Beyond the Limits of Digital Interaction: Should Animals Play with Interactive Environments?

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ABSTRACT
Our digital world evolves towards ubiquitous and intuitive scenarios, filled with interconnected and transparent computing devices which ease our daily activities. We have approached this evolution of technology in a strictly human-centric manner. There are, however, plenty of species, among them our pets, which could also profit from these technological advances. A new field in Computer Science, called Animal-Computer Interaction (ACI), aims at filling this technological gap by developing systems and interfaces specifically designed for animals. This paper envisions how ACI could be extended to enhance the most natural animal behavior: play. This work explains how interactive environments could become playful scenarios where animals enjoy, learn and interact with technology, improving their wellbeing.

Categories and Subject Descriptors
H.5.3 [**Information Interfaces and Presentation**]: User interfaces – *interaction styles, user-centered design, input devices and strategies.*

General Terms
Design, Experimentation.

Keywords
Animal Computer Interaction; Playful Interaction; Intelligent Environment; animals; interface.

1. INTRODUCTION
1.1 Animal-Centered Technology
Human Computer Interaction has provided countless benefits to human wellbeing. Understanding how humans interact with digital systems and interfaces has allowed Computer Science to evolve towards more natural and well-integrated digital devices. These intuitive devices and environments help us in several aspects of our lives: from Ambient Assisted Living scenarios in which the environment helps the inhabitants in their daily routines, to interactive videogames designed for rehabilitation tasks with impaired patients.

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In our journey towards a ubiquitous and supportive digital world, we have forgotten about our non-human companions - our animals, who also are a very important part of our lives. Animals could also benefit from the technological advances we have achieved throughout the digital revolution. However, the technology and computer systems remain almost exclusively human-centered. Thus, the interaction methods and systems' features have been shaped with only human requirements and characteristics in mind. Unfortunately, animals do not understand the digital world as we do, due to both their different physical features and mental processes. Even the most fundamental sensorial capacity, such as the vision, restricts how an animal perceives our digital surroundings: dogs are unable to watch television, as they need more than 70-80 frames per second to avoid flickering images [12]; and cats may not distinguish between two identical objects by their color, because they do not see the same color spectrum as humans [12]. Furthermore, the interaction mechanisms which may seem natural for us, such as direct touch screen manipulations using fingers, tend not to be applicable for other animal species, e.g. birds. Moreover, what is of most importance, our digital abstractions of the physical world may not be understood by animals, as their mental representation of the world differs from ours [11]: animals may not identify 2D digital representations of 3D physical objects, or they may not be able to abstract the manipulation of a physical element such as a button in a digital button-press action.

The aforementioned concerns are being addressed in a recent research field called Animal-Computer Interaction (ACI) [8,9]. ACI considers animals as the target users of digital systems, aiming at developing computer interfaces and digital systems specifically designed for them. For this purpose, we should learn how different animal species behave and interact with technology, in order to come up with the most natural interfaces for each one of them. Animal-centered interfaces and systems could enable the development of better technology to support interspecies communication, non-intrusive wearable devices to monitor animals' health parameters, comfortable haptic devices to simulate human touch, etc. Moreover, humans could also benefit from ACI advances: it would enable them better communication with their pets using the adequate interfaces, and they could let digital systems cater their animals' needs while they are away from home.

1.2 Digitalizing Animals' Playfulness
In this whirlpool of ideas and applications for ACI, we believe there is a niche research area in developing systems grounded on the most natural and intrinsic behavior among all animal species: play. Animals do not need to learn how to play as it stands as an intrinsic behavior. In fact, playful activities of each animal species emulate situations they need to prepare for: felines play simulating

chase and hunting, while antelopes oftentimes play by racing. Therefore, developing digital playful experiences for animals could be one of the most natural approaches to study animals' interaction with computer systems. Moreover, play is a worldwide understood form of communication, both intra and interspecies. Enhancing playful activities between humans and their pets could lead to higher levels of happiness and wellbeing on both species.

These playful experiences could succeed under the condition that there is at least a human being managing the digital game. But what happens when there is no human presence? Why don't we envision animals playing by themselves with computer systems? This way, pets alone at home may find a way of entertaining themselves and avoid boredom or anxiety. Even deprived groups, such as sheltered animals, could engage into playful experiences without the volunteers' supervision, alleviating their stay.

There are plenty of scenarios and situations where digital games could help to improve animals' wellbeing. A question could be raised from a developer's point of view: should we build a single game for each animal species and purpose? Wouldn't it be better if the system by itself could adapt the digital game to the context? This kind of transparent adaptation and context-awareness has already been studied in the field of Ambient Intelligence (AmI) [4,19,21], considering humans as primary inhabitants of those intelligent spaces. One of the goals in AmI is to have the environment learn from the user preferences and the context in order to, intelligently, manage the available devices of the environment and adapt them to the situation: adjust heating at home to achieve balance between comfort-energy saving, notify the inhabitant of abnormal situations during his absence, etc. Incorporating the same kind of intelligence into a playful environment designed for animals implies that several digital elements could be interconnected seamlessly, creating an enriched playful activity. The playful environment would learn from the animals' preferences and behaviors, adapting the game to a specific context, and creating engaging playful activities autonomously. We have named these kind of systems Intelligent Playful Environments for Animals (IPE4A) [14].

This paper briefly describes previous work on computer interaction and digital games for animals, and summarizes our recent contribution to ACI: Intelligent Playful Environments for Animals. The main contributions of these systems are: improving animals' wellbeing and supporting ACI studies using an intuitive way to interact with animals. Some possible applications of such environments will be presented. Finally, ongoing work and future research directions will be established. All the work detailed in this paper is a summary of an ongoing research and previous publications of the authors. For further information on Intelligent Playful Environments for Animals, please refer to [14,15].

2. RELATED WORKS

There have been many studies on animal communication mediated by technology and, in recent years, several games for animals have also been developed. This section gives an overview on the most relevant research which has inspired our contribution.

2.1 Animals Interacting with Computers

One of the first attempts to understand the communication capabilities of animals using technology and computer interfaces was the *LANA Project* [17,18]. Chimpanzees were presented a keyboard with *lexigrams*, i.e. abstract symbols representing nouns, verbs, activities, etc. Chimpanzees could construct English-like sentences in a language called *Yerkish* using these *lexigrams*. Lana was the first chimpanzee who learned how to use the keyboard, and she was able to effectively communicate with her human trainers. Further studies about chimpanzees' cognitive capabilities, such as the *Ai Project*, used touch screen computers and iconic keyboards [10]. The reason for using these interaction methods was based on the similarities between humans and chimps. Touch screens have also been used to study the communication between dolphins and humans in the *SpeakDolphin* project [25]. Within this project, dolphins touch a waterproof screen directly with their nose in order to select among a set of images, the one who corresponds to the real object the trainer shows them. Applying ACI principles to dog-human communication can also help saving human lives. Diabetes Alert Dogs (DAD) are canines paired with a human suffering from diabetes. DADs are trained to detect changes in blood sugar in real-time. Whenever the dog detects a rapid decrease of sugar levels, it alerts the human. However, if the human falls into a coma due to a hypoglycemic attack, the dog is unable to help him. This sparked the development of several dog-oriented interfaces that facilitate the dog to alert emergency services in such situations [16].

2.2 Digital Games for Animals

There have been several studies centered on enhancing playful activities using technology in order to stimulate the animals to perform physical exercise, enlivening training activities, or just directed at the pure fun of playing.

LonelyDog@Home [6] allows humans to interact remotely with their dogs via a web interface. Humans can watch their pets at home through a web camera, feed them by activating a pet feeder connected to the system, or play with them throwing a ball with an automatic ball thrower. However, dogs can't see their owners and are unable to communicate with them. *Canine Amusement and Training* [24] is a training system based on playful interactions, which allows inexperienced humans to train their dogs in an enjoyable way. Using a projector and cameras, lights and figures are projected on the ground. There are several kinds of games, and the human is required to give appropriate commands to the dog, which vary in line with the goal of the game. *Metazoa Ludens* [3] is a mixed reality game where a human and a hamster play together. The hamster can run across a moldable surface, chasing a bait controlled by a human on his computer. The hamster's movements are also tracked and transferred to the virtual game on the human's computer, in order to make the chase more realistic. *Cat Cat Revolution* [13] is a digital game for iPad which shows an animated mouse moving around the screen. The cat is encouraged to capture the mouse using graphical hints and sounds. Brightness, size, color and movement of the digital mouse have been tailored to cat's visual characteristics. Humans can let the cat to play on its own, by letting the mouse move randomly across the screen. However, a human can also control the movements and velocity of the mouse with an iPhone application. *Felino* [22,23] is another tablet-based game designed using ACI principles. The design of the game has been informed using observational feedback and the opinion of the cats' owners. The game shows a fish and several sea creatures moving across the screen. A human and a cat can play together: any time the cat captures the fish, a sphere is released, and the human has to capture it using a crab avatar. The human can control several aspects of the game, adapting it to the cat's reactions and preferences.

3. INTELLIGENT PLAYFUL ENVIRONMENTS FOR ANIMALS

3.1 Foundations

Although the games mentioned in section 2.2 are the first step towards a new era where animals are active participants in our technological world, they lack of two essential features: adaptation and integration. Until now, only single-purpose games with one interaction device have been developed, and each change in the requirements, such as the size of the animal, its species, or its humor requires human intervention to change the parameters of the game, stop it, or even start a new development iteration. However we believe that having multi-purpose games, which adapt themselves to the needs of a specific animal will be more powerful and efficient. The game could modify its parameters autonomously, in order to better suit the animal's requirements or preferences. Moreover, the playful environments should be comprised of several interconnected devices, which cooperate to create elaborated activities that can vary from one iteration to the next. In essence, intelligent playful environments for animals have been formally defined as follows [14]: *An Intelligent Playful Environment for Animals, or IPE4A, is an animal-centered ecosystem with intelligent capabilities which is able to learn from the animals' behaviors and interactions, using the acquired knowledge to adapt itself to the context, creating engaging playful activities which do not necessarily need human mediation to evolve.*

Let's illustrate a situation where intelligent playful environments could improve the animals' wellbeing:

On Tuesday morning, Sarah goes to work, leaving her two pets alone at home. Her cat, Felix, is sleeping in his favorite place, the living-room's couch. Felix is an elder, peaceful and independent cat. Bella is a young and frisky Golden Retriever, who never gets tired of playing and loves human company. When Sarah leaves, Bella tries to wake up Felix, who does not want to be annoyed, and thus Bella sits in her bed. After a while, the intelligent playful environment determines that Bella is becoming bored because she is getting neither exercise nor sleep. Therefore, an electronic ball is activated and starts emitting subtle lights and sounds. Bella is attracted by the sound source, and when she approaches the ball, it starts moving, rolling away from her. Through several cameras installed throughout the house and image recognition algorithms, the movement of Bella is tracked, allowing the electronic ball to avoid her. It becomes an amusing chase for Bella. As Bella gets immersed in the activity, the system decides it is a good moment to perform some training. Sarah has prerecorded several voice commands, and in her free time began to teach Bella different tricks. The system, then, stops the ball, reproduces a command through the home audio system and waits for Bella to perform the adequate action. If she does it correctly, the chase continues for a few minutes before giving a new voice command. If Bella fails in her performance, the system records it and starts up the ball again. Sarah could later review Bella's performance, decide which commands require further training, and reinforce them with Bella. At some point, Felix gets interested in the game and approaches Bella with curiosity. The system detects that a new player should be considered, stops the training commands and continues the chasing game. However, the physical condition of Felix does not allow him to play as vigorously as Bella. Thus, the ball speed decreases in order to allow Felix to participate in the game. Also, sometimes the ball hides under the couch or bed, which lowers the intensity of the quest, allowing Felix to participate in the activity without straining his physical abilities. After a while, the system decides that the daily dose of physical exercise of the pets has been met, and the ball stops moving.

3.2 Benefits and applications

There are plenty of scenarios where intelligent playful environments could help to improve animals' wellbeing. The story of Sarah, Bella and Felix shows how the environment could help to alleviate the stress and anxiety some animals experience when they are left alone at home. The environment created playful activities to entertain Bella and Felix while Sarah was at work and the animals were becoming bored or sad. This could be of special importance in zoos or shelters, where animals do not frequently interact with humans and spend the whole day alone inside restricted ecosystems. This way, the animals could play without the supervision of their caretakers or shelter volunteers.

Another problem for enclosed animals is the lack of physical activity. Depression or stress could lead the animal to rest for long periods of time and be apathetic. In such cases, physical activity could be stimulated with entertaining games to capture the animal's attention and encourage it to move. The system should adapt the activity to the animal's attributes such as weight or age - old animals should not perform as much physical exercise as young ones.

As it could be observed in Sarah's scenario, it was difficult for her to find time to train Bella and teach her tricks. Instead, Sarah lets the system train Bella in her place. The intelligent environment chose the optimal time of the day to perform training as part of a playful activity, i.e. when Bella's attention and motivation seemed to be higher. Thus, intelligent systems could assist in animal training, making the activity more amusing and less repetitive, and without requiring human supervision.

On the human side of things, intelligent systems could reduce the feeling of guilt or worry when leaving pets alone at home. Whenever the human wants, e.g. during a lunch break at work, she could communicate with the animals remotely, using cameras, speakers and a microphone, play with them or simply watch what the animals are doing in her absence. Even further, animals are known to be an extraordinary stimulator in the rehabilitation of people recovering from illnesses, disabilities or mental disorders [5][7]: patients' anxiety levels decrease when an animal intervenes in the rehabilitation tasks [2], dogs can be mediators in socializing tasks with autistic children [20], and equine therapy has proven to be very effective [1]. Therefore, playful activities could be a way of incorporating animals into therapy sessions. However, when the animal is unable to be physically present at the patient's location, the playful environment could serve as a bridge to bring the patients closer to the animals. Patients could remotely interact with the system via a human-computer interface, by activating devices in the environment or responding to the animals' interactions. As a consequence, a sort of non-verbal communication could emerge between humans and physically distant animals, enabling an enriching experience for both sides.

4. CONCLUSIONS AND FUTURE WORK

This work proposes a new line of research in the recently emerged field of Animal Computer Interaction: Intelligent Playful Environments for Animals. These environments will ground on the most inherent behavior of animals: play. The environment will

learn from the animals' behaviors and interactions, creating engaging games and adjusting them to the animals' needs and requirements. The benefits derived from these systems could apply both to human and animals' well-being.

We are already working in several studies in order to determine the most engaging mechanisms for dogs and cats in the different game phases, i.e. capturing the attention of the animal, maintaining the attention for a specific amount of time, and ending the activity gradually, without abruptly interrupting the game and thus cause frustration. In this study we will consider different kinds of stimuli in order to determine which one works better to attract each animal species, such as visual stimuli for cats or olfactory clues for dogs. Moreover, studying how the animals could indicate they want to play with the environment or withdraw from the game will be of major interest.

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