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Some Challenges Related to Music and Movement in Mobile Music Technology

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ABSTRACT

Mobile music technology opens many new opportunities in terms of location-aware systems, social interaction etc., but we should not forget that many challenges faced in "immobile" music technology research are also apparent in mobile computing. This paper presents an overview of some challenges related to the design of *action-sound relationships* and *music-movement correspondences*, and suggests how these can be studied and tested in mobile devices.

Keywords

Music and movement, action-sound

1. INTRODUCTION

With the appearance of workshops and conferences, and with the support of an active community, *mobile music technology* has been established as a separate research field during the last decade, located somewhere between ubiquitous computing and new interfaces for musical expression [12]. While this mobility opens up for new and exciting applications, e.g. based on location-aware systems and techno-social interaction, I shall argue that many research questions faced in "immobile" music technologies are equally (or even more) important in mobile applications. This paper outlines some of these challenges, with a focus on the potential conflicts between our music cognition and the new technologies mediating between movement and music.

My point of departure is the idea of an *embodied music cognition* [23], where the body (and its movement) is seen as essential for our experience with, and understanding of, music [7]. Despite the long tradition of neglectance in traditional musicological research, body movement is, by necessity, a very important part of both music performance and perception.[1] Fortunately, the field of music and movement has gained popularity over the last decades. A large extent of this work seem to be focused on the movements of musicians, e.g. the effect of *sound-producing movements* on expressivity and timing [6], the influence of *ancillary movements* on musical phrasing [35], or the importance of *entrainment* in performance [8]. There has also been some research on the movements of perceivers, e.g. [24, 4].

[1]I prefer to use the word *perception* rather than *listening* to account for the multimodal nature of our music cognition.

All of the above mentioned studies have been carried out on performers and perceivers that have been confined to a comparably small movement space. This is in line with how music performance and perception have often been seen as "immobile" activities; not in the sense that people do not move, but that the movements are restricted to spaces like a concert stage, or the dance floor of a club. Mobile music technology, on the other hand, is often based on the idea that the person involved is moving around in a comparably large space, e.g. a city. Also, mobile music devices are typically much smaller than immobile devices, so the movements with which the user is interacting with the device are relatively small. Thus, if we use *movement space* to denote the subjective understanding of an area in which it is possible to interact,[2] we may say that mobile devices have a comparably large *external* movement space and comparably small *internal* movement space, as illustrated in Figure 1.

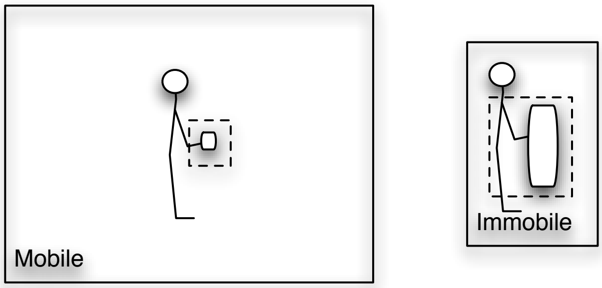

Figure 1: The differences in external and internal movement spaces in mobile (left: large external, small internal) and immobile (right: small external, large internal) computing.

This difference in movement space will necessarily influence our understanding of the *action-sound relationships* and *music-movement correspondences* found in a mobile device, but before discussing these concepts further I will have to define some key terms that will be used in the discussion.

[2]See [20] for a longer discussion on various types of *spaces*.

2. TERMINOLOGY

I often see that some key terms are used very differently in the literature, so I will start by defining the terms *movement*, *force*, *action* and *gesture*.[3] First, we may start with two physical concepts:

- *Movement/motion*: displacement of an object in space, e.g. moving an arm in the air.
- *Force*: push or pull of an object, e.g. pushing the button on a device.

From mechanics we know that movement and force are related, e.g. a push may result in movement, but not necessarily. I will argue that movement and force are objective entities, that can be measured and quantified with for example accelerometers and force sensing resistors.

While movement and force refer to mechanics, I will argue that the terms *action* and *gesture* refer to cognition:

- *Action*: a *chunk* of several related movements and forces, e.g. opening a door or playing a chord on a piano. They make up a coherent unit, and also seem to be a basic building block in our cognitive system [28], and falling within the idea of a *present now* [32].
- *Gesture*: the meaning (semantics) of an action, e.g. saying goodbye when waving the hand in the air.

In the following I will mainly use the word *action*, since I will be focusing on chunks of movement and force, and their relationships to sound.

3. ACTION-SOUND

Recent studies suggest that our experience with *action-sound couplings*, based on relationships between actions and objects and the resultant sounds, guide the way we think about both actions and sounds [15, 20]. This is based on the motor theory of perception [25], which suggests that we mentally simulate how a sound was produced while listening. Such close connections have been tested in a series of psychological studies of sound-source perception [14] and psychomechanics [27], and have to a large extent been neurophysiologically explained by the findings of *mirror neurons* in the ventral premotor cortex of the brain [9, 22, 29].

Borrowing a term from the ecological psychology of Gibson [13], we may say that the objects and actions involved in an interaction *afford* specific sounds based on their mechanical and acoustical properties (Figure 2).

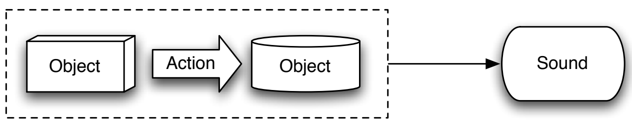

Figure 2: The mechanical and acoustical properties of objects and actions guide our experience of the appearing sound.

This means that we through our life-long experience with objects and actions have built up an understandig of how various types of materials and shapes sound like when excited in various ways. From this follows our ability to "see" the action of a sound we only hear, and "hear" the sound of an action we only see. Combining terminology from Schaeffer [31], and Cadoz [2], we may talk about three different *action-sound types* [16]:

- *Impulsive*: the excitation is based on a *discontinuous* energy transfer, resulting in a rapid sonic attack with a decaying resonance. This is typical of percussion, keyboard and plucked instruments.
- *Sustained*: the excitation is based on a *continuous* energy transfer, resulting in a continuously changing sound. This is typical of wind and bowed string instruments.
- *Iterative*: the excitation is based on a series of rapid and discontinuous energy transfers, resulting in sounds with a series of successive attacks that are so rapid that they tend to fuse, i.e. are not perceived individually. This is typical of some percussion instruments, such as guiro and cabasa, but may also be produced by a series of rapid attacks on other instruments, for example quick finger movements on a guitar.

Each of these categories can be identified with a specific action and sound profile, as illustrated in Figure 3.

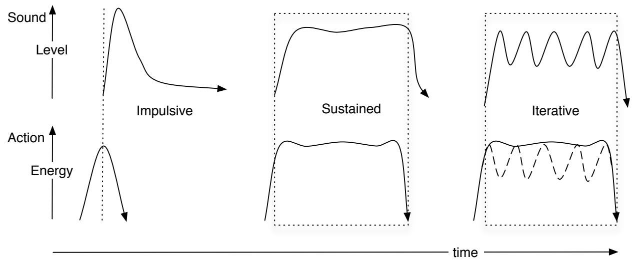

Figure 3: Sketch of action energy and sound levels for the different types of sound-producing actions (the dotted lines/boxes suggest the duration of contact during excitation).

Mapping action to sound has emerged as one of the most important research topics in the development of digital musical instruments [1, 19], and in general human-computer interaction [10, 11, 30]. However, to be able to create better artificial *relationships* between action and sound, I believe it is important to understand more about natural action-sound *couplings*. I prefer to differentiate between *couplings* found in nature and the *relationships* created artificially in technological devices. This is because I believe that a relationship can never be as sollid (cognitively) as a coupling (Figure 4). Take the simple example of an electronic doorbell. Even though the action-sound relationship in the doorbell has been working the exact same way for 20 years, and you have never experienced it failing, you can never be absolutely certain that it will always work. If the power is out, there will be no sound. This type of uncertainty will never occur with a coupling. If you are dropping a glass in the floor, you know that there will be sound. The sound may be different than what you expected, but there will certainly be sound.

[3]Please refer to [20] for a literature review and detailed discussion of these terms.

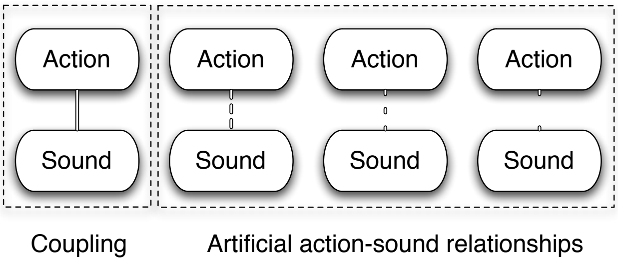

Figure 4: Artificial action-sound *relationships* (right) can never be as sollid as a natural action-sound coupling (left).

4. GOING MOBILE

In the Musical Gestures project,[4] we studied how the abovementioned theories on action-sound couplings and relationships influence our cognition of music. This included a series of observation studies of how people move to music, e.g. free dance to music [5], air instrument performance [18], and sound tracing [17]. Much work still remains before the relationships between music and movement are better understood, but we did find that there were large consistencies in how people, ranging from musical novices to experts, moved to music. We also found that properties of the action-sound couplings (or relationships) seen/heard/imagined in the music were important for the motoric response to the music.

How music changes movement, and how movement can be used to change music in mobile devices, is the topic of our new 3 year research project called *Sensing Music-related Actions*. After working on music and movement in a primarily immobile setting for several years, we are now excited to start exploring the topic in a mobile setting. One reason for this is the promising results in an observation study of how people walk to music [33]. This study revealed that people walk faster on music than on metronome stimuli, and that walking on music can be modeled as a resonance phenomenon such as suggested by van Noorden and Moelants [34]. Such a resonance phenomenon has also been seen in 10 hour recordings of people's movement patterns, which showed movement peaks with a periodicity of around 2 Hz [26].

Our approach will be based on the ideas of an embodied music cognition, where the limitations and possibilities of our cognitive system is used as the point of departure for understanding action-sound couplings and creating action-sound relationships. We will set up observation studies where people's movement patterns will be measured and compared to the musical sound, and investigate how it is possible to create *active music devices* based on the actions of the user.

It will be particularly interesting to explore the differences in movement spaces as mentioned in the beginning of the paper. Since the internal and external movement spaces in mobile music technology differs so much from that of immobile devices, we will probably have to rethink how we capture and process movement and force data. Today's mobile technology seem too much focused on duplicating the functionality of immobile technologies, where the focus is on capturing movement and force data from a device. In a mobile setting, however, we will probably have to focus more on the actions of the user rather than the device. This calls for developing new and better sensor technologies that better capture complex body movement, and accompanying segmentation methods that can be used to find the associated actions and gestures.

Finally, we believe it is important to develop solutions for measuring and understanding everything from low- to high-level features. There has been an increasing interest in finding relationships between low-level and high-level features, i.e. going directly from motion capture data to expressive features [3] or emotional response [21]. We believe it is also important to understand more about mid-level features, i.e. *action units*. This also requires a greater conceptual understanding of relationships between continuous body movement and the semantics, i.e. the *gesture*, of the movement.

Answering such questions will, hopefully, provide further knowledge about how we can develop better mobile (and immobile) music technologies.

[4] http://musicalgestures.uio.no

5. ACKNOWLEDGMENTS

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