Gesture control of musical processes - a MAX environment for the Lightning

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Abstract

This paper describes a software package developed in MAX, for using the gestures of a performer as control factors for music, via the Buchla's Lightning. The software not only tracks the *x* and *y* coordinates of each transmitter, but also calculates the direction, speed and acceleration of their movements in the whole space and relatively to each other. The program is very configurable, allowing to calibrate the data evaluation and to adjust the sampling rate of the values sent by the Lightning. These features have been applied to composition in two different approaches: as an interactive choreographic environment, and as a performing interface for musicians.

1. Introduction

A research project on interactive performance led to the development of software tools for control electronic sound via a gesture interface. The basic technological resource involved in this project was the Buchla's *Lightning* –a MIDI device that uses spatial movements of the performer to control musical instruments–. Objects written in MAX are used to process in real time the MIDI data sent out by the Lightning. The software also allows to control a synthesizer by triggering notes and by sending program changes and continuous controllers, in ways that link the gestures of the performer with the perceptive parameters of sound.

2. Development of the project and its constraints

The origin of this project were the problems posed by the composition of a piece that should interactively link the movements of T'ai-Chi Ch'uan with electronic sounds. The millenary practice of T'ai-Chi Ch'uan was developed by Taoist monks of China, as a way to harmonize man with the Universe. Their physical and respiratory exercises are intended to balance the energies of body, emotions and mind. As its teachers say, the form of T'ai Chi reproduces the circulation of energy in the Universe.

From the very beginning I envisaged that the hardware for the project should be easily transportable. That decided me to use a system composed by a Lightning, a Macintosh Powerbook running MAX, and a Yamaha TG77 synthesizer module.

The Lightning uses two infrared transmitters, which allow a sensor to detect their position and displacements: basically the horizontal and vertical position of each one, for a total of four independent coordinates. Ideally, my project should require five transmitters, for tracking independently the movements of hands, feet and trunk, but this is not possible with the present implementation of the device.

The built-in software of the Lightning is capable of computing velocity and acceleration of the transmitters, and of performing some elementary analysis of gesture (mainly rapid reversals of motion, "virtual strikes", and the depressing of the transmitters' buttons or a pedal). Despite this, I realized that the movements of T'ai Chi Ch'uan are very slow, and the performer would have no possibility of pressing buttons or foot switches on stage. As the stimuli recognition provided by the Lightning software doesn't fit the needs of my project, I decided to develop my own in MAX.

3. Objects for the lightning

The first objects developed were the ones that receive the output of the Lightning. By selecting preset 16 of the Lightning (called "Ears to MAX"), it is possible to get the *x* and *y* coordinates of each transmitter, as different MIDI continuous controller messages in channel 16. These objects are the only ones that are hardware

dependent, because I envisaged the possibility that in the future the piece could be adapted to another gesture device.

MAX proved to be a helpful tool at the first stages of the process, as a measurement instrument. By constructing objects that display the coordinates' changes of the transmitters and perform some basic calculations, it was possible to identify the most significant variables of the choreography for controlling sounds. Working with the performer, the data generated by displacements of hands and feet and their possible combinations were tested (two at a time). As a result, I decided to fix the transmitters in the forearm of the performer, feeding the computer with the data generated by the movements of the hands. I was particularly interested in using the *relative* movements of the hands as control factors, rather than the linear response provided by the Lightning (i. e. an individual transmitter entering a zone triggers certain output). This interest decided the further decisions.

4. Objects for the T'ai- Chi Ch'uan

Objects that combine the coordinates of the two transmitters, calculating their relative distance, were developed. An object called "differential" also gives their relative velocity and acceleration. This allows the computer to know not only if both hands are close together or far away, but also if they are approaching fast or maintaining their distance, for example. The comparison of the two "y" coordinates evaluates which of the hands is placed higher; combining the "x" coordinates the program knows if the performer has turned him or her back, or if his or her arms are crossed or not.

As the form of the T'ai Chi is a continuous displacement, knowing the absolute coordinates of the performer was also of the main interest. As it was discussed previously, the lack of a third transmitter for the trunk led me to the decision of calculating the absolute position of the performer as the middle point between the transmitters. Such a compromise is of course not very accurate, but proved to be a practical solution in performance. As it was done with the relative position of the transmitters, there are also objects that calculate the absolute velocity and acceleration of the performer (if he or she is moving slowly to left, or staying at a fixed point, for example).

The program can evaluate in which of the zones of the stage (left, center, right) is the performer. To avoid a continuous change of this evaluation when moving across the borders of the zones, a ratifying object was developed –for delaying the change till the performer has stayed at least two seconds in the same zone–.

All the magnitudes described (relative distance or velocity, absolute position, height of the hands, etc.) have three possible degrees when evaluated (close, separated, far away; approaching, maintaining distance, separating; left, center, right; down, middle height, up). An object called "calibrator" allows to change the limits of these evaluations, thus adjusting the sensibility of the program. Another object displays in real time all the evaluations, allowing to test the transmitters' movements and to monitor the functioning of the whole system.

For optimizing the computer performance, it was avoided to actualize the internal values of the program each time the Lightning sends a message (this would oblige the program to perform continuous calculations with no apparent effect in its sensitivity). By the contrary, the program samples the values sent by the Lightning at an adjustable rate, that can be set independently for position, velocity and acceleration. A sampling rate of four times per second proved to be effective to keep track of the low-speed motions of the T'ai Chi. Nevertheless, it is possible to modify the rates by means of the "calibrator".

As it was said before, all of these objects are portable and could be easily used with other gesture devices, since their input are integers in the range 0-127 (the data of the *x* and *y* coordinates of the transmitters).

5. The power of the invisible

After having designed the objects for capturing the spatial movements, it was the turn of the ones that perform musical actions. In my piece "The power of the invisible" the musical form is generated by a spatial environment: the stage is considered as a frame divided in nine zones (three horizontal and three vertical divisions, as explained above). Each zone has one or two virtual "instruments" assigned: when the performer enters a zone, it is activated and one instrument begins to trigger notes.

Different aspects of sounds are controlled by the spatial variables that the program recognizes. Pitches are controlled by the height of the hands; the loudness (MIDI note-on velocity) by the relative distance of the transmitters; the stereo panning by the horizontal displacements; the modulation wheel messages by the relative speed of the hands. The evaluation of vertical relative distance (i.e. left hand higher than the right one, or vice versa) results on switching between instruments, in the zones that have two instruments assigned.

A MIDI channel is assigned to each instrument. All of them have their own transposition of pitch and of note-on velocity, and their own duration of notes. A pitch filter makes possible to produce different scales on each instrument. These adjustments are changed throughout the piece, defining sections that correspond to the form of T'ai-Chi Ch'uan.

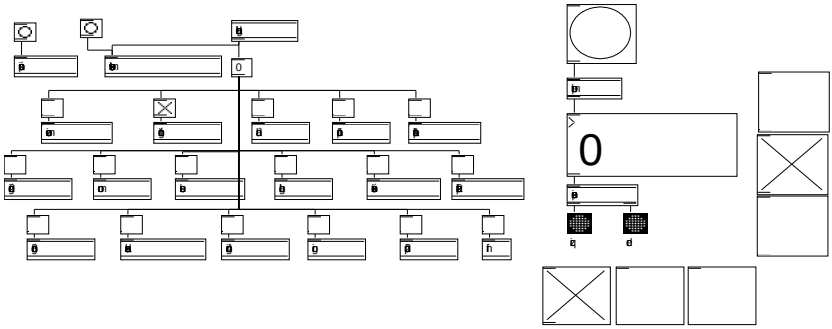

Figure 1 – Performing interface for “The power of the invisible”

These decisions were guided by the artistic goals that I was seeking. I was not designing an improvisational environment: the form of the T'ai-Chi is a fixed choreography. Furthermore, it has some gesture combinations that are repeated several times, at different places of the stage. I wanted to make these repetitions apparent to the audience: therefore an automatic response determined by the location of the transmitter was not suitable. For example, I programed a specific sound to be triggered only when a particular condition was achieved (when both hands are very far apart, that happens few times during the work).

The results are interesting in artistic terms, as the slow movements of the performer generate continuous nuances: when the distance between hands growths, the successive notes are triggered increasingly louder, producing a crescendo. Some of the instruments are sensitive to panning, so the displacements of the performer on the stage produce slight changes in the stereo image. In some of the sections, the relative motion of the hands can reinforce or release the tension of the sounds: by changing the instrument played when one hand goes higher than the other, or by increasing the modulation index in an FM instrument when they come very close.

The performance of the piece requires a computer operator, who changes the settings of the program for each section of the choreography. For this I developed a performance interface with on/off switches for the different sections of the piece, and that also shows the zone that is being activated by the performer, in a grid of three horizontal and three vertical divisions.

6. A PERFORMANCE INTERFACE FOR MUSICIANS

The second goal of the project was to develop an interface that could be used by a musician –not a dancer– as a performance tool.

I wanted this interface to be controlled by only one performer, without the help of an external operator. Moreover, I wanted it to be an instrument for playing, rather than a tool for conducting. Differently to the Mathews' conductor program for the radio-baton (Mathews, 1989) and to the conduct program of the Lightning (Buchla et al., 1991), in my approach there is no predefined score fed to the system: the notes to be triggered are defined in real time by the vertical position of the transmitters.

An expressive continuous pedal and a switch pedal were added to the system, providing additional control via MIDI continuous controller messages. Also a new performance interface was developed, taking into account that the performer should operate it directly. This user interface displays:

* The *x* and *y* coordinates of left and right wands, by means of vertical and horizontal sliders.

* Two leds showing if the respective wands are within the reception range of the Lightning.

* Two big toggles that appear checked when the button of the wand is pressed.

* A central slider displaying the position of the expression pedal.

* A big menu at the bottom showing the name of the section of the piece that is being performed.

* The menus immediately under the leds show the action mode that is set for each wand (as discussed lately).

Other features are the chronometer (for controlling the duration of each section), a "panic button" for killing hanged notes, a sequencer that allows to record and play back a performance, and the control of settings for left and right instruments.

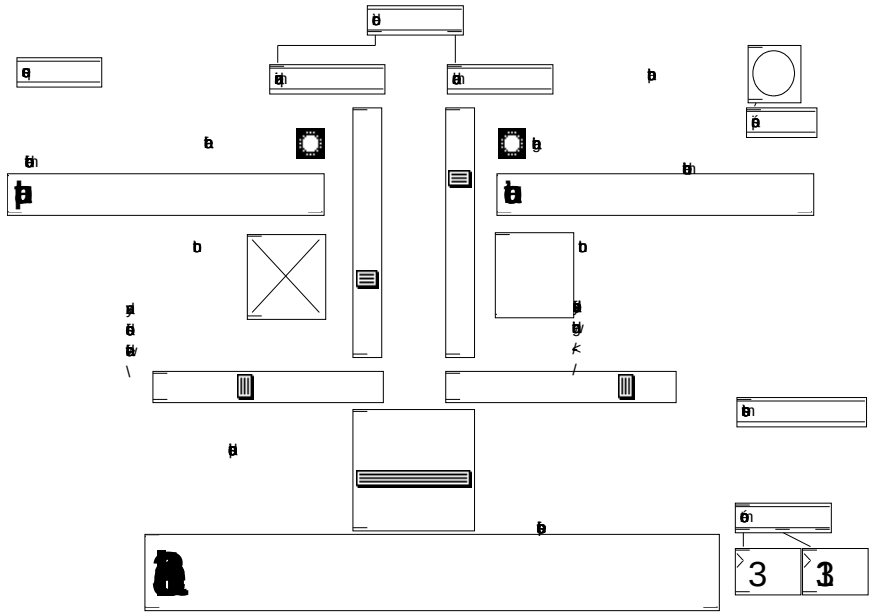

Figure 2 – Performing interface for “A mano alzada”

7. Action modes

Each wand has three possible action modes: punctual, continuous and combined control.

The two first modes allow each wand to perform a different instrument independently. The third uses both wands to control a single instrument. Their characteristics are as follows:

Punctual mode: the button of the wand triggers and holds notes. The height of the hand controls the note number (the lower the deeper). The *x* coordinate controls the MIDI velocity (the farther to the body the loudest). The vertical speed of each wand sends aftertouch messages, that affect the pitch bend of the TG77 sounds. By moving up and down the wands it is possible to get perceptible bend effects. The vertical acceleration sends control 6 messages (the faster the changes of speed the higher the value), that produce timbre changes in the sounds. Distance between hands sends control 1 messages, producing other kind of timbre changes. The position of the continuous pedal sends control 10 messages, thus changing the panning in the stereo output actually used by the sound.

Continuous mode: Notes are triggered automatically as long as this mode is selected. The rate of triggering and duration of the notes can be raised and lowered within certain range by moving up or down the wand while pressing its button. While the button is not pressed, the height of the wand controls the note number, as in the precedent mode. Aftertouch, control 1 and control 6 messages are also controlled in the same way as in the punctual mode. The *x* position of the wands sends control 10 messages (stereo panning). The position of the pedal controls the velocity of the notes.

Combined control: to use this mode it is necessary to cross one arm to the "opposite field" of the body. Two different instruments could be set, but only one can be played at a time (one with both arms to the left, the other with both arms to the right). As in the precedent mode, notes are triggered automatically, but only while the button of the main wand is pressed (the main wand is the correspondent to the side where the arms are: i. e. the one in the right hand if both arms are at the right). Releasing the button stops both the triggering and any held note.

The rate of triggering and duration, as before, can be raised and lowered, by moving up or down the *opposite* wand (the left one, in the example above) while pressing its button. As before, the height of the main wand controls the note number (the lower the deeper), the *x* coordinate controls the MIDI velocity (the farther to the body

the loudest), and the vertical acceleration of the main wand sends control 6 messages. The continuous pedal sends control 1 messages.

8. A MANO ALZADA

This software was used in the performance of my piece "A mano alzada" ("with the raised hand", but also "in a rough way", in Spanish). The switch pedal was used for moving across the different sections of the piece, changing the settings of the system (action mode of each wand, scale used for filtering the MIDI notes, repetitions allowed for each note, note transposition, velocity transposition, duration of the notes, MIDI channel, and rates for the random triggering of notes).

In this work I also took advantage of the two stereo outputs of the TG77 synthesizer, using one with the dry sounds and the other with reverberation, defining different reverb times for left and right channels. So, it was possible to change the ambient effect and the perceived location of the source, using the panning control.

9. CONCLUSIONS

* The tools developed in MAX proved to be useful for achieving artistic goals, avoiding predictable or lineal responses, thus widening the expressive possibilities of performers.

* The user interfaces allow a fluent control of the musical processes, both in rehearsal and performance.

* The software described is not related to a particular piece or aesthetics. As it is mostly composed of configurable objects, not hardware- dependent, it could be easily adapted by other composers, even for the use with other gesture control devices.

* The development of this project made evident the need and importance of further research on hardware devices, that could easily fulfill the expressive needs discussed above.

10. Acknowledgments

The piece “El poder de lo invisible” was commissioned by the Music and Technology Foundation, and premiered in Buenos Aires in November 1996.

I want to thank Felicia Tracogna, the performer of T'ai Chi Ch'uan and my teacher in these disciplines for many years. Without her enthusiasm and commitment this project could never be accomplished.

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