Multimodal Technologies and Interaction

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Editorial

Emotions in Robots: Embodied Interaction in Social and Non-Social Environments

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Received: 1 July 2019; Accepted: 10 July 2019; Published: 12 July 2019

1. Introduction

Whether they are considered discrete or dimensional, emotions are 'embodied' phenomena. The embodied agent does not play a merely passive role in emotion processing. Rather, the body itself, in interaction with its external environment, influences how real/imagined, environmental stimuli are perceived and acted upon. The body behaviorally orients and acts, and internally physiologically 'prepares' in relation to its external environment [1]. Today, we see a shift towards robots that need to interact in relation to the social and emotional aspects of human environments. There are at least two areas in which 'embodied' implementations of emotional processes can enhance robotic performance in human environments: (i) *improved human-inter-actor experience* and (ii) *facilitated competence*. The mode of embodiment of the emotion-guided robot entails not only its physical dimension regarding how and what it senses and appears to human inter-actors, but also its internal homeostatic aspects that regulate its goals and those very same interactions.

The increased emphasis over the past two decades in the area of social and non-social robotics on emotional activity is a testimony to its perceived importance within the robotics community. The embodied emotional activity in robots is perhaps most famously recognized in terms of emotion expression capabilities, above all with respect to facial expression [2,3]. The extent to which such robots socially appropriately express emotional or empathic states [3], e.g., according to underlying homeostatic computations [2], largely determines the extent to which the robots are positively received by their human inter-actors. Such aspects of embodiment to emotional activity in robots, including how emotions influence decision-making and aspects of functional (including non-social) interactive behavior, are often undervalued or at least sub-ordinated with respect to the expressive facets of emotional embodiment. The aforementioned role of homeostasis has been demonstrated to provide an important function for robots required to behave autonomously over unspecified durations, e.g., in not-well-understood, or otherwise inaccessible, environments [4–10]. This notion has more recently been extended to incorporate the notion of predictive regulation (or allostasis) [11,12] and has been considered with respect to artificial systems [13,14]. Providing the tools for robots to not just express but also interpret embodied emotional engagement, e.g., through the modality of tactile interaction [15–17], also provides an interesting area of relatively recent research. Robotic agents have also been used in clinical settings, e.g., to facilitate the development of autistic children for whom a robot, more predictable than a human, can provide a suitable interacting partner. The physical appearance, mode of embodied interaction, and environmental setting, all provide crucial elements in the emotional engagement that can ensue [18]. Even outside the clinical setting, robots designed to interact with humans over long periods, i.e., not just as care-givers or trainers, but as robotic companions, should engage with humans in ways that are functional, believable, and even creative [19].

2. Purpose of the Special Issue

Appealing to a diversity of research interests and applications, this special issue concerns how emotions in robots focusing on embodied interactions can be exploited in social and non-social domains. The aim of the special issue is to highlight that embodied emotional engagement need not always entail the more conventional use of facial emotional expression or perception. Researchers of emotions in the areas of neuroscience and psychology have long (over the past few decades at least) pushed for awareness of the role of emotions in functional and creative aspects of interaction, e.g., with respect to decision making [20] and creative constructive modes of being [21] that are not limited to the more classical view of basic emotion [22] as typically modeled in robot expression. This special issue therefore contains articles that demonstrate the wide range of possible applications of embodied emotions and social interactivity (physical or simulated) in robotic contexts that go beyond the more conventional view of classical emotions (facial) and emotional expression.

3. Paper Summary

This special issue covers a total of four papers that concern original research, position papers, and pertinent reviews. The areas concern a number of different aspects of embodiment as it concerns emotions in social and non-social robotics scenarios. Improved human-inter-actor experience has been investigated [23,24] through exploration of allocentric emotional affordances, and utilizing robots in a creative (painting) context. Characteristics of artificial agents (based on virtual reality and robotics contexts) are surveyed in [25] in relation to increasing competence for training/therapy in a clinical setting, i.e., with autistic children. Interactive Internal-social environmental embodied processes have been investigated using embodied (simulated) robotic agents [26] focusing on the notion of social allostasis, through hormonal modulation, as an extension of the cybernetic conception of internal and behavioral homeostasis [27].

In the paper "Allocentric Emotional Affordances in HRI: The Multimodal Binding" [23], the authors discuss a perspective of emotions as affordances triggered by object or human expression perception whose integration is modeled according to what the authors describe as an allocentric analysis. They introduce an explanatory model—AAA (Affordance-Appraisal-Arousal) model that is founded upon Plutchik's wheel of emotions [28]. Affordances are viewed as manifesting through stimuli being emotionally tagged so that robots can apprehend what objects have what affective-semantic value to particular social (human) agents. In this work, human–robot interaction through emotional affordances goes beyond modeling of the six basic/classic Ekman emotions and the modeling approach constitutive of the emotional affordance process, taking into account how moods and social affective expressions (crying, smiling, head down, frowning) can be utilized in robots.

The paper "Modelling Adaptation through Social Allostasis: Modulating the Effects of Social Touch with Oxytocin in Embodied Agents" [26], focuses on the use of a simulated hormone 'oxytocin' for facilitating interaction between embodied agents. The simulated agents produce tactile interaction in accordance with an internal architecture whose processing entails competitive decision-making based on homeostatic needs (of which sociality through tactile interaction is one) including physiological (homeostatically regulated) demands such as the need to eat. The hormonal effect of oxytocin, emitted in relation to tactile interaction, here is to increase saliency to the social need of the agent. The top-down effects it exerts can be viewed through the lens of social allostasis [12], whereby agents tend to suppress competing physiological needs in the service of the fulfillment of social goals that may require extended periods of time/behavior to realize.

In "Design for an Art Therapy Robot: An Explorative Review of the Theoretical Foundations for Engaging in Emotional and Creative Painting with a Robot" [24], the artistic/creative potential of embodied and emotion-oriented robots is investigated. The therapeutic benefit of such robots, able to paint, provides the main application area for this work. Furthermore, the use of the robot as an inter-actor during the creative artistic process is highlighted and a requirements/solution analysis provided for such robots for successful art therapy. Baxter is posited as a suitable robot here on account

of its humanoid embodiment providing familiarity to the inter-actor viewing the robot as a type of therapist. The effects on the core affective dimensions of valence and arousal of particular types, sizes, and composition of geometric shapes used during the artistic therapy are also indexed.

Finally, in the review article "Reviews of the Social Embodiment for Design of Non-Player Characters in Virtual Reality-Based Social Skill Training for Autistic Children" [25], another application for a therapeutic/clinical setting for embodied agents is reviewed. A focus on the social relevance of non-playing characters (NPCs) during human interaction with these virtual agents (with relevance to social robotics discussed) is referenced in the setting of providing social training to autistic children. These NPCs (non-human) guide verbal dialogue with the human-inter-actors appropriately engendering modulating mood and emotional state according to designs that promote perception of non-verbal cues of the human inter-actor. Design considerations are based on a number of large data corpora with respect to social skill training for autistic children and include core affective principles of emotional engagement such as facial mimicry and body gesture simulation.

In summary, this special issue offers four contributions that provide insights into how embodied aspects of emotion and social and non-social aspects of interaction can be exploited in robots for functional use. They go beyond the conception of emotion expression based on the classical view of discrete emotions to account for the role of emotions in regulation for autonomous decision making, creative and therapeutic forms of interaction, as well as modes of perceiving and engaging the world based on the affective coloring of it.

Acknowledgments: The author would like to thank all the contributors to this special issue.

Conflicts of Interest: The author declares no conflict of interest.

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