Toccando

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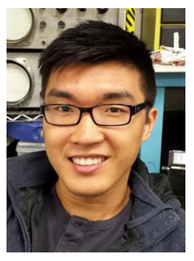
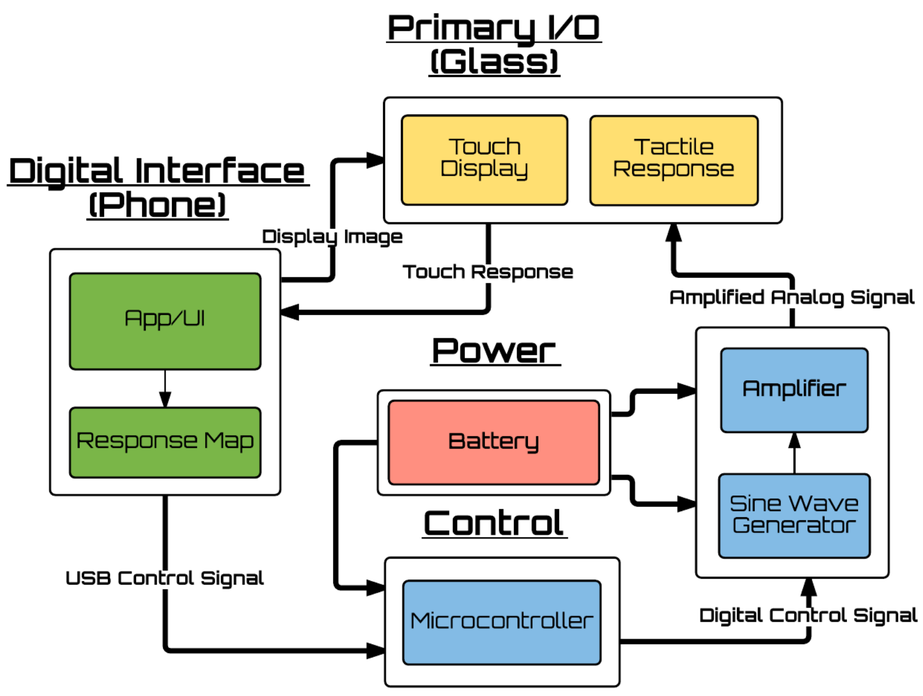


Abstract

Toccando is a device that provides haptic feedback on Android devices. The hardware consists of a piece of glass, fitted with piezoelectric speakers; an amplifier, and two microcontrollers. The software is an app that provides the user with visual cues. The microcontrollers act as the bridge between Toccando's hardware and software. A high frequency modulated wave is passed from the microcontrollers through the amplifier to the piezos. The vibration that the wave causes creates a difference in the dynamic friction of the glass. This is what the user experiences as haptic feedback. Haptic feedback can be useful to the visually impaired and in situations where vision is critical to another activity. Adding tactile feedback to maps is one example application of Toccando. Currently, maps for the visually impaired are custom printed or presented on expensive customized electronics. However, the Toccando system can be programmed dynamically and the hardware is much simpler and cheaper than other haptic devices on the market.

Block Diagram



Specifications

- Inaudible vibration at high frequencies (37kHz)
- Thin glass allows use of phone's touch screen (1.1mm)
- Long lasting battery (25 hours)
- Fast and smooth usability
- Light weight:

Battery	5 oz
Case	6.3 oz
Total	11.3 oz

Acknowledgements

We would like to thank our advisor, Professor Patrick Kelly; our evaluation board, Professor Robert Jackson and Professor C. Mani Krishna; and our department head, Professor Chris Hollot. We would also like to thank the local glass company in Worcester, MA, Howard Glass; and the researchers from Northwestern University, specifically, Joe Mullenbach.

Applications

Education of Visually Impaired

- Ability to feel shapes, objects, and letters

Accessibility

- Maps, tactile feedback along highlighted routes

Future Applications

- Tactile controls for embedded systems in cars
- Remote texture of products such as clothing

System Overview

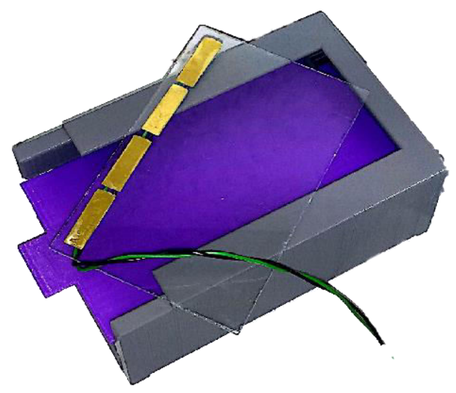
Android App:

The app provides a user interface with visual cues to add to the tactile feedback given by our system.

Microcontrollers:

Two microcontrollers are used. The IOIO board for communication with the phone and integrating with the app GUI and, a PIC32MX220 which is used to generate a modulated signal.

Glass with Piezos:



Piezos are super-glued to soda-lime glass in order to form the haptic interface. The piezos are excited by an amplified modulated signal and vibrate the glass. The vibration of this glass is perceived as a change in the dynamic friction of the glass by the user.

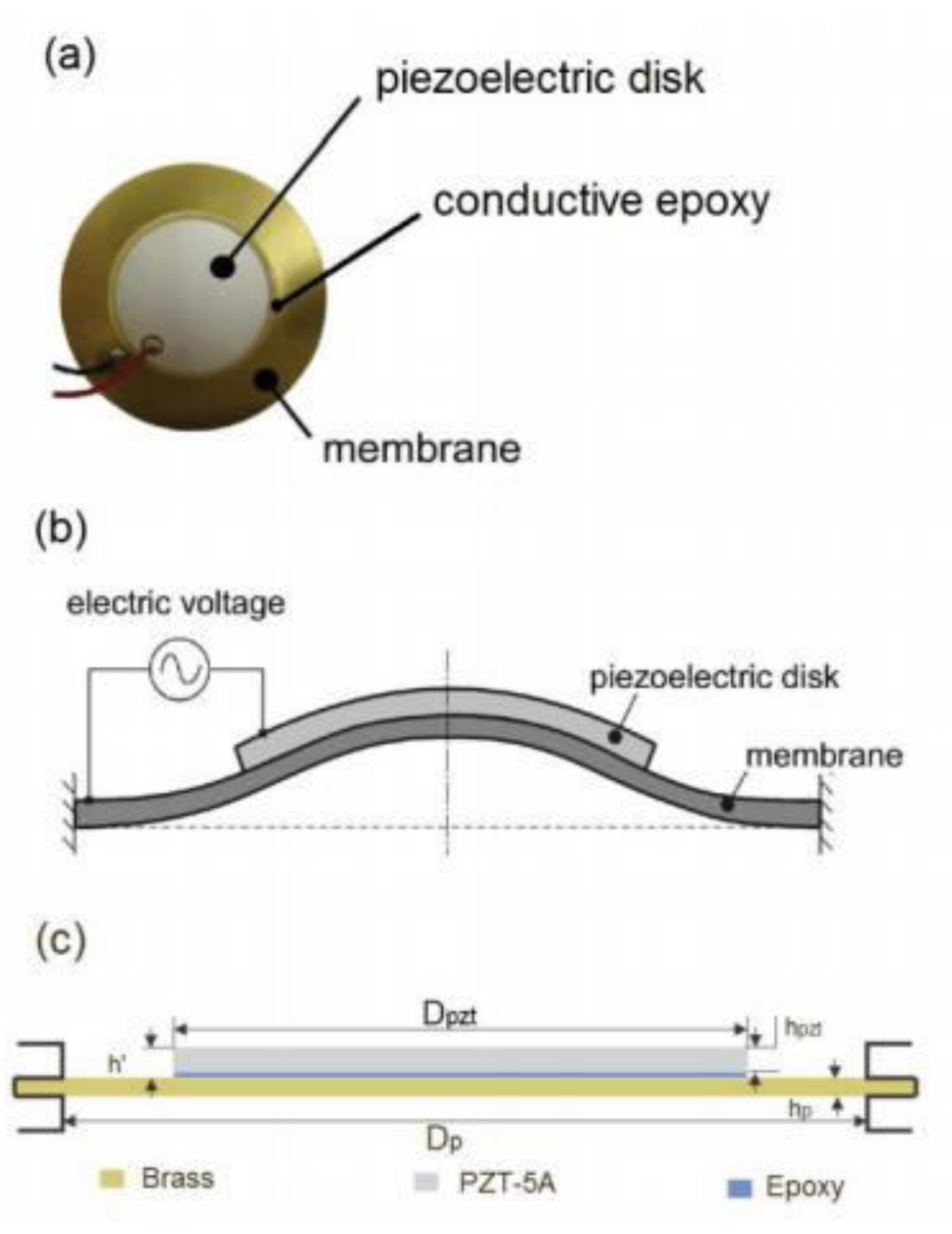
Results

A system that dynamically changes the friction of the glass generating haptic feedback to the user. Comments about the sensation include that it feels "wet", "vibratey", "rubbery", "grainy", and "resistive."

Piezoelectrics

Piezoelectrics are an essential part of our design. The piezos make it possible to vibrate the glass at the frequencies required.

A piezoelectric can generate an electric charge in response to applied mechanical stress like hitting it. This can be used in reverse by applying a voltage causing the material to change it's shape, specifically bending it. Although piezos are commonly used to create sound, they are able to produce vibrations even at ultrasonic frequencies.



(a) A piezo buzzer
(b) A piezo when excited by voltage
(c) A piezo in resting state

Image Source: A.G.S. Baretto Neto, A.M.N. Lima, F. Tejo, "Piezoelectric Buzzer Optimization for Micropumps", Proceedings of the 2012 COMSOL Conference in Boston, 2012.

Cost

Development		Production	
Part	Price	Part	Price
IOIO Board	$39.95	*IOIO Board	$39.95
Piezos (4)	$4.72	Piezos (4)	$2.18
M8297-ND (Inductor)	$1.10	M8297-ND (Inductor)	$0.52
IXYS IXDN604PI Driver	$1.80	IXYS IXDN604PI Driver	$1.80
LE33 Voltage Regulator	$0.75	LE33 Voltage Regulator	$0.75
8 MHz CLK	$1.00	8 MHz CLK	$0.112
Battery	$25.99	Battery	$25.99
3D Case	$36.83	3D Case	$30.00
PIC32MX220F032B	$3.10	PIC32MX220F032B	$3.10
IRF52NPBF (MOSFET)	$1.14	IRF52NPBF (MOSFET)	$0.525
Misc. (RC)	$0.40	Misc. (RC)	$0.04
Total	**$117.00**	**Total**	**$64.00**

*IOIO board will not be needed in production

How does it work?

It isn't all magic. You might notice that when your finger just rests on the glass there is no feeling. This is because Toccando plays with the dynamic friction of the surface. The coefficient of friction is changed by vibrating the glass. This is known as the squeeze film effect. Air is forced in between the finger and the surface of the glass creating a floating effect similar to touching an air hockey table. In our case the resonant frequency is 37 kHz. The effect takes place when the resonant frequency is reached. The waveform that creates this effect is effectively turned on and off. The faster the effect is turned on and off the smoother the feeling, and the slower the effect is turned on and off the bumpier the feeling.

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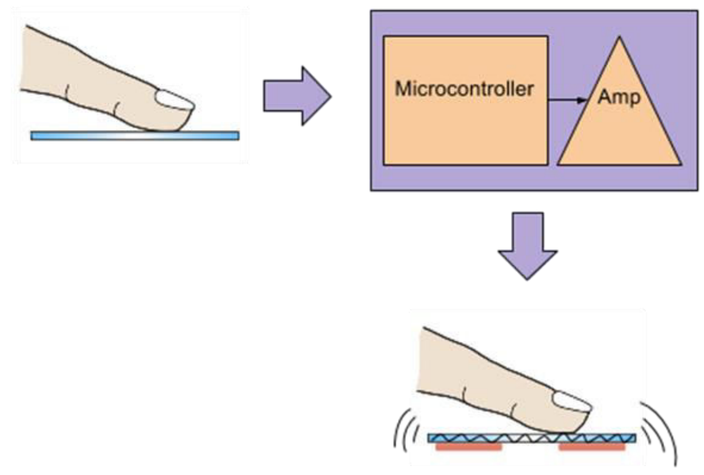
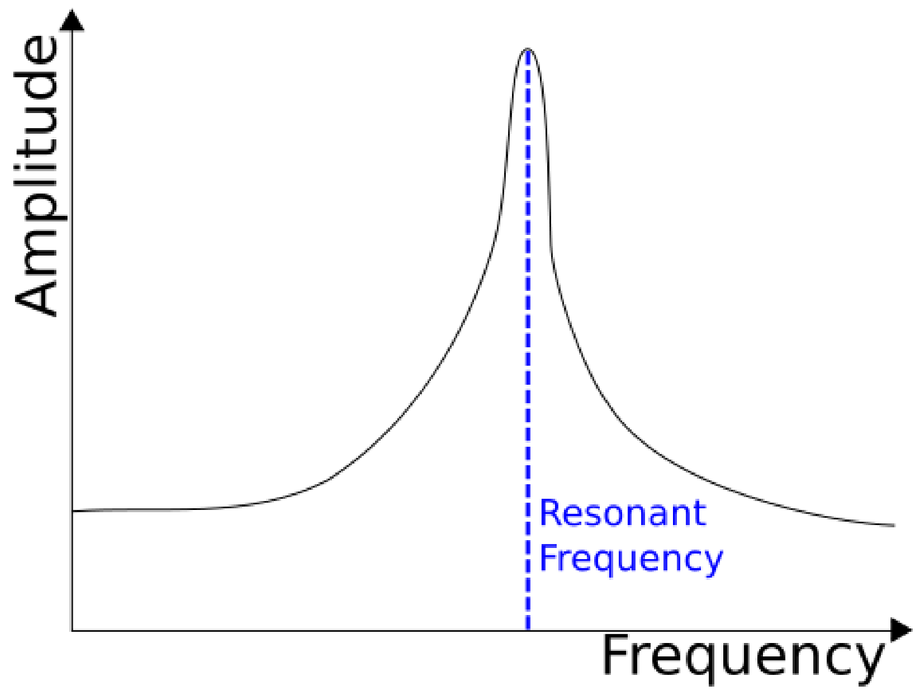


Resonance Experiments

To find the resonant frequency of the glass, we did a "salt" experiment. This consisted of hooking the glass and piezo system up to the function generator with salt placed on the glass. By empirical methods, we changed the frequency in steps until the salt bounced. This frequency was around 37 kHz. The bandwidth for the resonant frequency was narrow, only around 2 kHz.

The graph shows how resonance effects the amplitude of a wave. It is clear that the "feeling" would be most defined when the amplitude is at it's highest points.



Power

The circuit draws 200mA at 5V, using 1W of power.

Battery Capacity	5000 mAh
Current Requirement	200mA

$$\frac{5000mAh}{200mA} = 25hours$$

The battery will allow our system to run for 25 hours. This exceeds the time that a phone battery will typically last.