INSTRUMENT AUGMENTATION USING ANCILLARY GESTURES FOR SUBTLE SONIC EFFECTS

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ABSTRACT

In this paper we present an approach to instrument augmentation using the musician's ancillary gestures to enhance the liveliness of real-time digitally processed sound. In augmented instrument praxis, the simultaneous control of the initial instrument and its' electric/electronic extension is a challenge due to the musician's physical and psychological constraints. Our work seeks to address this problem by designing non-direct gesture-sound relationships between ancillary gestures and subtle sonic effects, which do not require a full conscious control of the instrumentalist. An application for the electric guitar is presented on the basis of an analysis of the ancillary movements occurring in performance, with specific gesture data acquisition and mapping strategies, as well as examples of musical utilizations. While the research work focuses on the electric guitar, the system is not instrument-specific, and can be applied to any instrument using digital sound processing.

1.INTRODUCTION

Instrument augmentation with real-time digital audio signal processing offers numerous possibilities for musical performance. However, integrating new features into an already complex instrumental playing environment is constrained by the musician's physical and psychological capacities of accomplishing multiple and simultaneous tasks [3][10]. There is always a tradeoff between the extended sonic possibilities and the ability of the performer to dynamically control them. In musical applications this often translates as an inability to simultaneously control the numerous parameters of the sound processing algorithms; a specific "effect" is applied to the sound and only its most prevalent perceptive features are controlled in time. The remaining "secondary" parameters typically stay static or are modulated by fixed-frequency LFO's. This leads to a lack of "liveliness" in the real-time processed sound, and certainly makes for an underuse of the processing algorithms' sonic possibilities. In our view, significant areas of sonic effect, subtlety and nuance are left unused. One established strategy of enhancing multi-parameter variation of DSP in time is the adaptative digital audio effects (A-DAFX): a content-based transformation where the sound features provide data to control processing parameters [12]. In the present work, we investigate another strategy, namely the possibility of connecting the performer's sound-ancillary gestures to the evolution of the processing parameters [14]. Our hypothesis is that instrumentalist's movements which are not directly involved in the creation of the sound convey performance-related information which may be used to enhance the liveliness of digitally processed sound.

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1.2.ANCILLARY GESTURES AND MUSICAL APPLICATIONS

Musician's performance movements which are not directly related to the production or sustain of the sound have received academic attention. In his study of Glenn Gould's piano performance videos, F. Delalande identified three levels of gesture which form a continuum going from purely functional to purely symbolic [4]. With his work on clarinet players' movements, M. Wanderley established the term ancillary gestures, signifying movements occurring in the performance which are not directly related to the production of sound [13]. This discretization of musician's movements was continued with the following typology [11]:

- Sound-producing gestures,
- Ancillary gestures (support sound-producing gestures)
- Sound-accompanying gestures (musically "engaged" body movements not involved in the sound production)
- Communicative gestures (communication between performers and towards the public)

In this article, we adopt the motion-related terminology mentioned above. Our project concentrates on the use of both ancillary and sound-accompanying gestures.

In instrument augmentation there is a general tendency to work on direct causal relationships between gesture and sound, either using the acoustic instrument's sound-producing gestures or by adding new interfaces with direct mappings. The use of ancillary or sound-accompanying movements is rather rare in this area. Previous applications include a flanger-effect control with clarinetist's ancillary movements [14], a weight balance tracking floor module [8], and the *Multimodal Music Stand* which tracks the instrument's tilt and the performer's head movements [1]. Our current project seeks to address the specific problem of digital signal processing "liveliness" by using the performer's sound-accompanying movements for dynamic variation of DSP parameters which affect the sound's subtle perceptive features (cf. 3.2). Our system introduces a second level of gesture-sound relationship into the augmented instrument-playing environment, where sound-accompanying movements provide complementary control data for the signal processing.

3. GESTURE-SOUND RELATIONSHIP: AN APPLICATION FOR THE ELECTRIC GUITAR

The initial research work was carried out on the electric guitar and its related set of movements.

3.1.Sound-accompanying movements

The electric guitar is traditionally related to popular music styles such as jazz and rock where there is a social acceptance and even expectation for an engaged performance body [5]. Embodied expression and rhythm are part of the guitar playing tradition. The sound-accompanying movements being thus relatively emphasized, the electric guitar provides for a fertile testing ground for our project. In order to analyze the different movements of electric guitar performance in standing position, we first set out to review video excerpts from a number of players. Subsequently we filmed a series of performances in laboratory conditions, allowing for a finer analysis of the players' movements and their relationships to the instrument and to each other.

Figure 1. Still images taken from our filmed guitar performances. Note the weight shifts and the head movements.

The analysis of our video excerpts revealed a set of sound-producing gestures on the hands, prolonged by ancillary movements of the arms and shoulders, and to a lesser degree, adjustments of the pelvis and torso to maintain the instrument level. Movements which were less involved in sound production included more ample torso movements, weight shifts, knee bends and head movements. A distinctive feature was foot tapping, which occurred often. While being highly individual in style and conduct, these basic movements were abundant and rather consistent from one performer to another. Concentrating solely on the sound-accompanying movements, we distinguished two fairly independent motion ensembles: firstly weight shifts resulting from the leg (knee) and torso movements and secondly seemingly autonomous movements of the head. Consequently, we decided to focus on the extremities of the body, the most remote areas from the sound-producing central area: head movements and body weight shifts.

3.2."Subtle" perceptive sound features

In hybrid acoustic-electric/electronic instruments such as the electric guitar, two levels of gesture-sound relationship coexist. The first is that of an acoustic instrument, where a direct causality connects gesture to sound through energy transduction from kinetic energy to acoustic waves [2]. This is not the case for the second level: the electric/electronic part of the hybrid instrument where the sound processing is not physically related to the initial gesture, the relationship between body and sound having to be defined via mapping strategies. The two levels of the "electroacoustic instrument" have specific sonic functions: the acoustic level determines the fundamental articulation of the musical discourse (pitch, duration, rhythm, basic timbre), whereas the electric/electronic level determines timbral transformations, spatialization, and sound structure modifications. The range of transformations applied on the initial gesture-related signal varies from subtle to radical. In this project, we seek to work on the more perceptively subtle features of the hybrid instrument's electric/electronic level's sonic possibilities, such as those appealing to the perception as modifications of sound color, presence, space and timbre. We use the term "subtle perceptive sound features" to term these somewhat moderate effects. In a technical perspective, this translates into inducing minor variations on the sound's spectrum, spatialization, reverberation, delay and granularity or distortion, among other numerous possibilities.

4.A NON-DIRECT GESTURE-SOUND RELATIONSHIP

In the present project, we investigate the possibility of avoiding saturating the augmented instrumental environment by introducing non-direct relationships between movement and sound into it. By voluntarily designing "loose" gesture-sound relationships we aim to give the musician the sensation of sound transformations which accompany the performance, without demanding conscious attention [7]. This enables for better concentration on the essential features of the instrument, while providing performance-related data for the signal processing. The established relation between movement and sound can be qualified as "loosely causal"; body motion induces changes in the sound's subtle perceptive features, but not in a direct, predictable manner. In order to achieve this "blurred" gesture-sound relationship, we explored the following design principles: complex, multilayer mappings [6], the non-reproducibility of one gesture-sound couple and maintaining the sonic effects subtle (ensuring that the musician does not feel "out of control"). In our view, these characteristics are necessary to provide a system that the musician may accept as a part of his/her instrument. The augmentation should find an equilibrium in the playing environment, not too obvious for the performer to be tempted to "take control" yet not too distant from the gesture so as not to appear as intrusive and disturbing. The introduction of "loose" connections establishes a hierarchy in the gesture-sound relationships of the augmented playing environment: the central constituents of the musical discourse are controlled by focused gestures and direct mappings, while secondary sonic features are induced by peripheral, non-conscious movements.

5.SYSTEM DESCRIPTION

5.1.Ancillary gesture data acquisition

The system extracts data from a selection of guitarist's ancillary gestures and uses it to produce sound variations via a two-layer mapping strategy. This system functions in parallel with the traditional instrument. The sound-accompanying movements are sampled in three points: on top of the head with a two-axis accelerometer and under both feet with a board sensing the weight distribution with four equidistant FSRs. The system outputs seven channels of data, which are grouped to represent three distinct variables: general "amount" of head movement, left/right and back/front weight distribution. In addition, the system seeks to capture particularly dramatic body imbalances such as standing on one foot, on the toe(s), or on the heel(s), by polling the four FSR sensor network for relative peak values. A detection of the feet's tapping movements is implemented, and it will be upgraded with a tempo tracking algorithm in a near future version of the system.

5.2.A kinetic metaphor as a mapping strategy

Our system seeks to establish a non-direct relationship between movement and sound through a two-layer mapping: the gesture data is first routed as an input to a mass-spring physical model which in turn modulates the sound processing parameters. The mapping strategy is inspired by a kinetic metaphor where the performance gestures are seen as energy inducing motion in an independent system affecting the sound processing parameters. The physical model has its own behavior and inertia which are determined according to the specificities of the target parameters. The mapping was implemented using the msd/pmpd physical model in the max/msp environment [9]. Each of the main input variables (head movement, 2-dimension weight distribution) feeds a distinct model, resulting in three mass-damper systems affecting the sound simultaneously. A minute tuning is required to achieve a "blurred yet connected" perception of the gesture-sound relationship. This may be achieved through careful selection of the physical models' inherent attributes (i.e. behavior), and by mapping relationships between the models' output and chosen DSP parameters.

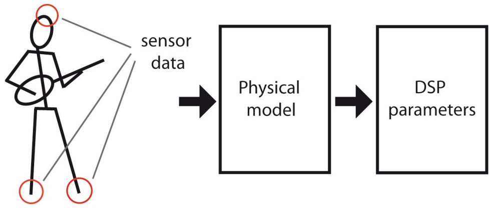

Figure 2. System schema

5.3.Applications

A series of test applications was implemented in max/msp, based on the electric guitar's use of real-time "effects". Testing our system in a musical praxis proved highly interesting, providing subjective insights to the "feel" of a non-direct gesture-sound relationship and to its' tuning via mapping strategies. Through practice, the head gestures and the body weight shifts acquired distinct connections to different sound parameters: the head movements linked well to minute, relatively high frequency variations of the sound's spectrum and space, while the weight shifts were used for slower and more important transformations of the soundscape. Following are some examples of the applications:

- *Spectral panning*: Body weight shifts were mapped to two physical models driving a four-section spectral stereo panning effect. Weight shifts would induce increased stereo field motion of the spectral divisions, while absence of motion would bring the soundscape to a standstill at the center. Head movements were mapped to the gain of an unobtrusive stereo delay, increasing the kinetic effect of the panning.
- *Autofilter*: A combination of an adaptative audio effect (A-DAFX) and non-direct gestural control. The autofilter would respond to the amplitude of the notes played, while the ancillary gestures would modulate the behavior of the filter. The weight shifts were mapped to the filter base cutoff frequency and the head movements to the filter's "slope" (Q). This produced a lively and musically rewarding autofilter application for the instrumentalist.
- *Drive and granulation*: This application sought to induce subtle variations in the saturation or "drive" of the sound; an important timbre element of the electric guitar. Weight balance was connected to the saturation level, and

head movements to the Q of a low pass filter. A variation of the effect was implemented with the msp munger~ object, working on the sound's granularity instead of saturation.

- *Stereo delay*: Weight shifts were used to control the stereo spread of two delay channels, similarly to the spectral panning application. The head movements were mapped to an amplitude modulation (tremolo) affecting the delay lines.

Gesture type	DSP parameters
Weight shifts (left/right & front/rear)	- Spectral panning width - Autofilter base cutoff freq. - Overdrive/granulation level - Stereo delay spread
Head movements	- Delay gain - Autofilter Q - Lowpass filter Q - Tremolo amplitude

Table 1. The ancillary movements and their corresponding DSP parameters used in the test sessions

The possibilities are numerous, and the system may be adapted to any instrument using digital signal processing. A case-specific study of the instrument's characteristic ancillary gestures is nevertheless necessary[1].

Figure 3. A still image from the filmed test sessions with the sensor board and head accelerometer

6.CONCLUSION AND FUTURE WORK

In this paper we presented a system connecting guitarist's ancillary and sound-accompanying gestures to subtle variations of the digitally processed sound. The resulting gesture-sound relationship is designed to be "loose", i.e. not requiring conscious control from the instrumentalist while providing gesture-driven sonic variations. The adopted strategy uses multi-layer mapping and physical models to establish a non-direct control of the DSP parameters. The initial results were musically inspiring, and they point to a vast domain of research on ancillary gesture-sound relationships, their perception (both from the musician's and the public's perspective), and their use in performance. These results suggest that a well-integrated ancillary gesture based control system for enhancing the liveliness of digitally processed sound is a promising perspective for instrument augmentation.

7.ACKNOWLEDGEMENTS

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