

Noise Pollution Clearing House, a well known noise control organization presented a prestigious award to Mayor Bloomberg for his 2005 Revision of the NYC Noise Code at the 10th Anniversary of Noise Pollution Clearinghouse. The award ceremony is described in a publication.

3.3 Safe in Sound Award from CDC/NIOSH/NCHA

This is the national Safe In Sound Award was granted to DEP in NYC and Orlando. At a ceremony on May 18th 2010 the award was granted to DEP. Safe-in-Sound Excellence in Hearing Loss Prevention Awards "Recognize the New York City's Noise Mitigation Rule The National Institute for Occupational Safety and Health (NIOSH), in partnership with the National Hearing Conservation Association (NHCA), presented the *New York City Department of Environmental Protection* and Parsons Brinckerhoff, Inc. the 2010 Safe-in-Sound Award™ in the category for Innovation in Hearing Loss Prevention in the Construction Sector. The *New York City Department of Environmental Protection* and Parsons

Brinckerhoff, Inc. were recognized for their combined efforts in developing, implementing and overseeing the *New York City Construction Noise Mitigation Rule*. The rule, which is a result of a Mayoral charge to update the New York City's Noise Code, established noise emission limits and mitigation measures for all city construction and also proactively addressed work-related exposures. The award was presented at the Building Trades Employers' Association Leadership dinner on May 18th 2010. Work-related hearing loss is a permanent but preventable problem. The Safe-in-Sound Excellence in Hearing Loss Prevention Awards™ honors hearing loss prevention programs in the construction, manufacturing, and service sectors. In addition, it recognizes individuals or organizations for innovation in hearing loss prevention and their dedication to fostering and implementing new and unique advances in the prevention of hearing loss."

3.4 Quieting The World's Cities Conference Internoise 2012

At the 2012 InterNoise conference, Thalhiemer and Shamoon were invited as Plenary Speakers to 1400 attendees. At the conference, they discussed the unique award winning NYC construction Noise Mitigation Rule. This rule mandates barriers and other engineering controls surrounding Construction sites. Also they discussed the DEP Vendor Guidance document, which lists quieter alternatives to heavy construction devices. In a separate presentation Shamoon went on to discuss the method DEP used to lobby stakeholders and legislators to get the Code passed unanimously.

3.5 New York City BUY QUIET TIME PROGRAM

E. New York City BUY QUIET PROGRAM [for Suggested tool use in NYC Construction. Noise Control Products and Vendor Guidance Sheets] As an innovation DEP formed this guidance to construction contractors with respect to findings and selecting suitable noise control products. These products and vendors may be helpful to contractors for achieving compliance with the New York City Noise Regulations. These items are provided only as suggestions for contractors to consider and should not be construed as an official endorsement of any product and/or vendor by the City of New York. Contractors are free to choose other products/vendors that meet the requirements of such Code. This sheet will be updated from time to time as new noise control technologies gain acceptance by the construction supply industry. The PDF document is on DEP's website[3].

4. NOISE MITIGATION: A CYBER-PHYSICAL SYSTEM APPROACH

Noise pollution and its impact on city-dwellers have not always been taken seriously in the past, and noise has traditionally been considered a *nuisance*. Since the 1970s, however, studies have shown correlations between urban noise and exposed health risks and its sonic "wear-and-tear" [1] on the human body. This includes health risks such as children's learning skills, hypertension, sleep deprivation, gastrointestinal, cardiovascular, and other physiological disorders [2]–[7] suggesting the need for controlling and mitigating urban noise. Although NYC has some of the most advanced and up-to-date noise codes, the current infrastructure to enforce, mitigate, and control noise is still problematic. One of the fundamental problems we face in noise control is its proper measurement. The current practice of assessing noisiness is to measure a sound source's raw dB(A) levels; and although this technique provides insights on "loudness" of a sound agent, *loud sound* does not automatically result in the perception of *noise*. For example, scratching a blackboard with one's fingernails at 90 dB is very differently perceived to hearing soothing oceans waves at the same dB levels. In short, the multidimensionality of sound, which is reflected in its temporal *and* spectral structures, affect how sound is *perceived*. Furthermore, "noise" is not always perceived as noise – it depends on physical and perceptual factors that are a function of time and space. It is clear that it is impossible to consistently and unequivocally identify a sound source as noise every time – at a certain point, it becomes an issue of *ear of the beholder*: noise can be annoying to one person while for another person it can be music for the ears. However, it is perhaps safe to assume that certain sounds, in any setting, will very likely be perceived as noise: extremely loud vehicular sounds in cities, loud talking by neighbors, and high dB music that is outputted from automobiles racing down the street. In short, there are sounds that we can agree and safely label as *noise*. A possible support of this assumption can be found in the NYC 311 calling system. According to 311 data analysis, the top complaints reported by New Yorkers over the past 11 years include car/truck sounds, loud talking, dogs barking, and loud music. Hardly surprising, but evidence of statistical and quantitative measurements of agreed upon noise classes that city-dwellers find annoying.

With an overwhelming consensus by New Yorkers that noise is a serious and fundamental issue of urbanity, one of the big questions is how to address its mitigation via enforcement procedures – i.e. dispatching offers to noise pollution scenes. A typical procedure reassembles the following sequence of events: (1) noise complaint by a resident, (2) dispatch of officer(s) to noise complaint scene, (3)

[3] http://www.nyc.gov/html/dep/pdf/construction_guidance.pdf

analysis of noise pollution scene by officer, and (4) fining perpetrator(s) if deemed necessary using a dB meter or relying on the opinion of the officer to make the decision whether a sound should be considered to be finable noise. This procedure is fundamentally impractical for a few reasons: (a) noise is constantly in flux, (b) noise in invisible and leaves no traces, (c) an issue of subjectivity and objectivity arises, and (d) using dB(A) measurements is a start but certainly not the end of determining whether a sound should be labeled as noise. One of the ways to begin addressing this issue is by creating a cyber-physical system (CPS) that can monitor sound in real-time with a high degree of temporal and spatial granularity using appropriate technologies including robust sensor networks, a multitude of remote sensing devices, citizen-science participation, and automatic urban sound identification. Such a CPS is introduced in the next section.

4.1 The Citygram-Sound Project Overview

The Citygram-Sound Project aims to contribute to the issue of urban noise pollution by creating a cyber-physical system (CPS) that automatically collects, processes, visualizes, classifies, and maps soundscapes. This is enabled by capturing soundscapes via a comprehensive sensor network comprised of remote sensing devices (RSD), server, and various software and hardware solutions. For our RSDs, we are currently employing a strategy that includes the combination of *fixed* and *mobile/crowd-sourced* solutions to create a *dense* sensor network that captures urban soundscapes in real-time.

The *sensor network* part for our collaborative project is built on Citygram's sensor network architecture, which is based on RSD deployed in urban environments via different hardware platforms. Our sensor network design philosophy is based on creating a high granularity of spatio-temporality whereby a dense network is formed via cost-effective and high-quality data capturing solutions. As such, two types of RSDs are used: (1) fixed RSDs and (2) crowd-sourced RSD. Fixed RSDs are calibrated sensor systems that are permanently deployed in urban environments allowing for transmission of consistent, reliable, and calibrated audio data to our server. Our crowd-sourced RSDs, on the other hand, are based on a design philosophy whereby *any* computing device with a microphone and Internet connection can become a senor node – a concept we call *plug-and-sense.* Examples of plug-and-sense devices include handheld hardware (e.g. smartphones, tablets, phablets, etc.), desktop, and laptop computers running on our freely available software. For our fixed RSDs, we are currently using the Android Operating System with run on a Tronsmart MK908 Android mini-PC with an A9 Quad Core processor, Quad Core GPU, 2GB RAM, USB, Bluetooth, Wi-Fi, and HDMI I/O. In lieu of the fixed RSDs we also provide real-time streaming and interaction solutions for citizen-scientists or the general public who wish to participate. The requirement for participation simply entails having a computing device, microphone, and Internet connection.

Another area of focus in the Citygram-Sound Project includes *automatic urban noise classification.* Automatic soundscape classification refers to the automatic recognition of sounds found in the environment – something we call *Soundscape Information Retrieval* (SIR). The field of automatic soundscape classification, unlike speech-based machine learning, is still in its nascent stages largely due to a number of factors including: (1) the lack of *ground truth* datasets for algorithmic development, (2) underexplored soundscape namespace, (3) overwhelming emphasis on speech recognition, and (4) sonic complexity and diversity of its classes. A soundscape can literally contain any sound, making such the sound classification task fundamentally difficult. Soundscape classification is an emerging field and is broader in scopes as all types of sounds can exist in an urban environment. Numerous research *subfields* exist, including classification projects related to surveillance, bird species, traffic sounds, and gunshot detection. Our current research focus is on urban sound and urban noise pollution. As such, we are currently exploring a number of approaches using discriminate and statistical machine learning techniques to automatically classify urban sounds captured through our sensor network. Once complete, we anticipate that our system will be able to automatically recognize sound classes such as dogs, sirens, trucks/cars, and loud music. These outputs will be mapped and overlaid on various visualization formats including in essence creating interactive, real-time soundmaps. A number of visualizations are currently being investigated and a prototype visualization format can be accessed at citygram.smusic.nyu.edu where RSD outputs (low-level acoustic feature vectors) are mapped in real-time on Google Maps as overlays. These visualizations will offer interactive mechanism to visually and aurally monitor noise pollutants in real-time. The CPS systems and its modules and sub-modules are currently being developed and are far from complete. However, many of its basic modules have been prototyped and tested and expect to make continued progress in the near future.

4.2 Citygram-Sound and Noise Code Enforcement

An important function of Citygram-Sound is in its strategic use in enforcing noise code of megacities. For example, we envision the current typical noise control procedure to change from the aforementioned procedure to the following procedure: (1) receive a complaint, (2) verify through our real-time

soundmaps the *type* of noise, *level* of noise, and time when noise is generated, (3) dispatch an officer, and (4) fine as appropriate. However, by the time an officer arrives at the scene, the noise and the person responsible for the producing the noise may longer be at the scene. The response time and verification process can, however, be significantly reduced and improved, and more importantly, by keeping a history of geo-tagged noise pollution agents, dispatchers may be strategically deployed in appropriate urban areas which will in turn improve effective noise code enforcement. Furthermore, by having a spatio-temporally dense representation of current and past noise pollution events, it will be possible to model future noise pollution occurrences using predictive modeling techniques. With the availability of huge amount of data, we can then conduct data analytics across different data modalities including spatio-temporal crime stats, census stats, real-estate information, and other data types.

5. CONCLUSIONS

In this paper we discussed NYC's new noise code and NYU's efforts to develop a cyber-physical system to help in the mitigation of urban noise pollution. There is clear consensus on the severity of urban noise for city-dwellers in megacities today, and experts recognize the potential of further increase in noise pollution with continued urban population growth. As such, efforts in developing a comprehensive cyber-physical system to capture, map, and analyze urban noise is underway and includes collaborators from NYC Department of Environmental Protection (DEP); NYU Steinhardt School; NYU's Center for Urban Science and Progress (CUSP); the NYU Polytechnic School of Engineering; and California Institute of the Arts (CalArts). Our CPS is based on creating a solution that is cost-effective, transferrable, and scalable which can also serve as a model for other cities worldwide. Furthermore, we believe that our plans will be acceptable to both *stakeholders* and *residents* in mitigating noise pollution problems by seeking to use innovative technologies to isolate specific enforceable noises in the megacities' total soundscape. Isolating and quantifying specific sounds can lead to noise mitigation innovation and new noise control legislation.

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