

The Socially Therapeutic Assistive Robot (STAR) Therabot and Its Modular Sensor Collar

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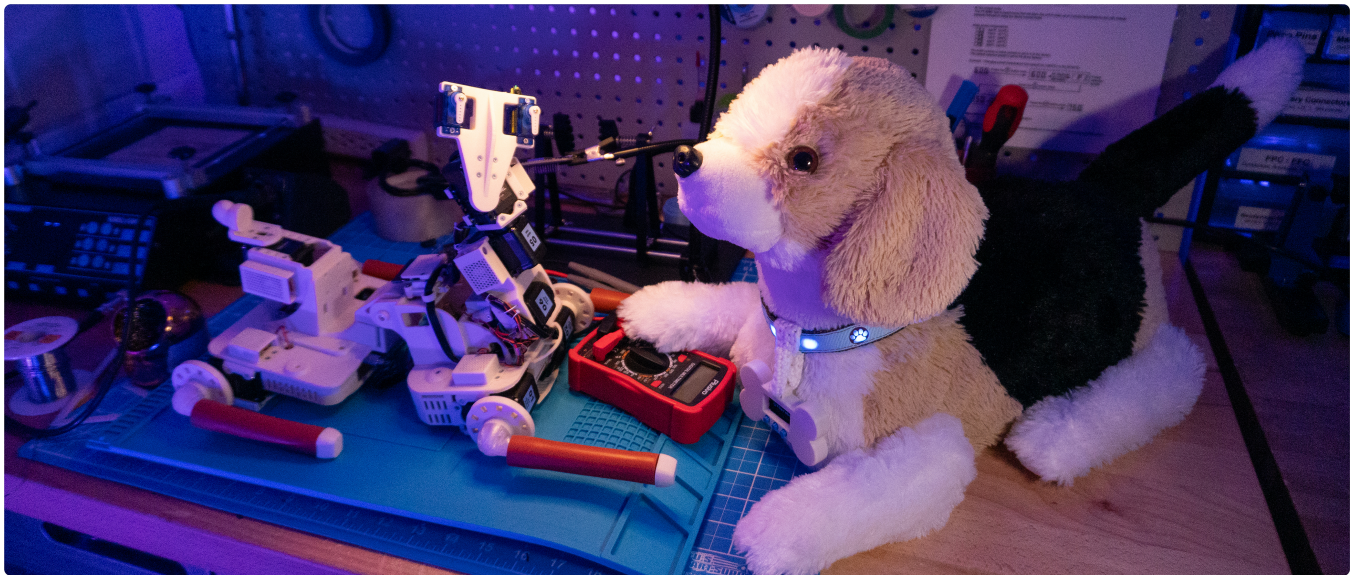


Figure 1: Two Therabot robots sitting on a workbench. The robot on the right has its full padding and covering, while the one on the left shows the internal structure.

ABSTRACT

Therabot is a socially therapeutic assistive robot (STAR) in the form of a stuffed dog designed for use in mental healthcare as a supplement to therapist directed interventions. The modular sensor collar is an adjunctive tool designed to facilitate the collection of contextual data in home environments across zoomorphic robotic platforms for the purpose of evaluating sensors and informing the design of machine learning models for context understanding. This demonstration will allow attendees to interact with the latest version of Therabot in both covered and uncovered (underlying robotic platform visible) forms. Additionally, attendees will be able

to use and examine the open source modular sensor collar platform. The purpose of this demo is to invite conversation and spark ideas among the community about the design of social robots for use in mental healthcare applications.

CCS CONCEPTS

• **Human-centered computing** → *Human computer interaction (HCI)*; Interaction devices;

KEYWORDS

socially therapeutic robot, socially assistive robots

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1 INTRODUCTION

As the need for mental healthcare has continued to rise, mental healthcare professionals have found themselves stretched beyond their capacity and seeking solutions to provide the care needed [3]. The prospect of employing social robots in the mental healthcare arena for supplemental therapeutic benefits presents a significant potential for a positive impact on society. While the use of social robots within mental healthcare has been a growing area of research for well over a decade with many promising inquiries and results (e.g., [5, 7]), the complexity of the domain leaves substantial work to be completed [6].

Therabot is a social robot focused on providing therapeutic benefit within clinical mental healthcare. Our current efforts are focused on using participatory design approaches with both clinicians and patients to better understand how the robot can contribute to therapeutic outcomes in a positive way.

2 THERABOT

Therabot is a socially therapeutic assistive robot (STAR) that has the appearance and feel of a stuffed animal [2]. Figure 2 shows the external appearance of the robot. Actuators allow movement of the robot's head, legs, and tail. Sensors throughout the robot's underlying structure and its soft covering allow it to interpret the world around it and react appropriately. Its primary purpose is to supplement therapist-led mental health interventions, serving as a tool for patients to use at home. Ongoing participatory design efforts with clinicians and individuals with depression and anxiety are focused on uncovering a comprehensive landscape of possible specific uses of the robot as a supplement within the course of therapy. Beginning development in 2012, the current version is the product of many cycles of iterative design and collaborations across disciplines and between institutions.



Figure 2: The external appearance of the robot.

The robot's underlying structure (shown in Figure 3) is composed of 3D printed parts that provide the basic shape of a four-legged animal. Actuated joints include: each of the four legs, head pan,

head tilt, head roll, two ears, and a tail wagging mechanism. Aside from the ears, each actuator has been modified and equipped with a small fan to assist in heat removal. The underlying structure houses the robot's single board computer, microcontrollers, a linear resonant actuator that simulates a heartbeat, speaker, supporting electronics, and lithium-ion battery. An inertial measurement unit and capacitive touch sensing electronics are also attached to the robot's plastic frame.

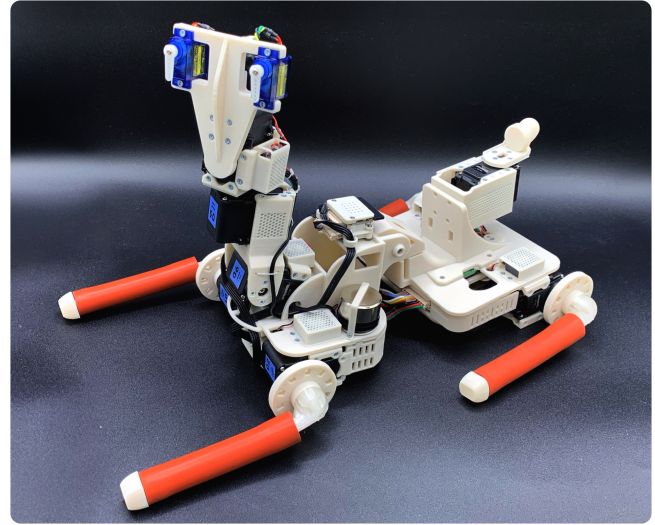


Figure 3: The internal structure of the robot.

A layer of padding surrounds the underlying mechanical structure to ensure the robot has a soft and comforting feel similar to that of a stuffed animal. Padding components consist primarily of fiber fill encased in 4-way stretch material. The robot's exterior covering wraps around the padding layer and enhances its exterior feel and appearance. The robot wears a collar containing eight RGB LEDs and an interactive hangtag that includes a small OLED screen and three buttons as a basic interface for controlling the robot.

The robot's high level control software is written in JavaScript and executes in a Node.js runtime environment on the single board computer. A web interface facilitates full configuration of the robot and allows the design of custom behaviors.

3 MODULAR SENSOR COLLAR

Developed as a vehicle for testing sensors and collecting environmental context data, the modular sensor collar is an adjunctive device fashioned as a pet collar for use with zoomorphic robotic companions (shown in Figure 4).

Figure 5 shows the modular sensor collars worn by two different robots. The system is composed of a single compute module and one or more sensor modules. The compute module is responsible for configuring sensors, recording sensor data, managing system power, and providing a user interface for the sensor collar system. A basic sensor module was designed to provide many commonly used sensors in a single small module. The basic sensor module includes



Figure 4: Two versions of the modular sensor collar. Each features a compute module and a basic sensing module.

a sound level sensor, high dynamic range digital light sensor, triple-axis accelerometer, relative humidity sensor, barometric pressure sensor, ambient temperature sensor, and gas (VOC) sensor.



Figure 5: Two zoomorphic robots each wearing a modular sensor collar

The modular sensor collar has been deployed on off-the-shelf Hasbro Joy For All robots for 2-3 week periods in 10 participant homes in South Korea and 10 in the United States in conjunction with an ecological momentary assessment smartphone application in order to gather ground truth data about the user’s environment and interactions with the robot. This data was used to train deep learning models that yielded 75% - 80% accuracy at identifying common household activities [1, 4].

The modular sensor collar is built using off the shelf electronics, 3D-printed parts, and standard fastening hardware. The collar’s design assets are open source, and the system is designed to allow easy expansion for supporting additional sensors¹.

4 DEMONSTRATION

Our demonstration will include covered and uncovered verisons of Therabot operating in fully autonomous or semi-autonomous modes. Each Therabot will be connected to an interface that allows attendees to see the system’s state and use its software to direct its behavior. Specific functionalities highlighted will be responsiveness, awareness, adaptability, and naturalistic movements. Attendees will be encouraged to pick up the robot and engage in a hands-on interaction; through this, Therabot’s responsive behaviors and environmental awareness will be showcased, featuring the responsive behaviors that are triggered when human interaction is detected by the inertial measurement unit (IMU), which detects orientation change, movement, etc., and capacitive touch sensors,

¹Source files available at: <https://stars.msstate.edu/sensorcollar>

which are configured to recognize and classify touch location, pressure, and directionality. To demonstrate the robot’s adaptability to in-home situations, sensor values can be simulated using the web interface; for example, attendees can adjust the light and sound levels to simulate nightfall and watch Therabot adapt by adjusting its interaction style.

We will demonstrate Therabot’s capacitive touch-sensing grid, which offers an additional interactive experience. This grid is composed of capacitive fabric electrodes; these electrodes are separated by a resistive layer, serving as a dielectric barrier between rows and columns. Under normal conditions, this grid is attached under Therabot’s external covering, to recognize touches and gestures. However, for our demonstration, we will present an auxiliary version, disconnected from Therabot and instead linked to a laptop computer. This setup allows us to provide real-time visualizations of the touch interactions. Our focus is to facilitate exploration of how the touch-sensing grid works, independent of Therabot’s usual behaviors. Since Therabot’s responses are intentionally probabilistic and responsive, this isolated demonstration will help in better understanding the touch classification.

In addition to the robots, several modular sensor collars will be available for examination and use by attendees. Supplemented by two tablets detailing the collar’s design and assembly, attendees will be able to explore the modular system in more depth.

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