Laser-Cut and 3D Printed Semi-Solid Surfaces as a Fabrication Technique for Developing Shape-Changing Displays

Aluna Everitt, School of Computing and Communications - Lancaster University, UK

***Abstract*— Semi-solid surfaces are 3D fabric-like materials that combine light elastic textiles with rigid support to form more dynamic three-dimensional structures. This work presents a design approach for rapid fabrication of high fidelity interactive shape-changing displays, using laser-cut and 3D printed, dynamic physical polygonal surfaces. First, we establish the design and fabrication approach for generating semi-solid reconfigurable surfaces. Secondly, we demonstrate the generalizability of this approach by discussing feedback from a design session to develop an application for a volcanologist. Finally, we reflect on the content generated to understand if this fabrication approach is effective at representing intended output based on a set of user defined functionality requirements**

I. Introduction

The majority of current shape-changing displays are one-off prototypes that are either restricted to linear pin-based or continuous surface outputs. These hardware systems limit the forms of data and information encoded within them due to the lack of resolution and dynamicity in the surface configurations, for both static and motion-based representations. Complex polygonal structures, meshes, or curved contours are difficult to construct. Semi-solid surfaces support a low-cost implementation method that combines the benefits of pin arrays and cloth surfaces. The combined flat solid panels and elastic material used enhances the design space for shape-changing displays due to its capability to represent more complex physical structures, such as curved contours, in comparison to traditional shape-changing displays.

The overarching goal of this work was to develop an approach for rapid prototyping high-fidelity dynamic shape-changing displays with interactive capabilities. In order to develop a more generalizable contribution, we focused on reducing the design and construction time and technical requirements needed to design and generate these dynamic physically reconfigurable hardware systems.

II. Design and Fabrication Approach

Figure 1 breaks down the fabrication technique for developing a shape-changing display using a laser cut semi-solid surface[1]. (1) Data Segmentation: Input data and interface designs are digitally segmented to generate a polygonal mesh of the semi-solid surface. (2) Fabrication: Polygonal mesh is laser cut on a thin solid material such as polypropylene. (3) Assembly: Polygonal mesh is attached to durable spandex to allow elasticity. (4) Visualization Design: Establish visual interface features. (5) Height Design: Identify variables from the data to represent surface movement and position actuators below the display. (6) Interaction Control: Implement interactive features of the display (e.g. gesture recognition, buttons).

Figure 1: Design and fabrication approach breakdown.

[1] Everitt, A., & Alexander, J. (2017, June). PolySurface: a design approach for rapid prototyping of shape-changing displays using semi-solid surfaces. In Proceedings of the 2017 Conference on Designing Interactive Systems (pp. 1283-1294). ACM.

The core fabrication concept is to use solid panels that are either laser cut and fused onto a flexible sub-surface such as spandex (Figure 2A-C), or are 3D printed and interlinked during the printing process (Figure 2D). These deformable continuous surfaces enable fluid movement and change in surface geometry when actuation force is applied. Each panel is rigid, but in aggregate they behave as a continuous surface. Unlike cloths and fabrics, previously used for shape displays, these surfaces can adapt in fluidity or rigidness based on their designs. By fusing or interlinking solid panels we can produce semi-solid surfaces that dynamically change in physical geometry and provide sufficient flexibility and rigidness to allow surface reconfiguration control where required.

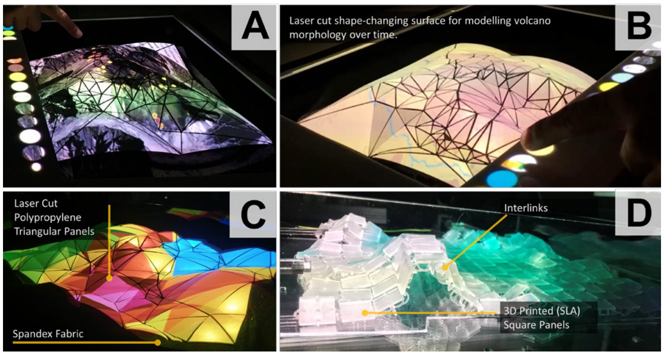

Figure 2: Semi-Solid laser cut surface for modeling a shape-changing volcano morphology (A-B). Breakdown of laser cut semi-solid surface structure (C). A 3D printed surface used to show oceanography wave simulations (DC).

Figure 2A-B is a shape-changing display for modeling volcano morphology over 95,000 years. It was co-designed with a volcanologist and build within 5 days using the fabrication technique described above. Figure 2C adopts a 3D printed semi-solid surface to physically simulate sea waves and oceanography data. The visualizations represent realistic sea conditions, e.g. white color represent foam on the waves, and blue represents the sea. I will be discussing the design and fabrication technique for implementing these displays as well as demonstrate the laser cut and 3D printed semi-solid surfaces used as an emerging fabrication technique for shape changing systems.

During this workshop I will be discussing the following:

1. The conceptual approach for designing and developing shape-changing displays using dynamic polygonal surface structures.
2. Laser-cutting semi-solid surfaces as a low-cost implementation method (see Figure 1) for rapid high-fidelity prototyping of shape-changing displays and interactive interfaces.
3. Implementing the approach to generate an interactive shape-changing display for a specific application (see Figure 2A-B).
4. Limitations and future directions of this fabrication technique applied to shape-changing displays using 3D printed interlinked surfaces (see Figure 2D) and a range of actuation technologies.