Some UX & Service Design Challenges in Noise Monitoring and Mitigation

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Experience Design Meets Service Design – Method Clash or Marriage? workshop in conjunction with CHI'18. April 22, 2018, Montreal, Canada.

Abstract
This position paper describes some of the challenges faced in SONYC, an urban noise monitoring and mitigation research project being undertaken in New York. It outlines how these challenges might be approached through methods adopted from both user experience and service design practice. It also outlines new problems posed by data and machine learning, for which neither practice has yet established accepted methods. This space, which is likely to become increasingly important to designers, is suggested as a likely area of collaboration and mutual research.

Author Keywords
Service design; UX design, urban noise mitigation.

Introduction
Interest in smart cities and urban interaction design are amongst the trends contributing to the emergence of scale as a concern for HCI researchers [2]. In an urban context, considerations of scale include: the potential number of different stakeholders interacting with systems; the geographical spread of human and computational nodes in the socio-technical network; temporal aspects, particularly the potential for delay between sensing and actuation in interactions; and

interactions with and between large amounts of real-time and historic data on which smartness is predicated. In this position paper I will begin to layout how these challenges are presenting within SONYC [10], a project that aims to support city authorities in New York respond to noise pollution with urban sensing and machine listening technologies. I will also outline how service design and user experience (UX) design are informing our work.

Background to the SONYC Project

SONYC (Sounds of New York City) is an ongoing urban sensing or smart cities research project that aims to monitor noise pollution at a city scale, use machine listening to describe acoustic environments, support city agencies in identifying and acting on breaches of New York's noise code, and broaden participation in noise reporting and mitigation activities. As is not uncommon in engineering led research, the focus of the first two years of SONYC has been on technical development; building sensing hardware, network infrastructure, and initial machine learning models. More recently, there has been a widening of this focus to include consideration of how citizens and civic authorities might interact with these technologies. Successfully facilitating this requires that we present UX as more than visual design of user interfaces, and show the importance of designing meaningful services that provide value to a variety of stakeholders.

Stakeholders

For UX designer-researchers, our focus has typically been on the "user"; i.e. a person or group of people that we envisage will be immediately interacting with a particular interface. In the context of urban-scale smart sensing systems, the notion of user can be more complex. There will typically be any number of candidates at different times and in different places, and whose interactions take different forms. For example, in SONYC, we might identify the citizen who is directly affected by the impact of noise pollution as our potential future user, or the enforcement officers who are charged with visiting a site to investigate and potentially issue citations for noise code violations. Other key stakeholders include: the dispatchers who prioritize enforcement visits; city data analysts and technology officers who develop and maintain the systems these officers work with; political representatives at different levels from local Community Boards to the Mayor's Office; and representatives of local business districts.

Some stakeholders may not be "users" at all, at least not in the sense of having intentional interaction with the system, but simply live in areas monitored by sensors. Others may work with noisy machinery on construction sites, or own the businesses and premises that enforcement officers are called on to visit. As our design work continues, it is likely that other stakeholders will also be identified. Understanding these different patterns of use and even 'non-use' is an important element in focusing our design activities.

To aid this understanding we are starting to explore relationships between officers within city agencies, and across different city agencies; and the relationships they have with representatives of non-governmental organizations, and with citizens and businesses. Methods we are using include stakeholder discovery workshops and contextual inquiry interviews [8]. These activities help us to build a picture of the positions different stakeholders may occupy within the existing

systems we aim to support, and within the proposed socio-technical system we are developing. Building these stakeholder maps, which are a common artifact in service design [9], will provide a richly informative background in which to place personas, scenarios, and other artifacts familiar within interaction design [4].

Time and Place

Our research aims within SONYC include investigating ways to augment citizens' engagement with local authorities to increase the quality of noise reporting, and to explore how engagement over noise concerns might be translated into raised civic awareness and community involvement. Here we see how research into smart city applications can pose challenges beyond UX design's typical concern with particular interactions, and introduce the need for longer-term value creation that requires a process focus in which individual transactions are considered part of building and maintaining a continuing relationship. Service blueprinting [1], with its focus on understanding and mapping customer journeys, offers a model for how this might be approached. Our initial focus is to understand the enforcement process from a citizen's first report through to the possible issuing of a citation (which may be the result of a number of individual reports, multiple officer visits, and numerous instances of possible violation).

Urban noise, unsurprisingly, occurs in the city. The process of moving from noise report, through investigation of the likely source of that noise, to resolution, involves changing locations as well as extended time-scales. Stakeholders may be mobile, geographically distant, or in places where interaction with digital devices is less than optimal. Because of this, the experience of each individual interaction remains crucially important. UX design's growing awareness of emotional and social aspects surrounding system use, through techniques such as Experience Prototyping [3], offers a suitable model here. However, understanding services as sequences of interactions can help us combine service design and UX artifacts and methods, building where shared techniques such as generative design research, co-creation and prototyping enactments already offer a common ground.

Large Datasets and ML Systems

City-scale sensing and analytic systems generate large amounts of data. At SONYC these data are of two types: loudness or sound pressure level measured in decibels; and audio recordings, currently used in training machine listening algorithms. Such data raise ethical issues, particularly related to privacy and trust. The technical solution to these issues has been to restrict our sensors to recording in ten-second bursts that cannot be used to reconstruct anything recognizable as conversation, and will eventually be to localize machine learning models that identify sound sources (e.g. jackhammer or car horns) onto the sensor so that audio no longer needs to be stored centrally. The legal solution to these issues has been to post signs next to each sensor that clearly outline their purpose and highlights the restrictions placed on audio recording. An important part of the UX response to these issues is to try to better understand and empathetically respond to the different feelings triggered by the presence of microphones on neighborhood buildings.

The use of machine learning (ML) also raises issues for UX designers, who are not typically well prepared or experienced in working with this challenging material [5]. The way that ML and algorithmic decision making changes peoples' work has been seen in many areas, perhaps most notably with regards to cab drivers following the introduction of Uber and Lyft services. A key consideration as the machine listening capabilities of SONYC technologies develop will be to work closely with officers from city agencies to understand their work practices and design service offerings that augment these and do not become a mechanism for removing officers' agency.

The challenges that large datasets and ML raise are to a great extent new to both UX design and service design, and so there are as yet no well established methods to follow. This is a clear research opportunity. In previous projects, I have explored how generative design research techniques and human creativity might help us understand the context in which data are generated, and in which the services they support might be used [6]; and similar methods to investigate new ways that data might be visually represented and structured to support the activities of professionals [7]. However, this work is at an early stage, and many questions remain.

Discussion

Our research aim, of helping mitigate New York's noise pollution, is a multi-scale problem that includes understanding existing systems and work practices, and discovering how we might augment these. It also requires us to consider ethical questions around technology's relationships with stakeholders who are not "users", the long-term impact of our interventions on the way noise is monitored, and how this research might affect the way authorities target potential offenders. We will also undertake inquiry into continued engagement, which is likely to consider reflection on longer-term noise patterns, how citizens' concerns might be validated, and working with noise mitigation advocates to reward best practice and self-regulation.

We are adopting service design methods as we aim to better understand the systems and transactional processes that lead to users achieving different goals, and UX design methods as we aim to better understand the emotional and social context around particular interactions. Other design practices including participatory design and critical design also offer lenses through which our activities might explore the impact on peoples' lives of the technology we develop. However, some of the biggest challenges, surrounding data and intelligent systems, are relatively new to both UX and service design, and so here we will be exploring new combinations of tools and techniques to develop sensitizing constructs. This, I believe, will be a key area that is of increasing importance to both UX and service designers; and which offers an intellectual space to share and blend methods, and to conduct collaborative research. It also raises the question of how traditional UX and service design approaches can be interpreted, adapted and extended to fit the demands of civic or social design situations. I am therefore excited by the opportunity to share experiences, consider practice similarities and differences, and form connections through which such research might be undertaken.

Acknowledgements

This work was supported by National Science Foundation award 1544753

(https://www.nsf.gov/awardsearch/showAward?AWD_ID=1544753).

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