Prototyping Interactive Fluidic Mechanisms

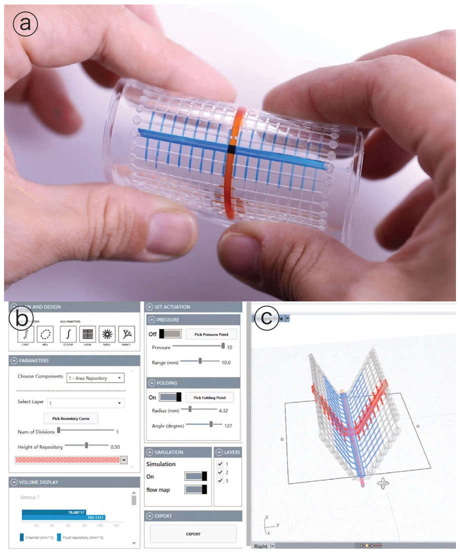

Figure 1: Design tool and UI for prototyping of interactive fluidic mechanisms. (a: example of a working prototype with folding input. b: The User Interface and design tool for modeling the fluidic mechanisms, implemented in grasshopper environment. c: The simulation of fluid flow and color according to input parameters in b.)

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ABSTRACT

In this hands-on studio we introduce a method of designing and prototyping fluidic mechanisms that utilize the flow as both deformation sensors and displays. A fabrication process and the featured materials will be provided to allow participants to design and prototype self-contained fluidic channels. These channels are designed to respond to mechanical inputs such as deformation and pressure with flow and color change. We will introduce a specialized software plugin for design and flow simulation that enables simple and rapid modelling with optimization of the fluidic mechanism. The goal of

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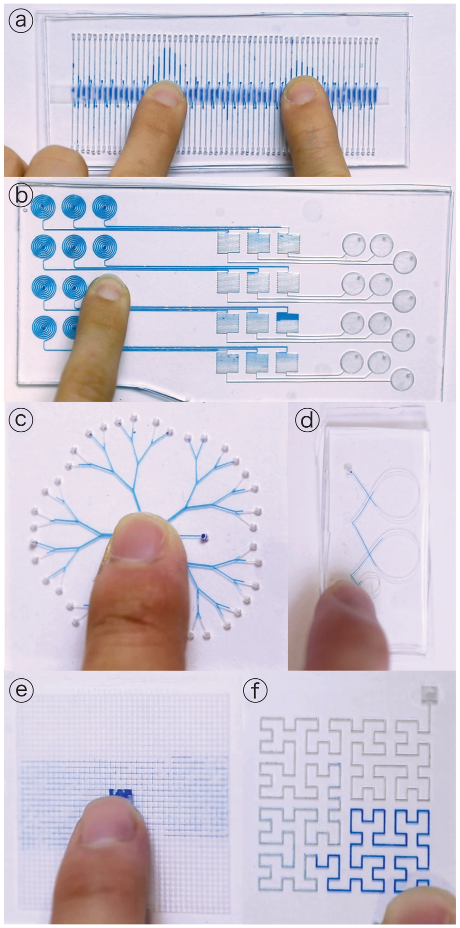

Figure 2: Fluidic channels primitive geometries. (a: Linear slider, b: Spiral fluidic transmission array, c: Branching, d: Intersecting free-line, e: Mesh, f: Fractal.)

this studio is to provide researchers, designers and makers with hand-on experience in designing fluidic mechanisms, coupling shape-change (i.e. deformation input) with displayed response. Our method allows participants to explore meaningful applications such as on-body wearable devices for augmenting motion and animating objects such as interactive books, lampshades and packaging.

CCS CONCEPTS

• **Human-centered computing → Interaction design process and methods**.

KEYWORDS

Programmable Materials; Tangible User Interface; Fluidic Mechanisms; Microfluidics; Prototyping

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INTRODUCTION

The ability of fluidic devices to both sense and display has been gaining interest in the fields of soft robotics, programmable materials and HCI [1, 4, 5, 7]. Researchers present various approaches in terms of the driving force of the fluid and sensing method such as digitally controlled pumps [2] and image analysis [5]. However, rigid parts and tethered devices in micro-fluidics has been one of it's limitation. We introduce the method and tools for creating self-contained (i.e. no battery) passive smart sensors: responsive fluidic mechanisms that change color according to deformation and allows users to directly interact with the displayed information. Inspired from recent work in programmable shape change and meta-materials in HCI [3, 5, 6, 9] in soft robotics, and microfluidics [4, 8], this approach allows the coupling of shape and color change, and by that, the opportunity to create new fluidic based tangible interactions.

WORKSHOP PROPOSAL

We propose a hands-on workshop, where participants will be guided through the creative process of planning, designing, simulating and fabricating functional deformable *fluidic mechanisms* (Figure 1). In this studio we will provide participants with previously established fluidic channels primitives (Figure 2) and a fabrication pipeline to allow attendees to plan and fabricate their concept and design using Polydimethylsiloxane (PDMS) as the substrate material. This method allows participants to iterate on the design, refill the fluid, connect between different designs and create multi-layered structures.

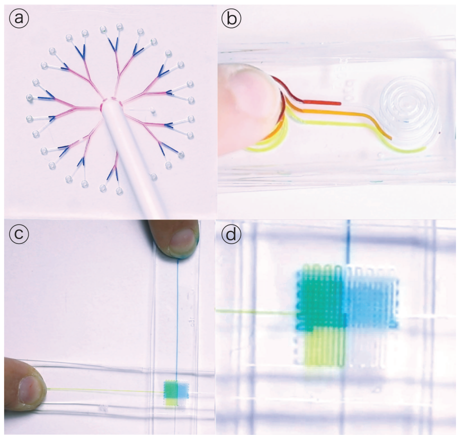

Figure 3: Color primitives. (a: Mixing colors. b: Color to pressure gradient. c: Overlaying colors. d: Overlaying colors - close up.)

Studio format

attendance will be limited to 12 participants divided into 6 teams. The ideal team will have complementary skill-sets with experience in 3D modeling or 2D vector editing software such as Adobe Illustrator or Rhinoceros and Grasshopper, and basic experience in design or art.

SCHEDULE

The workshop is composed of 3 phases. In *Phase 1*, we will give an introduction to the relevant topics and examples in the fields of HCI, soft robotics and microfluidics. In addition, we will introduce the process of planning and designing *fluidic mechanisms*, in particular we will cover the variations of primitives for flow response and i/o that can be used. We will also discuss different considerations and optimization of the fluidic mechanisms such as control of *sensitivity* (i.e. flow response time), dimensions, and display parameters. During *Phase 2*, participants will gain hands-on experience using pre-made examples of simple fluidic mechanisms. We will explain the flow-logic of these mechanisms and practice techniques such as layering, sealing, and injection. Then, participants will brainstorm their own concepts with a specific theme or application in mind. *Phase 3* will be dedicated to fabricating, prototyping and iterating on the concepts.

TOPICS TO BE COVERED: INTERACTIVE FLUIDIC MECHANISMS

This studio will introduce methods for design and fabrication of fluidic mechanisms. The substance material that we will use is PDMS film. We chose this material because it is transparent, flexible, stretchable, and self adhering. The flow mechanism is simple and driven by mechanical input such as pressure and deformation (i.e. bending, stretching, twisting). By overlaying more than one layer, or by connecting between more than one layer, attendees will learn how to control the color change and display such as overlaying colors, mixing colors and creating a color gradient (Figure 3). These mechanisms could be designed to provide both reversible and irreversible feedback.

We will introduce a specialized design tool (Figure 1) for modeling, simulation and optimization of the flow in non-intersecting, closed fluidic mechanisms. For this tool, we have created several primitive channel patterns that allows the rapid modeling of relatively large areas as well as fine tuning parameters of the geometry. In this tools designers can input the folding or pressure parameters and display a simulation of the flow and color change respectively.

Expected outcome

We will present applications examples that we previously prototyped (Figure 4). Participants will be encouraged to prototype within the following categories: on-body wearable application for augmenting body motions and animating objects for interactive design (e.g. lampshade, an interactive book, and

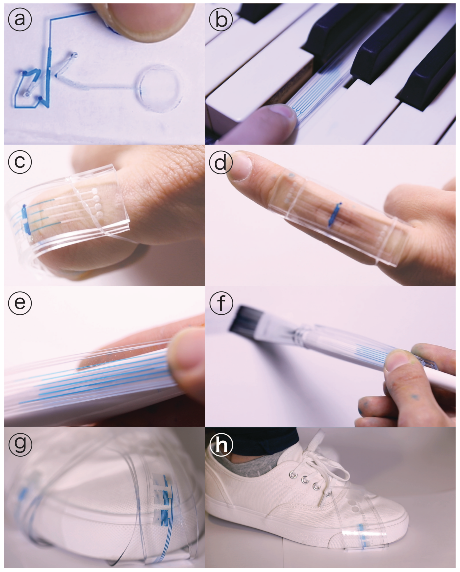

Figure 4: Examples for applications of fluidic mechanisms. (a: Text book animating the sequence of writing a Chinese character. b: Visualizing pressure applied on a piano key. c: Folded fluidic mechanism on-finger. d: Unfolded on-finger fluidic mechanism. e: Close up, brush handle. f: Visualising pressure on a brush while drawing. g: Shoe application close up. h: Fluidic transmission of the pressure from under the sole to top of the shoe.)

package design). We also welcome artistic projects, focused on the aesthetics and design details of flow patterns, colors and textures. We will provide various types of inks including different colors, fluorescence and thermochromic. We will provide the guidance for each group to have a tangible working prototype by the end of the day that we will video document.

LEARNING GOALS AND DISCUSSION

Participants will gain hands-on experience with the design and prototyping considerations that one has to take into account when designing fluidic mechanisms. Furthermore, we aim to inspire researchers and designers to discuss and prototype fluidic mechanisms as a new medium to Tangible and Embodied Interactions. We would like to stimulate meaningful discussions regarding the future of fluidic based mechanisms: how could we utilize fluid behaviour with internal structural engineering to create new passive smart sensors? How could these sensors function as tools in everyday applications and scenarios to enable new experiences?

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