Deformable Controllers: Fabrication and Design to Promote Novel Hand Gestural Interaction Mechanisms

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Abstract
When compared to mainstream touch/button-centric devices, deformable devices enable a more organic and tangible way for human-computer interaction. This studio provides participants an opportunity to have hands-on experience in fabricating controllers that use various deformation inputs (e.g., bending, stretching), and promote novel interaction mechanisms using hand gestures. Participants will learn different types of deformation inputs and create their own sensors. They will work in groups to design deformable controllers using both the sensors they make in-session and/or pre-built ones, to afford novel hand gestural inputs beyond conventional touches and clicks. The main objectives of this studio are to facilitate exchange of experience in fabricating deformable sensors/materials, and to foster creativity in using such controllers as inputs with hand gestures.

Author Keywords
Deformation; input devices; fabrication; prototyping; hand gestural inputs; tangible interaction.

Introduction
Recent advancements in sensing technologies have enabled user input modalities beyond touches and

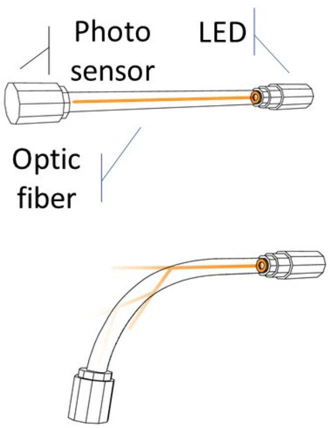

Figure 1. Illustration of an optical-based bend sensor. When bent, some of the light emitted from the LED escape, thus reducing the intensity of light reaching the photo sensor end.

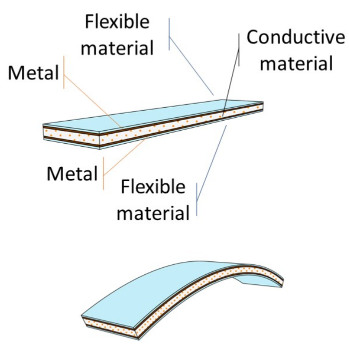

Figure 2. Illustration of a resistance-based bend/pressure sensor. When bent, the conductive material in the middle is compressed, thus reducing its resistance.

button-clicks on rigid surfaces, thereby creating opportunities for more articulate interactions. One such modality is deformation, involving user-driven changes of an object's shape, such as bend, squeeze, and stretch (e.g., [5,7]), as an input language. This form of input often leads to more naturalistic input mappings [11,12], especially due to its tangibility and intrinsic tactile feedback, and is useful in various contexts (e.g., games [10,11], interface navigation [2] and content creation [1,3]).

The increased availability of deformation sensors both commercially and in the DIY community [17], and their customizability in shape [13], have allowed researchers and designers to focus on how these deformable devices can better mediate human-computer interaction through hand gestures. Yet, as a relatively new interaction paradigm, there is still little knowledge in how they can impact our current ways of interacting, such as grip patterns and interaction metaphors.

Studio Proposal

We propose a studio that hosts 15-20 participants exploring the impact and potential brought forth by this new form of tangible interaction. We have designed the studio to educate our participants on deformable interactions, and encourage them to experiment with this new paradigm to create input mechanisms.

Participants are expected to be comfortable with crafting and have a basic knowledge of using Arduino (e.g., programming, circuit board wiring), and should bring a laptop with the Arduino IDE installed.

Studio Topics to be Covered

We intend to cover a variety of deformation sensors, and provide hands-on experience to build two of them.

Making Deformation Sensors

We present a brief history and basic working principles of deformation sensors, followed by a crafting session where participants make their own sensors. We selected two types of sensors that require no special equipment and use electronic components that are easily available, to complement previous work and workshops discussing printed circuitry or conductive ink [9,13,16]. Figures 1 & 2 show the basic working principle of these sensors that participants will be making at the studio.

Optical-based Bend Sensors – by measuring changes in the intensity of light passing through an optical fiber, one can determine the degree of bend (Figure 3). This method is inexpensive and robust [6], and is used in several prior projects [1,4].

Resistance-based Bend/Pressure Sensors – by measuring changes in resistance of a conductive layer, one can determine the degree of bend as well as amount of pressure (Figure 4). This method is a popular choice within the DIY community [18] due to the availability of the composing materials and ease of making (e.g., plastic sheets, copper tape, velostat).

Assembling Deformable Controllers

We demonstrate how multiple deformable sensors can be assembled into a controller, using prototyping tools such as foam boards, 3D printing, and silicone molding. By assembling sensors in specific ways, it is possible to detect complex deformations such as directional bends

Figure 3. Optical-based bend senor. (Top) Finished sensor wrapped to prevent light leakage. (Bottom) Internal components: LED, optic fiber, photosensor

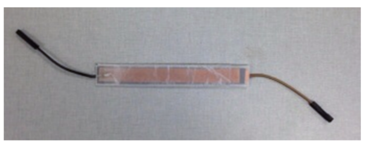

Figure 4. Resistance-based bend/pressure senor.

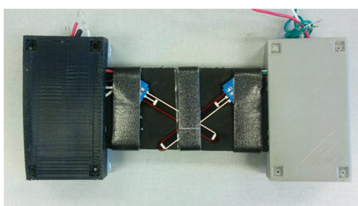

Figure 5. Placement of two bi-directional sensors in a cross pattern to detect bends and twists.

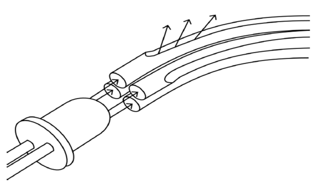

Figure 6. Placement of four optical-bend sensors along the stylus shaft to detect bend orientation [1].

and twist. For example, Bendtroller [11] puts two bi-directional bend sensors in a cross pattern to detect up-/downward bends and twists (Figure 5), FlexStylus [1] puts four optical bend sensors along the pen's shaft to detect bend orientation (Figure 6).

Designing for Novel Hand-Gestural Inputs
Sensing deformation allows novel interaction when the interactive device affords novel inputs. We will lead a design exercise that guides participants to create interactive controllers for various applications that use deformation as novel gestural interactions.

We will use games as a warm-up exercise and lead participants to first design gestural inputs using one or both hands, and/or wrist and arm movements inspired by in-game actions. For instance, what is a one-handed gesture that embodies the action of jumping? Next, participants will design hand-held devices with form-factors and affordances that support these interactions. Participant are then free to continue using the provided games, or other applications of their choosing.

Finally, we will have a demo session where the participants present their designs to each other. Presenters will have the chance to receive feedback from each other, and further improve their designs. We also invite participants to propose relevant discussion topics based on their own experience with deformable devices. If possible, the demos can also be presented to the conference attendees during the demo session.

Studio Learning Goals/Discussion Objectives

The first objective of the studio is to provide participants a platform to share resources and exchange experience in deformable sensor/material fabrication. Researchers have proposed novel ways to fabricate devices that detect various deformation types [4,9,13,14,15], and it is important to examine the strengths and weaknesses of these methods, such as ease and cost of fabrication, accuracy, and durability.

The second objective is to foster creativity in using deformable devices as input controllers harnessing the wide range of hand gestures. Besides fabrication techniques, researchers have also elicited interaction languages and metaphors with deformable devices [8], and explored their applicability in various context [1,2,3,10,11]. They have found that these novel input mechanisms lead to enjoyment and expressiveness not found in standard touch/click inputs, mostly due to better support for natural hand gestures [10,11]. Having a session to design controllers to promote hand gestural interaction will help advancing research and development of deformable interactions.

Finally, the third objective is to better understand how designers approach the creation of deformable interactions and controllers, in moving beyond recreating touch/click inputs in deformable devices. We aim to observe how researchers embody action and metaphor in the conceptualization of an interaction or a device. Our end goal will be to run this workshop with different participants and report our observations as design guidelines for such devices.

The experience shared and the ideas formed in the studio are directly relevant to Tangible Embedded and Embodied Interfaces, as evidenced by much related work in the conference proceedings (e.g., [10,12,13]).

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