TEI 2016 Studio: Inflated Curiosity

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Abstract
This studio introduces methods of making and controlling inflatable fabric. We provide materials and simple fabrication processes that enable designers to rapidly prototype inflatables with simple hinging transformations or texture change. Furthermore, we introduce a customized hardware that enables designers to rapidly prototype inflatable fabric. The goal of this studio is to provide hands-on experiences of designing inflatable fabric as shape-changing materials and research on shape-changing artifacts. Basic knowledge of programming in Arduino is required. Participants should bring their own laptop for the studio.

Author Keywords
shape-changing interfaces; textile; pneumatic; soft shape-change; wearables; haptics

ACM Classification Keywords
H.5.m. [Information Interfaces and Presentation (e.g. HCI)]: Miscellaneous; See http://acm.org/about/class/1998/ for the full list of ACM classifiers. This section is required. []

Introduction
Recently, soft shape-changing materials are gaining increasing attention in the fields of material science, robotics, and human-computer interaction (HCI). Especially in the context of HCI, soft material structures are useful as they

conform naturally to the human body and hence suggest applications including, but not limited to, tangible user interfaces [3], organic user interfaces [1] and wearable computing. Previous work in HCI has illustrated fabrication methods of soft materials and demonstrated the ability of these structures to change their shape and stiffness as well as sense human interactions. However, the currently used materials are limited to rubber/plastic materials which diverges from most wearables, which are typically composed of soft textiles.

We present fabrication processes and materials that allow designers to quickly create soft inflatable structures without going through the usually required, long-lasting steps such as molding/casting. It also expands designer's material choices when creating soft shape-change interfaces. Furthermore, we provide an Arduino-based programmable electromechanical toolkit - called Pneuduino - for controlling and sensing air pressure. The toolkit allows easy creation of air logic, control of inflation/deflation, and integrates pressure sensing capabilities. While there are few open-source hardware project concerned with pneumatic control [2], their lack of modularity and bulkiness makes them unfit for rapid prototyping.

Inflatable Materials

The workshop introduces Thermoplastic Polyurethane (TPU) coated textile as the material for inflatable structure. TPU has been widely used in industry applications for creating heat sealable sheets and additionally creates an airtight layer on any material it is laminated with. It can be easily applied on various materials such as cotton, leather, nylon, silk and paper. For the studio, we will bring TPU-coated cotton and nylon fabric with different color and pattern as materials resource. We will also provide TPU-coated elastic and non elastic fabrics for participants to try out and explore their different shape-change behaviour.

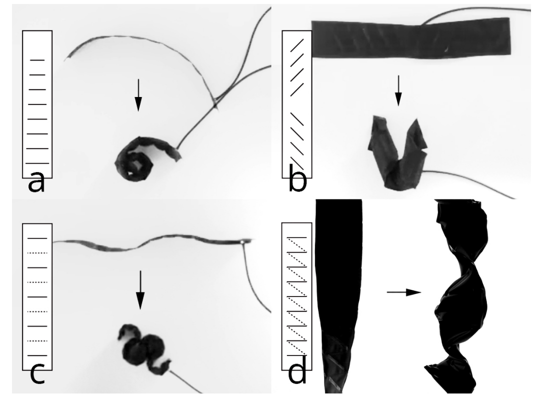

Figure 1: Inflated nylon fabric with different bending behavior.

In the studio, the inflatable textiles are fabricated via heat sealing. The machine utilizes heat and mechanical compression to seal two pieces of fabric. This process creates a gentle "folding crease", which slightly bends the fabric to the direction of the heating element. As the airbags are inflated, the compression force occurs and the textile bends in the direction of the folding crease. This convenient mechanism allows us to fabricate pneumatic foldable structures similar to creating origami with mountain and valley folds. The bending of each airbag can be determined by choosing which side of the two fabrics is sealed.

With the mechanism described above, we are able to create a series of shape-change primitives. Our approach can create strips that bend and curl, similar to the transformations demonstrated in PneUI [7]. However, creating inflatable fabric does not require long compositing and molding/casting processes. Furthermore, one can create strips that have hinges bending in alternating directions which enables the fabrication of serpentine and helix shapes. By laminating elastic fabric with an array of small air chambers, we can also create a tunable surface texture (Figure 3).

As shown in previous research in soft robotics and HCI, air pressure can be used to sense the amplitude of shape-change [4], external shape-deformation [7, 6] and can even be used to infer a range of human interactions [7, 5]. For each of these applications the used materials are a decisive factor for the quality of sensor data. By being able to utilize elastic and non-elastic fabric, we can apply some of these techniques to shape-changing inflatable fabric.

Pneuduino

The Pneuduino platform is an electromechanical modular toolkit that enables easy computational control of air pressure and rapid design of interactions with inflatables. The system consists of three different kinds of hardware modules that can be easily connected and disconnected via magnetic connectors and combined on demand (Figure 2).

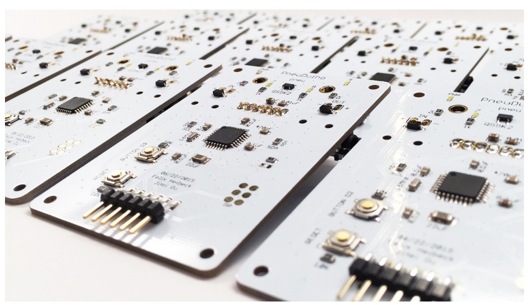

Figure 2: Master and slave boards of Pneuduino.

The most important of the modules is dedicated to the full pneumatic control of one airbag. It comprises two pneumatic valves (S070C), an air pressure sensor (MPXHZ6400), and an ATMega328P microprocessor. Each module also includes additional indicator LEDs to support a transparent behavior. An additional module can be used to provide simple user input with a simple button, potentiometer, and capacitive touch. This module proved useful for testing and adding additional interactivity to the produced artifacts. Finally, one module is designed to control the behavior of the modular system and supply it with power. The board features an ATMega32u4 microcontroller that allows easy control of the systems behavior with the Arduino programming environment. To support the toolkit's functionality, we provide an Arduino library that simplifies accessing each moduleâĂŹs functionality and makes it easy to program complex material behavior without cluttered code (FIGURE). In our design and implementation of all aspects of Pneuduino, our motivation has been to create a prototyping experience that has allows easy entry for non experts while providing the means for experts to create sophisticated artifacts.

Studio Proposal

The goal of this one day, hands-on studio is to introduce pneumatically driven shape-change fabric including our developed fabrication techniques and the Pneuduino toolkit to the researchers, designers, and expert practitioners who attend the TEI conference.

The topics of shape-changing materials for tangible computational artifacts and its integration with a variety of textiles and other materials, should be highly relevant to the TEI community. We believe that attendees would find the practical studio an educative and rewarding activity. Feedback from attendees would be directly used for refinement of the Pneuduino platform. In addition, the experience should form the basis of interesting discussion and reflection on the future of shape-changing artifacts and design of interactions with these novel interfaces.

Figure 3: Haptic glove. Surface texture change of the fabric gives one a sensation of touch.

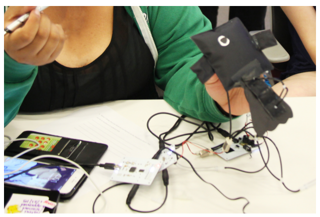

Figure 4: Soft robotic fish. Robotic fish that can move its fin. Designed by participant in prior Pneuduino workshop

Studio Format & Topics

We propose to organize a hands-on studio, where participants are guided through the process of designing, fabricating and programming a fully functional shape-changing artifact with inflatable fabric.

Attendance would be limited to 12 participants, grouped into 3 teams. In order to maximize the productivity of the studio, the ideal team configuration would include one person with some experience in Arduino programming. The remaining team members would ideally come from a complementary background - such as industrial design, art or education.

During the morning participants will be introduced to the concepts, fabrication methods and tools of inflatable fabric. Participants would then be asked to brainstorm a new concept around a specific theme. The rest of the day would be spent with participants designing and fabricating their concepts. Our goal is to allow participants to fabricate and program customized shape-changing artifacts. We aim to provide the required tools and materials for fabrication.

Expected Outcomes

Participants are encouraged to build prototypes within these categories: Haptic devices; shape-change garments; interactive toys; soft robots; kinetic installations. Alternatively, participants are welcome to situate the shape-change fabric in other interactive systems such as projection, sounds installations. We will provide necessary guidance to ensure each group will have a tangible result within the one day workshop.

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