Non-Zoomorphic Robots : The Role of Aesthetics in Social Robotic Design

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ABSTRACT

Social robots are becoming more important in everyday life due to the need of the health providers to cope with an ageing population and a general crisis in the health sector. Additionally, with increased computational power, social robots will be able to act as social companions in settings outside of health. In this work, we look at the methodology of design for new types of companions robots, in the context of a domestic setting. In domestic settings, personalisation is vital to successful products, but most human-robot interaction (HRI) research focuses on adaptive behaviour for social interactions using available commercial devices. These robots represent finished products, with very little room left for meaningful physical alterations. The goal of this work is a first investigation into meaningful aesthetic changes of a new social robot with a wide range of choices for personal customisation.

CCS CONCEPTS

• **General and reference** → **Design**; • **Human-centered computing** → *Systems and tools for interaction design*; • **Computer systems organization** → **Robotic components**.

KEYWORDS

"Social robotics, domestic robotics, personalisation, design, robot skin, embodiment"

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1 INTRODUCTION

The importance of the appearance of social entities, including robots, and their morphology has been studied widely [8, 21, 24]. Additionally, the role of the cultural context in which social robots operate has been found to play a crucial role in the acceptance and effectiveness of their usage [30]. Thus, both morphology and cultural setting point towards a significant impact of their acceptance and usefulness in a social setting.

In contrast to this, very little research has been conducted on the impact of the role of the aesthetics beyond simple morphology on the perception of a social actor or robot [10, 17]. In most cases, research focuses on the role of the overall shape as a means of efficiency and acceptability of social relation with robots [33]. Very little attention has been given to more design and consumer-focused concepts such as visual attractiveness and desirability. The rules of attraction and the sense of ownership over our possessions obey to very complex mechanisms [34]. To be able to design and build more effective social robots we argue that there is a clear need to define and understand measures of robot attractiveness in specific settings and cultural contexts and that we need to develop a rational set of tools. Domestic robots are not just invisible servants, they need to be considered as part of an ecosystem of desirable artefacts [2], meant to enhance our comfort and well-being.

The alarming amount of failing startups in the social robotics domain highlights a systemic problem. To date, no company has achieved to reach large scale adoption of social robots. Artificial Intelligence research and Cognitive Robotics may improve continuously the ways a robot behaves and engages with the world. However, as their minds evolve, their bodies, shapes and skins remain unaltered [4]. The way current robots are designed prescribes possible alterations and discourages active personalisation. It is not possible to alter either Pepper or Nao without loosing warranty or potentially breaking them. Given the current maker movement [12] and the increasing ease of use of new technology to manufacture physical artefacts, it seems crucial to allow the mind and body of machines to adapt at the same pace for the clear benefits of social interactions [13]. The role of design, supported by a precise methodology, should be able to support a robotic project from the beginning to the end. Dautenhahn argues against social intelligence being used as an "add-on" to make robots more attractive [9]. Similarly, design, viewed as a cosmetic discipline [19], should be part of a multidisciplinary effort to make social robots more attractive and encourage domestic assimilation at a large scale.

Due to lack of research and available platforms addressing the issue of design questions such as perceptual attractiveness and aesthetics from a design perspective, we propose a novel platform for engaging with design specific research in social robotics, the Maah. Consequentially, the subject robot Maah, see Figure 1, represents a conceptual and material exploratory study to approach this new paradigm. Based on the first study, the new archetype of our social robot will offer several ways to achieve customisation, present alternative tools to enhance ownership and ultimately aims to understand and reinforce the bond between robot/appealing artefact and users.

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Figure 1: Left (1) Maah cover with the 3D knitted robe (skin). Right (2) The internal structure of Maah developed with generative design. Maah is gentle, safe and easy to use robot. The concept resembles a living pillow, offering comfort and social presence to users.

1.1 Challenges

To guide the design and our approach of finding a new robotics platform we identified a number of key challenges.

• *Will this apparent simplicity, in physical and interaction design, be sufficient to emulate the basic social cues required to generate long term connections and attachment with humans?*

Anthropomorphism is a design factor when looking into current human-robot interaction and a machine may not need a complete representation of all physical human attributes to form a strong bond with a user [23]. A thorough investigation of the differences between human-animal interaction and robotic pet research will be required to support and complement our research.

• *How can a social robot, i.e. the Maah, develop and retain physical flexibility in its design?*

In order to remain of interest in a changing human environment, robotic shapes should evolve, along with their body, therefore the technology enabling the structure must authorise constant iterations and optimisation. But does flexibility means rapid change? The design of the structure of Maah embrace organic shapes, not only for their aesthetics but also for their effectiveness. To support the augmentation of the structure and shape of our social robotic study, we utilise generative design to improve greatly the mechanical efficiency and the development of alternate shapes/augmentation possibilities. It allows the designer to simulate, prototype and deploy complex mechanical concepts [16] without the constraints of classic production methods. Utilising a flexible internal structure with possibilities to augmentation can be a very beneficial advancement for the embodiment of robots, as it is now possible to constantly iterate shapes, with their mechanical properties simulated and optimised by powerful software for rapid prototyping. The advancement of additive manufacturing [28] does benefit the development of novel shapes and embodiment as well. It offers rapid localised production and advanced material generation through 3D printing. Thus, users of our platform are able to develop and augment their robots at home or in maker spaces without having to send in their robots for adjustments.

• *Could textile offer new opportunities for social interaction and effective personalisation?*

For current social robots, the external layer of a robot, or skin, is generally made out of metal or plastic, giving the robot an artificial feel. It has been shown that the sense of touch/texture is fundamentally important to humans[5, 6]. Hence, we believe it will be crucial for the next generation of commercially successful social robots to look into the use of other materials to enhance the sensory experience of a robot as well. To this end, we designed the initial shape of our prototype convex and minimalistic but flexible so that different skins can easily be fitted to it. Our ongoing research is also looking into 3D knitting to understand and enhance the benefits of the robot's appearance. This technology enables the creation of a three dimensional meta-material [32], while keeping all the properties required for unlimited creative design in terms of colours, see Figure 2, patterns and textures. The development of knit based skin can facilitate the personalisation of the artefact and it could favour a better sensory response while acting as a dynamic protective shell for our social robots. If appropriate sensors are implemented, the augmentation of its sense could encourage *"Affective touch"* [26]; when robots are used as a mediator between human-human relations and it encourages affiliate touch.

2 THE SOCIAL ROBOTIC PLATFORM MAAH

2.1 Motivation

The mechanism of anthropomorphism allows humans to feel and bond with a large number of non-human creatures and objects. From the most extreme cases such as the pet rock [22] to our devotion to domestic pets. Unfortunately, there are many barriers for the ownership of animals [1] such as allergies, living space, working life, age [7]. Interestingly, humans have the capacity to bond with animate entities. Indeed, neuroscience has demonstrated empathetic reactions to the simplest objects behaving with a simulacrum [3] of autonomy [20]. Miklósi et al. show that non-humanoid robots can facilitate relationships as much as humanoid robots [27]. By limiting the complexity of social interaction, it avoids misinterpretation and social discomfort. Duffy challenges the development of humanoid robots, arguing that anthropomorphism, as a design tool, can be used strategically to encourage social interactions [14]. Furthermore, he argues that robots can offer a different experience of design, in opposition to the current offer, as long as they respect fundamental rules. First, they must have ways to communicate with the user and express emotion. And second, they must be equipped with social mechanisms to encourage and sustain social interactions. Zoomorphic robots have been successfully used for a commercial project; paro [31], the robotic seal, has been adopted in care facilities across the world.

On the other hand, the development of robots with flexible morphology could be beneficial for human machines relationships, offering alternative textures, colours or shapes and opening the door to mass customisation. But it requires the development of technologies which are unconventional for the robotic industry. The development of the robot Maah, see Figure 1, started as a design case study meant to challenge industrial and social expectations. The unconventional aspects of its conception raise new questions about the relationship we expect with artificial agents and the viability of alternative technology of development. A key driving force for working on this platform is to enable the ability to experiment with flexible morphology and non-zoomorphic embodiment to understand the underlying baseline of human-robot social interaction.

Figure 2: 3D knitting allows a vast samples of colors and patterns to be easily manufactured, following the mass-customisation trend used by brands such as Nike for example [29].

Shibata, inventor of PARO, has contributed greatly to the field of domestic robotics. His research offers valuable insights into the development of zoomorphic robots. Robots like PARO are classified under the *interactive autonomous class*, meant to encourage a very personal and emotional approach to robotics. More precisely PARO is categorised as *"Mental Commitment robot"* [31].

> "Mental commitment robots are not intended to offer people physical work or service. Their function is to engender mental effects, such as pleasure and relaxation, in their role as personal robots. These robots act independently with a purpose and with motives while receiving stimulation from the environment, like living organisms. Actions that manifest themselves during interactions with people can be interpreted as if the robots had hearts and feelings." Shibata and Wada

The research on PARO is very valuable and introduced important guidelines for the design of artificial companions. Shibata and Wada summarise the design principles with the following arguments [31]:

(1) Mental commitment robots should stimulate physical user interaction.
(2) Non-verbal communication is primary characteristic for this robot type.
(3) Appropriate sense stimulation and clear expression of agent behaviour.
(4) User understanding through sensors, through a soft skin.
(5) Familiarity in the design of the shape raises expectations.
(6) Attention to detail increases the "coupling" or resonance with the device.

These guidelines laid the foundation for the design of MAAH. MAAH's main function is companionship, the shape intentionally resembling no specific animal (5) but made to evoke the comfort of a pillow (3). The purpose of its appearance is to blend in with (3) any type of domestic interior and recall feelings of familiarity. MAAH encourages physical interaction (1) by displaying emotional expressions through body language and basic vocalisations (2). Its soft skin is meant to enhance (6) the feeling of warmth, comfort and safety. Additionally, the skin's modularity (4) supports personal expression and customisation to encourage intimacy with it.

As a design research experiment, the development of MAAH is following an iterative process, allowing the development team to monitor and replicate the findings for future robot design and research. Design thinking needs a better framework to deal with a more involved process such as creating companion robots. More precise and complementary tools, as described by Easterday et al. [15], support the crucial multidisciplinary development of the MAAH along all process phases.

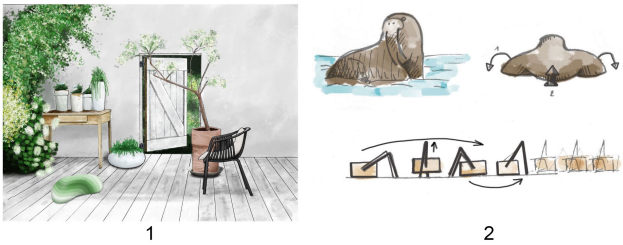

Figure 3: Illustrations taken from MAAH's design process sketch book.

2.2 Robotic Design

Building on Duffy's arguments for anthropomorphism [14], MAAH extends the concept to an extreme, it employs anthropomorphism as a key experimental tool to understand the mechanism of bonding during a machine-human interaction. By design, our robot is deprived of the classical visual cues such as an obvious head or eyes, in order to accentuate other forms of communication such as body language and auditive expression. A primary motivation behind the design of MAAH was to closer inspect and push the boundaries of social robot communication. By focusing on emotion expression solely through the body and sound modulation, we aim to investigate the capacity of a user to feel for and bond with this non-conventional social agent. MAAH's purpose is to give comfort and warmth. Its cushion-like shapes is intended to motivate physical contact and gain the benefits of the sensory experience. Even turned off, it will remain an accessible comforting object, on display in the home environment. As an extension of interior design, MAAH must blend seamlessly with its environment like a piece of furniture, see Figure 2. Inspired by furniture design, fashion and art, MAAH could offer an alternative concept for domestic robotics, meant to enhance long-term acceptance of robots in the home.

In the current version, its body movement is inspired by the locomotion of a walrus, see Figure 3. These gentle giants, use the entire mass of their body to propel themselves forward. A movement which is both smooth and non-intrusive as altering the speed of its execution does not affect the perceived effectiveness of it in contrast to walking or jumping. It is not very graceful, but we can empathise with the effort these animals have to deploy. Translated to MAAH, the movement gives the entire structure a dynamic appearance, as the whole body contributes to locomotion. The entire morphology of MAAH is about movement as the structure animates itself to express physical interactions. This conception facilitates body expression, giving MAAH a unique character. The only design imperative is to avoid any type of slivering or crawling movements, mainly responsible for instinctive rejection [25].

MAAH's internal strcuture requires a substantial amount of flexibility. Each part requires a certain amount of freedom to emphasise natural movements. Furthermore, the different elements need to

retain rigid structural property, mechanical strength and remain lightweight. Finally, its morphology is meant to be evolving, depending on user preferences, its size and proportions can change.

The skin of the Maah has a very important role. It is, after all, the embodiment of the visual experience of the robot, the way it is perceived in relation to the ecosystem of the home. It is an "organ" promoting the sensory experience of touch. This invitation to physical contact has profound importance in human psychology. Furthermore, the skin needs to be adaptive to Maah's morphology. The skin texture and colour have to be able to be modified seamlessly, similar to a product following trends and seasonal commercial rhythms.

3 FUTURE WORK

Based on the first prototype, a set of studies will be designed to analyse and understand the fundamental requirements for human-robot social interaction [9]. The Maah will be used as a foundation for these enquiries, offering a conceptual and practical background to assess these research questions and create a baseline of minimal anthropomorphic queues required for social robots.

Throughout the Maah development process, we aim to conduct an additional set of studies focusing on usability, acceptance, effectiveness as well as the importance of customisable robots; all this with a focus on long term/repeated use. A first step will be a comparative study using the Maah and other key social robotic platforms. For the embodiment, we are investigating alternative design methodologies for companion robots, the role of aesthetics and the adaptation of 3D knit base technology for adaptive and customisable robotic skins and study their impact amongst users.

Outside of the boundaries of a laboratory, a social robot is experienced by the users as a product. Therefore, people's interactions with an artificial entity, i.e. a robot, will be affected by their general consumer perception of said product. Consequentially, a person's opinion of a robot will not only depend on the technological performance or the accuracy of the social interaction but also on the aesthetic perception of that device. The attraction towards an object is the result of a complex cognitive assessment, involving conscious and subconscious analysis [18]. Subjective emotional responses are balanced by objective reasoning, to form and modulate our decision making as consumers. Understanding the experience of a product [11], such as the link between our emotions, the relational meaning of external influences and the importance of aesthetic "intrinsic pleasantness" could offer additional tools to improve attractability and long term acceptance of social robots. Thus, we believe in the importance of a multidisciplinary approach to tackle the design and conceptualisation of novel more engaging social robots.

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