Prototyping hand-based wearable music education technology

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ABSTRACT

This paper discusses perspectives for conceptualizing and developing hand-based wearable musical interfaces. Previous implementations of such interfaces have not been targeted for music pedagogical use. We propose principles for pedagogically oriented 'musical hand' and outline its development through the process of prototyping, which involves a variety of methods. The current functional prototype, a touch-based musical glove, is presented.

Keywords

Wearable electronics, glove, music learning, music education

1. INTRODUCTION

Mastering any musical instrument involves tactile and kinesthetic learning through which the external physical instrument ultimately becomes a 'part' of the player's musical consciousness. Achieving such level of technical skills usually requires years of practicing and commitment. Therefore it is justified to strive for any possible solutions, which can make this process easier for a music learner. One approach is to try minimize the need to master external interface mechanisms for playing music. Wearable music technologies embrace the ideal of bringing musical instrument closer to the human body, which potentially enables the utilization of already familiar sensory-motor skills in music making. Such a familiarity, however, is not a given or self-evident attribute of wearable interfaces, but rather, it remains as a challenge to interface designers to find out appropriate mapping strategies of sound and action [1] within the embodiment of an interface.

Our specific interest is in possibilities of using our most familiar 'interface element', i.e., our hand as an embodiment for getting *a grasp* on playing music and figuring out its structures. Instead of habituating our hands to use an external music instrument, why not to try to transform our hands themselves to an instrument. This is the rationale of the SmartHand project (2014-2015), which conducts research on this area by prototyping hand-based wearable musical interfaces. As one can argue that our hands inevitably partake in interactive experiencing and schematizing of the world that we live in [2], it is not far fetched to call our hands 'smart' as a way to appreciate the corporeal constitution of knowledge they possess [3].

The concept of hand-based musical instrument in itself is nothing new. Several interfaces have been developed mainly for the purposes of musical performance [4, 5, 6, 7]. The most common paradigm for such interfaces is a musical glove, incorporating hand movements (usually referred as gestures) as a basis for musical control and interaction. In most cases, this has been implemented through the use of motion sensors (e.g. accelerometers, gyroscopes, flex-sensors) embedded in a glove. So far only very few touch-based music glove implementations exist (extensively reviewed in [6]). Moreover, the attempts to create music glove purely for music educational purposes have not yet existed.

We aim to develop a wearable interface that helps and supports musician or music learner to perceive, understand and comprehend music through active musical play and music making with it. The pedagogical concept of 'musical hand' has existed nearly 1000 years through the work of Guido of Arezzo (Guidonian hand). The Guidonian music theory system was at that time proven to be effective in the memorization of musical structures. In contrast to the Guidonian hand that aims at projecting music theory statically onto hand, we rather see the structuring of music performatively, i.e., in *enactive* terms actualized when playing the hand as an instrument.

SmartHand project emphasizes the inherently action-oriented and multimodal nature of music learning as a starting point for the development of wearable music education technology. People can learn music through different modalities: visually, auditorily and kinesthetically, or through combinations of these [8]. Acknowledging that modalities should not be treated independently [9], the experiential integration of different sensory modalities, kinesthesia and motor actions forms a fundamental design principle for the current project. Hence, in our development of wearable interfaces, the emphasis is on prototyping embodied musical interactions for music learning, which constitute intuitive affordances for doing, experiencing and cognizing music. Our work targets the music learner and developing musician as a core user of the interface; thus trying to concentrate on technical solutions that are meaningful from music learning perspective. The educational design approach emphasizes qualities related to usability, accessibility and user-experience, which eventually should benefit also more professional users.

2. METHODS

SmartHand project utilizes different methods to investigate and study the necessary parameters of wearable music learning interface. Participatory design approach has been utilized in the conceptualization and design of the prototype. Throughout the design process, bodystorming practices [10] are used for tacit sketching of interaction experiences. In order to further define the SmartHand concept, use scenarios as first-person narratives [11], will be used to making explicit the experiential details of (1) the intended processes of learning through SmartHand in educational situations or (2) the aspects of expressing oneself

musically through the music interface in a specific context. Use scenario based methods can also be combined with bodystorming and sketching. The user experiences (interviews with students) will highlight important music learner related issues. Teacher interviews will be conducted to examine pedagogical requirements.

Table 1. SmartHand prototyping

Method	Target	Aims
Participatory design	Music students	Conceptualization and design
Bodystorming	Any	Experience sketching
Use scenarios	Any	Explicating (and sketching) concrete use situations
Interviews	Teachers	Pedagogical requirements
Interviews	Students	User experiences

3. GLOVE PROTOTYPE

The iterative process of *conceptualizing*, *prototype building* and *testing* has already led to the development of several functioning interfaces. The presented prototype in this paper is a musical glove with real-time touch capabilities.

Figure 1. Glove prototype

The guiding principle in our concept of the musical glove has been in touch interactions between two hands. The first hand, equipped with the glove and touch sensors, works as an instrument and the second hand plays it. The concept of the prototype utilizes both hands as structural counterparts for each other. In other words, the instrument is intended to be played with palms facing each other and every finger facing its equivalent. This potentially allows gaze-free playing of the instrument due to the kinesthetic familiarity between two hands. In order to benefit from the two–sided tactility of this setting, the physical form of sensors should not hinder the touch sensation too much. For this reason, the prototype glove utilizes thin and flexible capacitive touch surfaces placed on fingers. It is important to notice that the overall concept allows flipping the roles of hands: the glove-hand can actively touch and play the other hand as well.

The iterative prototyping method provides support for sketching and testing out the placement of sensors and their functional mappings that feel both intuitive and pedagogically appropriate. Mappings will also be studied in different music playing, making and learning contexts with end-users of varying age and musical skill levels. In the current phase of the development, the glove's musical note mapping is focused on the western tonal system but other systems can also be used with the prototype interfaces.

The prototype's real-time note and chord triggering features allow the music learner or teacher to use the glove like a musical instrument. Prototype's possible uses in music learning and education can include music playing, digital instrument control, arranging, composing and sound morphing. It can also provide the control surface or input device for music games and virtual (or augmented) reality applications. Providing the control for continuous musical parameters can extend the prototype's functionality.

4. FUTURE WORK

Within the project, new functional prototypes will be built. The music classroom use of multiple gloves will be studied closely in order to understand the possible collaborative functionality of such wearable technology. Furthermore, the SmartHand project studies the relevance of vibrotactile and visual feedback features in embodied music learning context. Wireless and seamless connectivity to other music technological devices and software will be examined and implemented through available wireless technologies.

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