Foldable Emotive Robotics

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I. INTRODUCTION

The integration of robotics into society is limited by many design considerations and little work has been done on the social consequences of emotive movements, materiality and touch-ok indicators in soft, interactive, non-humanoid robotics.

In order to assess human response to social emotive capabilities, our research focuses on the construction of a rolling robot with folding, spike-shaped actuation. We are interested in exploring how different shape states can indicate whether a robot may be acting 'friendly' or 'threatening'.

Here we describe the fabrication and testing of an origami-based actuator that will later be applied to a larger system. Our initial actuator design came from a survey of foldable structures by Nojima [1] that were inspired by organic systems. Because of the necessity for human-robot interaction and the potential for touch, we incorporate soft materials, such as silicone, into our design.

II. BACKGROUND

Shape change in robotics provides a varied range of interaction possibilities. Due to their space efficiency, origami robots can be used in situations with constrained proportions such as Miyashita et. al.'s robot that assists in healing stomach wounds [2]. Robots are also being tested for their usefulness in emergency situations [3], and future work in the area may find both shape flexibility and emotive capabilities to be a boon.

Non-verbal movement constructs in human interactions have been mapped and analyzed using Laban Efforts. In a 2016 study, these features were applied to both the Nao and Keepon robots for simple dance and search behavior and found to be, in general, legible to improve overall interaction [4].

However, very little work has been done combining origami and emotive capabilities in robotics.

III. FABRICATION

While a number of origami robots exist, very few focus on softer methods of actuation. Our actuator design came from a survey of foldable structures [1], and was chosen for its ease of construction. The design was reformatted into a 4 cm diameter cone, and fabrication was attempted in different materials, finally settling on 20lb paper. Thicker materials negatively affected the initial flat height of the paper cone and its ability to change shape.

To construct, the flat design was folded and the edges connected by paper glue. A base of 60lb paper (a strain limiting layer for later actuation) was applied to the cone. Fully flattened, the original cone had a height of 0.5 cm. The extended conical structure was then dipped in Ecoflex 00-30, and excess silicone was allowed to drip off of the structure. Future work will refine the application technique. A fully cured cone was then mounted in a mold and 10 mL of silicone was added to create a square base for the conical structure.

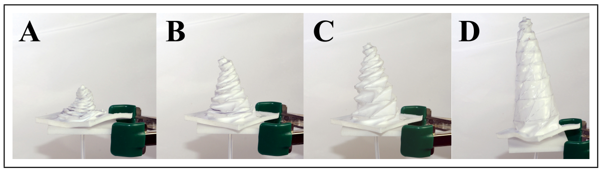

Fig. 1. Expansion of flat cone to fully inflated. (A) Show constricted height of 2.5 cm, (C) shows inflated height of 10 cm

IV. CHARACTERIZATION

The current paper actuator design, had an initial 'flat' height of .5 cm. However, the addition of the silicone to the paper limiting layer increased the original 'flat' height of the cone to 2.5 cm. When inflated, using a volume of approximately 60 mL of air, the cone rose to a height of 10 cm.

An example of the actuation process can be seen in Figure 1, where the cone starts in its vacuumed, 'flattened' state, and is inflated to its fully filled position.

The actuator was fairly robust compared to the original paper design, and when bent out of shape or crushed, the cone was typically able to reform back into its original configuration in a few inflation and deflation cycles.

V. FUTURE WORK AND CONCLUSIONS

Future work includes streamlining the manufacturing process for the soft origami actuators as well as minimizing the change from uncoated height to coated. We intend to characterize and determine movement capabilities based on the strain and compression that the actuators can handle. On a larger scale, we will apply our actuators to a robotic system and test the influence of patterns of movement on the human response, effectively determining the legibility and impact of non-verbal emotive capabilities in human-robot interactions.

REFERENCES

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