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A REVISED WEB APPLICATION FOR INTERACTIVE EXPLORATION AND VISUALIZATION OF ISO 12913 SOUNDSCAPE DATASETS

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ABSTRACT

The development of the ISO 12913 has led to the creation of standardized methodologies for collecting and analyzing individual responses regarding acoustic environments in context. This progress aims to enhance comparability, ensure replicability, and support the development of modeling algorithms for soundscape prediction and design tasks. Developing methods to represent and explore soundscape data can provide deeper insights into various datasets. Although it is unlikely that any single method will sufficiently capture all information in empirical studies, attempts are worthwhile to facilitate advancements in this realm. The underlying work expands a previously published web interface for comprehensive soundscape search, fostering interactive exploration of datasets based on ISO 12913. The application facilitates a comprehensive soundscape search using 10 items of the standard, 8 features characterizing the soundscape (e.g., intensities of natural, human, and technical sound sources heard), and 10 distinct acoustic features. While the search covers all possible combinations of these components, enabling detailed exploration, in-depth dataset overviews, and comparison of different datasets, this work further enhances the application by not only presenting single value metrics, but also visualizing the temporal progression of acoustic features, providing a quick impression of the temporal variation of the soundscape being currently listened to.

Keywords: *soundscape search, ISO 12913, audio feature visualization*

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1. INTRODUCTION

Over the past two decades, the focus on how to collect data on people's experiences of acoustic environments has become a central debate in soundscape studies [1]. While the field of research originated in the late 1960s with the pioneering work of people like Southworth [2], Schafer [3], and Westerkamp [4], the emphasis on developing methods for data collection within soundscape studies emerged more prominently only recently. To create standardized methodologies for collecting and analyzing individual responses regarding acoustic environments in context, with the aim of enabling comparability, replicability, and the development of modelling algorithms in soundscape prediction and design tasks, the ISO 12913 has been developed by a Working Group named "Perceptual assessment of soundscape quality" at the International Organization for Standardization (ISO) back in 2008 [1]. To date, three documents have been published within the ISO 12913 series on soundscapes. Part 1 (ISO 12913-1:2014) [5] is a complete standard that establishes a general framework and definitions for soundscape concepts. Part 2 (ISO/TS 12913-2:2018) [6] and part 3 (ISO/TS 12913-3:2019) [7] are technical specifications that provide guidelines for collecting and analyzing data, respectively. Since consensus around a single protocol could not be reached, part 2 of the ISO 12913 recommends multiple methods of soundscape assessment (triangulation). While research indicates that assessments should be approached from a holistic, multisensory perspective to capture outcomes that extend well beyond auditory judgments, Axelsson et al. [8] and Mitchell et al. [1] emphasize the need for a critical evaluation of existing soundscape theories and methods, advocating for a diverse, integrative approach rather than a single standardized protocol. Since no single method can fully capture the complexity of soundscape perception, Mitchel et al. [1] propose establishing a reference method to ensure comparability across studies. However, attempts should be made to both facilitate future advancements in this realm and develop a first-step approach that captures the inherent uncertainty in perception studies.

While some researchers employ audio feature extraction, clustering algorithms, and source separation for data visualization, aiming to analyze relevant acoustic events and to characterize soundscapes [9], [10], Mitchel et al. [1] compared different datasets by mapping items defined by the ISO12913 standard onto a scatterplot. While the authors provide a tool that offers a broad overview of entire datasets using only two items, we have previously presented a web application [11] that enables a more sophisticated approach to soundscape exploration and search, leveraging many different items defined by the standard. The application enables the precise identification of soundscapes matching specific search requests, ensuring a more focused and customized exploration process, for instance facilitating the selection of soundscapes for use in listening experiments. The same search applies across datasets, enabling both exploration and cross-dataset comparison. Given that the dataset primarily utilized in the current study [12] is focused on indoor soundscapes, the application incorporates additional items describing characteristics of indoor and at-home recordings. To further enhance the search, various acoustic features are included. Building on this foundation, the revised version of the web application, presented in this paper, extends its functionality by not only presenting single-value items but also visualizing the temporal progression of acoustic features over time. Since natural soundscapes often exhibit temporal variability that cannot be represented by single values averaged over the duration, this feature provides a visual overview of the acoustic dynamics, allowing users to quickly grasp the temporal variation of the soundscape currently being played. By highlighting these variations, the revised application enables efficient navigation, allowing users to skip directly to relevant segments and facilitating the identification of specific sounds or auditory events that may have influenced participants' perceptions.

2. THE CURRENT ISO 12913 FRAMEWORK

Although different methods are proposed for data collection in ISO12913 part 2, items of the dataset [12] used for the web application are derived from the questionnaire-based soundscape assessment (method A). The essence of this approach revolves around eight perceptual attributes (PA) initially identified in [13]: pleasant, vibrant, eventful, chaotic, annoying, monotonous, uneventful, and calm. These items are derived using a 5-point Likert scale, where responses are coded from 0 (strongly disagree) to 4 (strongly agree). Whereas in the questionnaire procedure, these PAs are assessed independently of each other, they can be combined to form two principal soundscape dimensions eventfulness and pleasantness (see [7] for a detailed explanation). Mitchel et al. [14] further refined this approach by introducing the SSID Protocol, which, among other things, categorizes sound sources into traffic noise, other noise, human sounds, and natural sounds, enabling a broader assessment of the sound environment.

3. THE APPLICATION

To ensure comparability across soundscape studies, our application allows for complex search requests using the eight PAs, the two soundscape dimensions eventfulness and pleasantness, and the four categories for sound source composition outlined in the SSID protocol. Furthermore, it extends beyond the initial SSID Protocol items to facilitate a more detailed analysis of indoor auditory environments. The application incorporates additional sound source composition items including household installations (e.g., ventilation, heating), signals (e.g., ringing tones, alarms), speech, various household activities, and music. Besides using situational factors, we decided to expand the search request by adding eight acoustic and psychoacoustical features extracted from each soundscape within the dataset. The features comprise the equivalent continuous sound level (LAeq), loudness, fluctuation strength, the Relative Approach (RelApproach), sharpness, roughness, and tonality. Since the acoustic features represent aggregated values for the entire soundscape recording, the Python library MOSQITO [15] was used to compute temporal progressions of the following five acoustic features using its time-varying implementation: loudness (ISO 532-1:2017), roughness [16] sharpness (DIN 45692), prominence ratio (ECMA 418-1), and tone-to-noise ratio (ECMA 418-1). To reduce the temporal resolution of the acoustic features, a one-second averaging window was applied to the features. This downsampling approach yields a more manageable feature set visualization while still preserving the essential temporal dynamics of the audio signal. Furthermore, the application includes a free text search for precise filtering of specific dominant sounds. Figure 1 presents an overview of the main page of the web application, which is organized into six distinct components: a multifunctional navigation bar (at the top), a radar chart (on the left) featuring the eight PAs for searching soundscapes using a nearest-neighbor approach, two sliders (at the bottom on the left) for

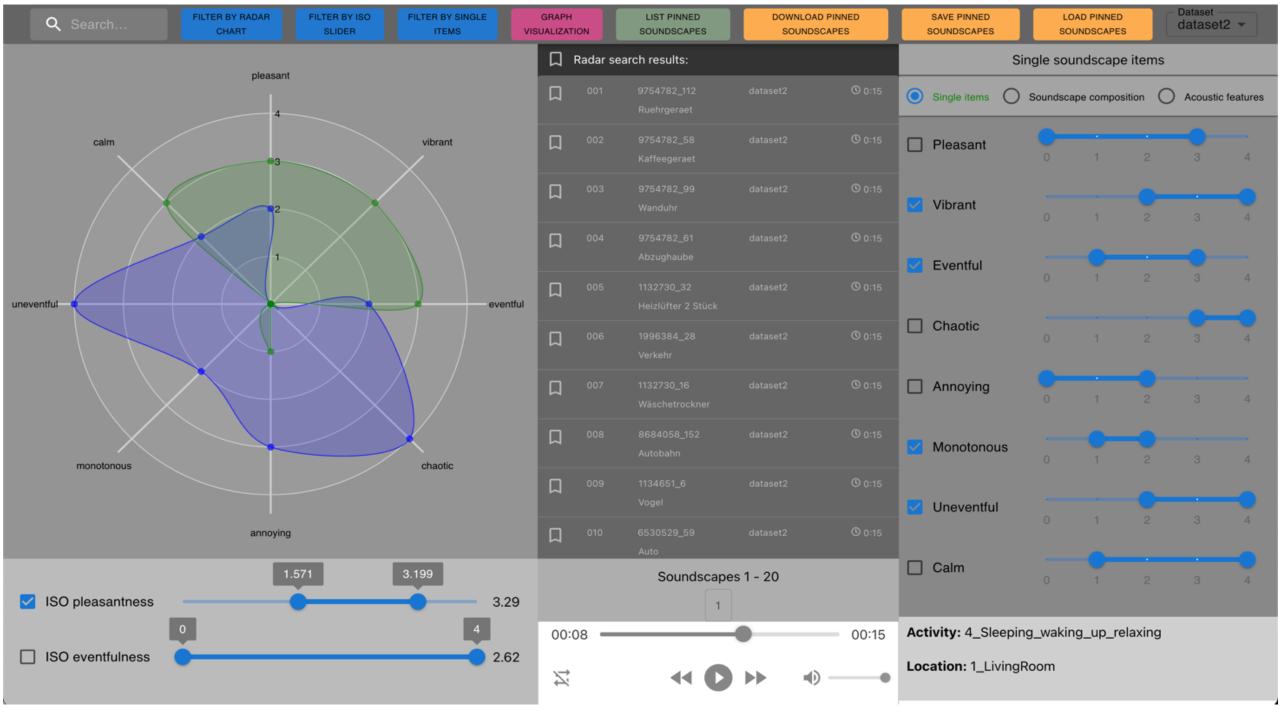

Figure 1. The main page of the soundscape search application.

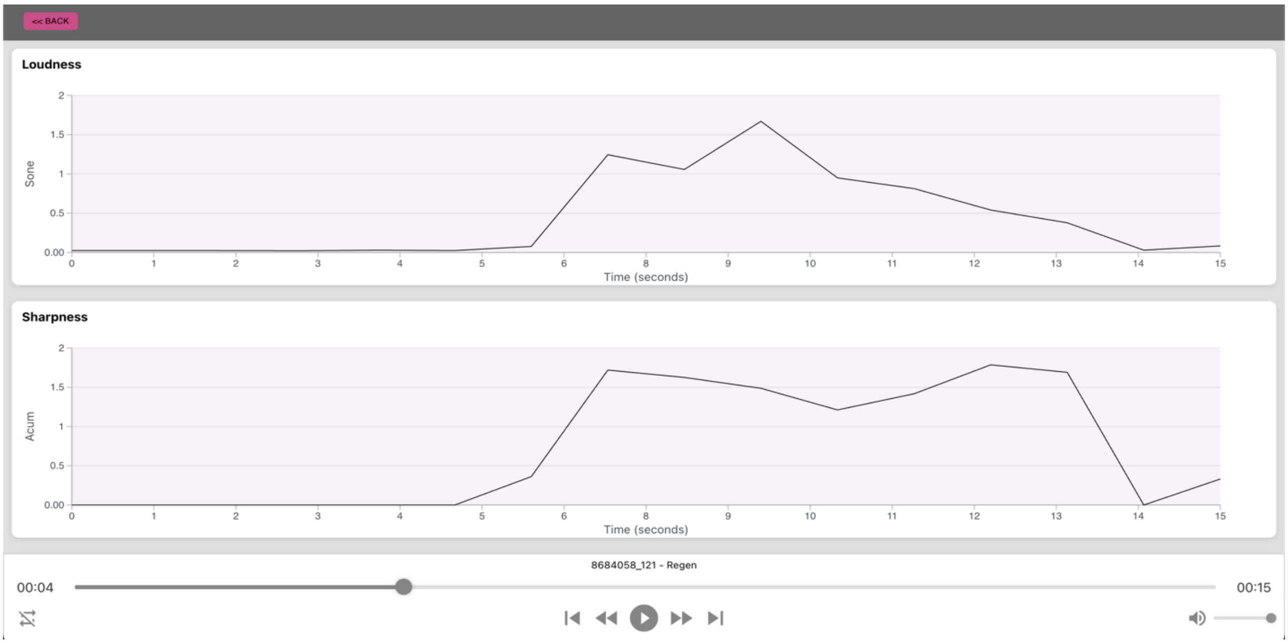

Figure 2. The scrollable second page displaying the temporal progressions of the acoustic features.

adjusting the dimensions eventfulness and pleasantness, a playlist component (in the middle) for soundscape selection, a component showing additional information of the current soundscape (at the bottom of the right), and a slider component (on the right) designed for single-item searches, encompassing the eight PAs, the items for sound source composition, and the acoustic features representing mean values. For a detailed explanation of the functionality of each component see [11]. To visualize the temporal variation of the features, the revised web application introduces a second page displaying the temporal progress of the features as graphs on a timeline (see Figure 2). This visualization displays the five acoustic features vertically stacked, with the respective metric values on the y-axis, allowing to scroll through and observe how acoustic features evolve throughout the recording that is currently playing. The y-axis range was established using the minimum and maximum values observed within the adjacent soundscapes, ensuring consistent comparability across successive and previous soundscapes. The source code is freely available on Github[1].

4. FUTURE WORK

While the revised application shows related soundscapes and visualizes temporal acoustic features of the currently playing soundscape, it does not show its distribution within the dataset. Future work could integrate global visualizations to represent the entire dataset while highlighting specific soundscapes. Emphasizing acoustic features for visualization and clustering, as outlined in [9] and [10], will also be considered to provide a concise overview of the entire dataset, thereby enhancing fast comparability.

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