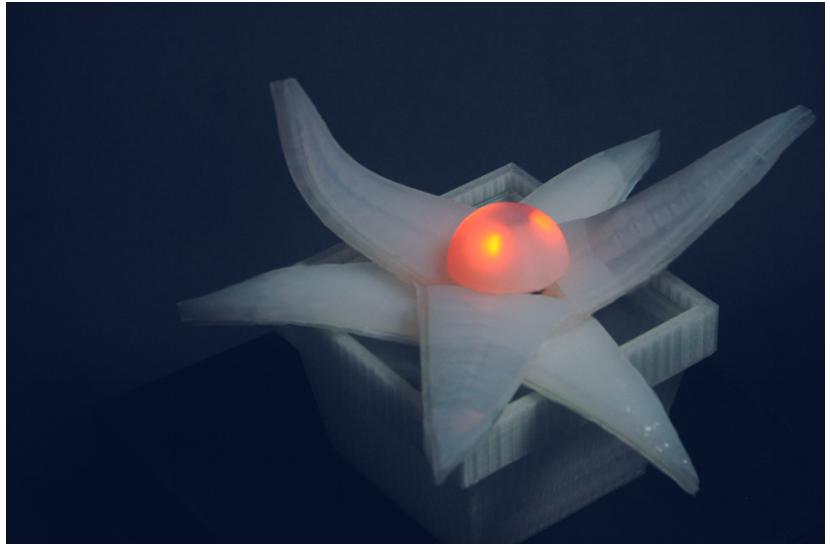


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# Heart of Mollusca: Heartbeat Sensing Soft Robot Interaction



## Abstract

There have been a lot of improvements on Soft Robotic technology recently. Many materials and actuators have been established which would be useful when creating soft robots. "Heart of Mollusca" is an artwork which was created to investigate more on the possibilities of human-soft robot interaction. To increase the strength of soft robotics, this robot added the biofeedback interaction by using the heartbeat sensor. Evaluating the result of those who has interacted with Heart of Mollusca, it could be concluded that the soft robotics interaction is different from conventional human-robot interaction. Soft robotics interaction may change the human-robot communication to be more organic.

**Keywords:** Soft Robotics, Human-robot Interaction, Physical Interaction, Heartbeat sensing, Biofeedback

## Introduction

In recent years, the field of robot engineering has been paying more attention in developing soft robotics. Soft robotics refers to a physically soft robot that can make flexible movements which could not be done with conventional robots.

In the field of soft robotics, there are many types of research on the material and movement, however, insufficient research has been done on soft robot expressions and interactions, such as how flexible movements of soft robots give users a sense of impression.

Because of its compatibility with bio-like movement [1], it is likely that bio-feedback interaction would suit soft robotics as well. This artwork proposes hypothesis that soft robots have the power to change the human-robot communication to be more organic.

## Background

Conventional robots were made of hard material to repeat fixed actions quickly and accurately. To the contrary, living creatures of nature have evolved softly so that they can cope with complex natural environments. Robotics engineers were inspired by such biological soft movement, and the soft robotics researches had been started [1]. For example, "GoQBot" developed by Trimmer et al., [2] performs rapid rolling movement inspired by caterpillars, and "Octopus-inspired robot" made by Laschi et al., [3] imitate the flexible tentacle movement of cephalopods. Thus, soft robotics is derived from biological movements, and soft robots can move more naturally and biologically than the conventional robots.

When considering human-robot interactions, there is an effect called biofeedback that reflects visible human ecological reactions. A variety of works that effectively use biofeedback have been produced so far. For example, "Empathetic

"Heartbeat" produced by Watanabe et al., [4] tries to make viewers feel empathy to the people in the image by watching the image of the person who is nervous while listening to their own heartbeat. Thus, biofeedback can have various psychological effects on people, and it is possible to give a wide range of reactions to the viewer.

## Implementation

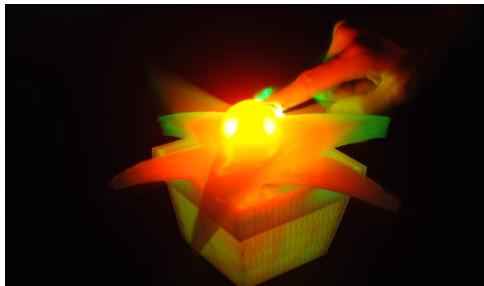


Figure 1: "Heart of Mollusca"

### Concept

"Heart of Mollusca" (Figure 1) was born to prove whether "biolikeness" can be strongly felt by the fusion of soft robot and biofeedback. "Heart of Mollusca" is a soft robot that moves with the heartbeat of human beings. This robot does not move when it does not do anything, and when it detects a person's heartbeat, it starts moving according to the person's heartbeat. The viewer first touches the pulse sensor at the part of the tentacle of the work. Then the center part of "Heart of Mollusca" slowly starts to shine red. After that, it repeats expansion / contraction as the part of the tentacle breathes with heartbeat. Because viewers touch the tentacles with their index finger, they can feel the expansion of the tentacles according to their heartbeat.

### Material

For the movement of the soft robot, this work used pneumatic system proposed by Filip et al., [5]. In this structure, silicone is separated in to two layers, a soft layer and a stiff layer. Air is inserted into the soft layer, and the inflated layer pushes out the hard layer, realizing a simple rounding motion. In this artwork, contractile silicone "Eco-Flex" is used for the soft layer, and harder type of silicone "Dragon-Skin" for the stiff layer.



Figure 2: the molding process

"Heart of Mollusca" is moving by inflating silicone by putting in air. In the production process, mold for pouring silicone was first created. The model is produced from a 3D model using a laser cutter and a 3D printer. A micro air pump and a valve are attached to the tube to be inserted into silicone, and the air pump, valve, LED, pulse sensor are controlled by Arduino. Silicone is used in order to implement the softness of the robot.

## Discussion



Figure 3: Viewer experiencing "Heart of Mollusca"

Movement like a molluscan using this softness by silicone brings a unique feeling to the viewer. Various reactions and opinions were given to this work at exhibitions. Among them, there were a lot of opinions such as "It looks like it's living", therefore expected results were obtained through this work which confirms the proposed hypothesis. The viewers who experienced "Heart of Mollusca" were surprised by the movement of the robot. They became interested in the difference of the movement between the conventional robots and the soft robot. Some viewers felt a physiological aversion to this artwork. Regarding the incorporation of organic representation, many people responded that the robot feels alive by linking heartbeat and movement. Also, many people felt interested on experiencing their own heartbeats, which they would not normally be aware of, with visual and tactile sensations. People who experienced "Heart of Mollusca" showed different reactions from conventional robots. There seem to be more possibilities to explore about further human-robot communication through this artwork.

## Conclusion

This artwork was focused on the natural and biological movement, which is the strength of soft robots, and attempted to create a "bio-like" soft robot. As a method of interaction with the robot, by incorporating biofeedback, an artwork "Heart of Mollusca" succeeded in producing a soft robot that feels biological. For further research, collaboration with biofeedback other than the heartbeat, and further exploration on expressions using softness of the soft robot is needed.

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