"THE FINGERS" – A TRIBUTE TO "THE HANDS"

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ABSTRACT

This paper describes an expressive interface called "The Fingers" currently in development by the author, which derives its underlying interaction design concept from "The Hands". The Hands was one of the first musical interfaces that was designed in an alternative form, as compared to the typical music industry approach of "copying" or simulating traditional instruments such as keyboards, guitars, etc. The development process of The Fingers is described herein, as the reader may find it useful to apply similar approaches when developing their own expressive interfaces. The development process utilized may best be described as "rapid-prototyping on a budget".

1. INTRODUCTION

The late Michel Waisvisz invented, refined, and mastered his performance techniques with The Hands [1], an expressive musical performance interface developed at STEIM, the Studio for Electro-Instrumental Music in 1984 (see figure 2). Michel performed for the first time with an early version of The Hands in the Amsterdam Concertgebouw in June of that year. In recognition of his great achievements and conceptual contributions to the field of interactive music performance, The Fingers retains and enhances many of the interaction methodologies used in The Hands, attempting to preserve and extend the legacy of this genre of music performance.

2. RELATED WORK

A basic problem with any custom-built musical instrument is scarcity. For musicians to adopt, develop mappings, techniques, and performance practices with an interface, it must be available to purchase or acquire through relatively simple means. The effect of this can easily be seen when looking at the number of musicians who have adopted game controllers and other commonly available interaction devices for performance use. The Fingers is no exception to this rule – it makes use of the Nintento Wii controller as shown in figure 1. Many other musical interfaces have used the Wiimote for input to control audio synthesis or effects processing; in fact, such interfaces are so numerous that it would be onerous to list them here. Some of the more notable related interfaces include the example of controlling the Symbolic Sound Kyma-X [2] with a Wiimote through a software package called OSCulator [3], and Alex Nowitz's performances with two unmodified Wiimotes [4]. The performance techniques used by Nowitz use various mappings and live sampling methods in the software packages LiSa and JunXion – both produced by STEIM – some of the same software used by more recent versions of The Hands.

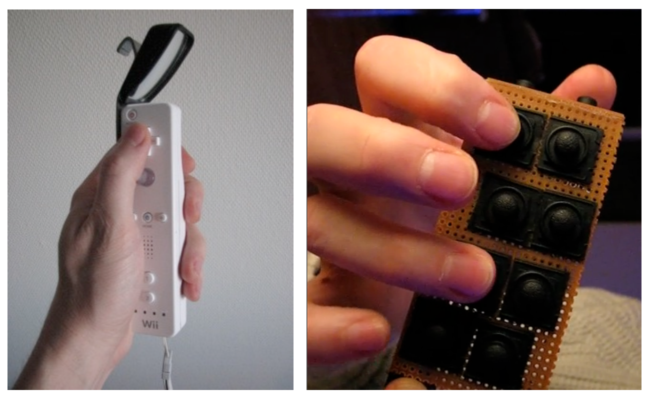

Figure 1. The Fingers: a performer uses the Nintendo Wiimote with a periscope-style mirror in their left hand, while the right hand uses a custom CREATE USB Interface (CUI)-based expression controller.

Figure 2. The Hands: image copyright Michel Waisvisz, 2005, as built by Jorgen Brinkman at STEIM, Amsterdam.

3. ANATOMY OF THE FINGERS

The Fingers is an expressive interface that makes use of the Wiimote, but also incorporates more expressive elements through the development of a custom input device based on the CREATE USB Interface (CUI) [5]. While the Wiimote is available worldwide, the amount of expressiveness it is capable of single-handedly leaves much to be desired. Alex Nowitz's approach of using two Wiimotes clearly improves this a bit, but still leaves room for improvement. Also, many musical interaction techniques with the Wiimote only use a portion of its expressive capabilities, e.g. they use the accelerometer but not the IR-camera in the Wiimote, or vice versa. The Fingers uses the full expressivity of the Wiimote in conjunction with the custom CUI interface, which focuses tightly on the precision fingertip-level sensitivity to micro-touch that humans are capable of mastering.

3.1. Fingertip Design Considerations

Human fingers are – just after our tongues – the most actively sensitive parts of our bodies [6]. Therefore, some of the most expressive music performances have always been (and presumably will continue to be) performed with our fingers. However, the common electronics design of pushbutton interfaces offers nothing to the fingertips other than simple on/off states, which is therefore "boring" and quite inexpressive. This unfortunately includes the buttons on the Wiimote, as they do not register the amount of pressure being applied to them.

This is the primary reason why a custom interface was developed for use with The Fingers. The CUI-based interface makes use of extremely responsive pressure sensors called MicroNav(s), made by Interlink Electronics [7]. There are ten MicroNav sensors used in The Fingers (figure 3), each of which has four miniature pressure sensors situated underneath a single finger's touch point, laid out in the four compass directions. Given that a fingertip is larger than the area taken up by all four of the miniature pressure sensors contained within each MicroNav, it is impossible for a user to activate only one of them. In essence, the MicroNav sensors provide a 3D-joystick interaction modality, wherein the X and Y-axes can be determined through the pressure differentials between the West/East and North/South sensors respectively, and the Z axis is found through the average of all four cardinal directions (figure 4).

The data from these MicroNav sensors is captured with 12-bit accuracy, since the latest version of the CUI has a high resolution ADC built in. Currently the connectivity is through USB, which allows extremely low latency (less than 2 ms) using a custom communication protocol. Sensor input is updated at a rate of up to 1000Hz. This allows for extremely expressive control over sound synthesis algorithms, at a level offered by very few other interfaces.

One exception to this rule is Serge de Laubier's *Meta-instrument 3,* which uses similar sensor configurations under each fingertip. The Meta-instrument does not use the MicroNav sensor, instead it has custom keys comprised of four small elements with the fingers placed at the intersections of these sensing groups; in this way, each finger can act simultaneously on four sensors, which together capture the longitudinal and lateral movements of the finger's pulp [8]. Both the Meta-instrument and The Fingers utilize passive haptics to allow the fingertip to sense small motions accurately.

While the Meta-instrument transmits its sensor data to a computer running Max/MSP/Jitter via 802.11 (wireless Ethernet), The Fingers will use Bluetooth wireless data transfer to enable un-tethered performance with a future firmware update (the Bluetooth hardware is already built-in). This will however be approached with caution, since any loss of expressivity due to slower update rates and bandwidth limitations may halt the use of Bluetooth.

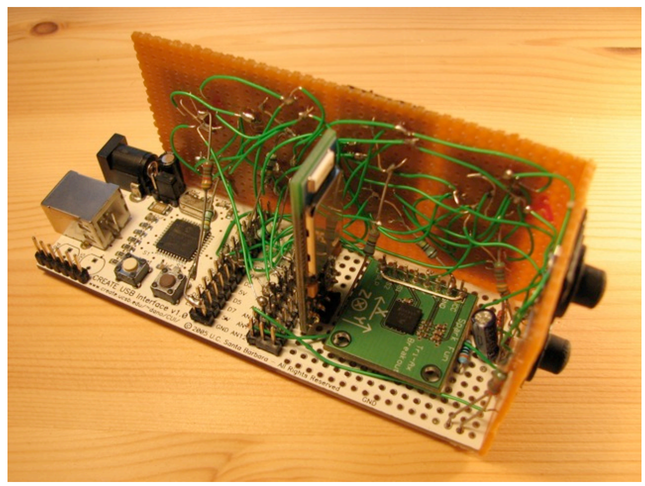

Figure 3. The completed electronics for the right-hand component of The Fingers.

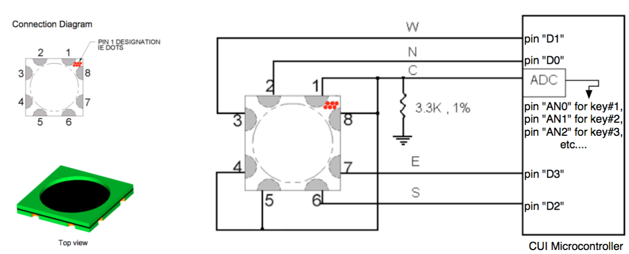

Figure 4. The basic schematic for the MicroNav sensors used in The Fingers.

3.2. Interaction Design for The Fingers

The primary reason for using a periscopic mirror attached to the top of the Wiimote is to allow relative location / distance / orientation sensing between the two halves of The Fingers using the Wiimote's internal camera. The particular mirror used is marketed as a "blind-spot" aid for drivers, and as such the manufacturer sells them in car-parts stores. The mirror features a convex design, which in this application provides an extended active area in which the two parts of The Fingers can "see" each other when held in the natural positions in front of the body, in the same way as The Hands.

The original technology used to sense the distance between the left and right halves of The Hands is time-of-flight measurement of ultrasonic pulses. This is changed in The Fingers, wherein the right-hand controller has 2 InfraRed (IR) LEDs mounted on it facing in the direction of the mirror on the Wiimote held in the left hand. Relative x/y/z location of the hands can then be determined (distance is derived from the length of a line drawn between the 2 tracked IR sources), as can the "pitch" rotation between them; the non-linear mapping due to the convex mirror may be corrected in software, or possibly "learned" by the human performer directly.

Another option would be to use 4 IR LEDs instead of just 2 (the Wiimote can track up to 4 IR sources), mounting them in a unique configuration such as the one developed by Oliver Kreylos [9] that allows for the determination of more than just a single "pitch" axis of relative orientation, to include relative roll and yaw. This would provide full relative tracking in six degrees of freedom (6-DOF, 3D position and 3D orientation), giving higher precision to the interaction; the upcoming availability of the "MotionPlus" add-on to the Wiimote may also help in this regard. However, even the basic method of optically tracking only 2 LEDs increases the amount of information that was available from the original ultrasonic sensors in The Hands (which just measured distance between the two halves).

Figure 5. Polymorph (Polycaprolactone) material, also known as "Shapelock" or "Friendly Plastic", will be used to sculpt the shape of the right-hand controller around the completed electronics for The Fingers.

Relative measurements of acceleration can also be compared between the internal 3-axis accelerometer in the Wiimote, and the 3-axis accelerometer which is mounted in the CUI-based controller. With a low-pass filter, this provides similar measures to those acquired through the above IR LED based techniques, but the instantaneous values of the accelerometers can also be used for other real-time interactions such as the gestural recognition of virtual drum hits and direct control of synthesis parameters like filter cut-off frequencies, etc. Given that the more expressive fingertip interactions are available on the right-hand controller, the buttons on the Wiimote held in the left hand will usually be relegated to modal mappings, such as the selection of different scales or sound-sets.

In the first trial mappings, a simple subtractive synthesis technique in Max/MSP/Jitter is implemented using only the right hand CUI-based half of The Fingers. The basic synthesis method is able to alter the pitch, amplitude and cut-off frequency of a low-pass filter for each note, corresponding to one of the MicroNav sensors. Mapping the X-axis of each MicroNav to pitch provides control of vibrato, while mapping the Y-axis to a filter cut-off frequency gives a swell-type effect. The Z-axis of each fingertip is simultaneously mapped to 2 elements of the sound in this simple scheme – both the amplitude and the Q-factor (resonance) of the low-pass filter. The overall expressivity of this initial mapping is shown in a 2-minute (28MB) video posted at the following website:
http://www.vrmedialab.dk/~dano/TheFingers04.mp4

The "final touches" to the hardware of The Fingers will address physical aspects such as ergonomics, durability, and practicality. The Polymorph material shown in figure 5 may be used to create the "enclosure" for the CUI-based right hand controller, or the model shown in figure 6 may be constructed using rapid-prototyping techniques. The polymorph material comes as small beads that are placed in hot water to become a solid lump of material, which can then be overlaid onto the electronics boards, and shaped to match the right hand by simply squeezing it into the proper form. Before this manual molding process (sort of a "poor man's 3-D printer"), small tubes would need to be placed around each of the MicroNav sensors, such that the tops of each of the 3D-joysticks end up slightly below the surface of the polymorph.

The form shown in figure 6 requires less craftsmanship to physically produce, as much of the work can be automated by laser cutting, 3-D printing, or CNC-milling. In any case, the final form will be sculpted part way around the back of the hand with an adjustable strap system, such that the The Fingers can be played without requiring any of the user's fingers to support the instrument once it is in playing position. This is a trait it has in common with The Hands – as they also allows full freedom of motion for the fingers while playing.

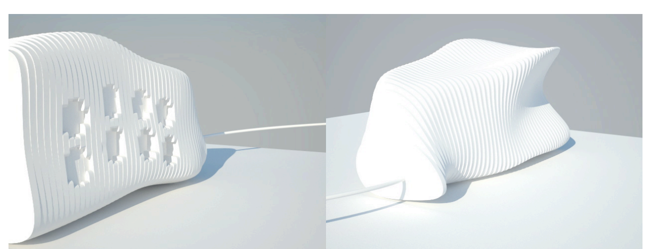

Figure 6. Two renderings of an ergonomic grip for The Fingers, industrial design by Esben Poulsen. This form can be laser cut, 3-D printed, or CNC-milled to provide an ergonomic grip for The Fingers when finished.

4. CONCLUSION

The Fingers is an expressive interface for musical performance – inspired by The Hands – that attempts to make the most of the Wiimote game controller due to its common availability. The interface is currently finishing the first iteration of its development process, and the combination of the Wiimote with more expressive fingertip-sensing capabilities provided through the use of the CREATE USB Interface and MicroNav sensors allows for valuable contributions to the field. The (open source) design presented already shows potential, and hopefully will inspire other people to approach the development of new instruments in a similar manner.

The author looks forward to exploring its live musical usage, the evolution of further mappings to combine its affordances effectively with the Wiimote, and the development of an opening repertoire for the interface. Imagination will likely be a key part of creating convincing musical performances with The Fingers, so the fun is just beginning, and the possibilities are wide open.

5. ACKNOWLEDGEMENTS

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