AoBachi: A New Interface for Japanese Drumming

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ABSTRACT
We present a prototype of a new musical interface for Japanese drumming techniques and styles. Our design used in the Aobachi drumming sticks provides 5 gesture parameters (3 axes of acceleration, and 2 axes of angular velocity) for each of the two sticks and transmits this data wirelessly using Bluetooth® technology. This system utilizes minimal hardware embedded in the two drumming sticks, allowing for gesture tracking of drum strokes by an interface of traditional form, appearance, and feel. Aobachi is portable, versatile, and robust, and may be used for a variety of musical applications, as well as analytical studies.

Keywords
Taiko, Japanese drum, drum stick, Bluetooth®, wireless

1. INTRODUCTION
This paper presents a prototype for a new music controller for drumming applications, inspired by and intended for Japanese drumming technique and performance. The interface itself is a pair of drum sticks of typical size for odaiko drum playing, enhanced with the ability to track gesture parameters.

This work presents the interesting challenge of assembling the hardware in a manner that will ensure its survival as the interface undergoes the extreme demands of taiko performance styles.

Below we discuss the inspiration and motivation behind the development of this controller, the design and implementation, future plans, and several possible applications for which Aobachi would be well-suited.

2. TAIKO BACKGROUND
The inspiration for this work is the family of Japanese drums known as taiko. Taiko includes one of the largest drums in the world, called odaiko, which is a large barrel-shaped double-headed drum. These drums are usually placed horizontally on a stand so that two players can play on each side standing up. A typical Odaiko drum measures about 2-4 feet diameter and 3-4 feet deep.

These large drums are struck with a large pair of wooden sticks called "bachi," whose dimensions are approximately 1.5 inch in diameter and 20 inch in length. The interface detailed in this paper, Aobachi, is modeled after this type of playing sticks.

The role the sticks have in the sound production makes the relationship between the player and their sticks very special, as they are the interface to their instrument. In fact, the sticks may seem to be both extensions of the player's body as well as part of the instrument itself. Interestingly, taiko musicians often spend considerable time choosing and caring for their playing sticks.

Through their bachi, drummers receive critical physical/tactile feedback as the sticks rebound off the drum head. In the case of the horizontal odaiko, this behavior is pronounced. Also, the massive sound of such a large drum is felt as well as heard.

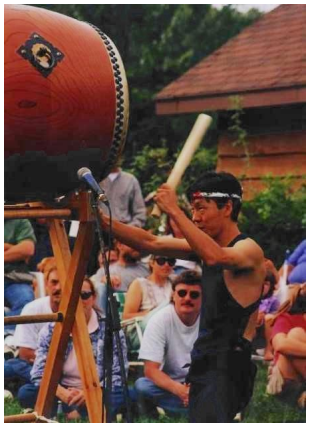

Figure 1. Ignatius Kim, of Arashi Daiko (Montreal, Quebec).

3. RELATED WORK
There are many electronic music interfaces based on or inspired by drums. Drumming techniques may be divided into two main types, those in which the hands of the drummer are used to strike the drum head directly and those in which an implement, such as a wooden stick, is used to strike. In the following survey, we consider projects that are defined mainly by the design of new drumming surfaces and those that rely on new kinds of playing sticks.

3.1 Drumming Surfaces
In addition to the many commercial drum pads sold for studio use, there are have been new drum interfaces that have focused on adding new functionalities to the head, or skin of a percussion instrument.

The Marimba Lumina [6], a MIDI controller, is a sophisticated variation on the traditional marimba. The playing surface of this interface is composed of trigger pads and strips and electronic bars, which are controlled by special foam covered mallets.

The Beatbugs [15] are networked percussion instruments, with a toy-like appearance and feel, that allow a group of players to enter rhythmic motifs and share them with other group members who are able to develop them further. Other work by Aimi explores the potential of manipulating the membrane of a drum by novel means. This Drum Network [1] uses each drum in the group as a controller that can sense pressure and strikes on its head and then pass them on to other players in the group. Audio

and tactile feedback are also offered as the drums may function as speakers by means of an added actuator.

Other interesting projects that involve the enhancement of traditional drums are the Electronic Tabla [9] and the Electronic Dholak [10]. Both of these interfaces use sensors to detect the pressure and location of finger strikes. This gesture data is then used to control sound and graphical feedback.

Another percussion interface that includes a strong graphics component is Jam-O-Drum [3], a new interpretation of a social drum circle, in which participants may tap rhythms on a sensor table that detects the hand strikes. Though very different in construction from traditional drums, the Jam-O-Drum offers many aspects of a traditional collaborative drumming circle.

The taiko tradition has also been extended, as the drumming ensemble D'CüCKOO created large trigger pads that were raised to a sufficient height to allow for traditional taiko playing style [2] with wood bachi.

3.2 Playing Sticks

Within this category are interfaces whose form or playing techniques resemble those of conducting batons, such as the Digital Baton [11], the Buchla Lightning [6], and the Radio Baton [5] and Radio Drum [4]. Though the playing techniques for these interfaces are much more similar to those of conductors than drummers, they are each interesting examples of expressive instruments whose sensing systems were constrained by the form factor and shape of a stick or wand. Recently there have a small number of interfaces have emerged that combine the use of an acoustic drum and an enhanced playing stick that measures aspects of a drummer's gestural performance.

In the case of the Electronic Dholak just mentioned, a second musician (in addition to the one playing by hand) plays the instrument with the Digital Spoon, a wooden spoon equipped with sensors to measure the location and pressure of its strikes on the drum barrel.

An augmented drum system was created featuring a standard drum brush enhanced with a flex sensor to detect the motion of the brush on the drum head [13]. Similarly, the Vodhran [12] depends upon the gesture tracking of a beater against the membrane of the drum to drive a virtual model of a bodhran.

An interface for controlling physical models of the Tibetan singing bowl, the Hyperpuja [16], has also been developed. Though this controller is not based on the bowl as a percussive instrument, the implementation of the gesture sensing system was largely confined to that of the wooden playing stick.

4. Motivation for New Approach

The related work mentioned above represents a large degree of sophistication in physical sensing methods as well as the introduction of many new and exciting musical possibilities. Through the development of our interface described below, we have combined some of the elements of these projects while adding more versatility and robustness to the controller.

Through its simplicity in form and function, the drum offers an incredibly satisfying performance experience for novices and virtuosos alike. It is well-understood that among the qualities that make acoustic instruments so compelling is the inherent physical feedback they afford, and the directness and immediacy of their interaction.

In this work we aimed to preserve these features of the drumming experience, while of course providing extended musical possibilities. In particular, we wanted to allow interaction with computers, audio processing, and synthesis while drumming on *any* surface, including real Japanese drums such as the odaiko.

Most electronic music controllers require a considerable amount of care in handling and even in playing. When developing new techniques and performance styles for these controllers, many of these new methods of expression are less physically demanding on the instrument than those corresponding to traditional instruments. In many cases, this may be true by design, but in others it is also the fragility of our new instruments that influences these interactions. With the Aobachi, we seek to create an electronic music interface that could be treated with as much abandon as an acoustic instrument.

5. AOBACHI INTERFACE

Below we present a prototype for a new gestural interface in the form of two drum sticks. The design of this controller adhered to strict constraints regarding implementation of the technology.

5.1 Design Requirements

The first priority established was the preservation of the feel of odaiko bachi. Toward this end, we used wood dowels, measuring approximately 20 inches long and 1.5 inches in diameter. These sticks were each hollowed at one end in order to create an enclosure for the necessary electronics.

Because we wanted to enable players of the Aobachi to use traditional playing techniques, we needed to implement technology in as unobtrusive a manner as possible. Therefore, in addition to embedding the electronics in the sticks, of course we endeavored to make them small, lightweight, and wireless.

In addition to keeping the embedded hardware compact and inconspicuous, we wanted to reduce the rest of the gesture sensing system to a minimum. This is, of course, beneficial for ease in performance setup, maintenance, and archival. Of even greater importance, though, is the need for a performer to be able to relate closely with an instrument, a need that becomes increasingly difficult to fulfill as the identity of the instrument becomes more distributed (with added hardware elements). Therefore, we sought to create a system with as few components as possible.

Because modern taiko performance is an ensemble tradition, we wanted to be able to support multiple drummers. At a minimum, we wanted to be able to support two odaiko players, i.e. 4 sticks, during one performance, using only one computer to receive and process the data.

In order to measure drumming gesture, we were initially interested in tracking all axes of acceleration and angular velocity. However, we decided that it would be sufficient for our early investigations to use only 2 axes of angular velocity, as the twisting motion of the stick about its own axis is not of great importance to taiko technique.

5.2 Sensors

This prototype includes 4 sensors that measure 5 independent degrees of freedom. We used 2 two-axis accelerometers from Analog Devices (ADXL202E) to detect changes in acceleration for all 3 axes. These are capable of measuring accelerations with a full-scale range of ±2g and in their current implementation have a bandwidth of 50Hz. We also included 2 single-axis

Murata Gyrostar gyroscopes (ENC-03J) to reflect the angular velocity of the sticks (the axial rotation of the stick was neglected in this prototype). This gyroscope has a maximum angular velocity of ±300?/s and a maximum response of 50Hz. Our microcontroller is a PIC16F877 (with built-in 10bit A/D converter) running on a 3.58MHz clock.

5.3 Bluetooth®

The system for wireless data transfer from each of the sticks became a defining feature of the Aobachi. Because of the speed and precision of the performers and the scale of the drums for which Aobachi was conceived, fast data transfer and large transmission distance were desired. Largely for these reasons, the hardware design of Aobachi included Bluetooth® communication.

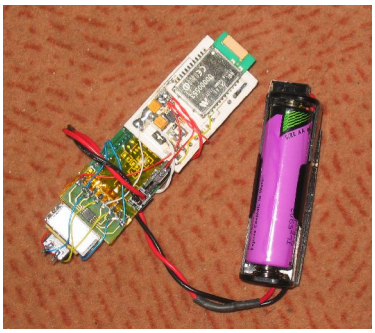

Figure 2. Aobachi embedded hardware powered by a AA size battery.

There were also added benefits, as this technology provides built-in error correction, and the ability to receive data from up to 8 different devices at once from one machine (providing support for 4 players). The Bluetooth® receiver exists in the form of a small dongle that plugs into a USB port of a computer, or, in the case of certain computers, is internal. Therefore, essentially all of the hardware associated with the Aobachi is embedded and the only external device is the computer.

This first version of the Aobachi has a sampling rate for all of the 5 sensors of approximately 120Hz and has a battery life of +18 hours. Because the Bluetooth® channel is represented as a serial port in modern operating systems, the Aobachi data can easily be received by computers of any platform.

The hardware used in each stick is seen in Figure 2. Note the Bluetooth® Class 1 module (Mitsumi WML-C11) at the top of the electronics board. Figure 3 shows the entire Aobachi interface.

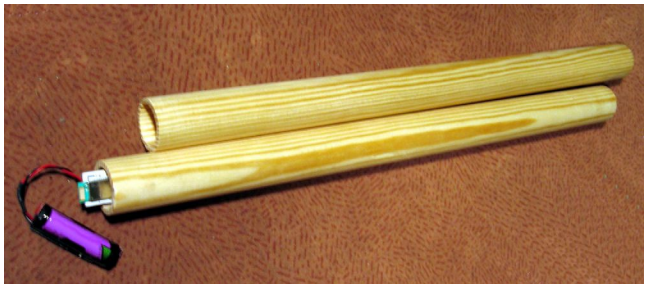

Figure 3. Complete Aobachi interface (battery and Bluetooth® module shown for scale).

5.4 Improvements

As the Aobachi are tested in different applications, evaluations of their performance may very well lead to new features and refinements of the measurement system and physical interface. For now, we plan to improve the integration of the electronics inside the Aobachi to withstand greater shocks. Though the current implementation has appeared sufficient thus far, we assume that once the Aobachi undergo more extensive testing from players of different techniques and strength levels, the hardware will need to be packaged better. Toward this end, we are planning on replacing the foam surrounding the electronics with rubber and placing a locking wood cap to cover the base of each stick.

6. APPLICATIONS

In designing the Aobachi, we hoped to make an interface that would be useful as a new instrument for musical expression, of course, but also as a device to facilitate study of drumming technique.

6.1 Drumming and Movement

The main performance goal of Aobachi is for it to develop into an exciting tool for use with real Japanese drums, odaiko in particular. One vision for this work was to facilitate true electro acoustic performances in which the Aobachi would be used to control both real drums and “virtual” drums at the same time, without having to alter the basic style of control gestures.

One of the reasons we chose to model the bachi is because they are often an integral part of the choreography, an intimate component of Japanese drumming style. The experience of taiko drumming, for performers and audiences alike, is defined not only by the music but also by the accompanying dance-like movements of the players. In other words, the movement of the sticks is an integral part of the art though it does not produce any sound. The importance of performance gestures is a point of considerable interest[8,14]. Although sensors have been used to track dancers' movements, with Aobachi the taiko musician's movement can be tracked using their proper instrument.

6.2 Analytical Studies

In addition to performance applications, the Aobachi may be used for non-performance applications, such as gesture-tracking of drum strokes, as in [8]. Insight into player control and instrument interaction may be gained in order to inform future interfaces and mappings. Also, it may be useful for pedagogy of drumming by monitoring the student’s stick motion. This may be especially importat for correcting the right and left arm imbalance experienced by most students.

7. CONCLUSIONS

Described above is an early prototype of a new music controller inspired by and designed for use in Japanese drumming. Modeled after the playing sticks of the odaiko drum, the Aobachi rely on specially designed hardware embedded inside the each of the sticks that measures 3 axes of acceleration and 2 axes of angular velocity. Central to this design is the implementation of Bluetooth® wireless transmitters. In addition to the many beneficial technical features Bluetooth® provide, integrating the transmitter modules into the Aobachi design resulted in reduced hardware in system overall.

We are now only at the beginning of experimentation phase with this device. In the near future we will be collaborating with taiko

players to determine the playability and robustness of Aobachi as well as suitable methods of analysis for the gesture data.

Though Aobachi is a very simple interface, we believe that its qualities of versatility, portability, and robustness make it a promising candidate for use in many different performance scenarios. Though capable of subtle measurement, perhaps the most exciting characteristic possessed by Aobachi is its ability to withstand the physical demands of rigorous playing styles.

8. ACKNOWLEDGMENTS

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