New Social Robots Design Methodology to Promote Empathy in Human-Robot Interaction

Luísa Fernandes[1], Alexandre Bernardino[2]

[1] Institute for Systems and Robotics, Instituto Superior Técnico – University of Lisbon, alfernandes@isr.tecnico.ulisboa.pt
[2] Institute for Systems and Robotics, Instituto Superior Técnico – University of Lisbon, alex@isr.tecnico.ulisboa.pt

Abstract — The introduction of social robots into society is an unavoidable reality and it is a matter of time to see a robot in every house and institution. However, their transfer from the research centers to domestic and institutional environments has been slower than expected. The current method of development of a robot centered on the user is typically based on a specific purpose, and the design process is constrained by the profile of a target user, ignoring the untapped social potential of the machines and possible cohabitants. We propose, alternatively, to support the creation process in a universal profile, by acquiring, through empirical studies and using innovative testing methods, standard features. Aesthetic, mechanical, ergonomic and behavioral features that promote empathy in humans, and that should integrate the genesis of the design of a machine when the goal is the direct contact with people, regardless of its function or target user.

Keywords — Human-robot interaction, emotional design, social robots, biological signal processing.

1. INTRODUCTION

In recent years, many robots have emerged, including social robots - the target of this study. There are several definitions of what is a social robot, but for the purpose of this study, it's defined as a sum of a machine and a social interface. The social interface is a metaphor that includes the social attributes through which the observer infers, or not, the robot as an interaction partner [1]. This research deals specifically with the definition of the social interface, in the determination of its features and in the evaluation of its impact on people [2]. To do so, we will try to access the visceral level of perception joining the fundamentals of *Emotional Design*, *Social Robotics* and biological signal processing.

The purpose of *Emotional Design* is to create products that provoke specific emotions in people to establish a positive experience and relationship with a product. According to Don Norman [3], humans have three levels of information processing when it comes to the emotional connection with an object: visceral, behavioral and reflective. The visceral level is described as the "gut" feeling that you get when you first encounter an object. At this level, the most influential features are related to the general aesthetics and materials: the way an object looks and feels gives you an instant engagement of the senses and a gut response, be it negative or positive. The behavioral level relates to usability and performance issues: the way that a person is going to use an object and how easy is going to be. The Reflective level is concerned with the impact of the product in our lives: what values, desires or status does it imply when you use it and how does it make you feel by owning it [3]. All three levels are equally important in the design process, but this research will focus on visceral level analysis.

Even though the singularity of individuals with different tastes and needs is considered, the visceral level of processing information [3] is intrinsic to the *modus operandi* of the human being, which resulted from centuries of evolution. For instance, we do not like to feel too cold or too hot, we do not like loud noises, there are colors, sounds and textures that transmit messages to our brains like "good", "bad", "safe" or "unsafe".

The aim of our work is to study the degree of impact of the characteristics that influence visceral response on people (emotional, intellectual, functional) and apply it to robot design to promote Human-Robot interaction.

2. STATE-OF-THE-ART

The Kansei methodology [4], also known as sense engineering, develops product features based on translated consumer sensations. This is a quite successful methodology that has been applied for several decades. However, its first step is defining the target user and the object function [2] [4], which can limit the social potential of the robots. The same shortcomings are observed in other methodologies used in HRI design that take into account people's opinions, such as User-Centered Design [5], Design Thinking [6], or Co-development [7].
Perhaps because there is always a specific problem to be solved or because the design process of the social interface mentioned above only appears later, it’s not yet possible to understand which are the transversal features of existing social robots that attract users, and which, on the other hand, repel them. These features are preponderant to the natural integration of social robots in our lives and spaces.

3. GOALS

As reviewed in the state-of-the-art, the current method of social robot design can be summarized in (Fig.1.):
1) create a robot to solve a problem/fulfill a purpose;
2) identification of target users, creating a profile to design towards;
3) iterative process of ideation, prototyping, and testing, until a satisfactory solution is obtained;
4) Implementation.

Although design centered on the user is important, this research intends to focus on a previous step, in which there is still no function or target user, not limiting a priori the social potential of a machine nor ignoring the cohabitants who can interact with it. Thus, it will be explored the existence of features (colors, shapes, sounds, motions, etc), for which we have, as human beings, a positive or negative visceral response, before any considerations on usability, functionality, or specific purpose (Fig.1.).
The primary goal is the creation of an innovative process of conceptualization of social robots that can guide roboticists in the design process to ensure a high level of acceptance of the machines by people and to establish a natural HRI, regardless of the purpose for which the product was created, its real function, and to whom it is intended.

4. RESEARCH APPROACH AND METHODS

The insertion of a robot in a social context with humans requires many concerns: technological, psychological, emotional, cultural, ethical, etc. This study focuses on the emotional and psychological levels, with the intent of fostering familiarity with a machine. By creating empathy on people who will interact with it, being the target user or not, we are facilitating its introduction into personal spaces.

4.1. Analysis and listing of robots

The first step was to do an analysis and listing of existing robots to form a delineation of the features that are considered relevant for the study – aesthetic, ergonomic, behavioral, shape, size, various idiosyncrasies – which are perceived consciously and unconsciously [8] [9] [10].

To make this list, we have to consider that the first robots came out dozens of years ago, and people's opinions are heavily influenced by social

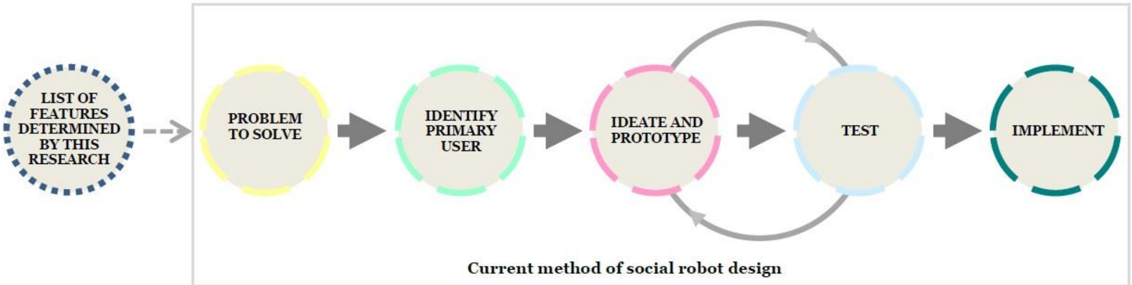

Figure 1. Diagram of social robot design steps.

media, literature, and the film/television industry. Most people feel disappointed when interacting with a robot because they expect it to be autonomous physically and intellectually. There is already a pre-conceived idea of the state of development of artificial intelligence, the mechanical properties, and the overall appearance of a robot. In order to avoid biased results, there will be an examination of the conscious and unconscious reaction of people to existing robots, fictional and real, looking for the aforementioned features in order to establish a pattern.

4.2. Emotional reaction evaluation

The evaluation of the conscious (C) and unconscious (U) reaction of people, will be done through surveys (C) [11] [12] [13] and biological signal processing (e.g. eye-tracking) (U) [14] [15] [16], in order to establish the prevailing attractive features.

Levels of exposure	*Target features for evaluation*
(1) Static pictures	General aesthetic features: different colors, textures, eyes, head, arms, etc.
(2) Short videos	Mechanical and ergonomic features; the mannerisms, sounds and several idiosyncrasies (like fluidity of movements, degrees of freedom, types of communication).
(3) Physical contact	Behavioral features; Interaction with the robot to have a clear perception of its features and personality.

Table 1. Emotional reaction evaluation setting

If we take as an example the PARO robot [17] - a seal shaped therapeutic robot, used mostly in hospital and nursing homes settings with seniors – we can already identify some features that contribute to a natural acceptance and empathy by the target user. First of all, a seal is not usually perceived as a threatening animal and the probability of a person having some kind of trauma related to it is low. Its neutral color and its size also contributes to that and makes it easy to hold and carry. Its fury looks and texture recalls to our friendliness with animals as do its big kind eyes. The sounds that it makes, stimulates our natural sense of protection and nurture and gives it a baby-like overall appearance (Fig.2.).

Figure 2. PARO robot - a seal shaped therapeutic robot

4.3. Iterative process of design

It will be implemented a process of rapid prototyping, changing or adding features in available social robots. These prototypes should undergo further conscious and unconscious reaction tests, such as those previously developed, for validation of the concept.

4.4. Creation of a guide

The compilation of the results will lead to a creation of a guide based on the results and validation of the creation process. For proof of concept, a social robot design or redesign will be carried out, in which the determined guide is applied.

5. CONTRIBUTIONS

This research will have two main outcomes:

1) Guide for Social Robots Design, based on the results of the tests that will include the desirable and undesirable features, to serve as a baseline for the design of better accepted social robots. Then, on top of these, can be added usability related features more appropriate to the target audience and specific function.

2) A Social Robot designed by following said guide. Furthermore, the social robot should be properly validated by users and on-site testing, in diverse environments (hospitals, schools, houses, offices, and others) and with different cohabitants.

In conclusion, we expect that the developed process will contribute to a larger acceptance of robots in society and facilitate their integration in diverse types of environments.

Acknowledgment — This work was partially supported by the project IntelligentCare – Intelligent Multimorbidity Management System (Reference LISBOA-01-0247-FEDER-045948), co-financed by the ERDF – European Regional Development Fund through the Lisbon Portugal Regional Operational Program – LISBOA 2020 and by the Portuguese Foundation for Science and Technology – FCT under CMU Portugal. Additional support is granted by the portuguese FCT through LARSyS - Plurianual funding 2020-2023 (UIDB/50009/2020).

References

[1] Hegel, F., Muhl, C., Wrede, B., Hielscher-Fastabend, M. & Sagerer, G., "Understanding social robots", In Proceedings of the 2nd International Conferences on Advances in Computer-Human Interactions, 169-174, 2009, https://doi.org/10.1109/ACHI.2009.51

[2] Huang, Y., Chen, C., Wang, I.C. & Khoo, L. P., "A product configuration analysis method for emotional design using a personal construct theory.", In International Journal of Industrial Ergonomics, v44, 1: 120-130, 2012, http://dx.doi.org/10.1016/j.ergon.2013.11.005

[3] Norman, D. "Emotional design: why we love (or hate) everyday things." Ingram publisher services US, 2004, https://doi.org/10.1108/07363760610655069

[4] Nagamachi, M., "Kansei engineering as a powerful consumer-oriented technology for product development", In ELSEVIER International Journal of Industrial Ergonomics, v 33, 3: 289-294., 1995, https://doi.org/10.1016/S0003-6870(02)00019-4

[5] Adams, J.A., "Critical considerations for human-robot interface development", In AAAI Fall Symposium: HumanRobot Interaction Technical Report FS-02-03, 1-8., 2002.

[6] Meinel C., Plattner, H. & Leifer, L., "Design thinking research", Springer, Berlin, Heidelberg, 2012, http://dx.doi.org/10.1007/978-3-319-19641-1

[7] Nagata, S., Šabanović, S., Piatt, J., Lee, H. R., Chang, W., Bennett, C. & Hakken, D., "Steps toward participatory design of social robots", In ACM/IEEE International Conference on Human-Robot Interaction, 244-253., 2017, http://dx.doi.org/10.1145/2909824.3020237

[8] Kamil, M.J.M. & Abidin, S. Z., "Unconscious human behavior at visceral level of emotional design", In Procedia - Social and Behavioral Sciences, 2013, http://dx.doi.org/10.1016/j.sbspro.2013.11.016

[9] Bedaf, S., Marti, P. & De Witte, L., "What are the preferred characteristics of a service robot for the elderly? A multi-country focus group study with older adults and caregivers", In Assistive Technology Journal, 2017, https://doi.org/10.1080/10400435.2017.1402390

[10] Von der Pütten, A. M., Krämer, N. C. & Eimler, S. C. "Living with a robot companion: empirical study on the interaction with an artificial health advisor", In Proceedings of the 13th International Conference on Multimodal Interfaces, 2011, https://doi.org/10.1145/2070481.2070544

[11] Paiva, Ana; Leite, Iolanda; Boukricha, Hana; Wachsmuth, Ipke., "Empathy in virtual agents and robots". In ACM Transactions on Interactive Intelligent Systems, v 7, 3: 1-40., 2017, https://doi.org/10.1145/2912150

[12] Watson, D., Clark, L. A., Tellegen, A., "Development and validation of brief measures of positive and negative affect: The PANAS scales" In Journal of Personality Social Psychology, v 54, 6: 063–1070., 1988.

[13] Bradley M. M., and Lang, P. J., "Measuring emotion: The self-assessment manikin and the semantic differential", In Journal of Behavior Therapy and Experimental Psychiatry, v 25, 1: 49–59., 1994.

[14] Song, Tengfei., Zheng, Wenming., Lu, Cheng., Zong, Yuan., Zhang, Xilei., Cui, Zhen., "MPED: A multi-modal physiological emotion database for discrete emotion recognition", In IEEE Access, v 7: 12177-12191., 2019, https://doi.org/10.1109/ACCESS.2019.2891579

[15] Kinner, Valerie L., Kuchinke, Lars., Dierolf, Angelika M., Merz, Christian J., Otto, Tobias., Wolf, Oliver T., "What our eyes tell us about feelings: tracking pupillary responses during emotion regulation processes", In Psychophysiology journal, 2017, doi: 10.1111/psyp.12816

[16] Henderson, Robert R., Bradley, Margaret M., Lang, Peter J., "Emotional imagery and pupil diameter", In Psychophysiology journal, 2018, doi:10.1111/psyp.13050

[17] PARO: https://ppl.pt/sites/default/files/styles/proj-inline/public/projects/img/foto2_2.jpg?itok=lUbtPVdG