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NoiseBear: A Wireless Malleable Multiparametric Controller for use in Assistive Technology Contexts

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Abstract
NoiseBear is a malleable multiparametric interface, currently being developed in a series of participatory design workshops with disabled children. It follows a soft toy design, using conductive textiles for pressure sensing and circuitry. The system is a highly sensitive deformable controller; it can be used flexibly in a range of scenarios for continuous or discrete control, allowing interaction to be designed at a range of complexity levels. The controller is wireless, and can be used to extend the interactive possibilities of mobile computing devices. Multiple controllers may also be networked together in collaborative scenarios.

Author Keywords
malleable controller Assistive technology; malleable interaction; participatory design; electrotextiles.

ACM Classification Keywords
H.5.2 [**User Interfaces**]: Input devices and strategies (e.g., mouse, touchscreen); K.4.2 [**Social Issues**]: Assistive technologies for persons with disabilities.

Introduction
NoiseBear is a malleable controller, being developed as part of a larger project that focuses on the development of assistive technology for physically and mentally disabled

children. This project follows a rapid participatory design approach, developing technology and designing interactive scenarios in school workshops with the children and their carers. The project initially focused on development of mobile applications in musical contexts, using iPods and iPads. Feedback from these workshops indicated that tangible interfaces would make a valuable addition to the workshop sessions, benefitting the children by providing possibilities for interaction beyond those provided by the sensors in the mobile devices. In particular, we observed how a class of autistic children carried out daily exercises using a range of small objects in personalised work boxes; these exercise were designed to improve their communication and interaction skills. One aim of NoiseBear is to fit into this paradigm, by creating a tangible interface that can be embedded into the children's daily learning practice, offering new interactive possibilities. Further to this, we wanted to explore the potential of malleable control for children with limited mobility. Overall, we wished to design a flexible interface that could fit into a number of workshop scenarios, and which could be used in solo or group work. Malleable controllers have the potential to fulfil these requirements; they allow expressive interaction at a range of complexity levels, they can be custom made in a range of shapes, and there is the potential to network a number of devices for collaborative work.

Background

Our participatory design approach follows from previous work in this area with children with disabilities, such as Frauenburger et. al's ECHOES project [3], Benton et. al's IDEAs project [1] and Hirano et. al's vSked [4]. Falcão and Price demonstrate the potential value of tangibles for children with intellectual disabilities [2]. A range of approaches to malleable control design can be seen in Smith et. al's 3D modelling controllers [7], Sato et. al's *PhotoelasticTouch* [6] and Weinberg and Gan's *Squeezables* [8]. NoiseBear is based on the *EchoFoam* system [5], a multiparametric malleable controller made with conductive foam, designed for use by computer musicians. EchoFoam provides high sensitivity by making multiple measurements of a single mass of pressure sensitive material, instead of using multiple separate sensors.

Sensor Design

NoiseBear offers significant design improvements over the EchoFoam system. EchoFoam uses a single conductive foam block with multiple electrical contacts. An Arduino controller measures the resistance between the network of contacts, which changes as the controller is deformed. This gives a complex but consistent output. Some significant changes were needed to adapt this system for use in assistive scenarios. Our principle requirement was for the controller to be robust enough for use by children, which meant making the controller wireless, and protecting the electronics from pressure and shock damage. These requirements naturally lent themselves to designing the controller in the form of a soft children's toy. This gave us two significant challenges; of making a small wireless circuit that was able to communicate with an iOS device, and of incorporating robust electro-textiles into the design.

Wireless Communication

Recent iOS devices include a BlueTooth 4.0 receiver; this low energy system was ideal for our purposes, and additionally allowed networking of multiple mobile computers and controllers. We chose to work with Bluegiga's BLE112 module, which has basic analog inputs and digital outputs, as well as networking capabilities. It was programmed to scan the pressure sensitive material and to broadcast the data to mobile devices at 40Hz. An issue arising from housing a bluetooth device in a conductive sensor was that the conductive material disrupted signal transmission. This meant that the controller needed to be designed with the antenna positioned outside of the pressure sensor.

Pressure Sensing

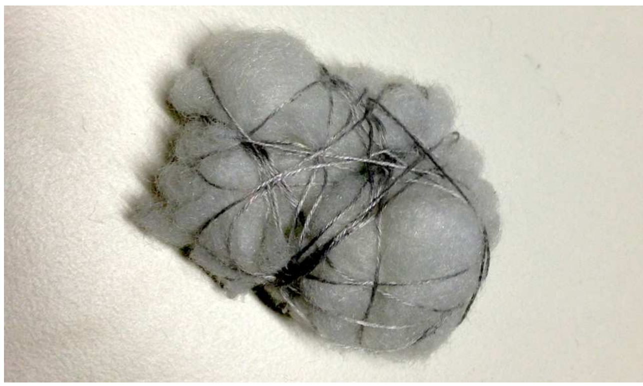

Figure 1: A Ball of Pressure Sensitive Stuffing

A woollen ball was knitted; this acted as the main body of NoiseBear, and as the main area for malleable sensing. Pressure sensitive arms and legs will be added in future iterations, along with a head to house the antenna. Various approaches to creating a pressure sensitive filling for this ball were tried, including using small lumps of conductive foam, and felting conductive thread with polyester cushion stuffing. We eventually settled on a simple approach of wrapping ping-pong ball sized lumps of cushion stuffing with conductive thread (pictured in 1) and placing them in the woollen ball. This created an arbitrary network of paths for current to flow through. As the ball was manipulated, the network changed, changing the resistance of the path between contact points. The approach was highly flexible, allowing many shapes of pressure sensor to be made. It also preserved the springy feel of cushion stuffing, making a realistic soft toy, and improving on the reactivity of EchoFoam's conductive foam as the material expanded to its default state more quickly.

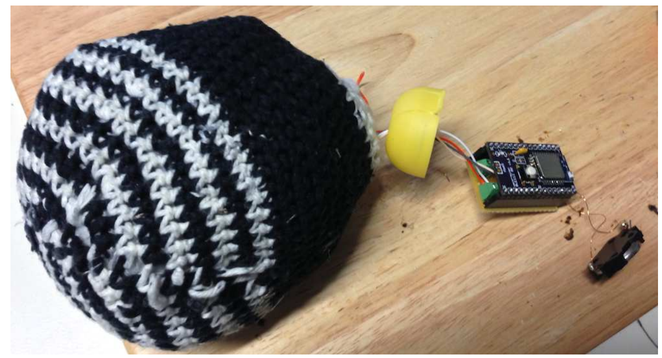

Figure 2: The Woollen Ball and Electronics

Conductive thread was used to create contact points on the inside of woollen ball, and these were wired into the BLE112 analog inputs and digital outputs. The sensor outputs sixteen continuous parameters which describe the current shape of the foam. Figure 2 shows the system with the circuit board sitting outside of the ball.

Interaction Possibilities

The sensor is highly sensitive to any type of deformation. These motions can be translated into continuous control streams, for example for the control of sound synthesis. They can also be interpreted as discrete gestures, for example detecting compression in specific areas of the sensor, or detecting a broad twisting or crushing motion. This allows the sensor to be used in a wide range of interactive scenarios. As the sensor is wireless and robust, it can be thrown around and knocked against surfaces. Several sensors may be used at once in group and collaborative contexts.

Design Iterations

NoiseBear's design is currently evolving as we iterate the design in workshops at UK special education schools. The workshop groups include children with limited mobility, learning disabilities and autism spectrum disorders. In these workshops, feedback is gathered from the observation of the children, along with direct feedback from the children and their carers and teachers. Smaller software changes are made during the sessions, while changes such as modifications of the physical design or larger software features are made between sessions. Along with focusing on design improvements for the sensor, we are experimenting with different mappings for the controller's output, and assessing the range of interactive scenarios in which this form of interface is most valuable. We are also exploring the system's potential outside of assistive contexts, for example in musical performance.

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