The Human Skin as an Interface for Musical Expression

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ABSTRACT
This paper discusses the utilization of human skin as a tangible interface for musical expression and collaborative performance. We present an overview of existing different instrument designs that include the skin as the main input. As a further development of a previous exploration [16] we outline the setup and interaction methods of 'Skintimacy', an instrument that appropriates the skin for low voltage power transmission in multi-player interaction. Observations deriving from proof-of-concept exploration and performances using the instrument are brought into the reflection and discussion concerning the capabilities and limitations of skin as an input surface.

Keywords
Skin-based instruments, skin conductivity, collaborative interfaces, embodiment, intimacy, multi-player performance

1. INTRODUCTION
Musical interfaces that are designed to control and manipulate computer-generated sound undergo an evolution through permanent processes of redesigning, change of use and transformative experiments. In comparison to the interface design of acoustic instruments, this rapid technological change ties human-computer interaction (HCI) to the question of form. By 'form' we herewith mean not only the body or shape of an instrument but also the arrangement and style that prescribes a certain human behavior and interaction with companions in playing the instrument. Miniaturization, the ongoing development, and the affordability of electronic components are some reasons as to why interfaces grow more and more diverse. Within DIY, hardware hacking, and open source communities the considerable increase of information on the development and design of alternative musical instruments foster this progress. In electronic and digital systems the structural decoupling of the performers gesture from the sound synthesis is crucial for the wide creative scope of experimental interface design [1]. Thus, a part of HCI research enters into the questions of what role the human body might play in interactive performances with computers, and how appropriate interfaces should be designed.

Our research approach bears upon a study done by Fencott and Bryan-Kinns by focusing on open-ended computer supported musical interaction and a less task-based context [2]. It overlaps by studying collective musical performances to inform interface/instrument design processes, but differs insofar as its setup is intended to afford whole body interaction through touch instead of a screen based performance.

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This paper seeks to contribute to the discourse on musical interfaces that include the human skin. Interfaces in which the skin not only serves as a surface or draws a spatial border between the human body and the physical quality of an instrument, but becomes a structural part of the instrument and a performative medium.

2. SKIN-BASED INTERFACES FOR MUSICAL EXPRESSION
An instrument has a "tactile" quality whenever it is understood to imply a physical contact between the performer and the interface, and also if the device often has merely an intermediary role. The aesthetic experience initiated by the interaction can range from simple sensations to multifaceted feedback (re-)actions. In any case the human organism obtains information through his/her cutaneous organ: receptors on the skin and in subcutaneous tissues are sensitive to pressure, thermal properties, softness, wetness, friction, texture, to name but a few [3]. Extensive research on haptic feedback and its benefit for continuous performance albeit not in the focus of our work, can be found in O'Modhrain's thesis [4].

In the following chapter we present an overview of existing interfaces with respect to the skin. The list of examples that are taken from an art context or HCI research makes no claim to completeness. The categorization is intended to reveal the differing utilization of skin as inherent part of the interface.

2.1 Skin as recipient
The skin acts as a recipient of information sent by a computational system. One exciting example of how a skin surface is synchronized with the music is given by the artist Manabe: in "Face Visualizer", electrical wires are taped to the skin and are used to stimulate different face muscles. Each electric stimulation – triggered by the rhythm of the music – makes the face flinch and cringe [5]. Since the 1970s, extensive research has been done focusing on the importance and sensuous enrichment of haptic feedback in musical interaction. Starting with the design of vibrotactile suits and "concerts for the skin", the research of Gunter et. al. led to the new artistic approach "Composing for the Sense of Touch" with respect to the cutaneous perceptual apparatus [6]. For a synopsis of haptic feedback instruments, we refer to Chapter Two of the book *New Digital Musical Instruments* by Miranda and Wanderley [3].

However, in the following text, we draw attention to these types of interfaces that apply skin rather for input and allow for a mutual skin-to-skin contact amongst several performers than to output.

2.2 Skin as Substrate

Skin-based interfaces apply theoretical embodiment concepts to musical performance in a practical way. The skin as an inseparable sensory organ of the human body entails phenomena that the design of interfaces take advantage of. First, the proprioception, i.e. both the conscious and unconscious perception of one's own body position and strength of effort being employed in movement. And secondly, when performing on stage the body is always present, and thus it is constantly available for physical interaction. From the "embodied" perspective on musical interaction, skintight suits come close to the concepts proposed by Dourish. He explores the relationship of phenomenological philosophy and computer interaction [7]. Kobakant has designed a soft sensor suit to control robotive musical instruments or samples during a dance performance. The sensors are sewn into place underneath the tight stretchy fabric of the suit [8]. In Pilditch's et. al work the performer's skin is coated with conductive ink and affords closing electronic circuits by pressing parts of the body onto a chamber's wall [9]. Referring to the skin as a central input surface, HCI research projects like Skinput [10] and Sixth Sense [11] adduce technological evidence of its practicability. Even though the sensor technologies of these projects differ from each other, they have in common the utilization of skin as a substrate, as a medium of which parts of the instruments are attached to.

2.3 Skin as Conductor

A wide range of measurable human biosignals has been sonified as a form of auditory display to inform physicians about patient's state of health. With his artistic work 'Music for Solo Performer' (1965) Alvin Lucier was a pioneer in the use of brain waves in the context of a concert [3]. Further technologies, such as the measurement of changes in electric currents across an organ or specialized cell system like the nervous system, have been applied to computer-supported musical performances. Chapter Four of the aforementioned book by Miranda & Wanderley gives an overview of existing principles exemplified by "conductor's jacket" and the braincomputer musical interface (BCMI-piano)[3].

With respect to the human skin we turn our attention to a specific characteristic of the human body: its electrical conductivity. Since the 19th century skin conductivity has been measured for the purpose of physiological and psychological analysis. Changes in the relative conductivity of an electrical current between electrodes can be measured and in experiments have been related to specific emotional arousals. If the reliability of this method and thus applicability in a psychophysical context is arguable, then it offers playful potential for musical interaction. The Cracklebox by Waisvisz is probably the most well known instrument, with an interface that includes the conductive features of human skin. It is a portable alternative 'keyboard' analog audio synthesizer with inbuilt loudspeaker that has its roots in the experimentation of and touching on electronic circuit boards. Waisvisz describes the role assumed by his skin:

"By patching the different parts of the circuit through my – conductive – fingers and hands became the thinking [wet] part of a electronic circuit and i started seeing my skin as a patchable cable, potentiometer and condensator." [12]

Setups of several musical interfaces follow up the structure, though they vary in operation and performance. By performing with systems like "Ground me"[14], "skinstruments" [13] as well as "Drawdio", the human body, its skin and its movements become active parts of the instrument. Furthermore, any number of persons can participate in manipulating sounds through touching each other's skin, as the experiment "Chain of Emotion" by the MuSE research group from SARC has demonstrated [15]. This manner of interaction is a unique feature of interfaces using the conductivity of the skin and extensive experimenting has been observed in several performances. The fact that the action of touching another person's skin during a musical performance challenges an individual's private sphere, and this needs attention. Whereas dance practically deals with the issue of interpersonal touch and intimacy, their critical examination is quite new to the research field of New Instruments for Musical Expressions.

3. 'SKINTIMACY' – AN INSTRUMENT FOR PERFORMANCE AND EXPLORATION

3.1 Interaction Methods

Skintimacy is an instrument by which both a sound synthesis and looped samples can be manipulated. Participants can act as a constituent of a specific electrical circuit. In doing so each affiliated participant assumes a specific role in the joint play. Through a skin contact with a "master" a corresponding circuit is closed (see Figure 2). Persons can join the performance by touching affiliated players and thus act as a conductive bridge. The action of one player touching another influences the sound by varying the intensity, the duration of contact and the movement speed. The hierarchical structure with the roles of "master" and "slaves" is based on the current state of development and is not proposed as a structural ideology.

Figure 1. Exercise with Skintimacy.

3.2 Setup

The technical construction of Skintimacy is as follows: The skin resistance value, tracked by a unit using the Arduino-Board, is sent to a PC where the mapping and sound synthesis proceeds using the visual programming language Pure Data. The audible outcome of an interactive performance depends not only on the interactive gestures but also on individual skin profile, and on various impacts such as moisture, pollution, etc. Thus, a reliable controllability of sound modulation is severely limited.

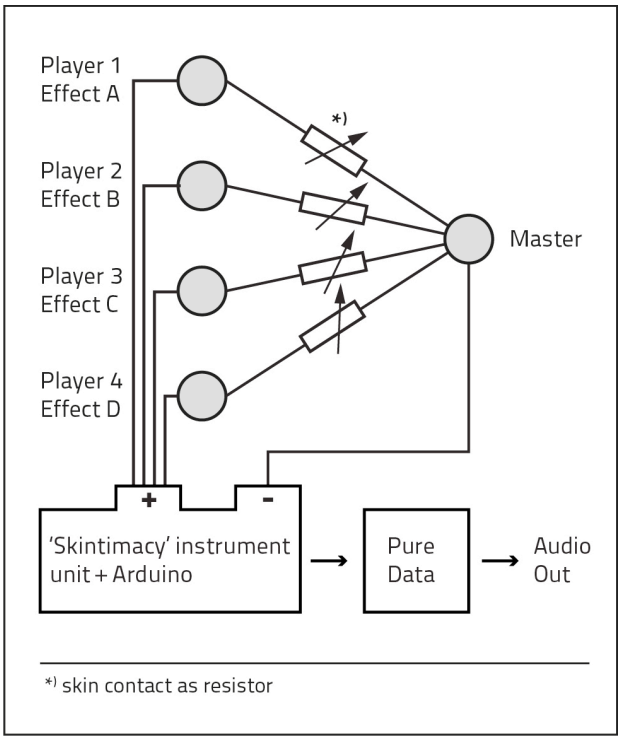

Figure 2. Instrument setup.

At the current state the instrument includes the following features:

- Up to five players can connect to the device via electrodes
- The control of effects is possible through body specific mapping
- Volume control, mode for direct control of FM synthesis, sample playback rate, reverb and balance – to mention just a few – are effects that have been implemented
- Fine-tuning to adjust the skin-conductivity to the sensor
- Variations of how to wire the performer to the instruments have been tested: Velcro bracelet, rings, a wristlet woven with conductive yarn, disposable electrodes

4. CONCLUSION – THE POTENTIALS AND LIMITATIONS OF SKIN-BASED INTERFACES

Based on observations we made during a one week student project – and also a festival where hundreds of visitors tried out the interface – we draw conclusions that might inform future design processes with skin-based interfaces for musical expression.

Arrangement of players

As the design of an instrument always has an impact on its interaction, modalities of touch can be influenced. The design of "Freqtric Drums" as an example for skin-based musical interaction invites the performer to keep hold of a conductive handle. Hence the movement of body parts is constrained. It provides for touch on the upper parts of mate's bodies [17].

Intimacy

The question of intimacy is brought to the foreground with the upcoming trend in HCI to use skin (and the precision of the sense of touch) as an interface. Benthien states that "*historically* […] *tactus was understood early on in the sense of intimacy, since* […] *it essentially precludes a collective experience*" [18]. In the field of HCI research different interpretations of the term 'intimacy' are existing. According to Fels, intimacy *"deals with the perceived match between the behaviour of a device and the operation of that device"* [19]. In the context of skin-based interfaces we adopt a definition of intimacy that relates to the individual emotion of privacy. We have observed that personal and intimate borders are shifting significantly in a performative context where a computational (musical) process is linked to interpersonal touch.

Figure 3. The intimacy of touch.

Discontinuous values due to individual properties

Individual properties of the skin have an unpredictable effect on the numerical analysis through sensory tracking. Thus a reliable tracking is precluded. This restriction on the one hand side faces the freedom of musical expression on the other. As Waisvisz puts it playing the Cracklebox:

"I derived lots of pleasure from the fact that there is, and is, no universal notation for sound. There was no way for me to start transferring laws and methods from existing tonal music concepts"[12].

Instruments that apply skin conductivity for sound manipulation merely give an example of rough sound control.

Cultural differences

The type, the period and the amount of touch varies according to cultural codes. Furthermore it depends whether the interaction manifests in public or private. Sex and relational stage have a substantial influence on haptic behavior. However the interpersonal relationship between performers can rapidly change through the shared experience of performing.

The Audience

In addition to the audio, visual information is a substantial element of skin-based interaction that is conveyed to the listener. The audience can see the performer's touch and recognizes the effort made to manipulate the sound. The handling of physical effort is part of a universal language [12]. As the "Chain of Emotions" has demonstrated, the audience can easily join the collective play [15].

Access to Sound

One advantage of (conductive) skin-based interfaces is that by intuitively touching another person one can learn to play these instruments without having to have schematic knowledge about the setup. Interaction schemes, electronic circuit theory and synthesis methods can be neglected in the first instance. In favor, it can be learned by playing by ear and played with tacit knowledge. Through playing on another person's body one can get the feeling of a direct relation to the immediate musical pleasure of sound.

5. FURTHER WORK

We plan to continue our cooperation with professional dancers to test and to improve the instrument on a technical but also on an aesthetic level. Furthermore, we are developing an open source ”Skintimacy construction kit“ that allows for individual exploration and redesign.

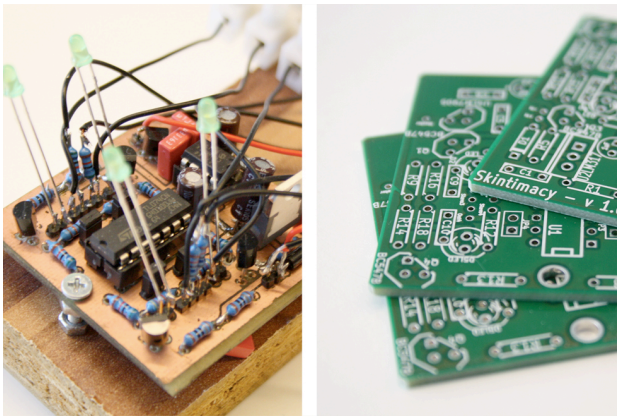

Figure 4. Prototypes of the construction kit.

6. ACKNOWLEDGEMENT

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