Robot Pets for Everyone: The Untapped Potential for Domestic Social Robots

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***Abstract*— While research has demonstrated the potential for social robots as companions in care homes, for targeted specialized therapies (e.g., children on the autism spectrum) or uses in clinical practice (e.g., to increase comfort or reduce pain), social robotic pets for the general public have not yet even been minimally successful. Despite ongoing laboratory success of social robots for shaping mood, building rapport and creating empathy, this has not translated to actual robot pets supporting people in their homes. In this paper, we highlight this untapped potential for domestic robots to discuss some of the underlying issues behind acceptance, describe a simple agenda to design novel domestic robots, and present our initial plans to understand social robot acceptance and promote them to be domestic companions as pets.**

Keywords— Human-robot interaction, social HRI, domestic robots.

Figure 1: In the lab, companion robots have been shown to support general wellness and reduce stress, anxiety and loneliness. Despite these potential benefits, companion robots have not yet been successful in homes, highlighting an untapped potential.

I. Introduction

Social robots are those that look or act alive, and interact using social means such as speech, gestures, or gaze [1]. Research has generally demonstrated the power, impact, and potential utility of social robots to create emotional connections with people and shape their mood and behavior [2]–[4]. Physically-embodied robots that interact using human- or animal-like techniques tend to garner stronger social reactions than other technologies or on-screen social agents [5], [6]. This ability of social robots to develop connections and social reactions highlights their potential to serve as analogs to pets in domestic environments.

A range of laboratory studies has highlighted that robots can broadly shape mood [7], build rapport [8] and create empathy [6]. Similarly, research has demonstrated the effectiveness of social robots to support people in clinical contexts, for example, reducing perceptions of pain during a treatment [9], reducing stress among older adults living in care homes [10], improving quality of life for people living with dementia [11], and for providing therapy with children on the autism spectrum [12]. This again supports the strong potential for social robots as supportive domestic pets.

Despite mounting evidence that robots can emotionally support people, social robots have not yet emerged successfully, on a wide scale, as companion pets in people's homes. One key reason may be the strong disparity between the uncontrolled, dynamic domestic environments, and how in-lab and clinical successes rely on complex infrastructure, a highly controlled study environment, and a team of experts to orchestrate the interaction (e.g., using "Wizard of Oz" [13]); such laboratory supports are often required due to the technical difficulty of implementing social robots. However this level of support and control is not possible in domestic environments, which alters the interaction experience, and leads to a gap in the research: we do not know how in-lab successes will translate to homes, or indeed, how a robot designer should create robots that people will adopt and accept. As such, we advocate for an increased research focus on actual robot use and adoption in homes, which is required to better inform us on the nuances and complexities of why and how people will (or will not) accept robots into their homes.

Novel technologies like robots can be considered as disruptive technology and may not be accepted as smoothly as incremental innovations of previously available technologies [14], [15]. For example, Roomba was accepted in homes for its utility as an updated version of the traditional vacuum cleaner [16]. Furthermore, robot acceptance in homes might involve predictors other than utilitarian factors. For example, people may accept robots because of their companionship (e.g., friendliness), or robot's behavior as a teammate (e.g., motivated) [17]. There might be more predictors other than the mentioned ones, and therefore, more research is needed to explore how people may (or may not) accept companion robots into their own homes.

In the remainder of the paper, we will highlight existing research showing the potential of social robots as domestic companions to support wellness. Then we will present a simple agenda for designing improved domestic robots. Finally, we will show a work-in-progress study design, explaining our initial plans to contribute towards social robot use in the domestic context.

II. Potential for Domestic Robots

In this section we provide an in-depth survey to highlight the broad, untapped potential for domestic robots to support people in their homes.

A. Companion Robots in Clinical Contexts

In clinical contexts, social robots have supported people in rehabilitation (e.g., autism, cerebral palsy, heart disease, stress, anxiety). For example, research with children on the autism spectrum shows the potential of social robots in social skills development and communication therapies [18]. Social robots can divert or distract one's attention, reduce perceptions of pain or reduce aversion to uncomfortable medical procedures, such as diverting children's attention away from on receiving a vaccine [19]. For example, a huggable robot could comfort children in a clinical situation to mitigate stress, anxiety and pain [20], or to socially engage them more [20]. Social robot can be used to motivate people in physical exercises. For example, research with the KineTron robot demonstrated how the robot effectively motivated children to perform physical therapy exercises [21]. In a similar vein, Robots such as Autom [22] have also contributed very similarly by motivating older adults to exercise for their general wellness. Researchers are trying to introduce more social robots in rehabilitation therapies. Recently, the NAO robot was introduced in rehabilitation therapy for children with cerebral palsy and waiting for initial trials [23]. From these works we can understand that social robots can be quite effective in improving mental and physical wellness in clinical settings. Thus, these robots have potential to help people in their homes too.

B. Companion Robots in Care Homes

Research has begun to demonstrate how adopting social robots for everyday use may bring positivity and improve individuals' quality of life. For example, research details that the seal-like PARO robot increased the social interaction level of older adults who interacted with it on a regular basis [24]. On a similar vein, social robots showed efficacy in improving communication skills of patients living with dementia [25] and decrease stress and anxiety [26]. These social robots have also corroborated to be quite useful in aiding older adults to improve their lifestyle [26], [27]. For example, a work with the social robot Pearl [28] describes that the robot performed effectively in assisting older adults with cognitive and physical activities, which eventually improved their quality of life. These works recommend introducing social robots in domestic environments to tackle wellness challenges for any individual as well as older adults.

C. Animal-Assisted Therapy

The successes of animals as pets or therapy to support people likewise motivates the potential for robotic companions – as analogs to pets – to support people. Interaction with animals has been shown to help reduce anxiety, stress and depression by promoting activity and social interaction [29]. The specific mechanisms and reasons behind why animals have such positive wellbeing effects on people is still under investigation (e.g., see [30]), although evidence suggests that interactions with animals in general can have measurable positive physiological effects within 15 minutes [31]. As social interactants, therapy animals have been trained and selected to exhibit pro-social and comforting behavior: they are calm and friendly, and people typically touch them [32]–[34]. Thus, researchers are investigating robot-based solutions to replicate the successes of therapy animals while side-stepping issues associated with animals, such as allergies, cost, fears, hygiene, and protection of animal welfare [29], [35], [36]. If social robots can be designed to be affectionate and caring as therapy animals, it will be easier to promote such robots for domestic use.

Pet-like robots can provide companionship to older adults [24], such as research with the iCat [37] detailing how it successfully accompanied older adults and provided them with their medication information. Further, research with the robotic dog AIBO showed that it effectively reduced the level of loneliness of older adults in a care home [38]. Such works can motivate the potential of adopting social robots in homes for people who cannot adopt live animals for the previously mentioned issues with living animals.

D. Domestic Robots in the Real World

Limited initial research has demonstrated the potential of social robots to be companions in homes. Some domestic robots have successfully integrated into homes as products in widespread use, such as the iRobot Roomba. [4]. Research suggests that households have accepted Roomba for its utilitarian purposes (vacuum cleaner) [4], which necessarily does not translate towards the robot being a companion. However, developing a connection with the robot helped people enjoy household chores and improve their social connections [4]. There is evidence (e.g., shape mood [7], trigger emotional responses [39], improve social dynamics [40]) suggesting that these robots in some ways become companions, particularly in some enthusiast communities [4].

Several long-time owners of the robotic dog AIBO showed a positive attitude towards having it in their homes because of the companionship the robot had promised [41]. A few people considered AIBO as a social agent and they showed a moral responsibility towards the robot by expressing anger and sadness when someone caused harm to the robot [42]. More research can develop a concreate understanding of this human-robot relationship in homes and the associated challenges in accepting domestic robots.

In addition to these actual robots deployed into homes, research is continuing to develop more advanced robot behaviors [39], [40], [43], [44]. However, further knowledge on human-robot relationship in homes can make the advance behaviors more intuitive for domestic robots.

III. Agenda for Designing Social Robots for Homes

We believe that focusing on user-centered design [43], a standard methodology in human-computer interaction, is the path toward bridging this gap between success in laboratory results and potential for companion robots in homes. So, while we accept that this approach is often taken in human-robot interaction work, in this section we highlight where user-centered design can be strengthened and how important this is for successful robots.

A key component of user-centered design is to focus on what people already do and how they already solve their problems. Thus, this supports our focus on animal-assisted therapy [29], as an existing solution that works and that we can learn from; we advocate for seeking out other existing support mechanisms people can use and exploring how they can be used by robots.

A. Participatory design

A standard pattern in HRI research is to develop and implement a prototype, perhaps based on research literature, but without involving actual users in the formulation or design of the prototype. Users are often only involved in the evaluation stage of a prototype, which does not necessarily give people a voice to raise their concerns about the designs at the early stages. Instead, we advocate for a stronger participatory design approach. Early on, involve users to ensure the robot behavior would serve an actual user need. Involve users in the prototype design to ensure that the actual robot will translate well towards their expectations from the robot, such as, robot's utility (e.g., performing tasks related to domestic settings), and social factors (e.g., communication, companionship). After the participatory design and early prototyping phase, short-term usability study and long-term acceptance study should be conducted for developing more capable domestic robots.

B. Short-term usability study

Short-term studies (e.g., one day or one week) are useful to gather rapid insights of a robot's impact on a specific phenomenon (e.g., effect on anxiety and stress) [45]. Such studies can give researchers the opportunity to quickly receive feedback from potential users of the robot. This feedback can be extremely useful for iterative prototyping [46].

Short-term studies can be conducted in environments where the research variables (e.g., robot behavior) stay in control of the researchers. Thus, researchers can keep track of how the study is going on and adjust the variables as required for valid results.

This approach of involving users in the iterative prototyping and rapidly changing the design as per the users' feedback should become a norm in the human-robot interaction field to develop better robots that people will use.

C. Long-term acceptance study

Long-term user acceptance studies can uncover previously unknown information on acceptance, use and non-use of social robots [47]. Longer-term interaction studies can be conducted for several days, weeks, months or even several years [47]. Such studies are considered as a sub-area of human-robotics interaction research that explores how the interaction pattern between the person and robot changes over time [47]. We can observe how robot integrate into human social contexts, and how the presence of robots can affect the interaction between people.

This technique of gathering data related to human social contexts by deploying robots in user's own homes for an extended period can immensely benefit future domestic robot works [47]. Researchers developed a standardized framework to systematically gather information on the factors that influences use and non-use of social robots in domestic environments over a long period [47]–[50]. Future research can use these methods for better data collection and use the collected data on developing improved domestic robots.

IV. Our First Steps – Feasibility and Needs Analysis

We see a bootstrapping problem of needs analysis and developing a companion domestic robot to be intertwined: it is difficult to gather needs without a real robot to relate to, and we should not develop a robot without first having clear needs analysis. Our solution is to do an initial set of experiments using an existing domestic robotic companion, with the primary purpose being to better understand feasibility for improving wellness, and for getting in-situ, first-hand feedback from users as a component of longer-term participatory design. For this work, we choose the Sony AIBO robotic dog [38] (available commercial product).

Our project specifically is to investigate the use of a domestic companion robot for supporting lonely people and reducing stress. First, we investigate the question of whether a companion animal actually can reduce stress in short-term interactions, which we believe will be an important factor for being a supportive companion domestic robot. Second, we want to investigate how a robot will enter and integrate into a home. As such, we conduct a longitudinal study to investigate the acceptance pattern and long-term impact on loneliness and stress. This work will be important for our needs analysis, helping to better understand what people's needs are with respect to domestic robots, positioning us to next develop original and improved companion robots. That is, we see this in-home study as the first information gathering step in our long-term participatory design approach.

A. Short-term Lab feasibility study

We will conduct a controlled in-lab study to investigate whether our target companion robot (Sony AIBO) can reduce stress in short-term interactions; the lab study enables us to have a highly controlled setup where we can measure our variables. We plan to induce participant stress using existing standardized techniques [51], have them interact with our companion robot, and measure their stress level throughout the study. Further, we compare against two alternate methods: a real dog, and a relaxing activity (coloring). This will enable us to understand how interacting with this robot relates to stress. After interaction, we will conduct a semi-structured interview to gather general feedback about their interaction experience with the robot.

We will analyze the participants' stress data to investigate if AIBO had any impact on participants' mental stress by comparing the result with the other groups. The result from this study will give us quantitative insights on a social robot's efficacy in improving people's general wellness and qualitative insights on people's view towards social robot acceptance for everyday use.

B. Long-term acceptance study

We will conduct a longitudinal exploratory study to assess acceptance patterns and associated challenges of domestic robot pets, while simultaneously investigating the robot's impact on loneliness. We will recruit participants who self-identify as lonely, give them an AIBO for six months to interact with, assess the robot's impact on participants' loneliness and explore participants' robot acceptance patterns. Since the study will be conducted in participants' own homes, we will not have any control over the robot, thus, the study reflects an ecologically valid scenario to assess domestic robots.

We designed the overall study procedure in five phases, and we plan to have regular semi-structured interviews in all the important phases and regular weekly interviews throughout the study process. The phases are - initial intake, first encounter, ongoing during-study, exit and follow-up.

Initial intake – This phase will provide important context for analyzing and understanding people's attitudes toward companion robots before use (rather than attitudes toward the robot from use).

First-encounter – Participants will interact with the robot for the first time in this phase. This will provide insights on the participants' perception about the robot, their interaction plan for the coming days, and their expectations from the robot.

Ongoing during-study – This phase will consist of weekly interview sessions that will have questions about the participants' general wellness, interaction process with the robot, and participants' social communication and relationship with the robot.

Exit – Participant will give the robot back in this phase, and we will conduct an exit interview to get insights on the participants' thoughts about the overall study, their general wellness and the robot's impact on their loneliness.

Follow-up - We will conduct a follow-up interview with the participants after a week of the study completion to investigate how they feel about not having the companion robot anymore.

We will use standard instruments to collect data on their loneliness [52], mood [53] and anxiety [54], and quantitively analyze the data to understand the social robot's impact on participant's general wellness. We will qualitatively analyze the interview data to know the participants' perception towards such robots in reducing loneliness and understand how they accept these social robots for everyday use.

V. CONCLUSION

In this paper, we highlight the untapped potential for domestic robot pets to support wellness for the general public. We present our concerns about non-adoption of social robots in homes and discuss why we need to increase domestic research works. We present a simple agenda for future domestic robot works and describe our initial plan to gather more data on the acceptance process of social robots in homes.

Understanding the issues related to what is preventing people from getting social robots into their homes is extremely important, and a key challenge to finally developing and deploying successful robots. Thus, more research work is needed, and we hope our proposed agenda can be helpful for future researchers to conduct more domestic companion robot research. The outcome of such works may translate towards novel domestic robots which will not be sitting on people's shelves, rather people will treat them as domestic pets.

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