JAMES DYSON FOUNDATION UNDERGRADUATE BURSARY

Distributed Sensing in Soft Robotics

ACTIVITY REPORT

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1 Introduction

The field of Soft Robotics is relatively new. This means that a lot of the cutting edge work being done still involves a heavy amount of prototyping. One of the materials used to produce the soft bodies of these robots is called Ecoflex. This is a soft silicone elastomer, produced by the company Smooth-On. It comes shipped as 2 parts: part A and part B, which, when mixed together, will cure into a soft, highly elastic material. Ecoflex was one of the main materials that I used in my project, and was also the focus of this outreach activity. The students were introduced to the concept of soft robotics by letting them produce various things using Ecoflex. They were first told to come up with their own shapes for molds, allowing them explore their creativity. Once these molds were cast, they were given molds to make jointed fingers, which were 3D-printed in advance.

2 Activities

Materials:

- Cardboard
- Hot melt glue
- Packing tape
- Scissors
- Ecoflex 00-35 (cures in 5 minutes)
- Mixing cups
- Stirring sticks (tongue depressors)
- Safety goggles
- Latex-free gloves
- Paper towels

2.1 Making cardboard molds

The students were first tasked with creating their own molds out of cardboard. Ecoflex would then be cast into these molds to produce any shape that the students could come up with.

The students would think about a design for their molds and then cut out all necessary cardboard parts to make that mold. All cardboard parts that needed to come into contact with Ecoflex were then covered in packing tape to allow the Ecoflex to easily release from the cardboard. Next, the students assembled their molds using hot melt glue. Any remaining gaps in the mold were then sealed using more hot glue, to ensure no Ecoflex would leak out during the curing process.

After each pair of students completed their own mold, they were given help to cast the Ecoflex into their molds. Separate mixing cups with part A and part B were prepared ahead of time, to allow for easy pouring. (Rather than pouring directly from the large buckets Ecoflex is supplied as.) Students were told to pour equal volumes of A and B (total amount depending on the size of the mold) into a clean mixing cup. The contents of the cup were then mixed quickly and vigorously, to combine A and B as thoroughly as possible, as quickly as possible, before the mixture begins to cure. About 30 seconds later, the contents needed to be poured into the mold as quickly as possible, while making sure every part of the mold is reached, without trapping any air.

(a) **(b)** **(c)**

Figure 1: The production of a cardboard mold. **(a)** A cardboard base for the mold, covered in packing tape. **(b)** The walls for a simple rectangular mold, covered in tape to seal them off. **(c)** The assembled rectangular cardboard mold.

2.2 3D-printed molds

After they had successfully cast their own molds, the students were given a 3D-printed finger mold, that was prepared ahead of time. After assembling this correctly and sealing all gaps using hot glue, they were once again helped with pouring Ecoflex into the finger

mold, following the same procedure as before. The Ecoflex needed to be poured as a thin stream into the middle of the finger mold, to ensure the liquid would not trap any air bubbles. After both molds became fully set, they were disassembled and the soft shapes revealed.

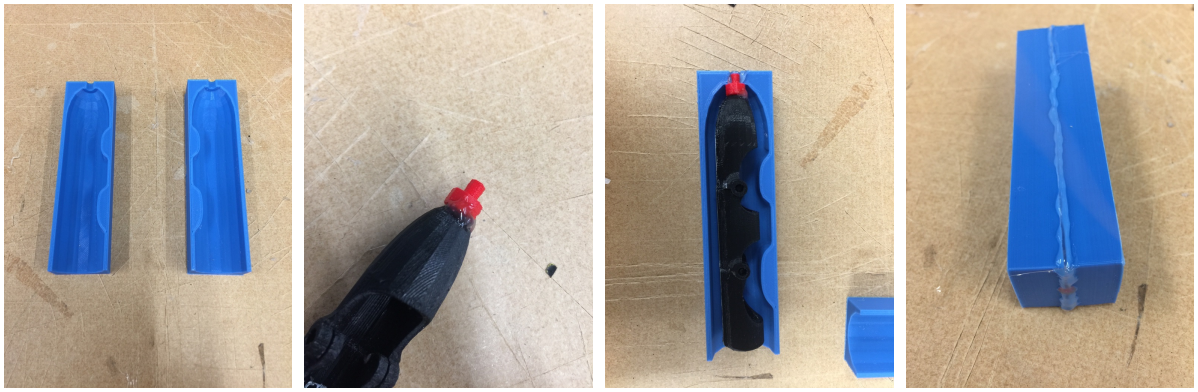

Figure 2: Assembling and sealing a 3D-printed finger mold. **(a)** The outer mold parts, to produce the external shape of the finger. **(b)** The tip of the inner finger joint, with the alignment pin glued into place. **(c)** The finger joint correctly aligned into the outer mold body. **(d)** The fully assembled and sealed finger mold.

3 Outcome and review

In the first activity, most students successfully produced cardboard molds, and were able to then produce their desired shape out of Ecoflex. Some students were even seen drawing up plans for their cardboard molds, which they then carefully translated onto the cardboard. Some asked for rulers, which was definitely great to see, as they were approaching this task very methodically, rather than simply 'eyeballing' the whole process.

There were also some problems, however. For example, one group of students did not fully understand the interaction between the cardboard, tape and Ecoflex, and covered the outside of the mold with tape. Another group also made an extremely large mold, not taking into account the amounts of Ecoflex that I was demonstrating the exercise with.

The finer details of creating molds were also not really picked up by many of the students. For example, they did not realize that hot glue could just be used from the exterior of the molds. Putting glue between two contact surfaces is actually unnecessary, and would often lead to imprints from excess glue in the final product.

The second activity was more successful, as the molds were standard. Most students quickly understood how to assemble the molds, and, with some extra information here and there, were able to produce correctly assembled, and fully sealed molds.

However, the main problem with the exercise was time. Having the students complete both of these activities in the allotted 30 minutes was clearly not realistic. The activity resulted in some students only being allowed to cast a single mold (either cardboard or a finger.) If this activity were to be repeated in the future, I would recommend to only do one of the two activities described above.

Overall, though, I believe the activity was a success. Students seem to be very entertained by the soft material and the soft jointed fingers they had produced.