SqueezeOrb: A Low-Cost Pressure-Sensitive User Input Device

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Abstract

This paper introduces a new low-cost pressure-sensitive user input device called *"SqueezeOrb"*. The device is built from an assembly force-sensing resistors embedded in an elastic hand exerciser. A USB-enabled microcontroller continuously samples the sensors, applies a double-exponential noise-reduction filter and streams the resulting "handgrip strength" measurement to an attached host computer at a frequency of up to 1000 Hz. When combined with optical motion-tracking, the *SqueezeOrb* becomes a pressure-sensing input device for three-dimensional interaction.

CR Categories: H.5.2 [Information Systems]: Information Interfaces And Presentation (e.g., HCI)—User Interfaces

Keywords: pressure-sensitive input device, force sensor, haptic monitoring, handgrip measurement

1 Motivation

Pressure sensing has been successfully applied to a number of different application areas in human-computer interaction. An example of how pressure-sensitive user input may be used to control navigation, exploration and editing operations is given by [Forlines et al. 2005]. When combined with 6-DOF motion-tracking, a hand-held pressure-sensing device becomes a viable interaction tool for three-dimensional user interfaces.

In the field of physiotherapy, force-measurement sensors can be employed in hand strength training to provide patients with audio-visual feedback and quantitative information about their performance. Several Virtual Reality (VR) assisted motor rehabilitation methodologies (see [Holden 2005] for a comprehensive survey) use force-feedback gloves to provide haptic monitoring of handgrip strength. However, the cost of such devices currently precludes patients from using this technology at home.

Our primary design goal was to build a low-cost, yet accurate and durable hand-held pressure-sensitive input device for VR-assisted motor rehabilitation. As a secondary goal, the device should also be suitable for use in the context of general-purpose 3D interaction.

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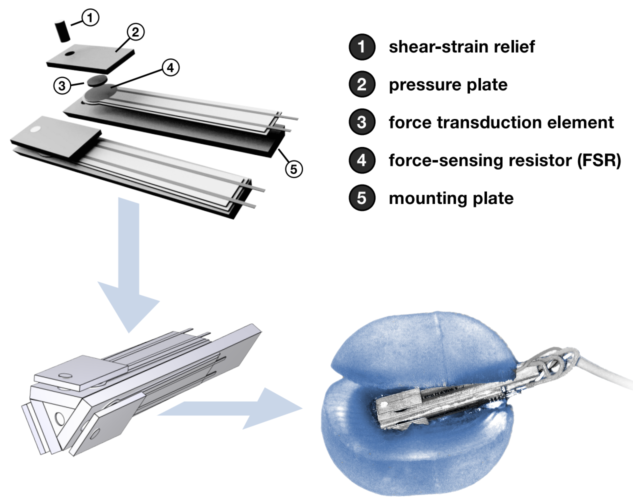
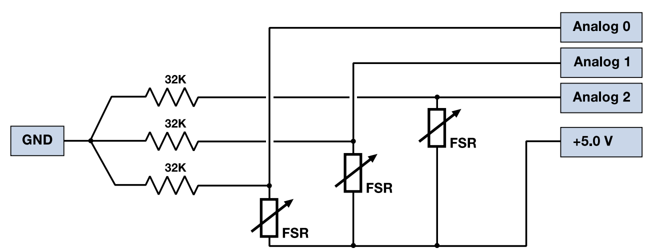
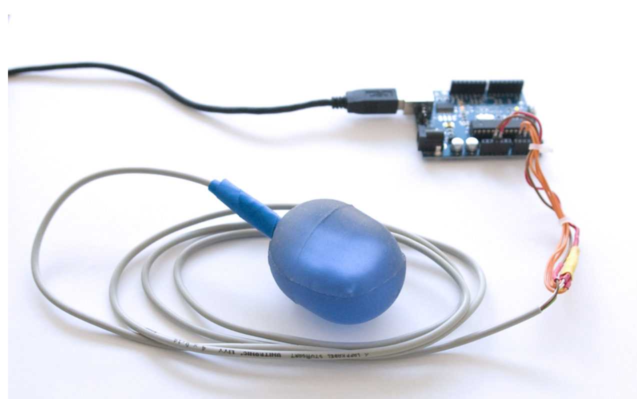


(a) *Mechanical assembly.*



(b) *Electronic circuit diagram.*



(c) *Assembled **SqueezeOrb** with USB interface board.*

Figure 1: *Hardware design.*

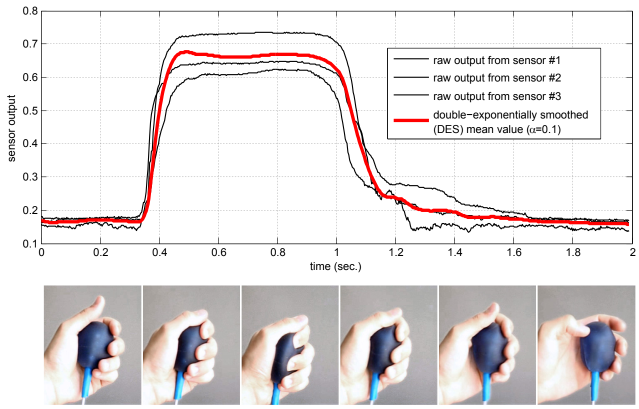


Figure 2: *Raw and filtered sensor output from a typical use-case.*

2 Hardware Design

Figure 1 illustrates the mechanical and electrical layout of the *SqueezeOrb* device: Three FSR-149AS (CP6)[1] self-adhesive force-sensitive resistor strips are mounted on a wooden triangular prism and secured with a shear-strain relief mechanism. Each of the FSR strips is electrically connected from +5VDC to a separate 10-bit ADC input of an Arduino[2] USB circuit-board and terminated by a 32K resistor to ground. The entire assembly is placed inside a hollowed-out translucent *Thera-Band Hand Exerciser*[3].

All the materials used for building a *SqueezeOrb*, including the Arduino board, cost less than EUR 100,- (at the time of writing).

We programmed the Arduino's Atmel AVR microcontroller to continuously sample the three ADC sensor inputs, compute the average value and filter the result using a double-exponential smoothing (DES) filter [LaViola 2003], which requires only a minimal memory footprint and is ideal for noise-reduction in embedded computing applications. The resulting compound "handgrip strength" measurement is transmitted to an attached host computer at a user-selectable rate of up to 1000 Hz.

A *SqueezeOrb* device driver for the OpenTracker [Reitmayr and Schmalstieg 2001] data-flow scheduling framework allows for a straight-forward integration of the pressure measurements into Virtual Reality applications. When combined with a rigid-body hand target for optical motion-tracking [Pintaric and Kaufmann 2007], the *SqueezeOrb* can be used as an analog button with 6-DOF pose (position and orientation) information, as shown in Figure 3.

3 Results

Preliminary results obtained from a *SqueezeOrb* prototype indicate repeatable, low-noise measurements with an absolute accuracy that is sufficient for fine-grained interaction. Figure 2 shows the raw FSR-output and DES-filtered pressure measurements for a typical use case.

4 Future Work

We are currently developing several game prototypes for VR-assisted upper-limb rehabilitation, in which the *SqueezeOrb* will be

Figure 3: *The SqueezeOrb can be combined with a rigid-body hand target for use as a general-purpose 6-DOF Analog Button.*

used for handgrip strength measurement. We also plan to investigate the broader topic of three-dimensional interaction techniques based on pressure-sensitive user input from a tracked *SqueezeOrb*. However, these applications are beyond the scope of this paper.

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