THE HYPER-KALIMBA: DEVELOPING AN AUGMENTED INSTRUMENT FROM A PERFORMER'S PERSPECTIVE

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ABSTRACT

The paper describes the development of the hyper-kalimba, an augmented instrument created by the authors. This development was divided into several phases and was based on constant consideration of technology, performance and compositional issues. The basic goal was to extend the sound possibilities of the kalimba, without interfering with any of the original features of the instrument or with the performer's pre-existing skills. In this way performers were able to use all the traditional techniques previously developed, while learning and exploring all the new possibilities added to the instrument.

1 INTRODUCTION

The Hyper-kalimba is a Digital Musical Instrument created by the authors with the support of the Input Devices and Music Interaction Laboratory [1] at McGill University, directed by Prof. Marcelo Wanderley. It consists of a kalimba (a traditional African thumb piano) augmented by the use of sensors, which control various parameters of sound processing performed by custom software developed in Max/MSP. All the sounds produced are the result of real-time processing of the kalimba sound. The hyper-kalimba has been used in concerts since October 2007, both in improvisational contexts and in written pieces. There were several stages in the development of the instrument. Throughout this development, all the traditional kalimba techniques and sound possibilities were preserved. In each of the stages, some performance capabilities were added to the instrument. The mapping was then fixed for a certain amount of time, allowing the performer to learn the new techniques, before more possibilities were added.

[1] www.idmil.org

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2 AUGMENTED INSTRUMENTS

Miranda and Wanderley indentify four main types of digital musical instruments, according to their resemblance to acoustic instruments: *augmented musical instruments*, *instrument-like gestural controllers*, *instrument-inspired gestural controllers*, and *alternate gestural controllers*[8]. Augmented musical instruments, also called hyper-instruments, are created by adding sensors and new performance possibilities to traditional, pre-existing musical instruments. Examples of augmented instruments include the hypercello created by Tod Machover [7] and, in the percussion area, a zarb with sensors developed at IRCAM by percussionist Roland Auzet [1].

Sensors added to an instrument can capture both gestures that are made to produce the normal sounds of the instrument (effective or instrumental gestures), as well as accompanying gestures that performers often make while playing[2]. New gestures can also be added to the performance technique. If new gestures are required of the performer, it is very important that they do not interfere too much with their existing playing technique. For example, most standing instrumentalists, like violinists, are not used to using foot pedals when playing, so this new gesture - pressing the pedal - can interfere with the performance[6]. The choice of sensors and the way they can be used and placed on the instrument require careful study. In developing the hyper-kalimba efforts were made to make use of existing instrumental and accompanying gestures from traditional kalimba technique, and only a few simple new gestures were used.

3 THE KALIMBA: CHARACTERISTICS AND LIMITATIONS

The kalimba is a modern development of the Mbira (a traditional African thumb piano). The instrument used in this project was the Hugh Tracey Alto Kalimba with pick-up. This alto model, created by the English ethnomusicologist Hugh Tracey, has 15 notes, corresponding to two octaves of a western diatonic G major scale (figure 1). It also has a built-in piezo contact microphone inside the wood body of the instrument.

The instrument is played with right and left thumbs pressing down pieces of metal of different lengths, which are called tines[3]. Each tine is tuned to one of the 15 notes. The right thumb usually plays the right side - tuned to thirds from G to G - and the left thumb plays the left side - tuned to thirds from A to F♯ (Figure 1). Two consecutive notes can be played with the same thumb, producing the interval of a third. Combining both thumbs can produce different intervals, but they are always restricted by which notes each thumb can reach. The range (2 octaves) and the tonality (G Major) are other limitations of the instrument. One effect that is possible to control in some acoustic kalimbas is *tremolo*. Some instruments have sound holes on the front and/or back part (figure 2). Covering and uncovering these holes (the front one with the thumb, the back ones with the third fingers) produces a tremolo effect. This is not acoustically possible in the kalimba used for this project, since it has a solid wooden body and no holes. The effect, however, can be imitated electronically, as will be described later.

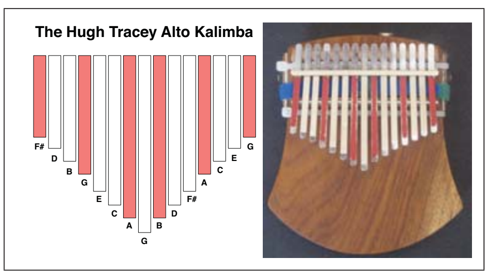

Figure 1. The Hugh Tracey Alto Kalimba.

Figure 2. Back view of a kalimba (with two holes); Back view of the hyper-kalimba (with two pressure sensors).

4 EXTENDING THE INSTRUMENT

4.1 The first version (October 2007)

The first sensors added to the instrument were two pressure sensors. They were added to the back of the instrument, inspired by the holes that are present in some kalimbas. A kalimba performer is accustomed to using the third fingers of each hand to cover and uncover these holes. The use of this instrumental gesture was thus very natural.

The pressure sensors detect the amount of pressure applied to them. The first two sliders in the Max patch shown in figure 3 register this: the figure indicates that the right sensor is not being pressed (value=0) and the left sensor is being moderately pressed (value=300, on a scale from 0 to 1000). These two sensors were used to control pitch modulation and ring modulation effects, which can also be used to imitate a tremolo effect (as described later in section 4.2.1).

The piece *A la luna*, by Fernando Rocha and Ricardo Cortés, was written and performed for the instrument at this stage of development. *A la luna* is a structured improvisation for hyper-kalimba and pre-recorded and processed voice sounds. The structure of the piece is based on the poem "Noturno Esquematico" by Frederico Garcia Lorca. The words of the poem (recorded by Raquel Gorgojo) were manipulated electronically by Ricardo Cortés to create a rich sound texture, which is combined with the sounds produced in real time by the hyper-kalimba. The result is a dense atmosphere of sounds, in which the words of the poem are masked, appearing clearly only in the last section, when they are triggered by the notes F♯, E, D and C, produced by the kalimba. The pitch detection was made with the use of the Max/MSP port of Miller Puckette's `fiddle~` object.

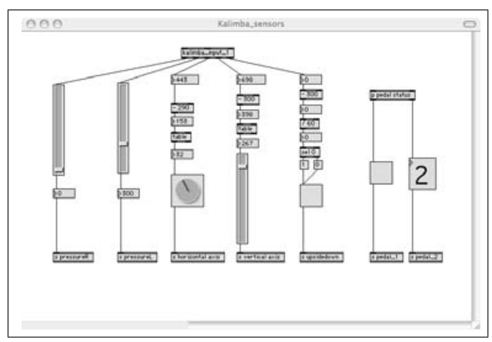

Figure 3. Hyper-kalimba Max/MSP patch showing input data from sensors.

4.2 The second version (February 2008)

The next sensor added to the instrument was a three-axis accelerometer, which enabled the measurement of the tilt of the instrument, both in the vertical and horizontal axis, as illustrated in Figure 3. The dial in the center shows the instrument's left-right tilt position (in this case the instrument is slightly tilted to the left). The next slider shows the instrument's front-back rotation, from a downward position of the front of the instrument to an upward one (in this example, the front of the instrument is in an upward position). Finally, the patch is able to recognize when the instrument is upside-down (since the box is not marked, in this case the instrument is not upside-down). Tilting the instrument is an accompanying gesture that is very common among kalimba players, and it does not affect the playing technique. Moreover, in many traditional African kalimbas, the front-back rotation is, indeed, an instrumental gesture. Some instruments present a metal ring placed around each tine (Figure 4). These ringers vibrate when the tine is vibrating, creating a buzz effect. Rotating the instrument controls the amount of the effect. By pointing the instrument down, the rings move close to the end of the tines (where they are fixed to the instrument). The vibration is then minimum, so it is the buzz effect. When the instrument is level and the ringers are in the middle part of the tines, the vibration is maximized and so is the effect[4].

Figure 4. The Hugh Tracey Karimba with metal rings for buzz effect.

4.2.1 Mapping of the instrument at this stage

Pressure Sensor 1 (pressureR): controls a pitch transposition effect. The harder it is pressed, the greater the effect.
Pressure Sensor 2 (pressureL): controls a ring modulation effect. The pressure applied to the sensor determines the frequency used to modulate the sound of the kalimba. When the pressure is low (less than 300), this frequency is less than 8Hz, which creates an effect similar to a tremolo. Pressing harder causes the frequency to become higher and the effect is a change in the timbre of the instrument.
Position (horizontal axis): controls a multi-tap delay effect. When tilted to the left the delay is panned to the left; when tilted to the right, it is panned to the right.
Position (vertical axis): Pointing the front of the instrument down adds reverb; pointing it up adds very short delays, imitating the buzz effect found in traditional kalimbas. Maintaining an extreme upward position can generate a feedback effect.

The vertical axis also influences the pitch transposition process. Pointing the front of instrument down causes the transposition to go down. The further down the instrument is pointed, the larger the downward range of the transposition will be. Thus, the lowest pitch can be obtained when the instrument is pointing down and strong pressure is applied to the right pressure sensor. Conversely, the highest notes on the instrument can be obtained by pointing it up and strongly pressing the right sensor. When the instrument is level, however, the maximum range of the transposition is one half tone up. In fact, at this position any pressure (on pressureR) larger than 600 produces a half tone transposition. This is a gesture that can be repeated with accuracy by the performer as well as captured by the sensors. By using it, the performer is able to play chromatic passages.

Upside down: When the instrument is upside down, the loop being played (if there is one) is randomly altered in speed and volume. After 45 seconds the loop goes to normal speed and fixed volume. If the instrument remains upside down, the loop starts to fade out. In addition to these sensors, two Midi pedals were used in this mapping. The information coming from these pedals is shown on the right side of figure 3. Pedal 1 is an ON/OFF switch; and pedal 2 triggers one of 6 positions.

Pedal 1: When the pedal is pressed (ON), it freezes the value of all the sensors, so the parameters for sound processing remain fixed until the pedal is pressed again (OFF position). The only exception is the right pressure sensor, which is also fixed when the pedal is ON, but as soon as it is pressed for more than 100 milliseconds, it starts to work again, allowing for pitch transposition.

Pedal 2: controls the recording and playback of the audio loops used in the performance. When the pedal is pressed (status 1), the patch records the live sound until it is released (status 2). When the pedal is pressed (status 3) and then released (status 4) again, the loop is played in reverse at a speed that makes the length of the loop the same as the time interval between status 3 and 4. Status 5 (pressing the pedal) starts a fade out, and status 6 (releasing) ends the loop. The next time the pedal is pressed this cycle starts again.

The work *Improvisation for Hyper-kalimba* is a structured improvisation that explores all these possibilities. It also highlights some traditional characteristics of the kalimba and its repertoire: its melodic aspect and the use of ostinato, here transformed by electronic treatments. The first phrase of the piece, e.g., is played at a lower transposition (one octave down), and recorded. This recording is later looped as the performer plays variations of the same phrase, untransposed (i.e., one octave higher). The piece ends after the performer places the instrument upside-down in a stand. This gesture, clearly a conclusive one, triggers an erratic effect of altering the loop in volume and speed, followed by a 30 second fade-out.

4.3 The current version (from July 2008)

In the current version, the pedals were replaced by two digital buttons, one placed on the left and one on the right side of the instrument. The buttons have the same functions as the pedals. With the use of buttons all the performer's control over the sound processing is made directly on the instrument.

Some new features have been added to the instrument, using combinations of gestures. Pressing the left button (which corresponds to pedal 1) and the left pressure sensor together adds an extra sound to the one played by the performer. If the instrument is tilted down the added sound is an octave lower; if the instrument is level it is a fourth lower; finally, if the instrument is tilted up, the added sound is a fourth above. To stop this effect the performer has to repeat the same original gesture. All and any of the three sounds can be combined, creating the possibility of playing chords. The current mapping also allows for starting the loops of phrases at the same speed at which they were recorded; after recording the phrase, the performer should just press and release the right button very quickly (less than 400ms between pressing and release). These new possibilities have been used in several concerts, both in Brazil and Canada.

5 TECHNICAL DESCRIPTION

Since the kalimba model chosen for this project already contains a piezo-electric contact microphone, it was only necessary to add sensors - for measuring finger pressure and tilt - and two buttons. An Arduino Mini microcontroller board [2] was used for sensor data acquisition and data were communicated to the computer over USB. Two Interlink force-sensing resistors were used on the underside of the kalimba to sense finger pressure; the sensors were covered with a layer of closed-cell foam to give the performer some kinesthetic feedback as pressure is applied. An STMicro LIS3L02AS4 three-axis accelerometer was used to measure movement and tilt.

The audio signal and sensor data from the hyper-kalimba is sent to a laptop computer, where a custom-made Max/MSP patch is used to map the control parameters to sound processing. The mapping used in the instrument aims to preserve the melodic characteristic of the instrument, but also to create new sound possibilities.

6 DISCUSSION: TECHNOLOGY, COMPOSITION, AND PERFORMANCE

The development of the hyper-kalimba was based on careful consideration and balancing of technology, performance and compositional concerns. An example of these interrelations is the evolution of the control over the transposition effect. In the first mapping of the instrument, the transposition was controlled only by the right pressure sensor and was always upward. Strong pressure could create up to a four-octave transposition, producing a very different timbre, which was explored in *A la luna*. However, small transpositions, like a half tone, were difficult to achieve accurately. With the introduction of the 3-axis accelerometer, the angle of the instrument could then be mapped to control the range of the modulation. This new mapping made it considerably easier to play half tone transpositions and also allowed for a downward transposition. These new features were used in *Improvisation for Hyper-kalimba*.

In fact, as the instrument developed, new gestures were explored and could potentially be mapped. Mapping choices facilitated certain sounds or effects, and this had consequences in the musical material. Conversely, when specific sounds were sought in the improvisations or compositions, effective ways and gestures to create and control them had to be found. The use of instrumental and accompanying gestures that are characteristic to the instrument was prioritized, since new gestures might interfere with pre-existing technique. The active participation of an accomplished kalimba player was essential to understanding and utilizing the gestures to be used. The new gestures that have been added are very simple: pressing and releasing the two buttons. Another important aspect was considered in the mapping choices: gestures that could be controlled and captured accurately were mapped to musical results that needed to be more accurately controlled (e.g., control of a half tone pitch modulation). On the other hand, gestures that could not be controlled or captured very accurately were mapped to musical results that allowed some indeterminacy (e.g., amount and speed of delay effect).

The realization of any piece of music, independent of style, period or culture, depends not only on the possibility of producing sounds but also on the level of control over these sounds [5]. The potential for incorporating both traditional techniques and new features with a considerable level of control makes the hyper-kalimba very engaging for performers, composers and audience. The instrument has already been used in several concerts, both in improvisational contexts and in different written pieces.

7 CONCLUSION

The sensors and the patch provide the kalimba with new performance and sound possibilities, such as pitch bend, tremolo, extended range, and delay. All the sounds produced are the result of manipulation in real time of the kalimba sound. This helps to preserve the melodic characteristic of the instrument and its own characteristic voice. In addition, the sensors added to the instrument do not interfere with the traditional technique. Rather, they create new gestures that complement this technique. All the new possibilities were

[2] www.arduino.cc

implemented in different stages. While exploring a new vocabulary of gestures, the performer was able to explore new sound possibilities, and composers were able to know the instrument better. The instrument was played and tested in several concerts.

Currently, new features are being added to the instrument. The main idea is to keep introducing new possibilities without affecting the technique already developed. Different mappings can be created and are welcome, but having one fixed mapping allows the performer to develop a better control of the instrument, being able to explore all its possibilities and nuances, like a traditional acoustic instrument. In fact, when one learns to play an instrument, he or she always starts with the basic techniques before moving to extended techniques. In this sense, the process of developing the hyper-kalimba, divided in stages, is closely related to learning an acoustic instrument, and it takes advantage of all the performer's existing skills.

8 REFERENCES

[1] R. Auzet, "Gesture-following devices for percussionists," in *Trends in Gestural Control of Music*, M. M. Wanderley and M. Battier, Eds. IRCAM, 2000.

[2] C. Cadoz and M. M. Wanderley, "Gesture-music," in *Trends in Gestural Control of Music*, M. Wanderley and M. Battier, Eds. Paris, France: IRCAM, 2000, pp. 71–94.

[3] M. Holdaway, *Kalimba Fundamentals*. Tucson: Kalimba Magic, 2005.

[4] ——, *Playing the Hugh Tracey Karimba*. Tucson: Kalimba Magic, 2006.

[5] F. Iazzetta, "Interação, Interfaces e Instrumentos em Música Eletroacústica," in *Proceedings of the II 'IHC - Interação Humano-Computador' Conference*. Campinas: Unicamp, 1998.

[6] M. Kimura, "Creative process and performance practice of interactive computer music: a performer's tale," *Organised Sound*, vol. 8, no. 3, pp. 289–296, December 2003.

[7] T. Machover, "Hyperinstruments - A Progress Report 1987 - 1991," Massachusetts Institut of Technology, Tech. Rep., 1992.

[8] E. R. Miranda and M. M. Wanderley, *New Digital Instruments: Control and Interaction Beyond the Keyboard*. Middleton, Wisconsin: A-R Publications, 2006.