THE STRINGBALL: A BALL INTERFACE WITH STRINGS FOR COLLABORATIVE PERFORMANCE

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ABSTRACT

This paper introduces *StringBall*, a ball-shaped controller with strings for gesture sonification and music performance. The device is embedded in a plastic toy ball, with a pair of ropes penetrating itself through the center. Players can control the motion of the ball by applying various gestures to the strings. A 3-dimensional sensor with a Bluetooth module seated inside the ball transmits acceleration/tilt measurement data wirelessly to a computer for sound synthesis and music control. In our description of this work we cover the design concept and implementation of StringBall, and highlight its potential for collaborative performances [1] .

1. INTRODUCTION

StringBall is a ball interface for sound control and motion sonification, designed with the possibility of collaborative performance in mind. It is a volleyball-size hollow plastic ball with a pair of ropes passing through the center of the ball. By handling these “strings”, players can cause certain ball movements that can be translated into audio information. Inside the ball is a circuit board containing a 3-dimensional accelerometer/tilt sensor and a Bluetooth transmitter, which detects the motion of the ball and sends out the measurement data to a computer. Data is then processed by Max/MSP for creating or shaping music and sound.

1.1. Related Work

Sound controlled by gestures has been of interest for musicians and electronics experimenters since the theremin. With the development of motion- and gesture-tracking systems, numerous composers have explored human movement as a means of creating or processing musical sound.

In this paper we pay special attention to ball-handling gestures. A ball is among the simplest, and most ubiquitous and familiar recreational devices. It has been used for millennia and across virtually all cultures in a wide variety of games and sports, mostly with collaborative nature.

Although relatively rare, several works have incorporated ball-shaped interfaces for creating music. Examples include the *StressBall* [7] by Heidema et. al., a rubber ball that contains an accelerometer inside and force sensors underneath its surface, thereby taking squeezing and shaking gestures as its control inputs. Sensor data from the StressBall is transmitted to a computer over a wired connection.

In [5], Hermann et. al. presented the *Audio-Haptic Ball*. This device consists of various sensors (i.e., force sensor, accelerometer, piezo sensor) and buttons/switches as well to provide higher dimension of control. In addition, it contains an actuator to generate haptic feedback. All these parts are integrated in a ball-shaped housing which fits into a human hand. Nevertheless, like StressBall, it is wired to a data processor, and therefore fails to give the freedom of motion.

Wireless technology has eliminated one of the main barriers in developing useful ball interfaces. The *MIDI Ball* [2] by the band *D'Cuckoo* is a giant, wireless, helium-inflated sphere that can be bounced around like a beachball. The ball is outfitted with touch sensors and a radio transmitter: each touch triggers Musical Instrument Digital Interface (MIDI) messages to play sampled sounds or visuals. The *Muggle* [8] is an RF-based handheld controller incorporating accelerometers and LEDs (for visual feedback) housed in a translucent plastic ball. Being wireless, the Muggle offers much more freedom of control. However, its fragile translucent housing prevents it from being handleable as an ordinary ball for sonification of various ball movements. In addition, an extra RF receiver is required for a computer to communicate with it.

Prior work on the use of Bluetooth in wireless control includes the *Bluetooth Beatbug* [1], a wireless electronic percussion controller for capturing and manipulating struck rhythm patterns. Bowen's *Soundstone* [3] is another Bluetooth-based wireless 3-dimensional acceleration sensor with visual and haptic feedback features.

In [11], Yeo presented *the Bluetooth Radio Ball Interface (BRBI)*. It is embedded in a palm sized foam ball containing a 3-dimensional acceleration/tilt sensor with a Bluetooth transmission module - the same circuit that we

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use for StringBall. Sensor measurement data of BRBI is transmitted to a computer, and then converted into Open Sound Control (OSC) messages for use with various applications.

1.2. Features of StringBall

Compared with the aforementioned existing works, the following can be proposed as distinct features of this research:

- Unlike other ball-shaped controllers, StringBall is controlled in an "indirect" way - by handling a pair of ropes that penetrate its center: players can move the ball by applying various gestures to the ropes. This indirectness makes itself moderately challenging, while still being easy and enjoyable, to play.
- StringBall is designed with collaboration between multiple players in mind. Since there are four endpoints of the ropes, up to four players can perform together with one StringBall. However, at the same time, the interface is still playable by only one person.
- Although StringBall is tethered by ropes, its data sensing/collecting mechanism is based on a totally wireless framework. This offers maximum freedom of controlling ball movements.

2. IMPLEMENTATION

The data flow for StringBall and its supporting system is illustrated in figure 1. 3-dimensional tilt/acceleration measurement data is received by W_2O - a Mac OS X-based data processor [10] for use with the Wireless Accelerometer/Tilt Controller. This processor then decodes and transmits the data as OSC messages to any compatible application: connection can be made within the same machine, or to a different computer on either LAN or WAN. Alternatively, measurement data could be directly transmitted to Max/MSP via serial connection.

2.1. Ball

Figure 2 shows a picture of StringBall: its components and their construction are illustrated in figure 3. A pair of ropes penetrate a hollow plastic ball - about 12 inches in diameter - through two open holes. Inside the ball is a short piece of rail with small casters: this holds the ropes in position and keeps them from being tangled, while ensuring smooth movements of the ball at the same time.

The sensor circuit board is attached to this rail. Together with the battery pack, it provides a proper amount of weight for optimal playability. Depending on the players' preference, however, more objects can be attached here to increase its weight.

A piece of the ball surface can be open as a lid, making the inside components easily accessible.

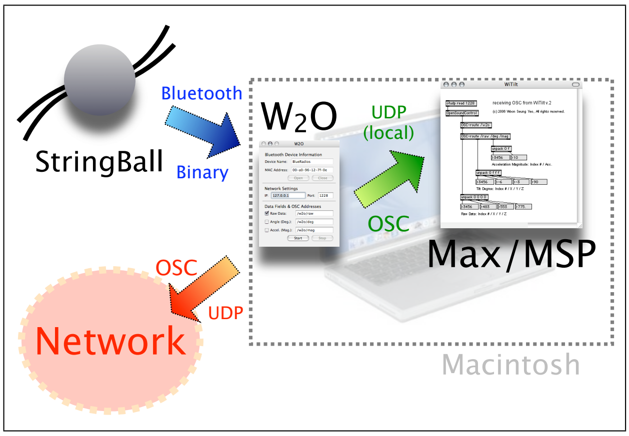


Figure 1. Signal flow of the StringBall system, with W_2O and a Macintosh computer.

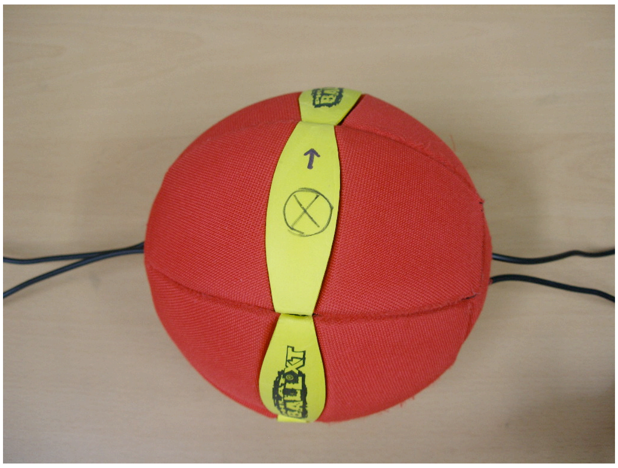


Figure 2. A picture of StringBall.

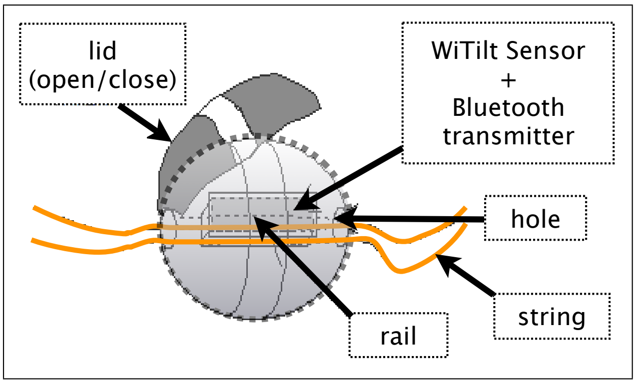


Figure 3. Components of StringBall, including ropes, rail piece, sensor/transmitter, and surface lid.

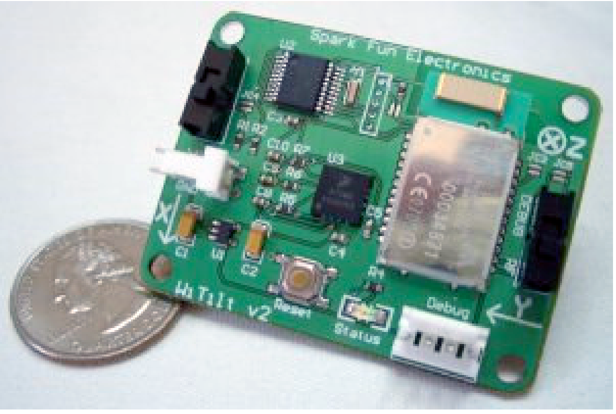


Figure 4. Wireless Accelerometer/Tilt Controller (version 2.0) by Sparkfun Electronics.

Figure 5. A picture of StringBall performance by two players.

2.2. Sensor

We use a *Wireless Accelerometer/Tilt Controller (version 2)* [6] (figure 4) to measure ball movements. This device contains an MMA7260Q - a 3-axis, low-g accelerometer [4], and a class I Bluetooth module, on a single PCB board. In addition, it offers a built-in command line configuration utility that allows easy setup of sensor parameters.

2.3. Data Processor: W_2O

Binary data transmitted from the sensor is processed by W_2O. More specifically, W_2O consists of a Bluetooth data server, a binary-to-OSC data converter, and an OSC client.

Compared with the direct transmission of binary data to Max/MSP, W_2O offers the following advantages:

- W_2O converts raw measurement values from 10-bit ADC (0∼1023) output into more user-friendly values, such as tilt angles (-90∼90 degrees) and ratio of acceleration magnitude to the acceleration of gravity (per cent).

- Moreover, the output is formatted as OSC messages with customizable target information and OSC address, and therefore can be utilized by any OSC supporting applications such as Max/MSP and Pd.

3. GESTURE MAPPINGS

StringBall is designed with playability and flexibility in mind. Its simple control mechanism allows for intuitive gesture mappings to sound: most players can learn and understand the rules without any steep learning curve. Furthermore, various rope-handling gestures can be mapped to the motion of the ball.

Meanwhile, it should also be emphasized that StringBall is played in an “indirect” manner: players move the ball not by holding it, but by applying gestures to the ropes. This adds a moderate level of randomness to its controllability, and helps the players to create interesting sounds.

In this section we showcase some gesture mappings of StringBall that has been used for actual performance.

3.1. Collaborative performance

Stringball is primarily intended to be played by two performers. A picture of actual performance is shown in figure 5: both players stand against each other, pull the endpoints of the ropes to make them straight, and then apply gestures to move the ball. They should cooperate with each other to control the ball movements as precisely as possible. A video clip of this performance is available online at [9].

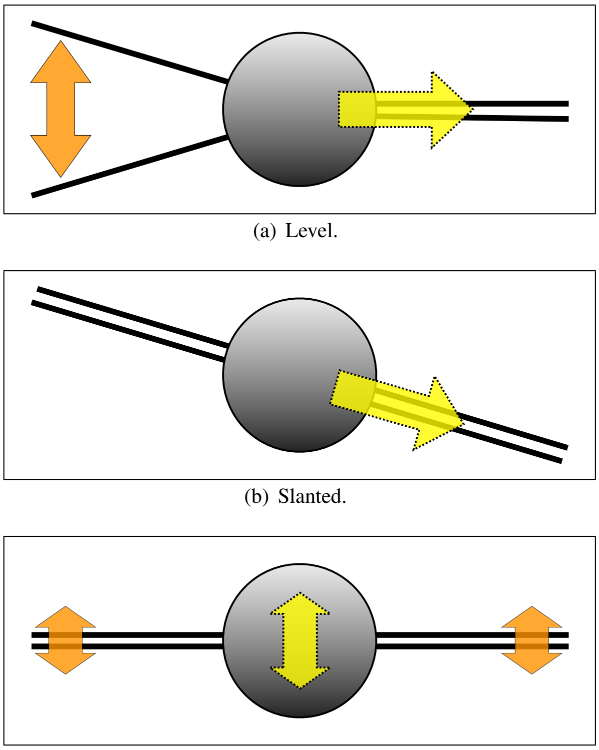
Figure 6 illustates some examples of the most musically useful ball movements in duo performance, as described below.

- By stretching the arms wide, one player can send the ball away to the other side (figure 6(a)). The ball then can be moved back to the original side by the same action of the other player. Repeating these actions causes the ball to move back and forth between the players. This results in high linear acceleration with little tilt angle variation.

- Lifting up the ropes on one side makes the ball slide down to the other end (figure 6(b)). Compared to the “active” motion above, this gesture leads to different variation pattern in the acceleration magnitude and introduces more tilt angle values.

- Vertical vibrations can occur when players shake the ropes up and down (figure 6(c)). Depending on the handling gestures and the mapping used, this could generate complex ball movements and produce virtually chaotic sound.

The acceleration magnitude and tilt angle values for three axes can be mapped to sound/music parameters in a number of ways. As one of the simplest examples, acceleration may be used to control the amplitude/pitch of



(a) Level.

(b) Slanted.

(c) Vertical vibration.

Figure 6. Examples of ball movements in two-player performance.

an oscillator, with tilt angles changing the amount of its vibrato and/or tremolo.

3.2. Solo performance

Although it was originally designed to be an interface for multiple players, StringBall can be played by only one person, too. For example, the performer may hold the endpoints of the ropes and swing the ball like a pendulum, or make rapid spins by twisting the ropes.

3.3. Performance *without* strings: a *StringLessBall*

StringBall can also be used without any ropes: player(s) can hold the ball itself and apply gestures such as rotation, shake, spin, roll, etc[2]. Since this becomes almost identical to the Bluetooth Radio Ball Interface, we refer the reader to [11] for more information on this case.

Although simple in structure, StringBall is a highly flexible controller and offers various playing options.

4. CONCLUSION

StringBall is a ball-shaped interface for collaborative performance. Its motion control mechanism - moving the ball by handling ropes - makes it a unique instrument with a huge potential as a music toy. Powered by W_2O, it provides a convenient and flexible method for sound control by gestures and ball movements.

In addition to more enhanced and robust physical implementation, future work will include tests and experiments with various gesture and sonification mappings. A particular focus will be set on the creation of musically meaningful sound from simple gestures, especially of non-musicians or children, to present StringBall as *an instrument for everyone*.

[2] Performance of some of these gestures has also been filmed in [9].

5. REFERENCES

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