Rethinking Human-Robot Emotional Interaction: the case of Socially Assistive Robots

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Abstract: This paper discusses about the need to overcome common limitations in emotional communications within Human-Robot Interaction (HRI). The example of DarumaTO social robot, designed to be employed with older adults, is useful to understand these limitations. After a brief overview of the concept of emotions in human cognition, we propose the application of the concept of emotional affordances to the present case of DarumaTO and more in general to Socially Assistive Robots.

Keywords: Human-Robot Interaction, Socially Assistive Robots, Artificial Emotions, Affordances.

1. Introduction and Background

The rise of ageing societies presents unparalleled challenges in delivering care and companionship to older adults. Many elderly individuals prefer to age in place, favoring the comfort of their homes, rather than opting for institutionalised care in sheltered homes or nursing facilities when age-related issues arise. This preference for independent living poses a need for solutions such as healthcare personnel and appliances of high-tech devices such as robots [1]. While there is an influx of adoption of robots, a significant challenge lies in enabling these robots to understand and respond to human emotions effectively, hence the rise of the importance of Socially Assistive Robotics (SAR).

An example of such an initiative is e-ViTA, an EU-Japan Horizon 2020 project that aims to develop a virtual coaching system promoting active and healthy living among the elderly, offering various devices, including social robots and holographic interfaces. Notably, DarumaTO and CelesTE (Fig. 1) incorporate religious elements into their design to bridge the technology gap for elderly users [2]. This paper particularly focuses on DarumaTO's potential for emotional interactions.

Figure 1a (left) DarumaTO-4W and 1b (right) CelesTE

2. Case of Socially Assistive Device: DarumaTO

2.1 Overview

DarumaTO-4W (*Daruma Theomorphic Operator version 4W*) offers a novel approach to addressing the needs of the elderly. As its name suggests, it takes the form of a traditional daruma doll, a culturally significant object for elderly individuals in Japan. Beyond its primary functions like medication reminders, it serves as a cognitive companion by providing services like mental support, backed by data from human therapists.

2.2 Interaction process

DarumaTO-4W utilises a Jetson Nano that is linked to various peripherals such as a microphone for voice input and a thermal sensor for user detection. When a user is detected, the robot processes voice commands, converting them into text and transmitting the data to the e-ViTA cloud, which contains diverse components to facilitate interaction. Particularly, the e-ViTA API (Fig. 2) analyzes audio data to determine the user's emotional state, categorizing emotions like Happy, Sad, Angry, and Fear. While voice commands offer a way for emotion detection, human emotion is primarily conveyed through facial expressions. Moreover, the robot lacks the ability to decide when to respond to these emotions. Understanding and responding to human emotions is essential for robots to exhibit empathy and enhance communication [3]. The absence of this capability in the Daruma robot emphasises the need to explore emotions further.

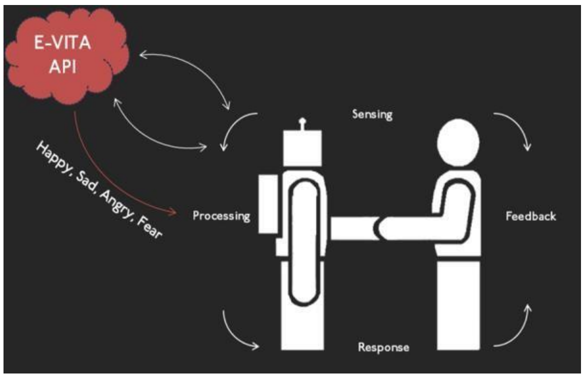

Figure 2 Emotion recognition in e-ViTA

3. Emotions and HRI

Damasio [4,5] describes emotions as an informational evaluative process in living entities, while Darwin mentions their role in communicating information. In robotics, emotions

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are represented using emotional models, like Ekman's theory of 6 basic emotions: Anger, Fear, Disgust, Surprise, Happy, and Sad [6]. One convenient model for categorizing emotions is Plutchik's Wheel of Emotions [7], where the main emotions are represented towards the center, while less intensive cases are towards the outer side. Plutchik's model has been previously used in robotics [8]. Moreover, it is difficult for the robot to understand when to express these emotions. Should it mirror emotions or employ a more intricate approach? For instance, when someone is sad, should the robot empathise or strive to bring joy? This question lacks a definitive answer, as it varies by situation and individual. Understanding this requires diving deeper into human cognition.

Cognition involves two aspects: reasoning, which is thinking-based, and reflexes, which are automatic responses to stimuli [6]. Reasoning can lead to emotional expression or actions, while reflexes prompt immediate actions. At the intersection of these processes lies 'affordance', which determines how organisms perceive and interact with their surroundings. In robotics, research on affordance is ongoing, and object affordance is the way robots know what to do with differently shaped objects. Emotional affordance, introduced in [10], is intended as a dual meaning: emotional affordance of objects and physical affordance of emotions. The former involves the process from object recognition to emotional display, like feeling disgust upon seeing an insect. The latter goes from recognizing emotional expressions to physical action, such as feeling like hugging a crying person as an empathetic response. This integration of emotional affordance and understanding how living organisms interpret stimuli and emotions is illustrated by the AAA (Affordance Appraisal Arousal) model, seen in Fig. 3.

The AAA model [11] illuminates how affordance works in living organisms. It begins with gathering sensorial input from various sources in the affordance phase to understand external events. In the appraisal phase, a neural mechanism classifies the input into emotional affordance of objects or physical affordance of emotions. This classification guides us to express emotions or perform physical actions, providing sensorial feedback.

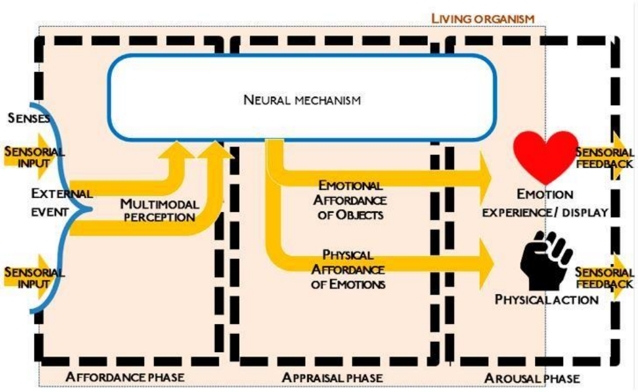

Figure 3 AAA Model for Living Organisms

4. Conclusion and Future Work

In this paper, we introduced the case of DarumaTO-4W, a social robot that features limitations in emotional interaction. Particularly, emotional affordances can serve as a bridge between emotion recognition and appropriate robot response. However, its application in robotics could be challenging due to diverse embodiments. Taking insights from the AAA model, our future work would involve extensive research on the adaptation of this concept to specific robots like DarumaTO. To collect sensorial input, we can employ sensors or similar devices to gain insights into external events. An affordance evaluation library then categorises these inputs as emotional or physical affordance, allowing the robot to respond accordingly. For example, if the robot detects the user's emotion as crying, it can use this library to perform actions like offering a hug.

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