Socially Assistive Robots for Inclusion

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Abstract. Building socially assistive robots, that are respected by and represent people, is a very challenging task, requiring a cross-disciplinary research. Certainly, on the one hand it is essential to make effort for advancing the Socially Assistive Robotics field, with the aim of facilitating any user to exploit these devices. On the other hand, this technology, to be successful, has to satisfy people, not only from a technical (performance) point of view, but especially in terms of human-robot interaction. In this paper we present some challenges we have been facing to make the socially assistive robots a platform to guarantee new inclusion opportunities.

Keywords: Brain-Computer Interface, Control, Human-Robot Interaction

1 Introduction

Over the years the field of Assistive Robotics (AR) is growing up and it has recently received significant attention from researchers. Indeed, it is expected that, with the demographic challenges worldwide, the future ageing populations might require the introduction of assistive technologies such as robots. Indeed, an assistive robot, according to the definition in [1], should give aid or support to humans through physical interactions. Therefore, research into assistive robotics includes several kinds of robots: rehabilitation, wheelchair, companion and educational robots, manipulator arms for physically disabled people. These are intended to be used in a wide range of environments as schools, hospitals and homes. However, in the last years, the Socially Assistive Robotics (SAR), born as expansion of AR, has been taking an important role. The main difference with AR, is that socially assistive robots operate also via social interaction. Moreover, they are designed in order to elicit emotions and empathetic reactions in people. In the SAR field, the robot's goal is to create a close and effective interaction with a human user for the purpose of giving assistance and achieving measurable progresses in convalescence, rehabilitation, learning, etc. For these reasons, this robotics technology has a high potential for being used in the areas of social and healthcare, in particular it promotes: entertainment, companionship, supervision or cognitive and physical assistance [2].

2 Socially Assistive Robots for telepresence

One of the most suitable area for inserting socially assistive robots are, undoubtedly, the telepresence context. In that case, a socially assistive robot, could be exploited as a “service body” of a person, allowing him/her to experience being in a location without being physically there [3]. Therefore, in addition to the possibility of monitoring sick and/or aged people through a socially assistive robot, this technology could permit patients to keep in touch with their relatives and friends [3], and hospitalized children to attend lessons [4] [5]. Thus, they might help people also to communicate with the other ones. For example, you can consider who has just come out of the coma, having trouble speaking, understanding the others and expressing his/her feelings for many days. In other words, socially assistive robots could become a medium for inclusion of people, when they are not able to reach some places and/or communicate for any reasons. In this respect, socially assistive robots, piloted by a person himself/herself, fit perfectly with these purposes, because in contrast to other devices (for example such as a web cam), they could represent him/her in a more human way, by speaking and moving.

However, one problem, that can be arisen, is relating to the possibility that not all people are able to find the fully support from this kind of robots. Therefore, especially for those who lack all muscles control or whose remaining control [6] due to complete paralysis (e.g. by amyotrophic lateral sclerosis (ALS), brainstem stroke and spinal cord injury) or disorders (e.g. severe cerebral palsy), this technology may become easily fatigued or unreliable. In other words, it could happen that socially assistive robots require not simple skills for people: for example using a controller to drive a robot for the telepresence purposes could be fully out of their possibilities. In this respect, with the aim of making this technology usable for the largest number of people, it is possible to integrate socially assistive robots with the Brain-Computer Interface (BCI) [7]. BCI is a well-known computer-based system able to detect and translate electrical signals produced by brain activity on the scalp or cortical surface, into outputs communicating the user’s intent without the participation of peripheral nerves and muscles [8]. Therefore the subject is asked to perform a specific task, related to the expected neural patterns in the brain signals, that are in turn classified and translated into commands for external devices such as a robot. The long-term objectives is to promote dependent living and improve as much as possible the quality of life of people also with chronic or degenerative impairments in motor, sensory, communication and/or cognitive abilities [9] [10] [11].

3 Research Questions and Current Challenges

In telepresence applications, the design of the right behaviours adopted by a robot symbolizing the user and, as well as, being identified by the other people as an avatar of the person, is not a trivial question. In this regard, we have been deepening many aspects of using socially assistive robots as platform for telepresence in order to guarantee new inclusion opportunities. First of all, we supposed that robots should be easily to control, even more it happens through the Brain-Computer Interface (BCI). As well the user drives the robot, this last one might drive the human. In other words, we believe that these kinds of robots should exploit artificial intelligence techniques in order to facilitate the user to pilot itself. Therefore, in comparison with the current literature, we are designing a new advanced system enabling the user to focus only on giving high level commands (e.g. the destination to reach) to the robot, while the last one should be able to solve low levels problems (e.g. avoiding obstacle, computing the best trajectory to move, understanding in which area it can go, etc.) thanks to its "intelligence". However, all the applications of the artificial intelligence techniques should be reasonable and especially transparent to the user to be acceptable. Thus, keeping in mind this aspect, we have been wondering how to combine the intention of the user, expressed also by using BCI, and the possible behaviours the robot will do and implement. In other terms, we have been facing with the research question: How can human be integrated in the well-known loop sense - plan - act, typically applied for autonomous robots?

In this regards, our contribution consists in modifying this loop by developing a new semi-autonomous navigation based on the shared control paradigm [7] that, at the same time, mixes the user's intention and the possible low level decisions taken by the robot. Namely it represents a solution in the middle of exploiting a very intelligent completely autonomous robot (not suitable in this context) and one based completely on the input given by the user with a very limited or without "intelligence".

Moreover, in the case that Brain-Computer Interface system is used, an another "intelligent" element will play a crucial role in the new human-robot loop. Indeed, underlying the BCI, the feature extraction and the classification modules try to detect the user's intention during the execution of a mental task, by applying machine learning techniques, and then on basis of which, a command is sent to the robot. Thus, a problem arises in the system clearly when the output of the BCI classifier is not correct and therefore the robot does not reflect the user. In case of false positive the BCI detects a command (e.g. related to a passive mental states), implemented in turn by the robot, even if the user does not want to deliver; while, in the case of false negative the BCI system does not recognise any command and thus the intention of the user is not expressed through the robot. This issue is still representing one of the biggest open challenges in the field of BCI and it is related to the distinction between the Intentional Control (IC) and the Intentional Non-Control (INC) states of mind [12]. Since this problem is still unresolved, it motivates even more our choices to put a sort of "intelligence" on board of the robot, interpreting the user's intentions given real-time environment information, in order to smooth the possible errors and therefore to avoid, as much as possible, unwanted behaviours. We are managing it by evaluating whether the input received by the BCI system is consistent with the readings of the sensors both on the robot and in the environment itself.

In the perspective of making this kind of technology suitable and inclusive for any user, we have been investigating also how children could use a socially assistive robot, combined with Brain-Computer Interface, for communication purposes, especially in the hospital context. The main aim is to alleviate the condition of young patients unable to express desires and feelings. In this regard, we identified three main multidisciplinary challenges on which we are focusing on: (a) to design and evaluate the possible BCI paradigms and therefore the kind of classification techniques to apply; (b) analyse the child-robot interaction to satisfy the patient; (c) develop the wanted behaviours through a robot. Surely, the choice of the most suitable BCI paradigm is fundamental for the next steps. Since we guessed it might be difficult to ask a child to execute motor imagery tasks for giving commands through BCI [13], due to the long and intensive training required, we have been exploring the P300 paradigm [14]. Indeed it very close to the natural functioning of the brain and already used for communication application over the years [15]. A series of events (e.g. image flashes) are presented to the child and he/she has to pay attention to one of interest while ignoring the others in order to communicate and to send the corresponding command to the robot. Currently few studies exist in the literature with this focus and involving children, thus we are testing the most common methods to classify the data from EEG signals - Linear Discriminant Analysis, Bayesian Discriminant Analysis and Stepwise Linear Discriminant Analysis - to evaluate generally which is the best one to control a robot by a child.

However, the whole matters, described above, make sense only if the interaction between people and robots is designed in a meaningfully way for humans. For that reasons, at same time, we have been investigating also the perception of social robots in young people and especially which kind of human-like actions they expected from them [16], hypothesizing that both aspects could be influenced by gender. Thus, we have been exploring which of twelve stereotypically tasks, people consider a social robot able to do, could be useful for humans and/or they would like the robot to perform. Overall, the first preliminary results suggested that neither in the perception of the robot nor the expectations of the task performed by it are affected by sexist stereotypes. Nevertheless both men and women anthropomorphized the robot, by attributing a sex and also they effectively characterised it with human qualities. They were not scared or intimidated by the robot, but rather they perceived it positively (good, friendly, sociable, etc [16]). At the end, both agree in considering the robot suitable for communication functions including speaking, listening and talking. Therefore these results suggest that this kind of technology might fit very well for telepresence applications and/or as a tool for helping people to express themselves.

4 Conclusion

In this paper we present and discuss some possible challenges to face in order to make socially assistive robots an open inclusive medium for telepresence and an alternative tool for communication. We remark the current and the future research directions we have been following, highlighting the need of combining expertise either in robotics, neuroscience, psychology or anthropology.

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