Investigating Augmented Reality Animals as Companions

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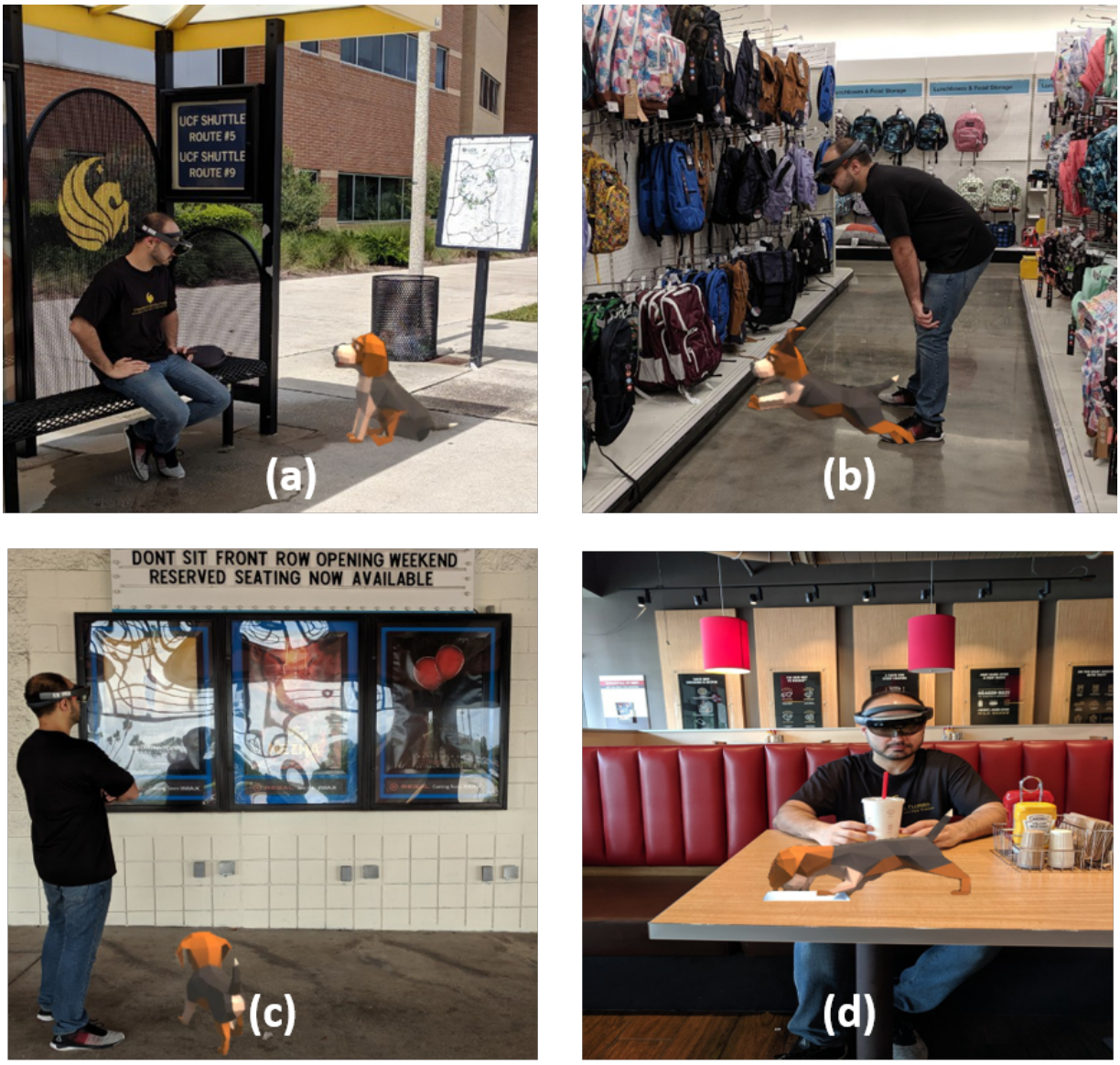

Figure 1: Mockup images illustrating four examples of the envisioned AR animal companions (a) at a bus stop, (b) in a shop, (c) at the movies, and (d) in a restaurant. The mockups show a real person wearing a Microsoft HoloLens in real circumstances, with our AR dog artistically overlaid in appropriate poses.

ABSTRACT

Human-animal interaction has been studied in a variety of settings and for a range of populations, with some findings pointing towards its benefits for physical, mental and social human health. Technological advances opened up new opportunities for researchers to replicate human-animal interactions with robotic and graphical animals, and to investigate human-animal relationships for different applications such as mental health and education. Although graphical animals have been studied in the past in the physical health and education domains, most of the time, their realizations were bound to computer screens, limiting their full potential, especially in terms of companionship and the provision of support.

In this work, we describe past research efforts investigating influences of human-animal interaction on mental health and different

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realization of such animals. We discuss the idea that augmented reality could offer potential for human-animal interaction in terms of mental and social health, and propose several aspects of augmented reality animals that warrant further research for such interactions.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Mixed / augmented reality; Applied computing—social and behavioral sciences—Psychology

1 Introduction

Over the years, research efforts documented the effects of human-animal interaction for human mental and social health in various contexts such as animal-assisted interventions and pet-ownership for different populations including but not limited to older adults [9], children with autism spectrum disorder [4], and homeless people [20]. Although the inclusion of animals for therapeutic purposes dates back to the nineteenth century, deeper investigations in their therapeutic benefits happened around the 1960s and the 1970s and were the result of Boris Levinson's efforts as a child psychotherapist [22].

To understand the source of these therapeutic benefits for animal-assisted interventions, Kruger et al. identified 3 main elements in human-animal interaction that would engender such effects. These elements are (a) reduction of stress and anxiety, (b) mediating social interaction, and (c) a source of long-term or transitioning attachment [13]. In an analysis of 49 studies focused on animal-assisted therapy, Nimer and Lundhal found positive results with moderate effect sizes in certain areas such as emotional well-being and children with Autism Spectrum Disorder [16]. For instance, looking at emotional well-being, Barker et al. found that animal-assisted therapy reduced fear and anxiety of patients who were about to receive electroconvulsive therapy [2]. It's important to note that these aspects are not limited to therapy animals and extend to the broader field of human-animal interaction which includes pets and companion animals. Reviewing 69 studies on the impact of human-animal interaction, Beetz et al. presented the positive benefits of such interactions on various social and physiological aspects for people with and without mental health [3].

With respect to technology, the field of robotics is rich with examples of socially assistive robots facilitating interactions specially with older adults and individuals with Autism Spectrum Disorder, with a wide range of physical representation including robotic animals [7]. Wada et al. found that interactions of the elderly with the seal robot PARO positively impacted the feelings of the elderly at a day service center and reduced the stress levels of the nursing staff [26]. Kramer et al. found that visits from the robot dog AIBO accompanied by a person provided the highest amount of stimulation for social interaction in older adults with dementia staying at a nursing home compared to visits by a person alone or a real dog accompanied by a person [12].

Graphical representations of animals have been studied more for younger populations. These entities were usually realized using desktop computers or cell phones and the focus was mostly physical health and educational applications. Johnsen et al. found positive effects in introducing a virtual dog as a way to encourage more physical activity [10]. Byrne et al. found that virtual animals capable of a range of positive and negative responses can promote healthy eating in adolescents [5]. Chen et al. found that introduction of personal and group pets in a class setting to 11-year old students positively impacted their learning efforts [6]. We do not know of studies focusing on mental health through virtual animals but the positive effects of these entities in other domains suggests their potential for further research in the area of mental health. Compared to the desktop computers and cell phones used in the prior work, augmented reality (AR) offers the potential to provide a more realistic and socially relevant interaction: the virtual animal would share the same physical space with its owner, and its posture and behavior would be matched to the real environment.

2 Possibilities for Augmented Reality

Figure 1 shows some mockup images illustrating four examples of the envisioned AR animal companions. Figure 2 shows an example of a person interacting with their AR animal using our current AR prototype. Looking at design aspects, when compared to virtual reality and computer displays, the AR realization gives these animals the ability to be part of the real world sharing the same physical space with the person they are supporting. As long as the user is wearing AR glasses, they would be able to see their animal interacting with them and the environment. Also, certain regulations that do not allow the presence of emotional support and companion animals in some public spaces [19, 25] will not affect these entities.

This is an important quality for companion and emotional support animals as it is important for these entities to be alongside their owners in most places. There is also more flexibility in terms of the type of animals, their appearance, and the number of animals surrounding one's space compared to real and robotic animals. For example, in a therapy session each person can interact with their favorite type of animal or the environment can be populated with as many therapy animals as there are participants without worrying about the availability of real animals and human handlers. The graphical representation of AR animals also results in a more realistic behavior/appearance compared to the mechanical movements and presentations of some robotic animals used in therapy.

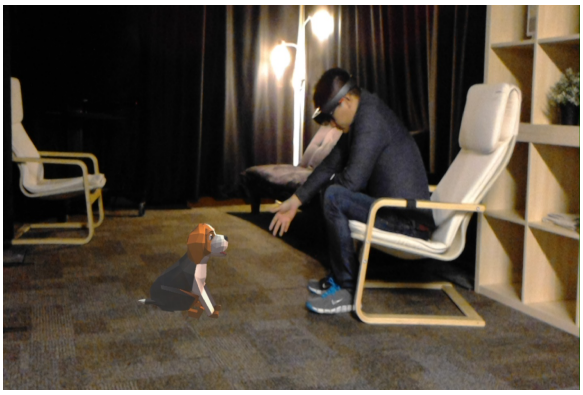
The happiness and comfort of a real therapy animal is another important factor in animal-assisted interventions. To make sure the animal gets enough rest, depending on the number of participants, the interactions are kept at shorter time frames and always with a human handler to ensure the safety of the animal and the participants. For instance, in two studies focused on animal-assisted activity for college students [1] and cancer patients [11] both research groups pointed out the importance of investigating longer interaction times and overall repetitions. In many of the cases, populations that receive animal-assisted interventions are populations that might not be able to care for the animal on their own, such as some older adults in care facilities. For older adults, one of the main populations studied for animal-assisted activity and robotic companions [12, 18, 24], AR animals provide the opportunity for longer and more personalized interactions, where in some sense each individual can adopt their own AR pet. Separately, the AR animal can be designed in a way where the requirements of its care (e.g. feeding, cleaning) can be modulated to match the needs of its owner. For instance, one can vary the number of times per week a virtual dog might need to go for a walk depending on the opinion of its owner with mental health and their therapist.

3 Interaction Limitations

It is important to note that we are not suggesting that AR animals are better than real animals or can replace them, but as mentioned earlier, interactions with real animals might be limited or not possible in certain circumstances.

In fact, AR animals have several limitations either due to the inherent nature of AR or certain technology constraints. For example, one cannot touch an AR animal, even though which it is common for people to touch/pet their own pets or animals they meet [8] and touch is usually an important part of animal-assisted interventions [3]. In addition, although AR technology has significantly improved over the years with more headsets available, not all of them have the required computing power to visualize an AR animal and array of interactions with the user and the environment, and the ones that are capable are heavier and more difficult to use for longer interaction periods specifically for certain populations such as children and older adults.

(a)



(b)

Figure 2: Human-AR animal interaction: (a) user's perspective of his AR animal and (b) user and AR animal attending to each other.

To facilitate interactions between the virtual and real entities, AR devices usually create a mapping of their surrounding environment. Through this mapping one can place a virtual vase on a physical table or have a virtual dog run around on the floor. These spatial mappings are susceptible to error with fast or sudden user movements. As a result, although an AR dog might act more realistically compared to a robotic dog, with the current technology they do not have the physical stability of robots. For instance, if the spatial mapping is not updated correctly the AR dog could be running around mid-air which can negatively impact user's experience. Last, in terms of public popularity, AR devices (due to some of the limitations mentioned above and price) are currently developer-based products unlike virtual reality headsets that are more commonly used by the general public and more content, mostly games and movies, is developed for them to use out of the box.

4 Future Research

Certain aspects of human-AR animal interactions warrant further research, some related to the qualities of the animals themselves and some related to the AR interaction space. Augmenting a physical space with virtual entities means that those entities are shared with other things and people in that space either directly or indirectly. By a *direct shared space*, we mean multi-user interaction spaces where different AR users have the ability to see all the virtual entities in their shared space and could interact with any of them or with each other. With an *indirect shared space*, we mean interactions where the AR user is able to limit the visibility of the virtual entities to others in their space (e.g. their AR dog is always only visible to them and not to other AR users), or the AR user is sharing the physical space with non-AR users who cannot perceive virtual entities in that space.

In a series of relevant studies investigating the privacy and security aspects of multi-user AR interactions, Lebeck et al. noticed interesting behaviors in their participants who were asked to play simple AR games either individually or in pairs while sharing a physical space [15]. Their findings suggest that the shared physical space had a strong effect on participants' perceptions resulting in the assumption that all virtual entities can be seen by everyone who share the physical space even if they were taking part in an individual experience. They also pointed out instances where participants "placed virtual objects in each other's faces or attempted to steal control of objects from each other," although as playful attempts. Understanding the implications of *direct* and *indirect shared spaces* becomes even more important for circumstances involving AR animals that are designed to be a source of comfort and companionship, as it is possible for owners to form a bond to these entities since past research points towards the strong bonds and attachments between humans and their real pets [27]. Also, mental health patients, children, and older adults are more vulnerable populations and interactions with undesirable connotations can impact them more negatively.

To better understand user's expectations of others and their AR animal in a shared space, We ran a study varying the awareness of strangers (i.e., confederates in the study) sharing a physical space with the participants and the awareness of their AR animal [17]. In one phase of the study, participants observed their AR animal being walked over by a stranger. The aware stranger had AR glasses on and verbalized that they saw the dog while the unaware stranger did not have AR glasses on and walked over the dog in a distracted manner. Separately, in response to the collision, the aware animal fell over and whined while the unaware animal did not react. Our findings suggest that regardless of the awareness levels of the strangers, participants associated lower affect to the strangers when the dog showed awareness of the collision.

The findings from the two studies above introduces new directions in terms of different types of interactions in a shared space and the behavioral requirements of an AR animal to remedy or avoid as much harm to the owner as possible for the design choices of these entities. For example, one can design an AR animal to be unresponsive or exhibit positive reactions to the environment in crowded spaces such as airports when other people are unaware of one's AR animal and to be highly responsive in personal spaces to maintain the interaction realism and a sense of companionship with their AR animal. Similarly, different behaviors needs to be designed for circumstances where the interaction of others with one's AR animal is more privacy invasive or negative as there have been examples of bullying or abuse in the case of virtual humans [23] and urban robots [21].

Also, it is important to further investigate possible solutions for certain interaction limitations. With touch being an important aspect of interaction with companion animals, we need to understand how the absence of this feature would affect the owner of the AR animal compared to interacting with physical companion animals, and consider some ways to remedy this shortcoming. Using contextually meaningful surfaces as mediators might help mitigate this problem, such as petting the AR animal when sleeping on a physical furry pet bed that can replicate the sense of petting a real animal.

Given the possibility that AR animals could accompany their owners in different places and under different contexts (e.g., driving), it's important to investigate how the AR content can be placed and when it should interact with its owner to avoid interactions that may be harmful to user's safety (e.g., AR dog incorrectly appearing

on a road sign) [14]. It is also important to understand the design requirements for the AR animal in terms of its effects on users' perceptions of reality and whether or not the AR animal is viewed as a distraction to avoid one's problems or as a companion providing positive support.

5 Conclusions

In this work, we presented past work on the inclusion of real animals as entities with therapeutic qualities and how different technological manifestations of such entities have been developed and tested. We then introduced the idea of augmented reality animals and discussed some of the advantages in studying them as entities for animal-assisted interventions and as companions. We discussed some of the current limitations of these entities and proposed new research directions based on past findings.

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