The Embroidered Musical Ball: A Squeezable Instrument for Expressive Performance

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ABSTRACT
In this paper, we describe the Embroidered Musical Ball, a soft, tactile computer/MIDI musical instrument, that lets untrained children, novices and/or professionals perform and manipulate expressive and detailed music with simple everyday physical hand gestures such as squeezing and stretching. Our new embroidered pressure sensors replace the hard, bulky and awkward continuous control sensors common in most computer instruments, i.e., sliders, knobs and buttons. The combination of this light and easily physically manipulated instrument with a new, *immersive* approach to musical software allows players to expressively explore music with an immediacy not experienced in traditional instruments, which emphasize years of training to learn the precise control of pitches, timing, levels and various expression instructions. Instead, the musical ball lets players manipulate and explore a complete musical composition that has been mapped to different embroidered sensors. This allows players to immediately squeeze and mold the ball to perform the pre-composed music in an expressive manner.

Keywords
Musical instruments, wearable computing, physical interface design, pressure sensors, industrial design

INTRODUCTION
Traditional musical instruments require years of practice to master the music theory and physical performance skills necessary to create and explore expressive and detailed music. Computer/electronic instruments often maintain the same difficult learning curve. Many computer/electronic instruments are physically difficult to manipulate because of their bulky and awkward continuous sensors, i.e., keyboards, sliders and knobs [1]. Software music tools and instruments often require players and performers to have much of the same knowledge of music theory required by acoustic instruments. The Embroidered Musical Ball was created to allow untrained children, novices (and/or professionals) to perform and manipulate artistic music with simple everyday physical hand gestures such as squeezing and stretching.

Figure 1, Embroidered Musical Balls

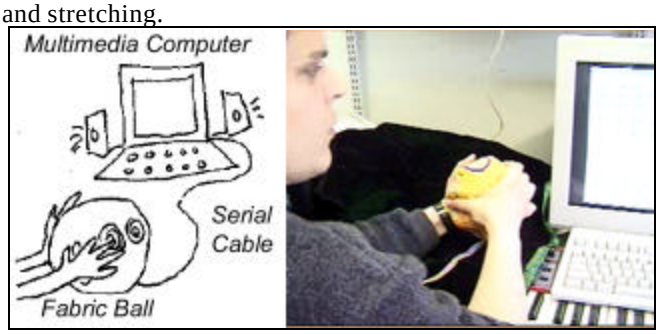

Figure 2, The Musical System

The System
The Embroidered Musical Ball system consists of a stuffed fabric ball embroidered with eight continuous pressure sensors sewn from conductive thread and a multimedia desktop computer, which takes in the sensor data from the ball and creates music. The ball contains a microprocessor, which measures the embroidered sensors capacitively and sends serial data through a wire to the desktop computer. This computer interprets the data and generates MIDI commands, which can control either an internal sound card or an external MIDI device.

MUSICAL IMMEDIACY

The Embroidered Musical Ball allows players to immediately and expressively explore music in two ways:

1) The ball uses embroidered fabric sensors to measure continuous pressure and replace the sliders and knobs of current electronic musical instruments. These sensors are made from sewn conductive thread which is measured capcitively. Such sensors are pliable and easily shaped, allowing designers to create computer instruments that can be any size, shape, weight, with any sensor configuration. In our prototype example, the sensors are sewn in a circle around a soft hand held ball. Simply holding the ball in two hands and squeezing lets a player immediately control eight channels of continuous pressure sensing. Squeezing a single ball is far more immediate and simultaneous than turning and pushing similar individual physical knobs and sliders. GUIs, or software versions of such instruments, require players to use a mouse, which can only control one sensor at a time. The soft, tactile and visually stimulating fabric material of the ball also encourages players to touch and explore it physically.

2) The ball's musical software implements an immersive approach [2], which presents the players with pre-composed music that they can manipulate and explore. Traditional musical approaches encourage players to construct various kinds of musical building blocks, (such as pitches, timing, levels, phrases, expression instruction etc.) into a complete musical composition. Although such constructive musical experiences can be valuable for learning as well as for composing and performing music, they are rarely designed to elevate the player towards an immersive musical experience, which is based on the notion that the musical whole cannot always be perceived as the sum of its components. Constructive experiences for novices and children may block expressivity and fun in playing a musical instrument due to physical and cognitive barriers, which they impose. By allowing novices to explore musical concepts such as rephrasing a melodic line, manipulating the timbre of a solo instrument, fading voices in and out etc., we can provide them with a meaningful and immediate musical experience that cannot be otherwise achieved at such a preliminary stage.

IMPLEMANTATION

Physical Design and Sensing

The sensors in the fabric ball were designed to give designers a new plastically controllable physical material for creating digital musical instruments that can sense multiple channels of continuous data. Commercial sensors have size, mechanical and manufacturing requirements that are incredibly limiting. They usually must lie flat on a rigid surface and be connected with stiff wires [3, 4]. In contrast, textiles and thread can be easily be shaped, cut and formed into an object of any shape or size. Textile sensors possess these same properties. The capacitive sensing method used in the embroidered musical ball builds on sensing method developed in the Musical Jacket [5]. The embroidered sensors are high impedance electrodes whose change in capacitance is measure in the time domain on a programmable microprocessor, PIC 16F84. The PIC measures the change capacitance on the electrodes and send that data serially to a desktop computer.

The Musical Application

In our prototype application, an eight-track composition was composed by author Gili Weinberg and imported into a Max [5] patch. Five of the musical tracks were assigned to timbre manipulation operators such as frequency modulation, filters, resonance and low frequency oscillators. Squeezing the respective electrodes could then generate a dynamic "soundscape" by continuously changing the "color", i.e., timbre, of the otherwise static musical texture. The other three musical tracks were mapped to the level and melody contour of three solo instruments (a piano, a flute and a glockenspiel.) Players could rearrange the structure of the piece and create versatile counterpoint combinations among these instruments by squeezing the appropriate electrodes. This architecture also allows professional musicians to import their musical MIDI file into the Max patch and assign different sensors to their prerecorded musical tracks. By expressively squeezing the musical ball they can then control and manipulate the music in a performance situation, adding a dynamic "live" sensation to their electronic sound.

SUMMARY AND FUTURE WORK

We believe that allowing novice and professional players to experiment with the Embroidered Musical Ball can lead to a better introduction and conceptualize of musical notion like timbre, pitch, contour, polyphony, structure etc. The use of textiles a material for creating such instruments allows the rapid and experimental prototyping of instruments with many physical designs and configurations. Such textile sensor objects also suggest new ways to create many different types of physical computing objects.

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REFERENCES

1. Chadabe, J. *Electric Sound* pp. 213-240 New-Jersey: Prentice Hall, 1997
2. Weinberg G., "The Musical Playpen: An Immersive Digital Musical Instrument" *Personal Technology – Computers and Fun* issue 1999
3. Marrin, T. *Toward and Understanding of Musical Gesture:* S.M. Thesis for MIT Media Laboratory, Cambridge, MA, 1996.
4. Paradiso. J, "Electronic Music Interfaces: New Ways to Play," *IEEE Spectrum Magazine,* Vol. 34, No. 12, pp. 18-30 Dec., 1997
5. Orth, M, *Fabric Computing Interfaces,* Proceedings of ACM CHI '98, Los Angeles, ACM, April 1998.
6. Opcode's Max MIDI programming language. Available at http://www.opcode.com/products/max/