Co-designing Technologies for Well Being: A Robot Companion for Older Adults

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Abstract. Robotics is an industry that has disrupted the health field in differ- ent areas, including older adult care. Robotic companions for older adults have proved to produce many benefits, including decreasing loneliness, anxiety, stress, depression, agitation, and contributing to the improvement of social relationships, to mention a few. Currently, there are different options in the market of robotic pets for the older adult population. Among them is the *Joy for All* line of products. In December of 2015, Hasbro released the *Joy for All - Robotic Cat* to the market. While the product has been successfully adopted by the older adult population, there are opportunities to improve the nature of advanced human-robot interaction. The class, *Technologies to Extend Life*, taught in the Master of Design program at the University of Cincinnati, focused on designing the next generation of *Joy for All* robotic intelligence that could provide psycho-social support for older adults. With this project, the class had two primary objectives: 1) Understand the real challenges older adults face in activities of daily living; and 2) Develop innovative hardware and software tools that can meet some of the identified daily challenges. The class had a co-design approach in the many phases that included different participants (older adults and caregivers), utilizing a variety of tools to assess, analyze, develop, design, implement, and evaluate the interventions with older adults and communities. The significance of this project is to use a participatory approach to assess and analyze the challenges older adults face in activities of daily living that robotic companions may help alleviate, thus having an empathic perspective to the creation of assistive technologies.

Keywords: Robotics · Co-design · Assistive technologies

https://doi.org/10.1007/978-3-030-73103-8_63

1 Introduction

Research has found that companion robots could benefit older adults in different ways, including decreasing loneliness, increasing pleasure and lessen anxiety, reducing stress hormones, depression and agitation, increasing brain functioning improvement, forge social relationships, to mention a few [1]. Moreover, companion robots can be as beneficial as companion animals [2]. There are many robotic pets available for the older adult population. Among them are Paro [3], Miro [4], and the Joy for All line of products [5]. Paro, a robot seal, developed by Japanese engineers as an alternative to animal- assisted therapy [3]. It is the most common SAR used in studies. Paro is modeled after a baby harp seal and has soft artificial fur and five kinds of sensors. With the tactile, light, audition, temperature, and posture sensors, Paro can perceive people and its environment. Paro can recognize the environment (dark or light), people's interactions (touch, hold, talk), and respond in different ways, such as moving the head or legs, blinking eyes, or making a sound of a real baby harp seal. Some research has shown that Paro could reduce loneliness in older adults and have an effect on depression and agitation for the ones with dementia in nursing homes.

Miro, an animal-like biomimetic companion robot, developed by Sebastian Conran Associates and Sheffield University as a friendly and approachable [4]. Miro has six senses, 3D eyesight, touch-sensitive, light-sensitive, stereo hearing, echo location and cliff sensor, for detecting its surroundings, face recognition technology, and more. It orients, approaches, and interacts. Miro can turn its head, move, blink eyes, wag tail. Like robot Paro, Miro could generate engagement in older adults and supplement human care.

There is also a line of companion robotic pets, including cats, kitten, and dogs developed by *Joy for All* [5]. In December 2015, Hasbro released to the market a robotic cat under the brand *Joy for All* with the strategy to address isolation within the older adult population. It was a great success, in which the company, now *Ageless Innovation*, later released other robotic pets including the robotic dog in and most lately the robotic kitten in late 2018. Several studies that have proven that the companionship of these pets can calm anxiety, improve communication, increase social engagement, and decrease loneliness. With the successful introduction of these robotic pet companions, there is an opportunity to expand the capabilities of the robots by asking the central question: What is the next-generation robotic intelligence that provides psycho-social support for older adults?

The Master of Design program at the University of Cincinnati created the graduate studio-based class Technologies to Extend Life, where an interdisciplinary group of students proposed the new robotic pet based on the robot from Joy for All. This paper will describe in detail the codesign methodology with participation of older adults and caregivers, and the development phase that rendered a prototype of a new robotic companion.

2 Motivations

The motivations for designing robotic companions are based on four main issues. First, the older population in 2030 is projected to be twice as large as their counterparts in 2000, growing from 35 million to 74 million and representing nearly 21% of the total U.S. population [6–8]. Second, about one-third of U.S. adults age 45 and older report feeling lonely, and those who have low income are especially vulnerable [9]. Third, approximately 15% of adults aged 60 and over suffer from a mental disorder [10]. And lastly, more than 1 in 5 adults over the age of 65 is a "solo senior", where the number of "frail" older adults without children is expected to double by 2040 [11]. The Gerontological Society of America calls for new and innovative frameworks to take care of aging Americans, integrating health care systems, social care systems, and family care systems [12].

With these issues together, an apparent problem arises with an aging population in dire need of care, and the opportunity to work with existing technology but expanding the capabilities while responding to the real needs of the population. The challenge is to design new models of care, all within the umbrella of developing affordable technologies- robotics —Affordable Robotic Intelligence for Elderly Support (ARIES) (see Fig. 1). In contrast to disembodied technology, physically present artificial agents— "robots" have a variety of advantages for attention, motivation, and enjoyment.

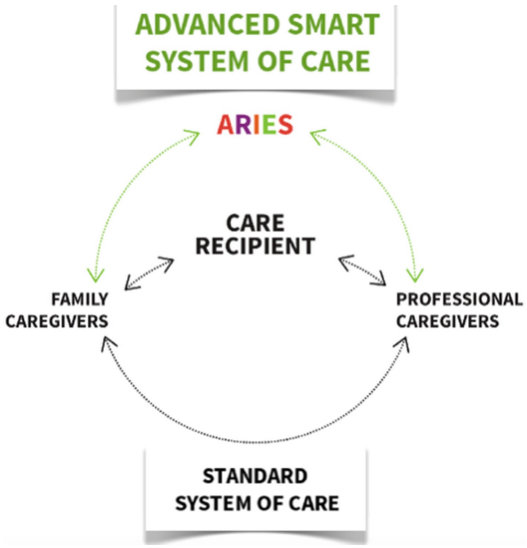

Fig. 1. Robotic pet companions as new models of care

3 Design Methodology

This project ARIES advances a co-design participatory approach in the many phases, utilizing a variety of tools to assess, analyze, develop, design, implement, and evaluate robotic companion interventions with older adults and communities (see Fig. 2). As such, older adults and caregivers are involved in the research and design process. With the project, there are two primary objectives. First, the objective is to understand the real challenges older adults face in activities of daily living. Within a co-design participatory approach, the goal is to assess and analyze the challenges older adults face in activities of daily living and how ARIES may help alleviate them.

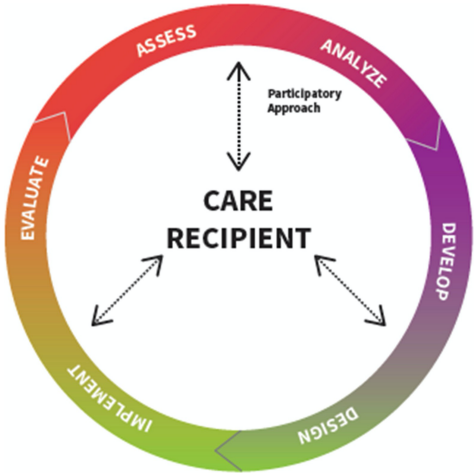

Fig. 2. Robotic pet companions design methodology

The second objective is to develop innovative hardware and software tools that can meet some of the identified daily challenges from the objective one. The end goal is to advance a smart system of care – a triadic system for linking caregivers (family/professionals) with the care recipient through the interactions with the robotic pet companion. As such, it is to develop innovative hardware and software tools that can meet some of the identified daily challenges and implement these tools in the next- generation engineering of Ageless Innovation's animal-like robot. The primary motivation is to design new models of care through affordable technologies-robotics with the end goal to advance a smart system of care – a triadic system for linking caregivers (family/professionals) with the care recipient through the interactions with the robotic pet companion.

4 Assess and Analyze

The focus of this paper is to describe the activities undertaken as part of the developing and designing innovative hardware and software for expanding the pet's capabilities and expansion of the Joy for All products. However, it is necessary to mention the results of the daily challenge needs as they relate to developing such capabilities. With the challenge analysis, we are now better understanding the difficulties our older adults experience in daily living and how to design smart capabilities. These areas include measuring vitals, falls prevention and emergency, memory assistance, and cognitive health as well as social connectedness (see Table 1). These results were used to experiment with conceptualizations in the development and design of the companion pet robotic capabilities.

5 Develop and Design

One of the main activities undertaken to develop and design the companion pet robotic capabilities was designing the curricula for a graduate-level course. A graduate-level course was offered and titled "Technologies to Extend Life," as a concept development project-based class. In this project-based studio class, students followed a design think- ing process from deconstructing current robots to understand technologies capabilities, to contextualize the problems such as questioning the human-animal relationships, to experiencing the pet companion robot. They also conceptualized ideas as experiments within the variables of pet type, and resolutions and types and validated design iterations various times in the semester with older adults via focus groups. The goal was not only to provide companionships but support advanced functionalities related to designing care capabilities for older adults. The next sections describe in more detail the curricular activities.

5.1 Expert Interviews

As part of the class, experts in the field were involved via guest lectures and field trips to educate the students. A total of three lectures were conducted: 1) an expert in social robotics who discussed areas for expanding the pet's capabilities; 2) ageless Innovation, discussing the mission, vision and lessons learned in the development of the robotic companions; and 3) a robotic technologist, who discussed the hardware experimentations as a repertoire for possibilities within an affordable umbrella.
The main takeaways points from the experts were:

- The pet is a bridge; it is as important for the end user as for the caregiver. Engagement should be designing to be continuous and sustainable.
- The real challenge of designing pet companions is to reframe simple technologies to advance "joy" while being careful with intrusion (e.g., surveillance cameras), keeping it natural while making people more social.
- When designing robotic pets, we should exercise a "SMART" approach: simple, meaningful, accessible, respectful and trusting.
- The more realistic the interaction/appearance, the more connectedness and attachment with the pet.

"The moment it stops being a cat, it loses its magic" Ted Fischer, CEO Ageless Innovation

Table 1. Robotic pet companion need opportunities.

Do you have difficulties with…?	**Mean**
Difficulties with technology e.g., cell phone computer, TV remote	1.18
Difficulties with misplacing or losing things e.g., glasses, keys, phone, wallet	0.96
Difficulties moving myself from seated to standing position or getting in/out of bed	0.76
Difficulties with my moods, keeping a positive outlook	0.59
Difficulties with speech and language e.g., speaking clearly, finding the right words, holding a conversation	0.53

Note: the scale ranges from 0-No difficulties to 4-Almost always

Would you adopt a robot for…?	**Mean**
1. Measuring vitals e.g. heart rate, blood pressure	1.04
2. Locating lost objects e.g. keys, reading glasses, wallet	0.71
3. Detecting falls and calling for help in medica emergencies	0.67
4. Playing cognitive games for cognitive health	0.61
5. Reminders of medication, appointments, exercise, etc.	0.61
6. Connecting with friends and family	0.59

Note: the three-point scale consist of 0-Not likely 1-Somewhat likely, 2-Very likely

5.2 Project Phases

Designing pet companions involved different phases in the process. These phases included: contextualization, deconstruction, ideation, inspiration, validation — focus groups/co-creative sessions.

Contextualization. During contextualization, students were tasked to understand the topic of designing pet companions under the following themes: 1) conduct competitor analysis of robot companions alike the joy for all robot; 2) conduct line-by-line analysis of news, blogs, comments of the current joy for all companion pet; 3) research the determinants of animal-human communication/expectations/attachments; and 4) con- duct ethnographic studies as participant observers by adopting a current joy for all pet companions.

The general findings of this phase included:

- While there is a broad spectrum of robots in the market and research laboratories, they can be classified in the axis of entertainment and companionship, and education and care; the care and companion quadrant is saturated with opportunities of character like and animal-like and not so much as humanoid-like.
- At the time of conducting online reviews, the Joy for All robotic companions' show a 4.7 out 5 stars in positive reviews, in which 80% are 5 stars, 10% are 4 stars, 5% are 3 stars, 3% are 2 stars, and 2% is 1 star. The positive reviews about the pet included interactivity in terms of response, movement, and life-

like features (e.g., heart rate),while the negative reviews were focused on the lack of settings related to type and amount of interactions such as barking. Nonetheless, the major negative review is related to batteries and replacement.

- One of the most critical aspects of animal-human attachment is related to emotion recognition. These emotional recognitions could be positive or negative, and they relate to the morphology and critical elements of the pet (e.g., snout). Moreover, the human brain responds to animals as cute, and the attachment becomes possible when humans can identify human features (e.g., babyface) in pets.
- Participant observations and experiences with the robotic companions reveal two significant aspects: 1) companionship is established quickly between the user and the pet, in which upon removal of the pet after a couple of weeks of interaction is felt like a negative experience (missing the pet); and 2) it is not so much about the type and number of interactions that the pet can afford since the experience is reduced to presence.

Deconstruction. This stage was aimed at disassembling the current joy for all pet companion, to understand the technologies used, the shape of the structures, the mechanical connection that affords movement, to mention a few. This activity was a class effort (see Fig. 3).

Fig. 3. Deconstruction

The initial goal of this phase was that the team could hack the system and repurpose some parts and the components (see Fig. 4). However, the team realized quickly that the parts could not be reusable. The class found out that there is a big emphasis on reducing the robot's components to their minimal expression with the goals of maximizing battery life and reducing the total weight of the pet. Additionally, there is a very successful highlight of life-like features (purring in the cat and bark-back).

After the deconstruction exercise, we questioned how to build a robot from scratch and started to evaluate the possibilities of fast manufacturing methods like 3D printing.

Inspiration. As part of the inspiration phase, the class visited Fabulous Furs, a leading alternative to real fur factory, to learn about the type, patterning and sewing techniques of furs (see Fig. 5). The major takeaway of this visit was learning that the manufacturing of furs has developed enough to offer not only realistic looks of furs but mainly a natural feel of furs. There is a wide variety of current furs, but new furs can easily be manufactured with patterning the hair colors.

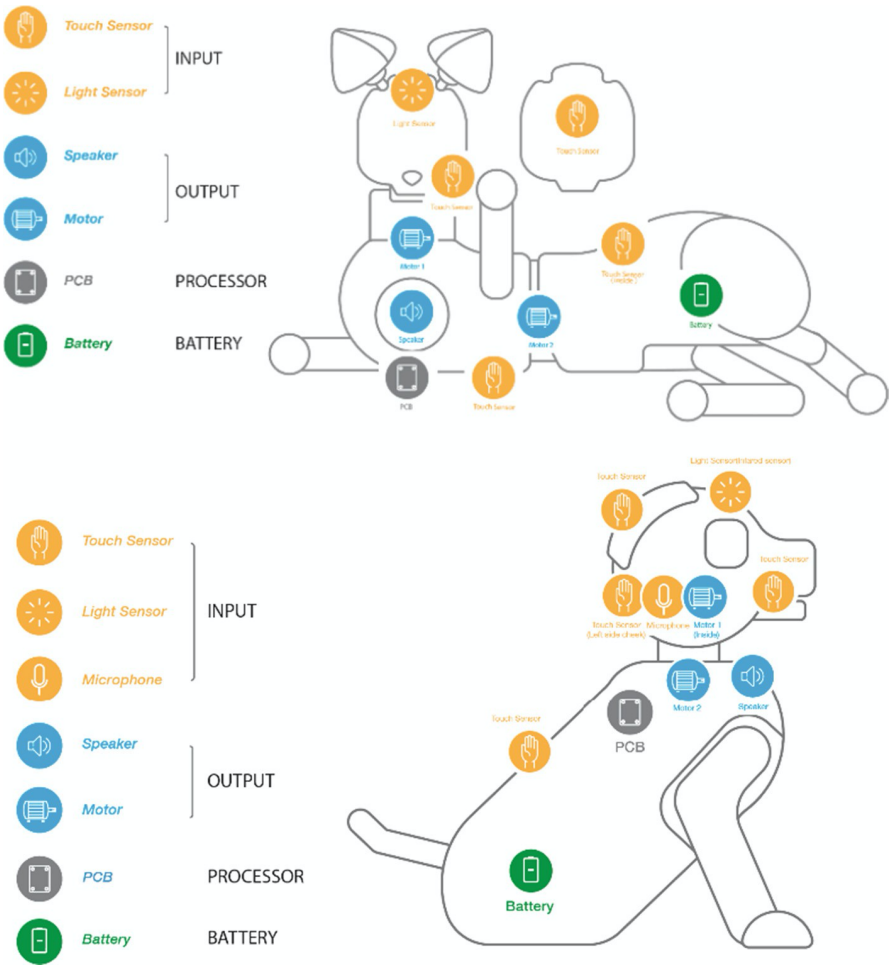

Fig. 4. Joy for all interactive technologies

Fig. 5. Alternative to real fur types

Ideation. As part of the ideation process, the class was divided into four experimental ideation groups. The ideation experimentation groups included designing robotic companions based on animal type (dog or cat) and resolution (realistic or abstracted) (see Fig. 6). Older adults were invited to the class in the form of a focus group to validate the ideation phase.

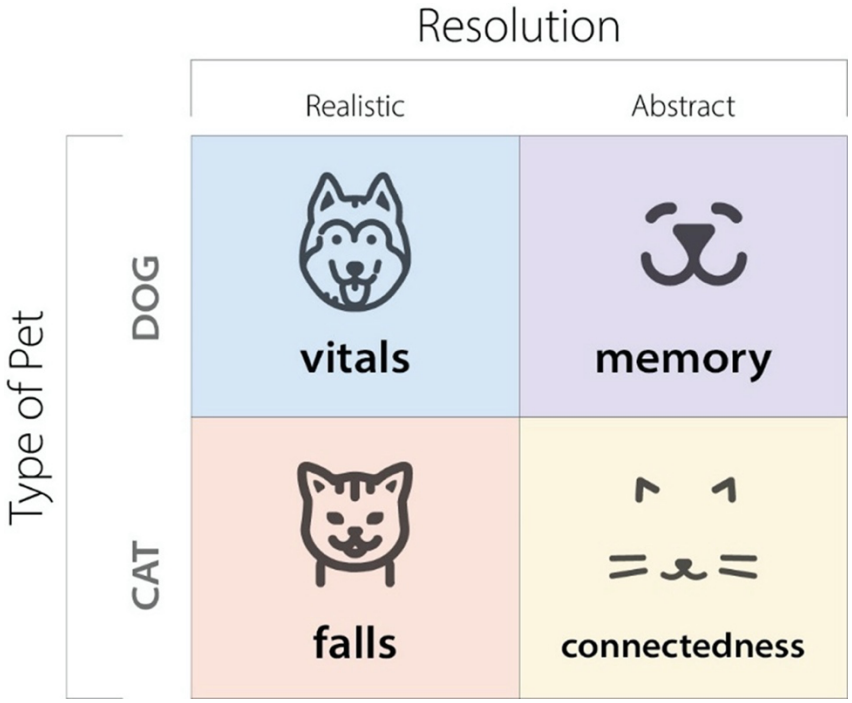

Fig. 6. Ideation experimentation

Results from the focus group indicated that the physical appearance determines the success of acceptance and engagement with the robotic pet companion and older adults. The abstract pets, for example, a body type like an Alexa with an expressive tail, might not be engaging enough for the older adults. Realistic robotic pets confirmed to be preferred and acceptable for older adults, which confirms the results from the expert interviews. Also, older adults indicated a preference in the following items. The pet should resemble or remind them about a past pet; the pet should have more realistic eyes, better quality fur. Moreover, the pet body and weight should be a soft, flexible body avoiding not hard plastic. While keeping the pet's weight for ease to pet and hold.

6 Designing Robotic Companionship Premises

The most important aspect of the project was the community partnership and engaging older adults via focus groups. We validated critical design decisions with older adults during the project in the classroom environment. With older adults' validations, student learning, and expert guest speakers, we advanced a set of premises for designing robotic companionship and advancing enhanced behaviors, including:

- Joyful
- Natural
- Personal
- Unobtrusive
- Preventive
- Reactive
- Connected
- Accessible (UD)

When designing a robotic pet companion, the proposition should be joyful as proposing interactions and appearances that make users feel happy and engaged. For example, a happy dog face engages the user's smiles. Natural appearances resonate better with users; these natural appearances are understandable and straightforward, where the user does not need to decipher what is it or what it does. Another aspect of optimal design is related to making it personal.

Users who adopt these pets often want to adopt a companion that resembles a previous pet. Offering furs options, types of animal noses, and ears can help achieve an individualized pet. Another major premise in the design should be the careful consideration of how technologies are implemented within the pet capabilities (see Fig. 7). Such integration should avoid being obtrusive. New integrated technologies and capabilities should offer preventive interactions, meaning the system having capabilities for counting/recognizing behaviors. Moreover, these recognitions should be integrated to alert the user/caregivers as acts on helping.

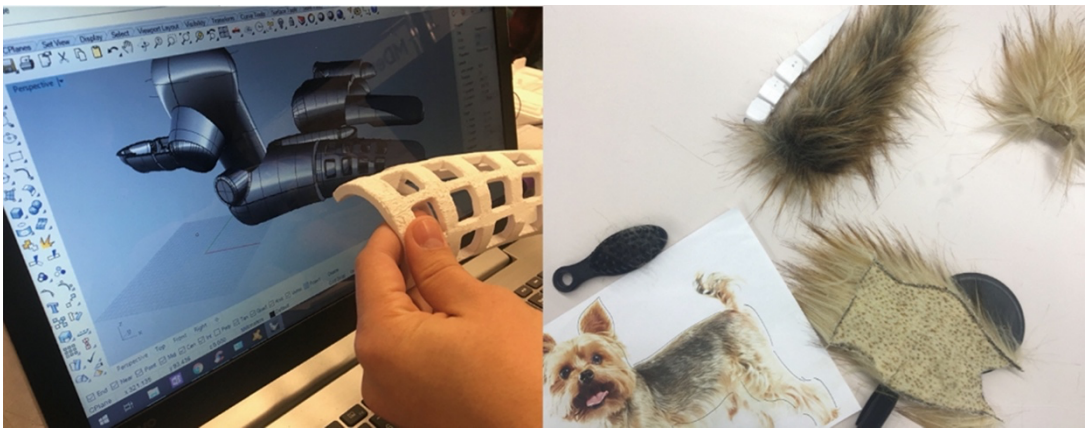

Fig. 7. Materializing behaviours

Lastly, pet interactions should incorporate the universal design principal to reach the broadest population; for example, a user with hearing impairments should be able to recognize when a pet might bark or meow.

These premises were used to experiment with materializing behaviors, modular systems, such as interchangeable noses, to respond to specific and individual needs of adopting a robotic pet that resembled a previous pet. Figure 8 showcases the final result "Scruffy," named after one of the older adult participants, which was inspired by the Yorkshire terrier as one of the preferred adoptions of dogs by the older adult population.

Fig. 8. Final robotic companion pet

7 Conclusion

The purpose of this paper was to describe the design process undertaken to improve the robotic pet capabilities based on the robot from *Joy for All*. More specifically, this paper discussed how the process advanced premises for designing the next generation of robotic companions for the older adult population. Designing pet companions involved different phases in the process. These phases included: contextualization, deconstruction, ideation, inspiration, validation — focus groups/co-creative sessions.

While the project/class was focused on enhancing the capabilities of current robotic pet companions, we found out that designing the companion was more critical as it is the primary interface between the user and its capabilities. When re-designing the pet companions based on the Joy for all pets, the following aspects were experimented with: materials such as natural aesthetics and feel of furs; inner body structures combining hard and soft parts; offering a modular system for generating personalized options (nose exchange, tail exchange, to mention a few); and size and resting position for the companion pet so as to be more graspable. In conclusion, this is a meaningful and exciting project illustrating the power of multidisciplinary collaborations, community involvement, and the integration of design in other disciplines and research projects.

The importance of developing and designing robotic pet companions is to advance new models of care while embedding technologies for the health and well-being of the older adult population. The significance of including users in early stages of design is to respond to the real needs of older adults, but also to create a collaborative relationship, that can connect the design and development team and produce better outcomes, mode desirable, usable, buyable products with more seamless interaction.

The main limitations of this project were time, as this project was planned for an academic semester, and the use of convenience sampling for our user interactions. Both of these will influence the layout of the next stages where the solution will be deployed in focus groups to test adoptability.

Acknowledgments. This project was funded by a grant from the National Science Foundation, division of Industrial Innovation and Partnership, No. 1717701. Next Generation Robotic Intelligence that Provides Psycho-Social Support for Older Adults.

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