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SKETCHING IN SOUND AND INTERACTION DESIGN

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ABSTRACT

The process of interaction design involves multiple stages beginning from user research and ideation that lead to working prototypes and user evaluation. Sketching is considered to be important in the early interaction design stages as a way to explore, store, but also communicate ideas. Sketching is, however, a graphical process and it is not always easy to integrate sound to it, even though sound is an important part of interaction. Sketching sound, on the other hand, has received significant attention in sound design. Here, we contrast sketching in interaction design with sketching sound in order to understand whether ideas from sound sketching can be relevant when sketching interaction. The literature indicates that sketching sound has been done almost exclusively in the auditory modality and takes place in a largely independent process that is not entirely harmonized with traditional graphical sketching and interaction design practices. While this may make sense when designing sonic interactions, it is not as supportive for other interaction design contexts. We discuss this finding while taking into account graphical approaches to sketching sound in the literature.

Keywords: sketching, sound design, interaction design

1. INTRODUCTION

Sketching is fundamental for design and is widely applied in interaction design to help elaborate, store, and communicate ideas. Sound design, originally practiced in music, film, and product design is being increasingly applied to designing sound for interaction, as in sonic interaction design [1]. Sketching sound has received significant attention in this context. But since sketching interaction is a visual activity, it is not clear how the sonic elements of interaction can be integrated in the sketching process and whether existing approaches to sketching sound can be beneficial in this context.

To illuminate this point, in this article sketching for interaction design is juxtaposed to sketching sound as practiced for sound design. It is found that even though the properties that would help classify a sound as a sketch are not clear, sketching sound is done primarily in the auditory modality. This is in contrast to sketching interaction which is done graphically but is more relevant for multimodal or *responsive sketching* [2]. We comment on this while also looking into the possibilities offered by graphic representations of sound to help address this issue.

The paper is organized as follows. First interaction design and sound design are introduced drawing on standard textbooks and influential articles. Subsequently, a systematic literature review on sketching sound is presented. A Google Scholar search was performed using the 'sound sketch' (154 results) and 'sketching sound' (98 results) keywords. The results were screened for relevance which narrowed the list to 48 publications. These were reviewed and summarized. The article concludes with a commentary contrasting sketching in the interaction design and the sound design practice and possibilities for cross-fertilisation.

2. SKETCHING IN INTERACTION DESIGN

Interaction design emerged as an attempt to incorporate design practice (but also research) in Human Computer Interaction which was dominated by research paradigms routed in the behavioral sciences and engineering. This progression is also evident in the so-called first-, second-, third- HCI waves (or paradigms) [3, 4]. Interaction de-

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sign is about shaping the use qualities of the digital material focusing in particular on time-based and nonlinear aspects [5]. The focus is often away from a view of interactive systems as 'means to achieve a goal based on the formulation of plans for subsequent execution' [5] and open-ended applications as well as aesthetics and affective aspects come into question.

Most interaction design processes involve qualitatively related steps. As a rule, the design process is iterative and includes a phase of understanding the problem domain and the target users, which is followed by designing alternatives, prototyping, and evaluation steps [6]. The target user(s) may get directly or indirectly involved in one or more of the aforementioned phases depending on the approach taken.

Sketching refers to the process of outlining the visual design of the solutions proposed by the designer using pen and paper. It has been studied extensively within graphic design, product design, and architecture. Sketches are often annotated using arrows, braces, numbering, spatial proximity or colour. Sketches also use images or photos, and may be connected with arrows to illustrate interaction flow. Buxton [7] writes that sketching suggests, explores, proposes, questions, or provokes and is tentative and non-committal. Sketching serves to store solutions and reduce cognitive load (the storing sketch), sharing ideas and information (the talking sketch), but also as a tool to support the designer thinking process (the thinking sketch) [8, 9]. Sketching enables the evaluation and adjustment of thought alternatives without executing all operations [10] in a *seeing-moving-seeing* process [11]. Visual sketching can be considered as an embodied thinking process [12]. Even if sketch-based reasoning facilitates the reorganization and creation of new knowledge, its status as the primary method of ideation has been challenged [13, 14] by studies which show that verbalization may contribute as much and even more in some cases and sketching may in fact slow down the ideation process [15].

Sketching is extremely popular when designing user interfaces for computers, mobile devices, but also tangible interfaces and VR. It typically takes place when designing alternatives. It is used to illustrate interface aspects but also summarize user journeys and scenarios in story boards. Its popularity is because sketches are easy, fast, and cheap to create but also iterate or discard. Several tools that provide digital support to sketching have also been proposed [16].

Prototyping is typically understood as a process in which ideas from sketching are concretized. Buxton [7] suggests that prototypes describe, refine, answer, test, depict, and resolve while they are didactic and specific. Prototypes can be categorized based on their role, look and feel, and implementation [17]. Another extensive review [18] identifies prototypes as design artifacts that can be classified in terms of representation, precision, interactivity, and evolution and contribute not only to contracting but also to exploring and expanding the design space. In this view, sketches can serve as prototypes and vice-versa and the line between sketching and prototyping is blurred. Löwgren [2] suggests that making can also be understood as a sketching process leading to *responsive sketching media*. Experience prototyping [7] employs techniques that may help articulate experiential aspects of interaction design sketches such as the wizard of Oz, animation, video, projection, but also movement and body sketching techniques.

We have seen that sketching is an integral part of the interaction design process which takes place during ideation and help specify and expore designing alternatives. We have also seen that the boundary between sketching and prototyping has become fuzzy and it has been proposed that prototypes featuring making and additional modalities may qualify as sketches. We turn now our attention to sound design and sketching sound.

3. SOUND DESIGN

The term sound design originates in film and product sound design, however, it is now found in video games, auditory display, sonification, sonic interaction design, and aural architecture. Based in Pierre Schaeffer's suggestion that listening has an intention, it has been argued that sound design is the process of making (listening) intentions audible [19]. Sound design may also mean to compose sound using a lexicon of physically-grounded phenomena, thus keeping a direct link to sound imagination [20].

Most sound design methods follow a linear evolution and design sound form (i.e., quality) and sound function (i.e., purpose in the context of use). A well-cited approach consists of analysis, creating, and testing steps [19, 21, 22]. The analysis step begins with the analysis of existing sounds used for similar purpose and ends by an acoustic and perceptual specification of the sound product. This is followed by an ideation process which may also incorporate complementary approaches such as ergonomic analysis, sound drama, voice imitations, bodystorming, or role-play. The creation step combines com-

posing and scientific skills to come up with a number of alternatives. These are then evaluated in the testing step to select the one which fulfils requirements best. A similar three-step approach called briefing, debriefing, and validation is presented in [23]. The first step relates to the communication of the problem formulation, the second to conceptualization and sketching, and the third to evaluation. Here, emphasis is given on tools to assist communication between stakeholders. Özcan et al [24] proposes a linear sound design process that involves problem analysis, conceptual design, embodiment and detailing steps and included small feedback cycles. Nykanen [25, 26] also proposed a linear process which involves identifying customer needs, establishing target specifications, generating, selecting, and testing product concepts, setting final specifications, and planning development. Focus groups may be used in order to come up with a final version [26]. Cera et al [20] suggest a sound design by transformation process which is based on transforming sound sketches into sound designs through a process of acquiring, transforming, and fine-tuning relevant sounds.

Working in a bottop-up manner, Hug et al. [27] identified tensions between sound design methods and sound design practice. In sound design practice, sonic quality emerges as a defining factor which is often overlooked when designing functional sounds (icons, earcons, and sonifications). In contrast to the approach taken when designing earcons, auditory icons, and sonifications, designers rarely communicate meaning using one to one mappings but rather use second and third order relationships and context. Furthermore, sound designers emphasize emotional and expressive qualities which are not addressed adequately in existing frameworks. Finally, sound designers are found to work independently, have little interest in evaluation and confrontation with stakeholders is often seen as problematic [28]. Sound designer activities are hard to identify as parts of a process, especially the artistic parts which 'are either hidden or contained in their own confined spaces'. A sound-driven design approach employing performance-led and increasingly complex and refined representations has been proposed [29]. Such approaches based on teamwork and making can help overcome the *fixation* problem [22] introduced due to the analysis step in the linear design process which may disrupt innovation.

Nearly all approaches consider sound sketching during the ideation and designing alternatives phase. Sketching sound is examined closer in the next section.

4. SKETCHING SOUND

It has been argued that sound sketching should act as a tool for sound-related conceptualization and thus take place in the auditory modality [12] in line with embodied approaches to sketching in interaction design [30]. Accordingly, Nykanen et al. [26] refer to the process of sketching sound as a listening - changing - listening (versus the seeing - moving - seeing [11]) process. Cera [31] mentions ambiguity and a short, unfinished, shifty form as sketch qualities and suggests that sketch alternatives form a final result whose coherence is not realized on a temporal timeline but more on a spatial continuum. Delle Monache et al. [12] presents a funnel like progression in which different sound sketching methods are differentiated based on whether sonic ideas are embodied as abstract concepts in sketches or as sounds in concrete sound examples. Sketching is an integral part of sound design and different suggestions can be found in the literature.

Sketching by low-fi sound: In music, low quality instruments are often used to sketch a musical idea. Sparse representations of sound or sound cartoonifications which are still recognizable [32,33]. Drawing on this, it has been suggested that unfinished sounds showcasing a given quality could be used as sketches [26,34]. However, the potential of such sounds to communicate ideas is very limited as people tend to listen to a sound as a whole and unfinished sounds are perceived as such [26, 34].

Sketching by similarity: Several authors propose creating sketches by using simple sounds which are close to the designer intention and obtained through recordings, found objects, or foley as sound sketches [26, 34–38]. Buxton [7] proposes sounding sketches in the form of recordings of any object that has the potential to represent the desired sound. Audiolization (with reference to visualization) is introduced as aural sketching by Özcan et al. [24] to quickly represent concepts conveyed through sound using recordings or collections of materials and objects exemplifying relevant sonic features. Franinovic et al. [39], propose using recordings of found objects for inspiration. Hug et al. [29] proposes integrating foley as sketches in the sound design process.

Performative sketching: To become integrated into interactive scenarios, sound sketches need to be arranged in time and activated in tandem with specific interactions. Radio Play [40] arranges sounds in a recorded narrative to represent intended use cases. Hug et al [29] suggest that samples and foley, combined with voice and body sound recordings can be controlled using a MIDI keyboard con-

trolled multi-sampler setup to yield a performative setting. It has been claimed that the resulting electroacoustic Wizard of Oz could work as a sketch in a visual design process. Sonic overlays, sound layering, and video prototyping have also been used in this context. Pauletto [41] proposes using techniques from theater and film sound design to play out interactions.

Embodied sketching: Özcan at al [42] consider sonic conceptualization to be an embodied process to be explored by doing something, in this case manipulating sounds. The approach is materialized in [35] in which a tool for sound sketching is proposed comprising a tangible interface and a sound synthesis engine which allows to create and manipulate samples from several sound classes based on sample playback but also granular synthesis. Voice and gesture have also been used as alternative embodied sound sketching tools. Several studies paved the way for a system that is using voice and gesture input for embodied sound sketching [43–52]. The system allows the user to vary model parameters using voice and gesture in order to create sound sketches while designing sound. MiMic [53] uses a microphone with two buttons and gesture recognition to sketch and manipulate sound designs. It is argued that the microphone operates here as a pencil.

Verbal sketching: Sketching based on verbalizations is introduced by Carron et al [23, 54] who established and validated for this purpose a sound lexicon of 35 words. The lexicon was augmented by manipulable sound examples and illustrated with pictures. The tool is targeting the conceptualization phase of sound design and aims to improve communication between stakeholders. Delle Monache et al propose creating a sonic sketchbook [12] in which several types of sketches can be integrated such as found sound objects, sound scribbles, gesture and vocal imitations of sound which can form the basis of collaborative sketching activities.

Other approaches: The concept of sketching sound has also received other interpretations. Everrett [55] proposes sketching as a way to design the spatial sonic aspect of museum exhibitions. Nedlich [56] discusses using VR as a tool to sketching sound for architecture. The term sketching has also been used when rehabilitating an open-air amphitheater [57], sketching architecture, soundscapes [58, 59], but also train interior sound [60]. Finally, [61] understands sketching in as sketching sound fields to simulate spatial sound distributions and design personal sound zones.

5. SKETCHING SOUND VS INTERACTION

In interaction design, sketching occurs when designing alternatives and is somewhat independent from the methods used in previous or subsequent steps. Sketching for established graphical user interface environments is still done in a pretty conventional way from a graphic design point of view and uses sketches, annotations, and graphical emphasis to communicate findings. It helps designers investigate, anticipate, store, and communicate interaction design choices. It has been suggested that sketching could be extended to incorporate other modalities and *making* techniques so that it can be applied to novel interaction paradigms.

How sketching sound can be part of the sketching interaction process is not entirely clear. Specifically, when it comes to sketching sound, the prevailing approach is that sound sketching should take place in the auditory modality. This is apparent in nearly all the different approaches to generate sonic sketches that we have found in the literature (unfinished sounds, short sounds, sound recordings, found objects, foley, performative approaches, embodied approaches). With respect to the potential of generating sonic alternatives, the potential to manipulate synthesized samples offered by the embodied sketching approaches seems to fit well to the reflective quality of sketching. However, while the sound sketching techniques mentioned above can certainly help generate alternatives, they direct attention away from the (often graphical) sketching interaction task at hand as designers engage in recording, sequencing, and sound manipulation.

Furthermore, the very perception of the outcome of the sound sketching methods in the literature as sketches is questionable. Importantly, the literature does not provide evaluations or a consensus on the properties that would result in that a sound is perceived or can function as a sketch. The problem is not trivial. For example, [26] mentions that unfinished sounds illustrating specific sonic potentials, but being otherwise unfinished, are not adequate to qualify as a sketch. Such unexpected findings call to re-examining the notion of sketching in the auditory modality. Similarly, the extend to which performative approaches to sketching sound are supportive to sketching the temporal aspects of interaction is not clear. Even if such methods provide a better feeling about the sonic outcome, their generative potential has not been clarified.

It appears therefore that a better understanding of what constitutes a sound sketch is necessary before we can treat sketching sound during interaction way in a coherent

way. Pending a more detailed investigation on the nature of sound sketches, it may be worth considering if visual sound sketching possibilities may have been abandoned all too soon. In electro-acoustic music, there is a long tradition of visually sketching sounds and compositions, as for example in the work of Iannis Xenakis, but also drawing on sound typologies [62], and reaching out to spectromorphology [63, 64], music visualization [65–68], and even sketching music [69–71]. A thorough review is outside the scope of this article, however, it is worth mentioning that there is considerable variation in the way sound is represented, the involved metaphors, and the support for free drawing or sketching.

Visual ways to describe sound have also been proposed within sound search and retrieval. Knees at al [72] proposed searching for sounds by visually sketching them, a query-by-sketch paradigm. They find that often visual attributes are used to describe sound using crossmodal associations between visual and auditory attributes such as pitch and height, visual and auditory brightness, but also colour and the temporal dimension of sound [72]. Other times users draw images to reference sounds. Similar findings are reported by Engeln et al [73].

Applications of visual approaches to sound sketching on sound design are not as many. Some years ago, pictograms [37] have been proposed as a way to help understand but also communicate the components of product sound. Pictograms follow an ecological approach and could show the parts of the objects that generated the sound and help communication in the product team. The use of visual representations in the sound design process has also been reported by Hug et al [74]. These were used to describe the sound itself but also its evolution over time. The level of abstraction depended on the auditory attribute to be visualized and could range from pitch to more complex aesthetic or perceptual impressions. It may follow that visual sketching could be applicable to sketching sound.

Visual sketching can also provide interesting possibilities for input. Tangible interfaces but also voice and gesture is a great way to engage the body and realize embodied approaches to sketching sound, however, they also tend to shape the outcome of the process. This is particularly evident for vocalizations which tend to force users to think in terms of ecological sounds. In addition, they are also not as straightforward to perform and can be embarrassing. A similar claim could be made for gesture interaction techniques. A further difficulty is that such approaches cannot be easily integrated with more traditional interaction design approaches to sketching such as storyboards, wireframes, and user journeys. Visually sketching sounds can help overcome such difficulties and provide a way to investigate the potential of cross-fertilisation between interaction and sound design [74].

Clearly, further studies are required to grasp how existing approaches can be used to sketch sound and interaction in a coherent way and the extent to which visual approaches to sketching sound can be of assistance when creating usable and enjoyable sonic interactions.

6. CONCLUSION

This article investigated sketching in sound and interaction design by reviewing existing literature. Several different approaches to sketching sound were identified. Even though these differ in terms of input technique, how samples are organized in time, and the extent to which they allow for sound manipulation, sketching in sound design is done almost exclusively in the auditory modality. Most existing studies and tools aim to produce sonic sketches. However, what makes a sound to be perceived as a sketch, let alone a successful one, remains unknown. Furthermore, the sonic nature of the sketches complicates the integration with sketching interaction methods. It is proposed that graphical ways to sketch sound could provide inspiration for future applications to make sketching sound for interaction design easier.

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