An Assessment of the Potential of Using Visual Abstraction & Sound for Inclusive Geodesign

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Abstract

In this paper we propose foregrounding concepts of visual abstraction and soundscape to inform a Geodesign process that is inclusive of a wider variety of people (designers, users, participants) and considers a wider degree of inputs (e.g. multimodal) in the design and planning of landscape. Two key research areas are reviewed: visualization abstraction (in relation to future uncertainty) & soundscape, followed by a discussion of sound sources and auralization techniques for environmental simulation, how they integrate, and future research areas identified. We conclude that the convergence of technology, methods and project requirements mean that there is great opportunity for these concepts to inform a more inclusive Geodesign process, though empirical research is required moving forward.

1 Introduction

Geodesign offers to bring "geographic analysis into the design process" (DANGERMOND 2009) by operating at the intersection of four areas – design professions, geographic sciences, information technologies and 'the people of the place', with the people identified as the most complex part (STEINITZ 2012). While the first three focus areas are currently represented relatively well in design and planning processes, it is the fourth that requires attention, and also stands to most benefit from increased opportunities for representation, participation and engagement.

Visual abstraction of uncertainty in the design and planning process, informed by soundscape research, offers one method to engage people and communicate concepts of landscape in a more inclusive way. The need for the integration of level of detail and abstraction tools into an idealized Geodesign system has been presented (ERVIN 2011), as well as, the inclusion of sound from an 'implementation' and 'interface' point of view. In addition, the potential of using sound in combination with visualization for environmental simulation has been presented (LINDQUIST & LANGE 2014), along with important auditory attributes for the auralization of urban soundscapes (SMYRNOVA & KANG 2010).

Research has demonstrated that all perception is multisensory (e.g. CALVERT & THESEN 2004). As such, current realism-based visual approach requires expansion. The aim of this paper is to review the current state of the art concerning the integration of visual abstraction and soundscape in Geodesign processes in order to inform future research. The two concepts are elaborated to provide the context within which to consider new tools and techniques of landscape design and evaluation. The paper reviews visual abstraction and soundscape concepts, discusses their potential, and concludes with areas for future research.

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2 Abstraction for Landscape Visualization

2.1 Realism, abstraction & level of detail

Perceived realism of visualizations has been argued to be of critical importance for communicating landscape change (e.g. LANGE 1994), but realism requires very detailed data and texture information (LANGE 2001). Future scenario planning requires visualizing uncertain futures, and as such, new tools and techniques are needed to convey uncertainty that reflects the underlying data (LANGE 2005). Abstraction in visualizations can reflect uncertainty, and can originate from at least two sources – abstract information (e.g., scientific data or concepts) and nonconcrete reality. It is the focus of this paper to address the latter, while acknowledging the former would benefit from further research. This paper focuses on abstraction in relation to uncertainty, rather than level of detail (LOD). LOD can be a function of underlying accuracy of data or limitations / possibilities provided by computer hardware and software, and is typically associated with distance of view within a visualized scene. LOD is defined here as lower realism due to a 'less detailed version of reality', such as the absence of photorealistic texture on a building, or fewer or no leaves on a tree. Abstraction is defined as the deliberate modifying of (what someday could be) reality in order to convey uncertainty (e.g., blurring, colour modification, or transparency).

2.2 Uncertainty, fuzzy boundaries & abstraction in visualizations

Incomplete or unknown data is common in many scientific and professional disciplines. As a result, methods and techniques have been developed that attempt to draw conclusions, and make useful, such data using fuzzy modelling. Fuzzy modelling has been used in GIS when traditional data, defined by explicit true or false properties, is ill defined or unavailable (FISHER 1996). Fuzzy boundaries and 'soft space' are now a necessary part of the planning process in the UK, evidenced by the push for regional devolution and the blurring of previously distinct administration and spatial scales (HELEY 2012).

Uncertainty in the design and planning process can be at the macro scale (e.g., political instability casting doubt on future processes) or micro scale (e.g., funding for a specific design element within a new park), and can enter the visualization process in various forms (e.g., early stages of design). ERVIN (2001) reminds us of the exploratory intent of (some types) of visualizations, viewing this fuzziness not as a problem, but an integral part of the process, and in turn embracing a variety of types of landscape models at these stages. In addition, ERVIN (2004) identified four abstraction levels with respect to visualizations: diagrammatic; evocative; illustrative; and realistic, each serving its own purpose at different (or overlapping) stages of design. In the urban design realm abstraction has been presented as a necessary element, to be balanced with, and differentiated from, realism and accuracy (PIETSCH 2000).

A number of authors have outlined theories of visual abstraction for landscape visualizations, which are summarized in Table 1. Research in computer science has lead to abstracttion techniques that are illustrative and non photorealistic, using stylizing filters that relate to analogue techniques (e.g. hatching) developed in computer science (COCONU et al. 2005), and have been proposed as being good for presenting certain types of information, though have yet to be empirically evaluated.

Table 1: Theorized approaches to representing uncertainty in landscape visualization

Method	Description/Source	Design/planning phase
Level of detail	Deliberately creating low-detail visualisations (or elements within them)[1] 4 bit colour[2] 'Cut out' filter[3] Using 'Stikkies' placed in the scene[4]	Design development[3]
Silhouette; B/W 'sketch'	Rough model allowing impression size, spatial effect[1, 2, 3]	Drawing board phase[4] Site analysis, conceptual design[3]
Blurring	Details included in colour with a 'lack of focus' indicating flexibility of position[1, 4]	Rough location[4]
Transparency	Full colour, high level of detail, elements behind visible[4]	Fine tuning location[4]
Altering colour	Altering colour, either by adding false colour or desaturating (greying out)[1] Provisionally fixed location with high resolution and level of detail[2, 4]	Preliminary fixing[4]
Photorealistic	Represented as a lifelike possibility, end of planning process[4]	Final design[4] Final renderings[3]
Alternatives	Providing a range of possibilities[1]	
Text	Written information, either on labels within the image or accompanying text[1]	
Sound	Augmenting visual material with sound[1]	

[1]APPLETON et al. (2004) [2]DANIEL and MEITNER (2001) [3]FESER (2002) [4]REKITTKE & PAAR (2005)

3 Soundscape

Soundscape has emerged as a field of study that promises important and timely connections to landscape and visualization research. Soundscape was initially conceptualized in order to consider the total acoustic environment over time, space and across cultures (SCHAFER 1977). More recently the ISO/TC43/SC1/WG54 working group propose for their ISO standard that soundscape is “the perceived sound environment in context by an individual, a group, or a society” (KANG 2010).

3.1 Sound & landscape perception

The interaction of audio and visual stimuli in landscape perception and preference studies has received some focus. The interaction of visual and acoustic characteristics has been shown to have a significant impact on responses to a real or photographed setting (ANDERSON et al. 1983). Sound has shown to have a significant impact on both negative and positive environmental evaluations using photographs (CARLES et al. 1999), and is important for influencing judgement of dynamic landscapes (HETHERINGTON et al. 1993). More recently it has been shown that sound alters visual perception of tranquil spaces (PHEASANT et al. 2010), findings that are supported by physiological (fMRI) evidence (HUNTER et al. 2010). Conversely landscape influences soundscape perception, with research suggesting that spatial patterns of the landscape could be more influential on soundscape perception than on-site visual features (LIU et al. 2014).

3.2 Sound & virtual environments

Soundscape and virtual environment research have come together to develop perceptually based audio rendering (e.g. TSINGOS et al. 2004), as well as, more physically accurate techniques (e.g. RICHMOND et al. 2010). Spatialized sound provides an important cue within virtual environments which greatly increases the sense of presence (BLAUERT 1997), and even non-spatialized audio has shown to increase the perceived level of presence and reality, and can improve memory tasks (DINH et al. 1999). DAVIS et al. (1999) report that the use of ambient sound not only increases a sense of presence but enhances the subjective 3D quality of the visual display, which has been verified by further empirical research (STORMS & ZYDA 2000). Within the context of creating photorealistic virtual environments sound has been identified as a significant addition in increasing presence when compared to unimodal visual information (SERAFIN 2004). In a related project it was reported that sound alone could create a sense of place in a virtually recreated environment (TURNER et al. 2003).

3.3 Sound & GIS

The potential to use sound with GIS has been presented, with important contributions identified as narration, redundancy, anomaly detection, visual reduction or alternative and an indication of altered data (KRYGIER 1994). One of the first uses of sound with GIS was sonification, representing uncertainty in satellite imagery (FISHER 1994). In addition, GIS tools have been developed to compute estimates of accurate sound levels in the landscape (KAMPANIS & FLOURI 2003). More recently a sonification tool has been developed for commercial GIS software, allowing sound to represent uncertainty in data visualization, with early studies indicating that sonification provides greater understanding of the data for the user when compared to visually representing data alone (BEARMAN & LOVETT 2010). Conversely, GIS has been used for sound mapping, allowing anyone to view noise maps for any location in the European Union (KANG 2006).

3.4 Sound & landscape visualization

Combining sound with landscape visualization has been proposed (e.g. APPLETON et al. 2004; LOITERTON & BISHOP 2005), though relatively few realized projects have been reported, with empirical research on perceptual dimensions lacking. In one of the few studies on using sound with landscape visualization, sound was shown to enhances perceived visualization realism and promote attention and recognition, with the authors concluding that the correct sound could be more important than getting visual elements totally realistic (ROHRMANN & BISHOP 2002). More recent projects focuses primarily on wind farm evaluation, and use bespoke software (BISHOP & STOCK 2010) or game engines (MANYOKY et al. 2012) to produce the visualizations combined with audio. In addition, bird song sourced from survey data has also been used (MORGAN et al. 2012). As of the time of writing empirical results have not been presented from these studies.

4 Discussion: Geodesign, Abstraction and Multimodality

4.1 Sound sources for Geodesign (multimodal environmental simulation)

For multimodal environmental simulation sounds need to be auralized to augment visual material, for which there are a variety of options (Table 2). At the most realistic level a recording of another place, unmodified, can be played back to portray a comparable soundscape. This technique has been used in the majority of laboratory-based studies investigating perceptual responses to landscape and sound (e.g. ANDERSON et al. 1983; CARLES et al. 1999). Recorded sounds can be edited to remove or enhance sonic aspects, or mixed together to create a new sound, which has been used to investigate responses to noise in parks and rural areas (e.g. BRAMBILLA & MAFFEI 2006).

Recorded sounds may not offer enough diversity for specific applications, and as a result audio synthesis methods based on analogue and, more currently, digital oscillators have been developed. These methods synthesize sound based on algorithms that can produce sounds using abstract synthesis algorithms, synthesis from scratch, or synthesis from existing sounds (MISRA & COOK 2009). It is the latter (synthesis from existing sounds) that the authors propose work well for sound textures and soundscapes.

Table 2: Approaches to auralizing sound for multimodal environmental simulation

Method	Description/Source
Reality	Recording of real environment[1, 2]
Remixing	Concatenative: editing a sound to create a new sound based only on aspects of the original sound varied in time[3] Subtractive: editing and / or remixing a recording of a real environment to remove or enhance sonic aspects[4] Additive: combining recordings of real environments to create a new sound[5]
Synthesizing	Semi-automatic generation of ambient sounds[6] Using probabilistic models to create soundscapes that are responsive and diverse[7] Using algorithms to automatically generate an acoustic environment[8] Generating sound from 3D spatial models using interpolation procedrues[9]

[1]ANDERSON et al. (1983) [2]CARLES et al. (1999) [3]MISRA and COOK (2009) [4]SERAFIN (2004)
[5]BRAMBILLA & MAFFEI (2006) [6]CANO et al. (2004) [7]BIRCHFIELD et al. (2005) [8]FINNEY & JANER (2010)
[9]RICHMOND et al. (2010)

Methods for synthesizing sound have used techniques that semi-automatically retrieve sounds from a database and mix those sounds into ambient background sound (CANO et al. 2004), which has been advanced by providing dynamic, rather than static, sound files (BIRCHFIELD et al. 2005), and extended to use community-provided, unstructured sound databases (FINNEY & JANER 2010). Using crowdsourced sounds via online databases offers the potential to automatically generate an acoustic environment using algorithms, such as the Freesound.org database, which has been used to automatically generate soundscapes to augment Google Streetview imagery (FINNEY & JANER 2010). Methods for identifying, cataloguing and the subsequent retrieval of environmental sounds from databases are being developed (e.g. WICHERN et al. 2010), and a new method for identifying different kinds of sounds uses psychoacoustic parameters of fluctuation strength, loudness, and sharpness to objectively categorize common urban and natural sounds (YANG & KANG 2013). Finally, sounds can be generated from a 3D digital model using an interpolation procedure that combines ray-tracing and radiosity to render binaural sounds for playback (RICHMOND et al. 2010).

Another option is to focus not on the entire soundscape, but one element (e.g. foreground or background), for which a method has been outlined by SCHWARZ (2011) for the automatic generation, and use, of sound textures. Sound texture is differentiated from the overall soundscape as it is comprised of ‘‘many micro-events, but whose features are stable on a larger time-scale, such as rain, fire, wind, water, traffic noise or crowd sounds (SCHWARZ 2011, p. 221) and are important in cinema, multimedia, games and installations. Sound textures offer a promising technique for inclusion in audio-visual interaction studies as they provide a more neutral ambient or background sound than environmental recordings. Each sound source can interact with visualization abstraction at different phases of the design process. Figure 1 provides a framework for an integrated model for aural-visual combinations for a Geodesign process.

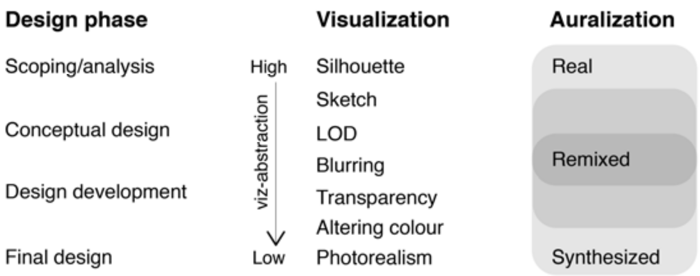

Fig. 1: Integrated aural-visual model responding to uncertainty in phases of the design process

5 Conclusion and Outlook

Geodesign offers an opportunity to incorporate new simulation methods and techniques in the design and planning of landscape by embedding visual abstraction and auralization tools and techniques within the process. The convergence of project requirements, technological and methodological advancement lead us to conclude that it is timely to foreground abstraction and soundscape concepts for the design and planning process. Project requirements such as wind farm siting and evaluation have resulted in research being carried out on auralization of wind turbine noise (HEUTSCHI et al. 2014; PIEREN et al. 2014), potentially providing a framework for other simulation contexts. As discussed in this paper, concepts have been proposed for incorporating visual abstraction in landscape visualization, and auralization techniques sufficiently developed to justify research on perceptual and cognitive effects of these developments.

Visual abstraction and sound each have the potential to contribute to improved design and planning processes that can engage a wider audience. The impact can be expanded by integrating these concepts, using sound with abstract visualization to enhance simulation realism, without relying on potentially misleading visual detail. Preliminary results by the author investigating perceptual responses to the interaction of varying levels of visual detail with different sound sources offer a starting point for multisensory environmental simulation research, and indicate a complex relationship between variables and the importance of congruency of the visual and aural stimuli (LINDQUIST et al. 2013). Further research is needed on perceptual responses, and appropriateness of various techniques, at different stages and scales of design and planning, as well as, research on the necessary types of simulation environments.

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