SQUEEZY: Extending a Multi-touch Screen with Force Sensing Objects for Controlling Articulatory Synthesis

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ABSTRACT

This paper describes Squeezy: a low-cost, tangible input device that adds multi-dimensional input to capacitive multi-touch tablet devices. Force input is implemented through force sensing resistors mounted on a rubber ball, which also provides passive haptic feedback. A microcontroller samples and transmits the measured pressure information. Conductive fabric attached to the finger contact area translates the touch to the bottom of the ball which allows the touchscreen to detect the position and orientation. The addition of a tangible, pressure-sensitive input to a portable multimedia device opens up new possibilities for expressive musical interfaces and Squeezy is used as a controller for real-time gesture controlled voice synthesis research.

Keywords

Musical controllers, tangible interfaces, force sensor, multi-touch, voice synthesis.

1. MOTIVATION

With the increasing popularity of portable multi-touch tablet devices such as the Apple iPad, a large number of developers and researchers are working on mobile applications. The ever-increasing processing power and multimedia capabilities of these devices not only allow more demanding computations, but their convenient form factor and touch input also provide new modes of interaction for the user. Although a multi-touch screen offers a rich set of hand gesture interactions, current implementations lack force input that can be useful for many musical applications. Additionally, interaction with a touch-screen is usually done with virtual widgets inside the screen, and adding a physical object can provide a more intimate user experience [3]. For our particular application, force control provides a suitable input for exploring activation parameters for articulatory speech synthesis.

2. RELATED WORK

The AudioPad [8] is a table-top tangible interface that consists of physical knobs that are tracked using RF resonance. The position and orientation of multiple pucks are tracked and used to control audio synthesis. Another similar interface is the reacTable [4], where physical pucks are tracked visually using cameras. In comparison, Squeezy achieves the tracking using the built-in feature of the touch screen which results in a more portable package.

PreSense [11] combines a capacitive sensor with a resistive sensor and can detect the location and force of a single finger press. A piezo-actuator provides tactile feedback. By using a touchscreen, Squeezy can detect the orientation in addition to position of more than one object.

The SqueezeOrb [9] is a wired force controller built into a hand exerciser. Although it only measures a single force input, the device is complemented with a 6 DOF optical motion tracker.

3. SYSTEM COMPONENTS

The Squeezy, as shown in Figure 1, consists of a modified rubber stress ball augmented with electronics. The stress ball allows the user to squeeze the device and force sensitive resistors (FSR) measure the applied force. The finger pressure exerted on the ball create resistance changes which are connected as a part of a voltage divider and the output voltage is measured by the analog input of an Arduino Pro Mini microcontroller. Passive force feedback is provided through the elastic nature of the ball. The microcontroller is connected to a Bluetooth serial port that wirelessly transmits the measured pressure.

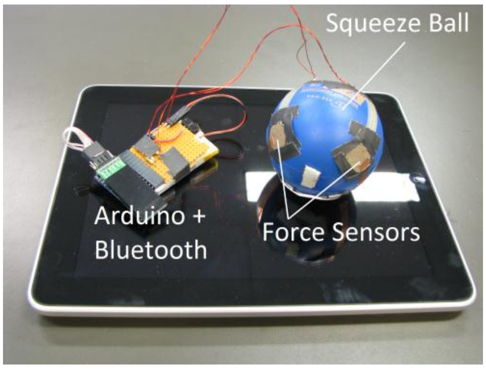

Figure 1. The Squeezy Controller on the iPad

Conductive fabric connected via copper tape towards the bottom of the ball as shown in Figure 2 transfer the finger touches when the user holds Squeezy. Spots of conductive fabric are exposed at the bottom, which is cut flat so it can rest on the touchscreen.

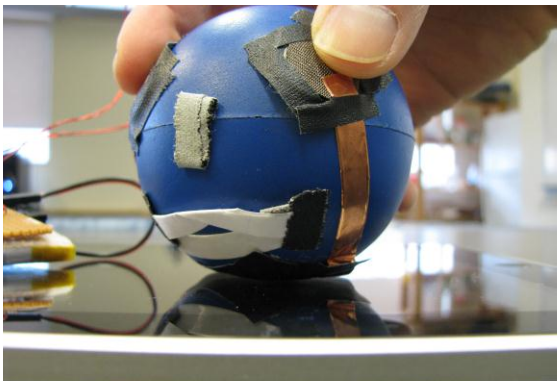

Figure 2. Finger touch transfer mechanism

The position and orientation of Squeezy are determined by the location of the touch spots detected on screen when a user's fingers are placed on the conductive pads. As a first prototype, two points are implemented for each Squeezy ball and hence 180 degrees of rotation can be detected (Using three points would allow detection of the full 360 degrees of rotation). The following table shows the number of points required for the detection of each feature:

Table 1. Number of touch points per Squeezy

# of points	X-Y Position	0-180° orientation	0-360° orientation
1	Yes	No	No
2	Yes	Yes	No
3	Yes	Yes	Yes

The maximum number of detectable touch points (11 on the iPad) and the number of touch points per Squeezy limit the total number Squeezy's that can be used at a time.

The X-Y values of each touch spot is transmitted via Wi-Fi using OSC [7] implemented in a simple openFrameworks [6] application running on the iPad. For the force values, a simple Max/MSP [5] patch parses the Bluetooth serial stream and translates the microcontroller's analog readings. For visual testing of the system, a Processing [2] sketch displays the position and force values.

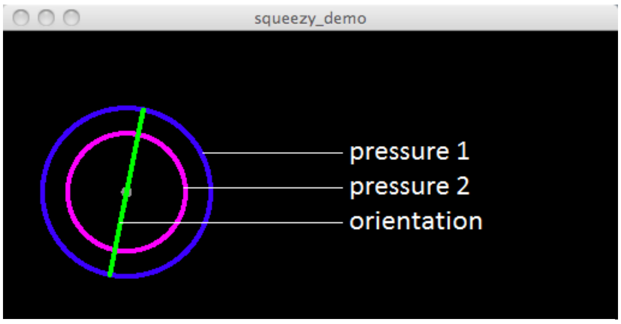

Figure 3. Location, orientation and pressure visualization in a Processing sketch

In Figure 3, the centre of the circles corresponds to the physical position, calculated by the midpoint between the two touch spots. The line across the circle represents the orientation, and the radii of the two circles are proportional to the pressure detected by each force sensor.

In theory, the entire end-application could reside on the tablet device. However, due to the iPad's lack of support for the Bluetooth Serial Port Profile (SPP), the force sensor values had to be sent to another computer first. This would not be necessary for other devices, or an HID Bluetooth device (which the iPad does support).

The Squeezy electronics are powered by an 850mAH lithium polymer battery, and has an estimated runtime of around 8 hours. The total cost of Squeezy is less than $100.

4. APPLICATION

The Squeezy is currently used as an experimental input device to drive a biomechanical model of the vocal tract for speech synthesis as a part of the DiVA project [10]. Currently the 2D position of the Squeezy is mapped to a vowel space while one force sensor drives the pitch. In the next stage of development the squeezing forces will be applied to muscle activations of a bio-mechanical vocal tract model as developed in [1].

5. CONCLUSION

By making use of the physical nature of capacitive touchscreen technology, a simple tangible interface is implemented using low-cost components to complement the input system of a popular tablet device. Concepts similar to Squeezy can be used to extend interfaces to provide more expressive controllers.

6. REFERENCES

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