Touchibo: Multimodal Texture-Changing Robotic Platform for Shared Human Experiences

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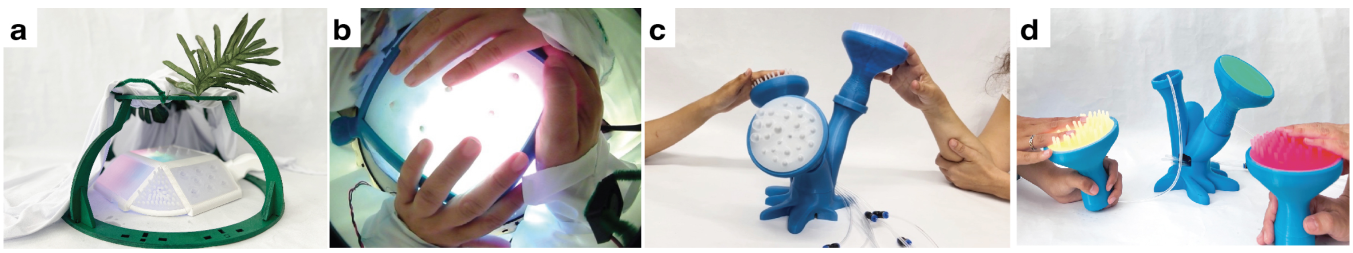

Figure 1: Two platform prototypes: (a) Touchibo Turtle and its (b) internal view; (c) Touchibo Tree and its (d) modular structure.

ABSTRACT

Touchibo is a modular robotic platform for enriching interpersonal communication in human-robot group activities, suitable for children with mixed visual abilities. Touchibo incorporates several modalities, including dynamic textures, scent, audio, and light. Two prototypes are demonstrated for supporting storytelling activities and mediating group conversations between children with and without visual impairment. Our goal is to provide an inclusive platform for children to interact with each other, perceive their emotions, and become more aware of how they impact others.

CCS CONCEPTS

• **Human-centered computing** → *Accessibility systems and tools*; **Haptic devices**; • **Hardware** → Emerging interfaces; • **Computer systems organization** → Robotics.

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KEYWORDS

soft robot; pneumatic; texture; children, human-robot interaction; storytelling; multimodal; inclusion; haptics; emotions; platform; olfaction; conversational dynamics

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1 INTRODUCTION

This work presents Touchibo, a robotic platform that enriches children's interactions by generating physical sensations using texture-changing skins, scents, and lights.

Similar to how humans convey their emotions in various ways including gestures, heartbeat, and sweat, robots could also display emotions more diversely through physical expressions [7, 9], including auditory (hearing), olfactory (scent), and tactile (touch) [8]. In this way, robots also become more accessible and easily perceived by participants of different age or sensory ability, and especially in mixed-visual ability groups where non-visual feedback is of utmost importance [1, 6].

While texture change for emotional expression has previously been explored without a robotic embodiment [3, 4], integrating texture changing modules onto a social robot in a real-world application remains fairly unexplored. Combining touch experiences with other modalities such as sound, scent, and light also needs further exploration.

We propose a design space for robots' emotional expressions using multiple modalities, where participants can share multisensory experiences regardless of their visual abilities. In order to demonstrate the flexibility of Touchibo platform in different contexts, we present two prototypes: **Touchibo Turtle** for storytelling activities and **Touchibo Tree** for mediating group conversations.

2 DESIGN AND IMPLEMENTATION

We engaged in a two-month co-design process with four psychologists, two teachers and one blind teenager. The main goal was to create multimodal robots to enhance group activities equally perceivable by children with and without visual impairment. This section describe three multimodal technologies, including tactile (texture-changing skin), visual (lights), and olfactory (scent box).

Texture-changing Skin. We integrated a dynamic texture-changing skin to enrich the tactile sensation and expressiveness of the robot. Each soft-skin module comprises a silicone body and air cavity that can be pneumatically controlled to generate surface texture changes [5]. We designed five bio-inspired texture shapes (Figure 2, row 1, 2): **Wrinkles** generate haptic tension when vacuumed - expressing confusion and concentration. **Goosebumps** express excitement, while **spikes** display anger and defense with sharp haptic tips. **Stomata** simulates breathing of the robot by opening and closing the "pores". **Tentacles** inspired by sea anemones express a sense of liveliness in a robot. A network of air chambers connects individual groups of textures for separate control. The textures can be uniformly connected and actuated together or separately controlled via multiple channels. Figure 2 (row 3) presents 3-channel goosebumps achieving different surface dynamics with independent control. To control dynamic texture movements, we used a *FlowIO* [10] device. The device allows for independent control of five channels to perform inflation, deflation, vacuum, and hold - with pressure sensing as control feedback to achieve pre-calibrated deformation. By dynamically controlling the pressure, flow-rate, and frequency, we can achieve different texture dynamics (Fig. 2 row 4).

Light Module. We added a visual communication channel through predefined color patterns penetrating the robot's skin. We embedded LED rings of uniform sizes under the skin units. Lights are controlled remotely via WiFi without needing physical wire connections. The wireless connections allow designers to build robots with modular/detached bodies, as demonstrated in section 2.

Scent Box. For smell manipulation, we developed a scent box that shifts between a discrete set of smells to enrich a robot's subtle expression. A scent box (Figure 3) is composed of four pieces of scented cotton, with the scents of campfire, grass, rain, and dust. A mini fan is installed behind each scented cotton. When a fan is turned on, the wind blows air through the scented cotton, spreading the smell to the environment.

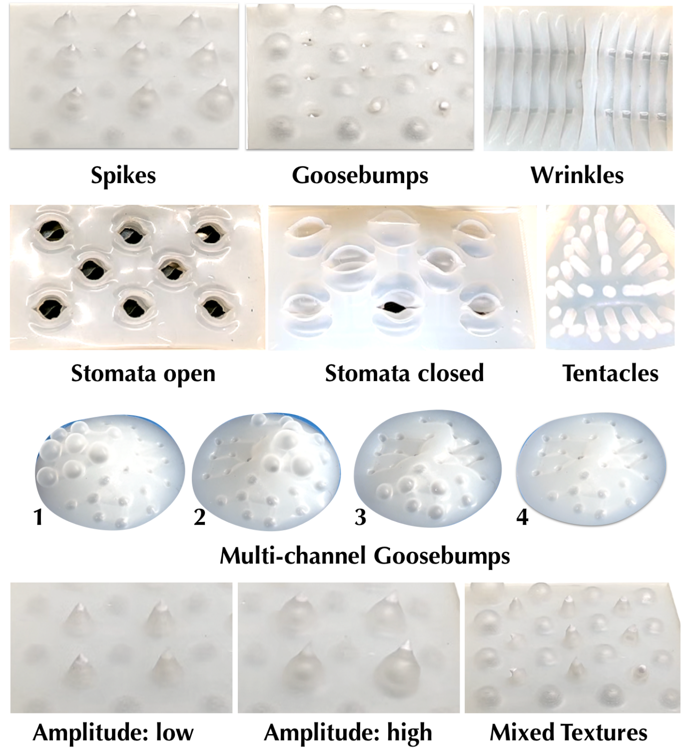

Figure 2: Design space of texture-changing skin (shape, connection, control amplitude and frequency).

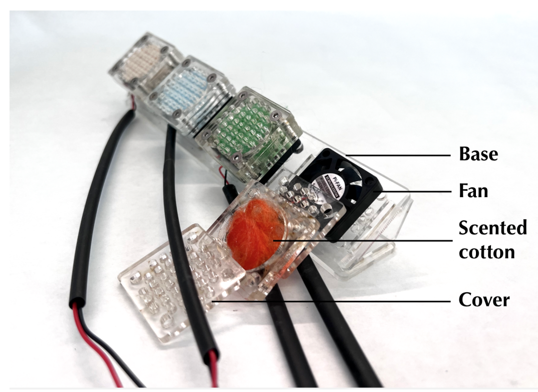

Figure 3: Composition of a scent box

3 APPLICATIONS

Storyteller. Inspired by the mixed visual-ability group and psychologists' storytelling activities, we designed **Touchibo Turtle** as a storyteller that enacts different physical sensations of characters such as *happiness*, *sadness*, *fear*, or *anger*. Its size allows four children's hands to physically and socially explore its nine touch zones. As shown in Figure 1 and 2, it has five evenly distributed texture types, providing equal skin type experience per hand and animated synchronously. The robot is hidden inside a cave made of fabric with sleeves, so children cannot have visual access to the robot and focus their attention on other senses. In addition, we use audio, textures, wind, lights, and scents to create an immersive experience. The background music sets the scene and overall mood; silence and lights for marking scene-changes and promoting children's curiosity; texture-changing skins to convey different feelings; and wind to enact the breathing flow. Lastly, scents aid in defining the surrounding environment. Future explorations for richer tactile sensations can investigate underwater setups and temperature.

Conversation Companion. Inspired by previous research [2, 11], we built **Touchibo Tree** which becomes *afraid* of aggressive conversations and *bored* of long monologues so that children can learn the impact of their behaviors on others through the robot's behaviour. The robot's branches embodying tentacles and goosebumps with three activation zones (figure 1). Using frequency, amplitude, and texture variation, the robot expresses a breathing metaphor: curious (fast breathing), boring (slow breathing), and afraid (irregular breathing). In the demo, we present two scenarios: (1) the robot displays *boredom* or *curiosity* textures in response to speaking time, encouraging balanced participation; (2) the robot expresses *fear* with intense texture changes in reaction to high volume speech, promoting respectful conversations. In addition, the prototype is modular, allowing customized texture combination and stand-alone branch separation. By reacting to conversations through tangible feedback, we expect the robot to enrich the physical experience and deepen the social connection within groups.

4 CONCLUSION

This work presents a two-month co-design process to build inclusive experiences for mixed-ability groups of children. Given the insights into children's needs, we designed Touchibo platform that explores various complementary modalities such as audio, textures, wind, scent, and light allowing children with or without visual impairment to have shared experiences.

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