In-Situ Design and Manufacturing Tools for Micro-Aerostats in Soft Robotics

Context

Lighter than air structure are usually quite large because of the volume/surface ratio. In HCI most DIY processes to create shape changing surfaces are limited by the size of the machines or by their precisions [1]. In this context a process combining both is relevant to create device floating and interacting with users and environment.

Objectives

The end goal of this thesis is to create new aerostatic devices that could interact with users and their environment. The first step toward this goal is developing the tools and process needed. With such a device there is a new design space to explore.

References

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2. Siéfert, E., Reyssat, E., Bico, J., & Roman, B. (2020). *Programming stiff inflatable shells from planar patterned fabrics. Soft Matter*, 16(34), 7898-7903.
3. Jennifer Pulley, J. P., Dr. Edgar Waggoner, E. W., Dr. Jaiwon Shin, J. S., Tom Brooks, T. B., Mehdi Khorrami, M. K., Heather Maliska, H. M., & Tom Rigney, T. R. (2014, 3 février). *NASA X : Revolutionary Evolution - ERA*. NASA. Consulté le 1 février 2022, à l'adresse https://www.nasa.gov/nasax/nasa-x-revolutionary-evolution-era
4. Furumoto, T., Kasai, T., Fujiwara, M., Makino, Y., & Shinoda, H. (2021, October). *Midair Balloon Interface: A Soft and Lightweight Midair Object for Proximate Interactions*. In The 34th Annual ACM Symposium on User Interface Software and Technology (pp. 783-795).
5. Jaramillo, J., Lin, A., Sung, E., Richter, I. J. H., & Petersen, K. (2021, July). *Mobile, Inflatable Interface to Support Human Robot Interaction Studies*. In 2021 18th International Conference on Ubiquitous Robots (UR) (pp. 320-325). IEEE.
6. Gohlke, K., & Hornecker, E. (2018, October). *A stretch-flexible textile multitouch sensor for user input on inflatable membrane structures & non-planar surfaces*. In The 31st Annual ACM Symposium on User Interface Software and Technology Adjunct Proceedings (pp. 191-193).

Creating Balloons that Change Shapes to Interact with their Environment

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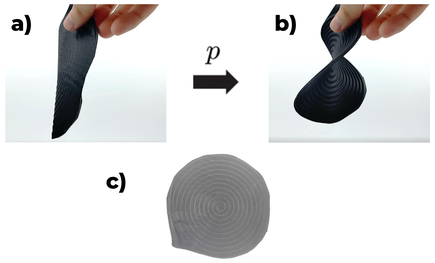
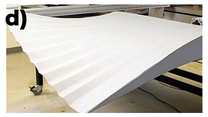
Principle

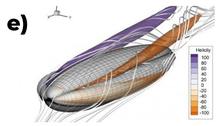


Inflating a) channel patterns obtained by heat-sealing superimposed flat quasi-inextensible fabric sheets induces an b) anisotropic in-plane contraction. The c) channel patterns encode the shape of the deployed structure [2].

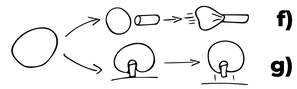
Applications



Wing morphing from the NASA Dryden Laboratory [3]. The main objective is to rethink the moving parts of the wings.



Concept of a dirigible with a shape changing envelop from A-NSE. It is thought to improve aerodynamics



Changing the shape could create a variety of application ranging from d) & e) improvement in flight efficiency to new capabilities such as f) slipping through tight spaces or g) grasping.

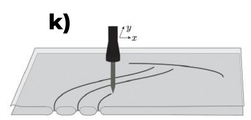
Interactions

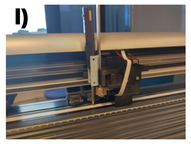
Midair ballon interface presented by Takuro Furumoto. It use a combination of ultrasonic levitation and LTA technology to stay in place and detect input from the users. [4]

« Blade Free Drones » Made by Docomo in 2021. The balloons uses ultrasonic device to propels themselves without using moving parts.

Floating inflatable device will unlock design opportunities recently unveiled by devices using h) & i) ultrasonic levitation. Enabling the device to float by itself may boost its development.

Fabrication





By using a modified j) cutting plotter and a k) soldering iron it is possible to heat-seal two flat superimposed fabric sheets along any desired path with a heating head [2]

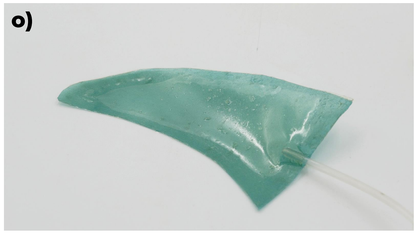
Sensing

Martha, the Mobile and Inflatable Interface for Human Robot Interaction of Cornell ECE has an internal camera to detect the interaction of the user on its surface [5]

Kristian Gohlke explore Bio-Inspired Fluidic Soft Actuators and Sensors for the Design of Shape Changing Tangible User Interfaces in his Doctoral Research project [6]

The object's ability to sense their envelop shape and interaction with users or its environment has been demonstrated for soft and m) & n) inflatable object of all materials

Future Works



Trials on the process using Agar Agar done by Valentin Martinez-Missir at the DVIC for a study on « soft biobotic »

There are countless of development to imagine once the devices and their process exists such as o) an exploration on the material used or the design space created by those interactions.

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