

Computational Model of Anthropomorphism for Human-Robot Interaction

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Abstract—Anthropomorphism is one of the most extensively studied topics in HRI. Various factors were reported as affecting the degree to which a robot is perceived as human-like. However, our knowledge of this phenomenon is segmented as there is lack of a comprehensive model of anthropomorphism that could consistently explain these findings. I propose a preliminary model of anthropomorphism that is based on the reverse process to anthropomorphization, known as dehumanization. I hypothesize that the same attributes that people deprive dehumanized others can be used to affect robots anthropomorphism. Since embodiment of a robot can influence what and how these factors can be implemented, the ultimate goal of my research is to propose a method for applying the model of anthropomorphism to different types of robots. Moreover, the impact of interaction stage and context on the model will be explored.

I. INTRODUCTION

Epley et al. [1] defined anthropomorphism as attribution of human-like properties or characteristics to real or imagined non-human agents and objects. Various factors – related to a robot, perceiver and interaction context – were shown to affect a machine’s anthropomorphism. However, all these studies mainly investigated the role of a single or only few factors at a time. Studies of the uncanny valley theory were focused mainly on a robot’s appearance with little consideration for HRI, e.g. [2]. An appropriate match between a robot’s level of anthropomorphism and task can influence its acceptance [3]. Therefore, there is a need for a more comprehensive computational model of anthropomorphism that would enable robots to adapt their behavior to the user at an adequate level of perceived anthropomorphism for a specific task, e.g. more anthropomorphic when a robot is entertaining a user and less human-like when it conducts a medical check-up.

A model of anthropomorphism for HRI should not only indicate what attributes affect the degree to which a robot is perceived as human-like, but also how strongly they affect that perception and interact with each other. A computational model will enable robotic system researchers to design fine grained behavior by indicating which characteristics have the biggest influence on anthropomorphism. Although there is strong evidence that embodiment plays an important role in perception of a robot’s human-likeness (eg. [4]), the current technology does not permit robots to change their physical appearance. Therefore, the ultimate outcome of my research

will be a toolkit for fellow researchers for assessing human-likeness of different types of robots.

II. PRIOR WORK

The development of a method and validation of a proposed model require adequate measurement tools. Questionnaires are commonly used for measuring anthropomorphism in HRI. However, the established questionnaires, despite supposedly measuring a robot’s human-likeness, cannot be applied to real humans as the meaning of a subscale changes when applied to a human being (e.g. Fake - Natural [5]). Therefore, due to the way that they are constructed, they indicate that a target of an evaluation can be a robot rather than human, which on its own can affect provided responses.

In my previous work I focused on the development of a measurement tool that used visual cognition in order to measure a robot’s anthropomorphism [6]. This tool used the inversion effect, a phenomenon when upside down objects are significantly more difficult to recognize than upright objects [7], as a measure of anthropomorphism. The inversion effect affects only recognition of human body postures and faces, and different processing mechanisms are involved in recognition of humans and inanimate objects. In our study we showed that robots invoke the inversion effect similarly to humans and therefore on the cognitive level are processed differently than other objects. Furthermore, we found a linear relationship between the inversion effect and robots’ anthropomorphism. However, an additional analysis showed that the newly validated measurement was outperformed by the questionnaire based Godspeed Anthropomorphism Scale [5].

III. CURRENT WORK

I am currently working on a computational model of anthropomorphism that could not only explain in a systematic way robust amount of research on anthropomorphism, but also provide a mathematical formula for estimating how different factors will affect perceived level of a robot’s human-likeness. The currently available findings on this topic are segmented. Although they indicate ways in which a robotic system’s anthropomorphism can be modified, they do not consider interaction between different factors. A computational model can enable researchers to create fine-grained behavior at the level of anthropomorphism that is optimal for a given task.

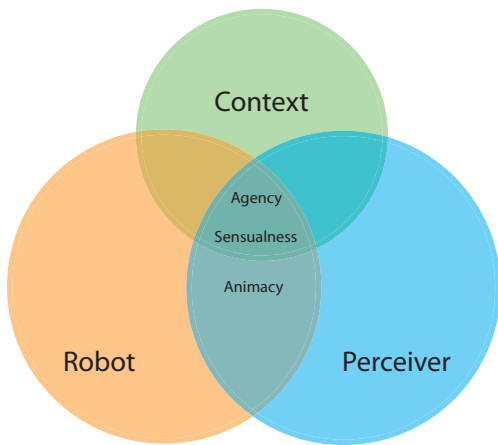


Fig. 1. The mediating effect of a robot, perceiver and interaction context on the preliminary model of anthropomorphism.

That may ultimately improve acceptance of robots. I propose that the key factors affecting a robot's anthropomorphism can be derived from psychology studies on the opposite process, known as dehumanization. If people objectify human beings by depriving them certain attributes, which form the core of humanness, the same attributes exposed by a robot can lead to its higher perceived human-likeness.

Haslam [8] showed that there are 2 distinct senses of humanness: characteristics that distinguish human beings from animals (such as intelligence, emotion recognition or self-control) and those which distinguish human beings from objects (such as primary emotions, warmth or personality). Therefore, anthropomorphism might be also not a uni-dimensional space, but it can be formed by the characteristics from these both senses. These two factors were called respectively agency and animacy in the preliminary model. Furthermore, there are physical attributes that distinguish robots from humans and these were incorporated in the model as the third factor called sensualness. Each of these factors is formed by literature review based and newly proposed indicators. Moreover, an embodiment of a robot, perceiver and context of interaction are expected to have a mediating effect on some or all of these factors as shown in Figure 1.

This preliminary model will be evaluated in a study involving NAO robots. Regression trees [9] will be used to determine which factors/indicators are the most affecting perceived human-likeness and to create a computational model of anthropomorphism for a NAO robot.

Moreover, I am currently working on a questionnaire of anthropomorphism that would overcome the shortcomings of existing questionnaires and which will include suitable subscales for measuring the proposed factors of the model. Compared with the Godspeed Anthropomorphism Scale, this new questionnaire will measure human-likeness based on attribution of characteristics found in studies of dehumanization. Therefore, it will not imply that an evaluated object could be

not a human. The validated questionnaire will be used in the future studies as a measurement tool of the proposed model of anthropomorphism.

IV. FUTURE WORK

The computational model validated in a study with NAO robots will enable to determine what are the key indicators of anthropomorphism. However, there can be other mediating factors (Figure 1). Therefore, my goal for the future work is to explore how they affect the model. The context and stage (pre-interaction, short-term and long-term) of interaction are expected to determine the factors that impact perceived anthropomorphism the strongest.

Another study will focus on the role of a robot's embodiment in the model. This study will enable validation of the proposed computational model of anthropomorphism for robots with different physical appearance and creation of a set of guidelines for other researchers for applying the model in their research. It is not possible to test all robots in all possible configurations of factors, which would be required for a computational model generalizable for robots in general. Therefore, the developed toolkit will provide much greater flexibility for other researchers to assess anthropomorphism.

The final contribution of my work will broaden our knowledge of anthropomorphism by establishing a model that could explain the segmented findings on this phenomenon. The proposed method will include a validated measurement tool, list of factors and guidelines needed for obtaining a computational formula for different robots. As an outcome, I believe that HRI will be improved by enabling robots to adjust their perceived level of anthropomorphism in order to optimize their task performance and ultimately increase their acceptance.

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