CycBot: A Cyclical Soft Robot for Nonverbal Communication with Humans

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***Abstract*— In this project, we present CycBot – a soft robot designed for nonverbal communication with humans. The robot's design incorporates silicone materials and 3D printing. Our robot was inspired by toys like Furbies and Tamagotchis [3], [1], aiming to create an engaging interaction experience. We achieved a successful design and fabrication of CycBot, demonstrating its ability to express emotions using soft robotics actuator. In our Human-Robot Interaction (HRI) experiment, we evaluated the robot's effectiveness in conveying emotions and engaging users.**

I. INTRODUCTION

A. Design of the robot

Our robot, CycBot, was designed in Fusion 360 and fabricated using a combination of 3D printing and silicone molding. The robot's body consists of a 3D-printed frame, while the body and ears are made from Ecoflex 00-30 silicone. The robot uses one servo motor to rotate head, three air pumps, and two air valves to control the inflation and deflation of the ears. To make robot more human-like we casted "belly" and ears using skin-colored silicone. TO keep robot upright we poured small amount of hard silicone on the bottom of the robot. The robot is controlled using an Arduino microcontroller, which manages the servo motor and air pumps/valves. The robot's behavior is programmed to respond to human interactions, allowing it to express different emotions through ear movements and head rotations.

B. Human Robot Interactions (HRI)

We designed our robot to show five distinct emotions: Interested, happiness, annoyed, and sadness. Each emotion is expressed through a combination of ear movements and head rotations. We designed our robot to have human input, Inflatable belly of the robot has a pressure sensor that detects when a human is touching it. Robot can detect two types of touch: light touch and strong touch.

TABLE I
ROBOT EXPRESSED EMOTIONS AND CORRESPONDING EAR/HEAD MOVEMENTS

	Ears Movement	Head Movement
Idle	—–	—–
Interested	Slowly swipe head	—–
Happy	—–	Move ears one at time
Annoyed	Rapid head movement	—–
Sad	—–	Both ears down

C. Robot behaviour

Our robot operates based on a state machine that tries to interact with humans by expressing different emotions. The robot starts in an idle state, where it waits for human interaction. To attract human attention, the robot periodically enters the interested state, characterized by slow head swiping movements. When a human touches the robot's belly lightly, it transitions to the happy state, expressing joy by moving its ears one at a time. If the robot experiences a strong touch, it becomes annoyed, demonstrated by rapid head movements. Whole interaction cycle is shown in Figure 1.

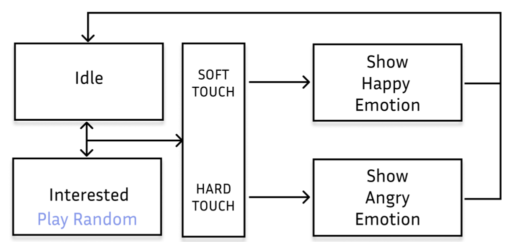

Fig. 1. CycBot state machine diagram.

II. METHODS

A. Fabrication

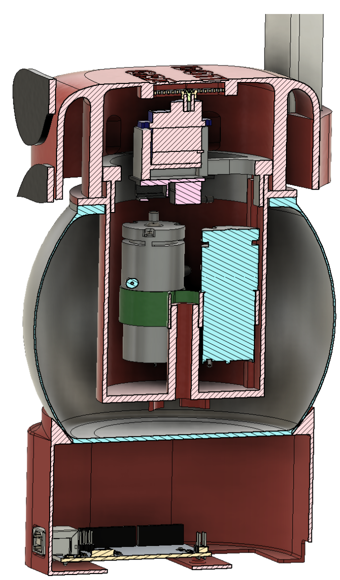

Fig. 2. CycBot section view showing internal components and silicone parts.

Hardest part of CycBot to make was the silicone belly. To make the silicone belly we designed and 3D printed a mold shown in Figure 3. The mold consists of four parts: split outer shell, inner core, and a cap to hold the inner core in place. The first step in making the silicone belly was to assemble the mold by placing the inner core inside the outer shells and securing it with the cap. Then we sealed all edges with duct tape to prevent silicone leakage. Because of the wall thickness of the belly (3 mm on the walls and 8 mm on the bottom) and the mold being relatively tall we were concerned about air bubbles getting trapped inside the silicone during pouring, which would make our part faulty. To keep our silicone bubble free we put our silicone mixture in a vacuum chamber for 15 minutes and then poured it slowly into the mold through a small hole on the top of the mold cap. After pouring we placed the mold in a vacuum pot for 45 minutes to further eliminate any remaining air bubbles.

Fortunately our part came out bubble free on the first try. We then placed the mold in an oven at 60°C for 2 hours to cure the silicone. We put our mold in the oven for longer than recommended by the silicone manufacturer to make sure the silicone was fully cured because 3D printed molds tend to absorb some heat during the curing process.

After curing we disassembled the mold and removed the silicone belly. The final step was to trim any excess silicone and glue the belly to the robot frame using Sil-Poxy silicone adhesive. Figure 2 shows a section view of the CycBot with all internal components and silicone parts.

In the end our mold design worked very well and we were able to make a high quality silicone belly for our robot.

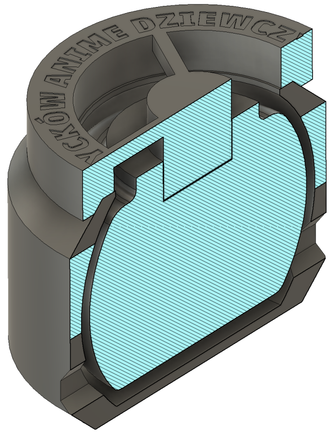

Fig. 3. 3D model of mold used to cast CycBot's silicone belly.

B. *HRI experiment*

Signals used in experiments are robot behaviours explained in the table above I

Hypothesis H1: Participants will touch robot more while presenting Interested or Annoyed expression.

Measure: Number of touches during each behaviour. **Analysis:** One-way ANOVA test to compare means of touches during each behaviour.

III. Results

A. *HRI experiment data*

Participants interacted with the robot while it expressed different emotions in a cycle shown in Figure 1. Participants could touch robot's head or belly freely during the interaction. We recorded number of touches during each robot behaviour. The collected data is summarized in Table II.

TABLE II

Count of touches during each robot behaviour in HRI experiment

Expression	Touch count
Idle	—
Interested	—
Happy	—
Annoyed	—
Sad	—

IV. Discussion ($\sim$ %20)

The discussion section is where you put your interpretations, extrapolations etc. It normally starts with concrete conclusions that come directly from your data itself, then gradually becomes more abstract as you extrapolate into the future and into broader research areas. You should start concrete, to show people that you are working with fact and not fantasy. But there is no harm in claiming potential greater significance for your results, if justifiable. Go back and check again, that what you have written in your discussion section ties in properly with the results you included in your report. What is the main message that you want readers to take home? Make this the primary focus of your discussion! The rest of the discussion should provide supporting arguments for this, your main thread. Your discussion section could address, e.g., select aspects of the robot's performance compared to the state-of-the-art and results and implications of your HRI experiment(s).

V. Conclusion ($\sim$ %5)

A conclusion may review the main points of the work, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications, extensions, and improvements.

Appendix

Insert the link to an edited video (unlisted Youtube) of your project and a brief description of supplementary materials (code, properly labelled data, etc.). State each student's contribution to the project and report according to the provided template on ItsLearning.

References

[1] Tamagotchi, https://en.wikipedia.org/wiki/Tamagotchi, accessed November 2025.

[2] Ecoflex 00-30, https://www.smooth-on.com/products/ecoflex-00-30/, accessed November 2025.

[3] Furby, https://en.wikipedia.org/wiki/Furby, accessed November 2025.

[4] Making 3D Printed Molds for Silicone Casting, https://www.youtube.com/shorts/DatZ0Fbp9No, accessed November 2025.