Designing Adaptive Behavior in a Social Robot

Eleonora Zedda
CNR-ISTI& University of Pisa
Pisa, Italy
eleonora.zedda@phd.unipi.it

ABSTRACT

Robots are becoming more and more present in our daily activities. In order to improve user interaction with them, it is important to design behaviors in robots that show social attitude and ability to adapt to the users. For this purpose, robots should adapt their behavior recognizing the user's emotion, also considering the actual user with cognitive and physical disabilities. However, most contemporary approaches rarely attempt to consider recognized emotional features in an active manner to modulate robot decision-making and dialogue for the benefit of the user. In this project, I aim to design and implement a module in a humanoid robot to create an adaptive behavior in a Social Robot for older adults who may have cognitive impairments.

CCS CONCEPTS

• **Computer systems organization → Embedded and cyber-physical system**; Robotics;

• **Human-centered computing → Human Computer Interaction (HCI);**

KEYWORDS

Human-Robot Interaction; Social Robot; Robot Learning

ACM Reference format:

Eleonora Zedda. 2020. Design adaptive behavior in a Social Robot. In *Proceedings of ACM IUI conference (IUI'20). ACM, Cagliari, Italy, 2 pages.* https://doi.org/10.1145/3379336.3381510

1 Introduction

In the last decade, the aging of society is occurring worldwide. Aging has a considerable impact on the health of the old people that suffer from cognitive and physical impairments [1]. At the same time robots become more common in our daily life. One goal of their introduction is to help humans doing their daily activities and assist users with health problems. For this purpose, it is important to improve their interaction and the capability to understand and recognize human emotions and intentions. A growing multidisciplinary branch of robotics, that include psychology, sociology, computer science is Social Robotics [2]. Robots need to learn autonomously but also through social interaction with users, considering their emotion. Human emotion expression is a natural way to communicate social signals, and emotional communication has shown to be essential in the learning process. Currently, however, there is no clear approach on how to generate and interpret behavior in the context of a robot that learns tasks using reinforcement learning. The robot should learn by trial and error and by expressing emotions for help and confirmation, they will need the affective abilities to express and interpret human emotions in the context of their learning process. I focus on older adults with cognitive impairments because the older population is growing rapidly worldwide, and it is becoming an increasingly important demographic to understand. Robots can be an effective tool that helps the older adults during their rehabilitation and training. Engaging the user in cognitive stimulation activities may reduce the risk of cognition and physical decline. Such stimulation activities can be obtained by using a social robot in order to create an affective interaction that could help the user to reduce their stress and improve their engagement during the training. The humanoid robot can obtain better results in terms of performance of the task performed by the users. In fact, the interaction with the robot can create an engaging environment for the older adults because social robots can adapt their behavior to the users helping them in their rehabilitation.

IUI '20 Companion, March 17–20, 2020, Cagliari, Italy

ACM ISBN 978-1-4503-7513-9/20/03.
https://doi.org/10.1145/3379336.3381510

2 State of art

Recent research [3] demonstrates that Social robots are able to improve mood, emotional expressiveness and social relationships among users and proved that humans could consider the humanoid robot like a companion with their intentions. In the last years, the humanoid robot technologies are progressively improved: they are able to recognize faces, reproduce emotion, move in the space, simulate empathy [4]. A humanoid robot can show emotions, and this feature helps the user to facilitate the interaction with the robot. Recent study [4] have used humanoid robots as Assistive robots for cognitive training with older adults with cognitive impairments and they have found that the users have not particular status of anxiety when they use the robot, and the cognitive training showed improvements in the post-test evaluation state of memory. In those studies, the robot does not learn how to behave with the user, but it is important that the robot can adapt its behavior to the user, in order to show human-like behavior while interacting with the user. In this way it can improve the user engaging and can achieve better results in the specific domains of cognitive rehabilitation.

3 Research Project

In May 2019 the HIIS laboratory of CNR-ISTI in conjunction with the Neuroscience Institute of CNR of Pisa collaborated in a project that involved a humanoid robot and older adults with mild cognitive impairments. The older adults approached the humanoid robot as a human and a stimulus to go to the clinic to do the rehabilitation and the exercise. For example, the older adults talked to the robot as the robot had its own personality. Taking into account this experience, my Ph.D. research addresses two limitations in prior work: adaptivity and robot learning. The idea behind this project is to design and implement adaptive social robot behaviors, according to the user's emotional state. The robot learns the user's emotion and according to this emotion adapts its behavior (e.g. by changing its eye color, changing movement and animation, the way of speaking).
Research question: Can an adaptive behaviour in a Social robot improve the cognitive performance in the user?

3.1 Robot, Method and Evaluation

3.1.1 Robot. The robot that I want to use is a Pepper Robot. The interactivity is the key feature of Pepper Robot. It has multimodal interfaces for interaction: touchscreen, speech, tactile head, hands, bumper, LEDs and 20 degrees of freedom for motion in the whole body [5]. To develop the humanoid behavior of Pepper Robot I will use the Naoqi framework. Different software development kits are provided to control Pepper: Python, Java, C++, and Robot Operating System (ROS) Interface. The Naoqi framework offers a module that allows recognizing five types of emotion *(*neutral, happy, angry, sad, surprised*)* but is not efficient and accurate.

3.1.2 Method. The goal is to create an adaptive behaviour of the robot using Reinforcement Learning (RL). RL is a computational technique enabling agents to learn skills by trial and error. In a typical Reinforcement Learning scenario, there is an agent that lives in a context or environment and is capable to receive the state of the context. The agents can do or execute an action in every state. Each action brings a reward that can be positive or negative. Using the reward, it is possible to educate the system to learn. This approach uses trial and error and the main goal of the reinforcement learning algorithm is to learn a policy [6]. In my PhD project, I want to use the Reinforcement Learning algorithms in order to adapt the robot behaviour and the cognitive training tasks to improve the memory, attention and alleviate physical degeneration for older adults. According to the emotion captured by the robot, in the first moment, there will be a phase of exploration in which the robot will try to learn which attitude to associate to the state of mind of the user and will learn to change also its behaviour in a specific context. In the mechanism of reinforcement learning the Agent would be the Pepper Robot that will do some action in a specific context and according to the reward obtained it updates the state. To this purpose, it will be important to verify and check which is the best algorithm to obtain an Adaptive behaviour in this context. I plan to apply this type of approach to the design of serious game that have the aim to stop the cognitive decline of older adults. For example, one of those games could be games like "memory" or cooking games in which the user should remember and recognize the order of some images or ingredients to complete the game. Another game could be a music game that ask to reproduce some melodies using arm and hand's movements.

3.1.3 Evaluation. For the evaluation study, I want to define two experimental conditions: learning condition in which the robot has a social behavior and the control group in which the robot does not adapt its behavior. Before the test, the users will be subjected to the STAI questionnaire [7] for evaluating the anxiety status of the user. The variables to be considered to evaluate an improvement in memory domain are reaction time, error, success, time session, number of tentative, etc. For evaluating the engagement with the robot, I can consider the number of smiles and time lengths of smile and gaze and the User Engagement Scale questionnaire [8]. The interaction will exploit all the multimodal possibilities offered by the humanoid robot (voice, gesture, movements). Learning to adapt to the user's mood will allow the robot to improve its interaction with the user.

ACKNOWLEDGMENTS

I would like to thank my Ph.D. advisor Prof. Fabio Paternò for his support and guidance.

REFERENCES

[1] Bishop, N.A., Lu T. (2010). Neural mechanisms of ageing and cognitive decline. *Nature International Journal of Science 464(7288)*, 529–535. DOI: 10.1038/nature08983
[2] Calvo, R. A., D'Mello S., et al. (Eds.). (2015). *The Oxford Handbook of Affective Computing*. Oxford University Press. USA. DOI: 10.1093/oxfordhb/9780199942237.001.0001
[3] Bechade, Lucile, et al. (2019) Towards Metrics of Evaluation of Pepper Robot as a Social Companion for the Elderly. In *Advanced Social Interaction with Agents. Lecture Notes in Electrical Engineering*, 89-101. Springer, Cham. DOI: https://doi.org/10.1007/978-3-319-92108-2_11
[4] Pino, Olimpia, et al. (2019) The Humanoid Robot NAO as Trainer in a Memory Program for Elderly People with Mild Cognitive Impairment. *International Journal of Social Robotics*, 1-13. DOI: https://doi.org/10.1007/s12369-019-00533-y
[5] Pandey, A.K., and Gelin, R. (2018) A Mass-Produced Sociable Humanoid Robot: Pepper: The first Machine of Its kind, *IEEE Robotics & Automation Magazine.* 25(3), 40-48, DOI: 10.1109/MRA.2018.2833157
[6] Broekens, J., and Chetouani. (2019) "Towards Transparent Robot Learning through TDRL-based Emotional Expressions. *IEEE Transactions on Affective Computing.* DOI: 10.1109/TAFFC.2019.2893348
[7] Marteau, T. M., and Bekker, H. (1992). The development of a six-item short-form of the state scale of the Spielberger State—Trait Anxiety Inventory (STAI). *British Journal of Clinical Psychology*, *31*(3), 301-306. DOI: 10.1111/j.2044-8260.1992.tb00997.x
[8] O'Brien, H. L., Cairns, P., and Hall, M. (2018) A practical approach to measuring user engagement with the refined user engagement scale (UES) and new UES short form. *International Journal of Human-Computer Studies 112, 28-39*. DOI: https://doi.org/10.1016/j.ijhcs.2018.01.004.