DeformaBall Controller

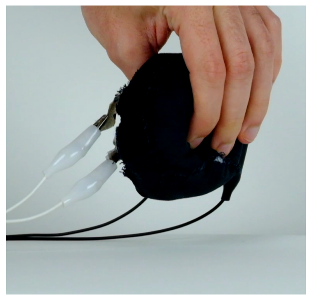

Figure 1: An example of a user interacting with DeformaBall.

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Abstract

DeformaBall is a ball shaped musical controller that can be used to modulate audio when touched and squeezed (See Figure 1). The ball explores some of the gestures that our hands are capable of. This deviates from usual musical input devices, as the input interface is a fabric material that responds to applied pressure. We aimed for the DeformaBall to be a fun, simple to use controller, which gives the user a novel way to interact with sound. We trialed different pressure sensor designs and explain their strengths and weaknesses. We also trial example parameters and audio that show how a musician could use DeformaBall in their workflow. 4 out of 5 of the trial users thought that the ball gave a novel way of interacting with music.

Author Keywords

Deformable Interfaces; Musical Controller;

Introduction

The current generation of digital musical input devices are based on percussive or keyed instruments. Controllers typically require you to press a key or tap a pad. Other devices use sliders or potentiometers that users slide or rotate respectively.

This, however, does not take advantage of the advanced manipulation abilities of our hands [1]. To complement existing devices and to take better advantage of the wide range of our fine motor abilities, we have designed a new musical controller that you can deform. We chose to base our controller in the musical domain as it is one that provides many challenges, and is particularly expressive. [2]

We present different example mappings between pressure input and final audio output. We have chosen to take advantage of modern audio-related software (Max, Ableton Live) to demonstrate how a user could fit the device into their workflow. In our example we modify various features of waveforms according to the intensity of the gestures.

The major contributions of our work are a novel controller that can be deformed to control music. We also examined hand gestures that users prefer to use when interacting. We provide examples of an environment in which a musician could use DeformaBall, and which specific parameters were best suited to modulation by the ball.

DeformaBall

DeformaBall development, connections and applications are discussed in the next area of the paper. We divided them into these sections:

- Sensor Development
- Handling the input
- Application Scenarios

Sensor Development

Our prototype consists of a ball which is connected to an Arduino, connected to a laptop. We present below how the most recent prototype was made. The details of other designs may be found in the appendix.

We had issues with the size of the sensing area on the original prototype, so we settled on the design below to combat this problem.

The new design for fabric voltage divider can be seen in Figure 2. This design focuses on enlarging the area in which the input pressure is detected. The figure shows two images of the same fabric voltage divider – one for each side.

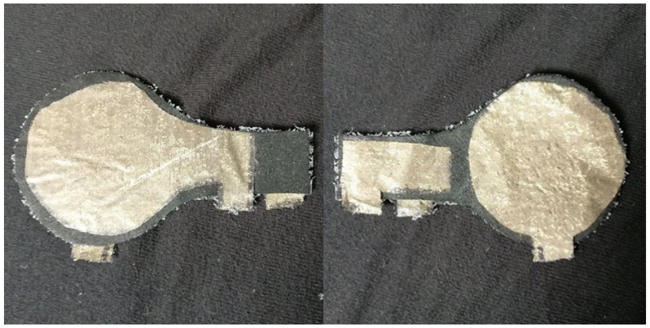

Figure 2: Fabric voltage divider for the second prototype

The 5-voltage output is attached to the leftmost conductive flap (left image), the Arduino input is attached to the middle conductive flap, and the ground output is attached to the rightmost conductive flap. This design was more successful as pressure could be detected on the larger surface areas. We met our goal of making the device more interactive with users.

We had an issue with the number of wires from the ball, so we decided to use internal software pull-up resistors. This technique lets a pin in the Arduino behave as the voltage provider, while also measuring a current, which floats to an internal ground. By adding an external ground a portion of the current will float to the external ground, instead of the internal ground.

This lead to the following design of a resistive sensor (Figure 3).

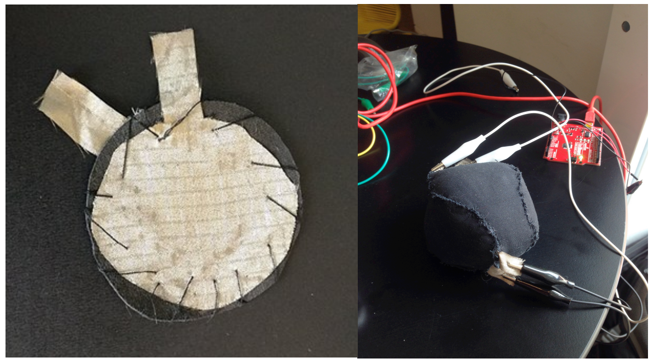

Figure 3: Final design of the resistive sensor (left), Final design of the DeformaBall (right)

This Arduino samples the sensor using an internal pull-up resistor. This creates a variable voltage divider where R_1 is the internal pull-up with a fixed resistance and R_2 is the piezo resistive fabric with a variable resistance. When the fabric is compressed, its resistance drops and the voltage at the analog input drops correspondingly. Changes in pressure are inferred through the changes in sampled voltage. These values were more reliable (i.e. fluctuated less) than the input read from the original fabric voltage divider design. The rightmost image in Figure shows the final design for the DeformaBall.

Handling the input

The process of generating sound can be divided into two sections; first the Arduino will interpret and calibrate the raw input from the pressure sensors, and then Ableton will receive the calibrated input and generate sounds.

INTERPRETING THE RAW INPUT

By using internal software pull-up resistors, the values read by the Arduino range from 1 to 1024. If no connection is found between the voltage provider, and the external ground, then 1024 (or close to) will be read. As pressure is added to the resistive sensor, the resistance between the voltage provider and the external ground is decreased, and the values read by the Arduino is lowered.

When the ball is by itself there is still a connection between the voltage provider and the external ground – so some unknown value between 1 and 1024 (usually around 500) will be read.
To tackle this issue the programmed Arduino will for the first couple of seconds detect the average values read, referred to as the background noise, when the ball is not subject to any actions.
After this step we can create calibrated values by subtracting the background noise by the raw input values. Hence values of 0 are attained when the ball is not being touched, and when the pressure is added to the sensors, the calibrated values go up. The calibrated values are then parsed through Max, and into Ableton Live.

Generating sounds with Max and Ableton Live

As elaborated below, we used Max for Live and Ableton Live (a common DAW) to create example environments that a user could take advantage of the ball's capabilities in. From the values read in from the Arduino, the Max patch reads the values, maps them to a suitable scale, and monitors for changes in values. From this, it uses the Live Object Model to interact with different parameters inside of Ableton Live. Inside of Live, we decided to stick with simple presets that could be created quickly for any user, and to not confuse users who were not familiar with complex audio synthesis. Any audio clips used were taken from the core library provided with Ableton Live, to avoid any copywriting issues and to allow users to replicate the sounds at home. Both of the synthesis engines chosen use Ableton's 'Operator', which is an instrument that combines FM, additive and subtractive synthesis (for more details visit https://www.ableton.com/en/packs/operator). We chose the presets after selecting ones that had pleasant sounds, that best lent themselves to the controller we had created. We tried mapping the values from the Arduino patch to several parameters inside Ableton Live, the final results which were tested can be seen below. The audio samples were selected after trailing several to see which fit best.

Application Scenarios

For our example musical controlling environment, we decided to use Max and Ableton Live in order to use these values to modulate parameters of audio clips and synthesized audio. We chose this as both are commonly used environments for musicians. The Max patch inside Ableton Live is run using Max for Live, which then maps the pressure values read from DeformaBall, to parameters inside Ableton Live. We chose a few different scenarios that could best take advantage of the unique interface that DeformaBall provides. Table 1 outlines some of the mappings that we found best incorporated with DeformaBall's design.

Sensor 1	**Sensor 2**	**Use Cases**
HPF frequency on oscillator	Overall Song Tempo, with a drum loop sample	Scenario 1: A musician wishes to modulate the music they are creating on-the-fly.
Sample 1 trigger (chord progression)	Sample 2 trigger (A drum loop)	Scenario 2: A musician is looking for a new way to interact with music they have already created.
Frequency of oscillator	High-Pass filter on same oscillator	Scenario 3: A musician wants a finer, more tactile response for their interactions than is yielded from conventional controllers (knobs, keys).

Table 1: 3 Example scenarios that we trialed with the users.

The above options were considered after taking into consideration the work done by Troiano et al in examining how users especially use deformations to 'filter and modulate sound.' [3]

Initial Users Reactions

Of the 5 users we asked to interact with the ball, 4 said they found the experience to be novel and a usable way of interacting with music. All of the 5 users fell in the 18-30 range, but given a greater timespan, we would have liked to test on an older and younger demographic, based on the findings of A.R. Jensenius et al. [4] 3 of the users particularly found the final use case in the table presented them with a more enjoyable experience than simply using a knob, or a keyboard. One user commented on enjoying the natural feedback given by the ball (i.e. the stuffing causing resistance against their hand, and springing back into shape). These results are ideal, as we were aiming to create a novel experience for the user.

Examining Specific Gestures

While testing our own usage of the controller, and through noting the results of other users with the ball, we examined which specific gestures the users of the ball favored.

Unfortunately, since our prototype only uses simple pressure sensors, our ability to detect the fine differences between various hand gestures (such as pushing, squeezing, poking etc.) was somewhat limited. However, in noting how various people chose to interact with DeformaBall, we could see which of the gestures users preferred to use to interact, which we would use in the future to provide finer control. We compare this to the work done by Troiano et al [3] in comparing with how they found users best interacted with deformable interfaces. We also noted their results on which aspects of audio were best modulated by the controller.

In order to have a clear distinction (the line between a push and a squeeze can be quite relative), we decided to only ask the 5 users about poking vs squeezing. See Figure 4 for examples of both. We found that 4 users said that the squeezing was the most intuitive deformation for the ball, with only 1 saying that a poke felt more intuitive. The users also reiterated the information above, in that the controller seemed the most intuitive when it was used to filter or modulate sound.

The work by Troiano et al. showed that squeezing was the interaction of which users spent the second most amount of time performing (~22%), only second to pressing. Our results contest this as most of the users found squeezing more intuitive than pressing. From the paper, the views expressed by some of the users were

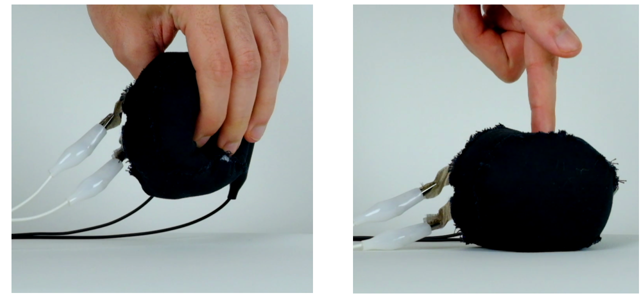

Figure 4: Images shown to users about what constitutes a squeeze (left) vs. a poke (right).

that the deformations were the most intuitive when used as a filter or effect. We also found this in our results, particularly that the correlation between the intensity of the squeeze and the ‘intensity’ (i.e. amount) of the filter of effect.

We can find a similarity between the ‘pressing’ action discussed in the work by Troiano et al and the ‘poking’ action that we tested on our ball. From this, we can contrast their results of finding using ‘pressing’ more than any other interaction. We believe this is to do with the ubiquity of ‘press’ interfaces, as described above. These could be keys, buttons, switches, where even features such as after-touch could relate to an extended press action. For our project, ‘squeezing’ was found to be the preferred mode of interaction. This may be due to the nature of the interface – ‘poking’ a ball type object is not especially common, whereas a ‘squeeze’ is fairly common, such as in stress balls. From this, it makes sense that ‘squeezing’ was the preferred interaction. Troiano et al tested on many different sorts of interfaces, and a wider range of subjects, so their results may be applied more generally to a set of deformable interfaces, whereas our result mostly correlates with our interfaces, or those similar to it.

Related Work

Our work relates to today's literature in the deformable interface area [3] [5], as a new possibility to control sound with gestures, but also an inexpensive and easy to use musical controller. Being a new area in HCI, the deformable interfaces may still be explored with different gestures and applying them in deformable controller, while at the same time doing it in a familiar object such as a ball. We can divide the related work in two major areas:

- Deformable interfaces: HCI area where the interfaces can be bended according to some objective outcome [6] [7].
- Sound and music computing: using sound and music computation on objects that change the sound according to some action has been done before [3] [8] as we try to correlate this idea using deformable interfaces using the squeeze and poke gestures.

In the creation of our prototype, we considered the paper 'The embroidered musical ball' [9], as well at the patent for a continuous music keyboard [10], and the multi-touch eTextile for music performances [11]. These were all taken into account in the selection of both how to best form the deformable object into its final ball shape, and for which domain to the deformable interface is best suited – music. As shown, there exists a substantial amount of work of deformable interfaces and music, so we aimed for our work to build upon the works of others.

We also considered some of the other deformable interfaces presented by Troiano et al in [3], such as the 'Sonic Banana' [12], and 'The Music Ball Project'. [4] Clearly, in particular we were influenced by the findings of [4], which found that the ball shape gave many different types of use, including a more playful one, which made it popular among a wide demographic, old and young.

Furthermore, we noted their results on the importance of producing a ball that is particularly durable, simple, and inexpensive. Given greater time we would have liked to act upon the 'non-electronic feel' aspects, by working on hiding the wires by incorporating a wireless solution. However, we did find that the familiar, typically non-electronic feel of the fabric, and the ubiquity of the ball object meant that users understood what we were trying to achieve with the ball without great explanation, and to some gave greater satisfaction than a typical non-deformable interface.

Limitations and Future Work

As stated above, due to time constraints our prototype is very simple, and is unable to discern between many different types of gestures. We would also aim to increase the durability, and non-electronic feel of the ball, as well as incorporating a greater number of sensors. We would also find it essential to test on a bigger demographic to see how the ball best worked with both the old and the young.

Conclusion

We succeeded in creating a simple, cheap, intuitive deformable music controller. We also examined that users found that squeezing was the most natural interaction with a ball, especially when it correlated to a filter or an effect, and its intensity. Our example environment also worked well as a test environment for which parameters were best suited to modulation

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Appendix

Below we include more information about the development of the ball, and other information that was not included in the paper.

One of the earlier designs for the ball is presented below. The fabric made ball is created using the materials listed. The initial approach is creating two similar shapes (5). Next the shapes are sewn together, and filled with stuffing.

- non-functional fabric (regular clothing)
- conductive fabric
- resistive fabric (eeonyx etc.)
- needle, thread and scissors
- stuffing material

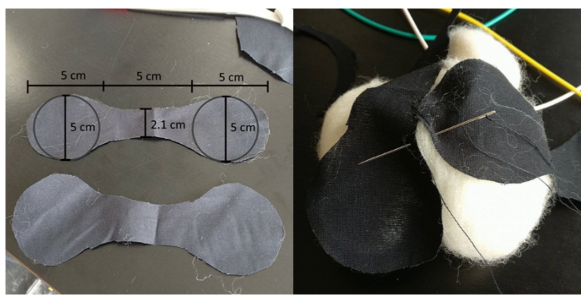

Figure 5: The fabric used to make the ball with measurements.

The initial approach was to build a fabric voltage divider, the design of which can be seen below.. A fabric voltage divider serves as a resistive sensor.

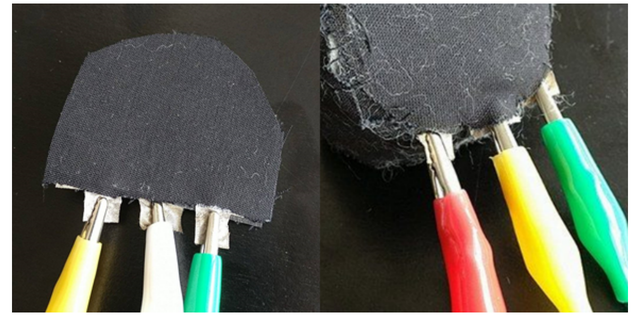

Figure 6: Fabric voltage divider outside the ball (left) and inside the ball (right)

By interpreting the first image in (Figure 6), the crocodile clips are connected to the Arduino sockets, such that,

- The yellow clip is connected to the 5V (5 volt)
- The white clip is connected to A0 (first input)
- The green clip is connected to the GND (ground)

.

We have built a fabric sensor which detects pressure. The second image in figure 5 shows the final ball. As stated above, we decided against this prototyping method as the area upon which pressure could be detected was deemed to be too small.

The voltage divider was developed using this method:

Figure 1 How to make a voltage divider by Paul Strohmeier [13]