Prototyping Sonic Interaction For Walking

Nassrin Hajinejad
City University of Applied Sciences
Hochschule Bremen, Germany
nassrin.hajinejad@hs-bremen.de

Barbara Grüter
City University of Applied Sciences
Hochschule Bremen, Germany
barbara.grueter@hs-bremen.de

Licinio Roque
Department of Informatics Engineering
University of Coimbra, Portugal
lir@dei.uc.pt

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Abstract

Sounds play a substantial role in the experience of movement activities such as walking. Drawing on the movement inducing effects of sound, sonic interaction opens up numerous possibilities to modify the walker's movements and experience. We argue that designing sonic interaction for movement activities demands an experiential awareness of the interplay of sound, body movement and use situation, and, propose a prototyping method to understand possibilities and challenges related to the design of mobile sonic interaction. In this paper, we present a rapid prototyping system that enables non-expert users to design sonic interaction for walking and to experience their design in the real-world context. We discuss the way this prototyping system allows designers to experience how their design ideas unfold in mobile use and affect the walking.

Author Keywords

Sonic interaction design; rapid prototyping system; walking phrases; mobile context.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

Sounds that accompany our everyday actions play a profound role in the way we perceive and interpret our activity and the world around us. A well-known demonstration of how what we hear serves as an interpretation frame for what we see is to change the soundtrack of a movie scene and thereby to modify the audience's emotional evaluation of the very same scene (Kuleshov effect). Sonic Interaction Design (SID [5]) deals with the design of interactive systems that interweave the user's physical actions with sonic feedback and thereby affect the user's perception, movements and emotions towards an intended experience. Thus, SID can be understood as a means to design for experience by drawing on sound as a medium and the user's listening abilities. Sound has beneficial characteristics to be used in interaction design for mobile activities. Supportive systems can use sonic representation to provide activity-related information preserving the users' mobility and without demanding their full attention. However, designing sonic interactions also poses a number of challenges, such as understanding how the sounds that are elicited by the user's movements affect the way the user perceives and experiences the activity. A challenge related to the mobile activity is to account for the changing context conditions and to design sonic feedback with regard to the user's varying attention [1]. Another challenge is to design scaffolding for aesthetic orchestration of various sound tracks that are dynamically composed in a particular use situation and may or may not be heard concurrently [14].

Generally speaking, the experience of interactive sound in a mobile setting is affected by a variety of factors and substantially differs from experiencing sound in a static setting. We argue that this requires from sonic interaction designers a direct experiential awareness of the varying interplay of sound, body movement and use situations. In this paper, we present a rapid prototyping system that enables the design of sonic interactions for walking and their exploration in real-world contexts. We discuss how this prototyping system provides a short design-experimentation-feedback loop within the walking scenario, and enables an experiential approach to explore and understand possibilities and challenges in the design of sonic interaction for the mobile context.

Related Work

In this section, we provide an overview on how sound can be used to influence different dimensions of the walker's experience, and refer to the impact of the activity context on the walker's listening mode. Sonic interaction designers have a multitude of possibilities to modulate the walker's experience as sound can convey various types of information [17]. Auditory stimuli can be used to direct a person's attention towards particular events and objects. By translating information into sonic attributes, inaudible things and places become perceivable for the walker and, mundane and unnoticed spaces turn into places of interest [13]. Sonic structures, such as timbre and melodic contour, have been shown to convey affective information [6] and musical attributes can be used to attune the walker's mood to affective qualities [9]. The organization of motor behavior can be entrained to auditory rhythm and other musical features [10]. Drawing on the influence of sound on body movement, researchers in HCI have started to examine the use of auditory feedback to modulate a person's walking movement. Findings indicate that walkers change their

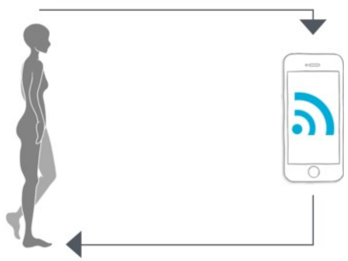

Figure 1: The Mobile App detects the user's walking movements and responds with sonic feedback.

walking pattern according to the sonic feedback they trigger with their footsteps [3]. Sonic augmentation of footsteps has also been used to alter the frequency of the walker's natural footstep with the result that walker's gait, perception of body weight and emotional state was altered [15].

To sum up, it can be stated that by changing their properties along a person's activity, sounds can draw a person's attention towards specific events and processes, attune the person's emotions and entrain the person's body movements. Consequently, sonic interactions can be used to support the emphasis of certain qualities within the person's experience of an activity. However, at the same time that sound acts upon a person's experience of an activity, so do a person's activity and its contextual conditions influence the perception of sound. Embodied approaches to listening point out that perception of sound is experience is dependent on the way the sound is involved in the situation and how we see its relevance to the context of interaction" [17:1]. The particular context within which sound is perceived can be decisive for the sonic properties that the listener focuses on and hence color the perception and interpretation of sound. The interplay of contextual conditions, the listener's attention level and the effective listening mode has been discussed in the research field of soundscape studies [16,17]. A person's attention capabilities vary according to context conditions and lead to more or less receptivity for processing sound. Moreover, the listener's body movement has an influence on the way sound is perceived [12].

Design Rationale

In our design project, we explore how sonic interaction for walking can be designed to enrich the walker's experience. Ordinary walking is a movement activity in the mobile context. As set out above, movement elicited sounds can modify perception of movement, and the performance itself, but at the same time, the perception of sound is situated. Following this line of thought, we argue that to support a person's mobile activity through sonic interaction, designers need to take into account the specific circumstances and how they affect the user's experience of sound. To put it differently: "The multisensory aspects of interactive sonic experience that SID is concerned with must be designed with consideration of the orchestration of the auditory, tactile, visual, and kinesthetic senses within real-world context. " [5:xi]. Accordingly, designing sonic interaction for walking involves designing sound with regard to a) its influence on the walker's movement, and b) the changing conditions of the mobile context. Within the walking scenario this means that designers need an experiential understanding of how walking "feels like" when it is accompanied with a particular sound in a particular situation. We argue that, in order to inform the design of mobile sonic interactions, designers need to experience from a first-person perspective the interplay of sound, body movement and context. The necessity to include a first-person perspective in the design process has been emphasized by researchers in the field of movement-based interaction design [8,11]. To enable designers an experiential awareness for how their sound design unfolds in interplay with body movement in the mobile situation, we developed a rapid prototyping system.

	Phase I	Phase II	Phase III
Activity	Editing	Experiencing	Evaluating
Medium	Editor Interface	Mobile App	Process Data

Table 1: Phases in designing sonic interaction using the Prototyping System.

A Prototyping System

The proposed prototyping system supports the exploration of sonic interaction design for walking in an iterative manner. The designer runs through three phases in each iteration cycle (Table 1).

In the first phase, the designer uses an Editor Interface (desktop application) to specify the sonic response to a predefined set of walking movements and states. In the second phase, the designer uses a mobile application (Mobile App) to experience how the sonic interactions that have been designed unfold while walking in-the-wild. In the third phase, the designer draws on process data recorded by the Mobile App during the walk to reconstruct, analyze and evaluate the aesthetics of the sonic interactions that have been designed.

Moment	Manner	Location
Step R/L	Normal	Inside
Stop	Fast	
Turn	Steady	

Table 2: The Mobile App detects three types of walking events.

For clarity, we first describe the sonic interaction mechanics that are implemented by the Mobile App and enable users to experience sonified walking. We then continue with an overview on the design phases that are supported by the prototyping system and allow editing, experiencing and evaluating sonic interaction for walking.

Sonic Interaction Mechanics For Walking

The Mobile App is an iPhone application that provides the user a sonified walking experience through a set of sonic interaction mechanics. These mechanics use events and states of the user's walking process to trigger and modify sonic output in real time. The sonic interaction mechanics are enabled by functionalities of two kinds: a) tracking: detection of walking events and states and b) sonification: organization and playback of sound files.

Detection

The Mobile App utilizes a number of detection algorithms that recognize events and states of the walker's activity process using the internal sensors of the iPhone 4S (gyroscope, accelerometer, and GPS unit). A common model of walking is to describe it on a biomechanical level, by the cyclic movement of two consecutive steps, referred to as a gait cycle [2]. The detection component uses the iPhone's measurement rotation rate to identify two points in the gait cycle and thereby to recognize the moment when the walker's left resp. right foot hits the ground. Further algorithms build up on the step detection and track changes in the walking manner (e.g. whether the walker speeds up the pace) and walking events (e.g. the walker stops walking). Moreover, the detection component uses the iPhone's GPS unit to inform on location-related states of the walker. For this purpose, the GPS coordinates of locations where the walker starts and ends walking sessions are permanently stored and an area geo-centered on these locations is created (personal area). When the walker is moving within one of these personal areas (also in future walking sessions) the state *Inside* is invoked. Walking information is encoded through the walking event types presented in table 2.

Sonification

The sonification functionalities translate walking events gained by the detection component into sonic output by means of mapping objects (M-objects). There are four types of M-objects, each corresponds to a particular type of walking event: *SoundEvent, WalkBeat, SoundCarpet and WalkAlong (Table 3)*.

M-Object	Parameters
SoundEvent (sound triggered once)	- One audio file - Volume
WalkBeat (step sonification)	- Audio files - Running order - Volume
SoundCarpet (random played sounds)	- Audio files - Pausing interval - Volume
WalkAlong (WalkBeat & SoundCarpet sequences)	- Sequencing values - WalkBeats - SoundCarpets

Table 3: M-Objects translate walking events into sound and can be specified through parameters. The designer uses the Editor Interface to define M-Objects.

SoundEvent is the simplest M-object type designed for the walking events *Turn* and *Stopping*. A *SoundEvent* object holds one audio file, which will be played once with a volume that can be set by its parameter.

WalkBeat objects are designed to translate the walker's steps into sonic output (step sonification) and can hold a variable number of audio files. A *WalkBeat* can be assigned to the left or the right footstep and will trigger the playback of an audio file when a step is detected. The possibilities for ordering the available audio files are: a) always the same sound, b) rotation principle, c) random and d) playing one audio file and switching to a different audio file every designated number of steps. Again a volume can be set, however depending on weather the left or right footstep is assigned a panning effect is added so that the sound will be predominantly louder on the according headphone side.

SoundCarpet is designed for the state *Inside* and can hold a variable number of audio files. As long as this state is detected, playing the available audio files in a random order composes an ongoing sound track. Through setting parameters of the object a pausing interval in between the audio files can be determined as well as an overall volume.

WalkAlong is designed for the state steady walking manner and allows changing the sonification after a designated number of steps. A range of values can be set to divide the walker's continuous process of steps into different sequences. For each sequence an individual set of WalkBeats can be selected to sonify the left /right footsteps. Furthermore, an individual *SoundCarpet* can be selected for each sequence.

Designing Sonic Interaction for Walking

Editing

The Editor Interface is a desktop application that allows designers without programming skills to edit the sonic interaction mechanics of the Mobile App. The Editor Interface consists of a number of editing screens that enable the designer to specify the sonic interaction mechanics of the Mobile App in three stages: a) input audio files, b) create M-objects and c) link walking events to M-Objects. First, the user inputs audio files to be played as sonic response into a sound library.

Walking Event	M-Object
Steps L	WalkBeat
Steps R	WalkBeat
Steps L fast	WalkBeat
Steps R fast	WalkBeat
Steps steady	WalkAlong
Stop	SoundEvent
Turn	SoundEvent
Inside	SoundCarpet

Table 4: Using the Editor Interface, the designer connects predefined walking events with M-Objects.

Second, the user creates M-objects (WalkBeat, Soundcarpet, WalkAlong), selecting sounds to be used and defining setting parameters. Third, the user designs for a particular sonified walking experience using a mapping screen. In this screen the different the different walking events and states are listed and the user can connect each of them with a corresponding M-Object (Table 4). Finally, the user pushes a button to compile the sonic interaction mechanics for the Mobile App. Now, the designer can use the Mobile APP to experience sonic interactions while walking and to explore how the designed interaction mechanics unfold in mobile context.

Experiencing

The Mobile App can be used to experience sonified walking on any route. The user pushes the record button to start a walking session and will see a short tutorial that explains the correct usage of the App. In addition to putting on headphones, positioning and orientation of the smartphone in the user's trouser pocket is important to ensure a reliable detection of the walking movements; a further tab on a play button will start a counter. The user is given eight seconds to put the smartphone into the trouser pocket and start walking. After the countdown the App starts detecting the user's walking movements and translates these into sonic output in real time.

Evaluating

As the user walks with the Mobile App, various time-coded data streams are gathered and stored in log files on the iPhone. This un-intrusive caption allows designers and researchers to reconstruct and study the user's sonified walking experience afterwards. The sound composition that the user creates and hears while walking is recorded as an audio file. The walking events and states that have been detected during the walk are logged and each is marked with a timestamp. The GPS-positions of the user's walking route are logged. After the walk the designer (resp. researcher) can download these files from the device, and for instance listen to the sound composition that was composed by the walker's movements. For a more detailed analysis, the various data streams can be synchronized (e.g. using systems such as ChronoViz [4]) to get a highly detailed account on the walking process.

Reflecting the Prototyping System

The prototyping system enables designers a rapid implementation of sonic interactions for walking and to experience their design in the real-life context. In this section, we discuss design parameters that designers encounter when using the prototyping system and through which they can design for very diverse kinds of sonified walking experiences.

Constraints and Opportunities

The walking events that are detected by the Mobile App are limited and users of the Prototyping system can design sonic response to a few walking moments only. The advantage of this limitation is that it narrows the designer's focus to walking-sound-mappings and encourages them to explore how different sounds (and their interplay) impact the walker's experience. For despite the detection constraints, the designer can a) select a specific subset of walking events to be sonified. For instance, the designer might choose to sonify the footsteps of one leg only. Depending on the set of events that are sonified, particular walking qualities are emphasized and brought into prominence in the walker's experience. Moreover, having the possibility b) to choose any kind of sound to be triggered, the designer can design for very diverse kinds of sonified walking experiences. The designer can explore, in an experiential way, how different acoustic properties affect the walking movement. For example, how does walking feel like when your steps elicit percussive sounds (e.g. drum sounds) and how does it differ from when they elicit flat choir voices?

In one prototype [7], for instance, we used the WalkAlong object to gradually change the sonic response when the walker keeps walking in a steady manner. Our aim was to explore what kind of impact this aural structuring has on the walker's experience. The participating walkers could experience this design on individual ordinary routes. Our interview findings indicate that the aural structuring interrupted the walker's flow of thoughts (e.g. rumination), redirecting their attention to the present moment. Analyzing the collected data streams we found examples of entrainment of walkers step length. In another case, students designed a prototype to explore how sonified walking can enhance the identification of players with the role of an investigating inspector in a location-based game. Towards this goal, the students engaged in designing a mapping that allows the player to compose a musical detective theme through walking movements.

Activity-centered Soundscape Design

During mobile activities a person's attention is distributed across various processes. While walking, we coordinate our walking movements; observe traffic, sort thoughts, to name a few. What the designer imagines to be engaging in front of a desktop might be stressful for the walker when crossing a crossroad. Experiencing their design ideas in the mobile context, designers will understand that walking states are accompanied by different conditions and they need to account for these conditions in sound design. Thus the designer will engage in balancing complexity according to the walker's situation.

Designing interactive sound is challenging and differs from designing the soundtrack of a movie. The specific temporal arrangement of events is not predefined and the designer has to account for the dynamic interplay of various sounds. The designer needs to consider the overall soundscape that will evolve when different sounds are heard in succession, when they overlap, or when they are triggered simultaneously. How to provide structures of a soundscape that harmonize but are distinguishable from each other? Using the prototyping system may help the designer to understand that to design an aesthetic soundscape for walking goes hand in hand with exploring the structure of the activity.

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