Audio Cartography: Visual Encoding of Acoustic Parameters

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Abstract

Our sonic environment is the matter of subject in multiple domains which developed individual means of its description. As a result, it lacks an established visual language through which knowledge can be connected and insights shared. We provide a visual communication framework for the systematic and coherent documentation of sound in large-scale environments. This consists of visual encodings and mappings of acoustic parameters into distinct graphic variables that present plausible solutions for the visualization of sound. These candidate encodings are assembled into an application-independent, multifunctional, and extensible design guide. We apply the guidelines and show example maps that acts as a basis for the exploration of audio cartography.

1- Background and Objectives

Human, cultural, and environmental sciences are concerned with the effects of sound in urban environments. They examine medical and social problems of acoustic immission caused by increasing transportation and industrial production. For example, the World Health Organization (WHO) documents several direct relationships between constant noise nuisance and medical or psychological damage, such as hearing impairment or high blood pressure (WHO 2009). In the political arena, the European Union (EU) released the directive 2002/49/EC (END) to attend to the expanding

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noise exposure. Since 2002, European agglomerations are legally obliged to conduct noise mappings and to publish the results on maps (EU 2002).

In physics, improvements in computing and simulation algorithms enable the advanced geometric modeling of micro- and macro-scale sound propagation, such as in streets or large urban areas (Kang 2007). Psycho-acoustics analyzes the subjective perception of sound and emphasizes the influence of urban parameters, such as the contentment with the residential area or the importance of the sound source (Lercher 1998). With an anthropogenic and sociological background, an international research network works on soundscape analysis where linkages between environmental sound and society are explored (soundscape-cost.org 2011). Concurrently, the International Organization of Standardization (ISO) develops standards for the perceptual assessment of soundscape quality and discusses definitions and methods (ISO 2010). Also, planning disciplines developed a conspicuous awareness of auditory aspects of urban and architectural designs (Arteaga and Kusitzky 2008). Some of these research results attracted public interest to the extent of triggering several national and international initiatives, such as local action groups or the International Noise Awareness Day (Deutsche Gesellschaft für Akustik e.V. n.d.).

Each of these domains deals with different facets of the sonic environment. Whilst each focuses on spatial characteristics of sound, they develop individual means of its description. These might be considered different languages for visually describing properties of sound. Their incompatibility means that, when it comes to an exchange of perspectives, interdisciplinary discourse is difficult. Appropriate tools for supporting this activity do not exist.

The objective of this study is to provide fundamental building blocks for communication, documentation, and presentation to involve all stakeholders concerned with the sonic environment. This includes systematic visual encodings and mappings of acoustic parameters into distinct graphic variables as plausible solutions for the visualization of sound. Consequently, the codifications lead to the compilation of guidelines according to specific tasks. They are assembled into an extensible visual design guide as the basis for audio cartography as a visual communication framework for the systematic and coherent description of the sonic environment.

2- The Visualization of Sound

The human process of external cognition uses graphical representations to describe and exchange mental concepts (Scaife and Rogers 1996). The creation of visual metaphors for information depicting structures of the real world aims to reveal patterns, amplify cognition, and generate insights whereby insight enables discovery, decision-making, and explanation (Card et al. 1999, Ware 2004). These principles specify the missing components in connecting the diversified knowledge of the sonic environment. The display of sound in varying contexts would enable the visual utilization of acoustic information and provide a solid common level of communication. Based on extensive research of multidisciplinary perspectives on the sonic environment and their visual communication techniques, the visualization of sound has to meet the following challenges.

2.1 Envisioning Sound

Envisioning sound involves the fundamental problem of designing visual presentations of information that has no clear relation or association to familiar physical geometries (Bugajska 2003). Sound is an audible and invisible entity, and human perception is not familiar with its visual interpretation. Depictions of acoustic data range from musical notations and synaesthetic images as subjective visual perceptions of music to aesthetic visual installations of acoustic signals in the field of artistic visualization (Woolman 2000, Baron-Cohen and Harrison 1997, Nicolai et al. 2008). Although these concepts mainly relate to musical compositions, they can be assigned to the visualization of sound in large-scale environments. The universality and uniformity of music notations underline the requirement to develop a general and consistent visual encoding of acoustic information. Synaesthetic perception, even when it is rare, suggests the capability to transfer an auditory stimulus to a visual metaphor. Artistic transformations of sound highlight the possibility to visualize abstract acoustic data in an appealing and aesthetic way.

2.2 Mapping Sound

Over millennia, maps have been powerful instruments to communicate geographic spaces that are too large or too complex to be seen directly (MacEachren 1995, Dodge et al. 2008). Existing communication techniques indicate that mapping sound is an appropriate instrument for an integrative and interdisciplinary documentation of the sonic environment. One of the main tasks of the END is the publication of noise maps to communicate immediate problems of noise exposure to the general public (EU 2002). Concepts developed in multimedia cartography add audio visual features to noise maps to facilitate their understanding (Scharlach 2002). Cartographic visualizations within soundscape research highlight acoustic spatial identities or auditory effects of the sonic environment by using simple black-and-white points, lines, areas, or graphic semiologies (Southworth 1969, Servigné et al. 1999). Cutting-edge simulation approaches implement sound propagation based on punctual or spatially extended sound sources. This allows for the graphic representation of sound in relation with other topographical objects, such as buildings (Michel 2008). Graphical intersections with other topographical objects are important to provide orientation in the setting, give insight into the spatial dimension, or reveal interactions of the acoustic parameters. Consequently, the visualization of sound demands an integrated map design that suits the perspicuous presentation of both acoustic and topographical objects.

3- Approach

The heterogeneity of disciplines dealing with characteristics of the sonic environment opens up a huge range of involved stakeholders, such as domain experts, scientists, planners, decision-makers, people concerned with noise, and the general public. Therefore, we need a cross-disciplinary communication framework that is suitable for multiple applications according to specific questions or target audiences. This includes a medium- and application-independent concept to guarantee its general qualification and usage. Furthermore, the design has to operate on a broad range of media formats, such as paper or computer-based and mobile devices.

Our approach is to develop a simple graphical language that connects the above mentioned knowledge levels. This consists of an appropriate set of