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Animal Ludens: Building Intelligent Playful Environments for Animals

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ABSTRACT
Look:ing for effective ways to understand how animals interact with computer-mediated systems, Animal-Computer Interaction (ACI) research should rely on the most natural and intrinsic behavior among the majority of living species: play. Animals are naturally motivated towards playing. Playful environments are, therefore, a promising scenario in which to start developing animal-centered ecosystems, and there are plenty of circumstances where playful environments could help to improve animals' well-being. However, developing a custom system for each possible context remains unfeasible, and more appealing solutions are required. If playful environments were equipped with intelligent capabilities, they could learn from the animals' behavior and automatically adapt themselves to the animals' needs and preferences by creating engaging playful activities for different purposes. Hence, this work will define intelligent playful environments for animals and explain how Ambient Intelligence (Aml) can contribute to create adaptable playful experiences for animals in order to improve their quality oflife.

Author Keywords
Animal Computer Interaction; ACI; animal; interaction; play; intelligent environment; smart environment; interface.

ACM Classlfication Keywords
H.5.3. lnformation Interfaces and Presentation: User interfaces -interaction styles, user-centered design, input devices and strategies.

INTRODUCTION

Play is one of the animals' most natural and inherent behaviors [13]. In Huizinga's own words:

"Play is older than culture, for culture, however inadequately defined, always presupposes human society, ami animals have not waited for man to teach them their playing. "

Animals do not need to be taught to play with each other or with humans. For them it stands as a natural activity which may have severa! purposes that are not yet completely understood [4]. In fact, one of the main aspects of play is simply that it is fun, which is the main source of motivation for all sorts of animals, including humans.

The funny aspect of playing has motivated humans not only to play but to design artifacts that m.ake the play activity even more attractive. The nature of human play has therefore evolved with technological innovations from primitive stone skipping to modern interactive electronic games. However, in this hominid evolution giving rise to what Huizinga called the *homo ludens* and sorne call today *homo ludens electronicus,* other species have been left behind.

The Human-Computer Interaction (HCI) community has now begun to realize the benefits of lDlderstanding how animals react to and interact with digital systems. This, in tum, has led to the emergence of a new discipline called Animal-Computer Interaction (ACI) [17,18]. ACI considers animals as the target users of digital interfaces and systems with the belief that understanding their behavior with computer-mediated systems could help both humans and non-humans to improve their quality of life. The ACI community should take advantage of this natural disposition of animals towards playing and set playfulness as the basis of any system targeted at them, giving rise to the era of the *animal ludens.*

Designing playful experiences for humans has been the focus of many research efforts [7] and, as pointed out in [10,11] the pleasures of play should be studied by considering multiple pleasure categories related to Creation, Exploration, Discovery, Difficulty, Competition, Danger, Captivation, Sensation, Sympathy, Simulation, Fantasy, Camaraderie and Subversion. However, these constituent elements of playful experiences that apply to humans may not be applicable to other species. They may need to be adapted for different types of animals or even be tailored for specific individuals or situ.ational contexts in a transparent way.

Context-awareness, adaptation and transparency are the main building blocks of the growing technological

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approach known as Ambient Intelligence (AmI) [22,32].By applying sorne sort of intelligence to our surroundings, environments can leam from people's behavior and automatically adapt themselves to the situation, even anticipating people' s needs. Similarly, playful environments could be provided with the same kind of intelligence in order to extract knowledge about the animals inhabiting them. The environment could rely on this infonnation to evolve and auto-adapt to the situation, creating playful activities which fit the animals' needs for a given context. This work, therefore, defines intelligent playful environments for animals (IPE4A) with the above goals in mind. It also establishes the direction of future research in this field by describing sorne possible applications that could bring considerable benefits.

RELATED WORK

Despite ACI being a recent research field, studies conceming animals, their cognitive capabilities and the way they understand their surrounding have existed for a long time [20,26]. The use of wearable technologies and tracking devices has also been applied to studies involving animals (e.g., [15,16,24,30,31]). These studies aim to discover whether these technologies affect the animals' behavior, and more importantly, if they improve the animals' interactions with human beings.

The reason why animals play has been the focus of many dissertations [5,6] and several studies have used the concept of play as a tool to stimulate animals to participate voluntarily in their experiments.

One of the issues the ACI community has attempted to overcome is the animals' sedentary lifestyle. Several studies have attempted to motivate physical activity among pets using playful interaction mechanisms. *Feline Fun Park* [34] is a tangible interface which promotes pet activity and can be controlled remotely. It has three different sensors in order to monitor the pet's activity level. It also has three different actuators (two mouse toys and tracer lights) to motivate the animal to play at various intensity levels. *Feline Fun Park* has an automatic mode in which the toys and lights are activated based on the pet's activity level. The system can also be controlled remotely by the owner, who can look at the detected activity level and activate the appropriate mechanism of the tangible interface. *Pawsabilities* [19] presents a HUI (Human User Interface) and a DUI (Dog User Interface) to reduce canine boredom while their owners are not at home. When the system detects that the dog is becoming bored (e.g. by lying on its bed), the IIlJI notifies the owners remotely so they can activate a mechanism to throw a ball for the dog to play with. On the other hand, whenever a social activity is detected on the human side of the system, the DUI activates the video streaming, showing the owners' activity to entertain the dog.

Other works such as *Canine Amusement and Training* [33] have used play as a mechanism to introduce dogs to training. It offers several kinds of games focused on calmness, obedience and joy. In each game, figures and lights are projected on the ground, providing visual clues to the human about where the dog should move or stay. The human is required to give appropriate commands to the dog, which vary in line with the goal of the game, e.g. obedience games require the dog to remain quiet beside the human. The dog's movements are tracked in order to determine whether he performed correctly or not. The system allows humans to spend more time with their companion dogs. Moreover, humans are helped through a complex task such as dog training, while the dog leams how to obey commands in an amusing experience for both participants.

Metazoa Ludens [9] goes beyond the physical world and proposes a virtual game in which a real hamster and a human play together. The hamster playground is a physical, moldable surface that adapts its shape by mechanical actuators. The hamster's movements through the surface are captured and transferred to the virtual game. Meanwhile, the human user controls a digital avatar on his computer, and his virtual movements are transferred in the contrary direction: from the virtual game to the physical playground. This enables a chasing game between the hamster and the human, both in the digital and the real world simultaneously.

Some other systems were conceived purely for the fun of playing and competing. *Cat Cat Revolution* [23] is a digital game for iPad which shows an animated mouse moving around the screen. The iPad application combines graphical hints and sounds to incite the cat to capture the mouse. The digital mouse can be moved randomly across the display or controlled by the pet's owner on her iPhone. The *Playing with Pigs* project [1] is designed to strengthen relations between humans and pigs as companions. The pigs are situated in front of a large touch sensitive display showing a light ball controlled by a human player through an iPad application. The iPad application shows the virtual replica of the light ball and the pigs' snouts when they approach the hall. The user has to keep the pigs in contact with the ball and lead them through a triangular target on the screen to score points.

Although ali these projects are based on play activities, each one has been specifically designed for its own purpose. Moreover, these systems do not adapt automatically to changes and in most cases the activity has to be initiated by a human. Ifthe ACI community wants to take a step forward in developing natural systems for animals, intelligence, automation and reactivity have to be present in playful environments. In the same way as Ambient Intelligent systems adapt themselves to their inhabitants, by recognizing and anticipating their needs, intelligent playful environments for animals must leam animals' behavior and preferences in order to react

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properly. A playful environment with such features could automatically create and adapt play activities to engage the animals in physical exercise, raise their mood or train them while having fun. The next section will give a definition for future IPE4A and the features these systems should include.

SITUATING A PLAYFUL INTERACTION ENVIRONMENT

This work sets the foundation for intelligent playful environments for animals starting with a definition of what they are:

An intelligent playfal 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 playfal activities which do not necessarily need human mediation to evolve.

In order to provide a conceptual taxonomic framework for the future construction of these environments, their requirements are listed as follows:

- *Playfulness.* The environment has to consider play as the conductive engine of any activity the environment creates.
- *Intelligence.* The environment must be able to capture and analyze the occupants' interactions and behaviors, extracting patterns and preferences. This knowledge will be useful for the creation and evolution of playful activities, whose purpose and dynamics will be adapted to the context.
- *Reactivity and interaction.* The system must react suitably to the animals' interactions, and also provide proactive stimuli to the animals to foster commwrications between the system and the users {both human and non-human).
- *Animal-centered design.* Every intelligent playful environment must be designed and developed specifically for animals, with appropriate devices and interaction methods and prioritizing the animals' comfort, safety and well-being.

There are also several features that can vary from one playful scenario to another and should be considered in the design of future IPE4As:

- *Number of participants (single-player, n-player & multiplayer).* The playful environment can be designed for one participant (single-player), a fixed number (n-player) or it can respond to any of the participants that walk into the ecosystem (multiplayer). If more than one participant is considered, the design of the environment should include ways to handle abandoning scenarios, i.e. when one or more players leave the game or physically come out of the ecosystem.
- *Participants' species (one species vs. mu/tiple species).* Animals probably do not perceive their environment in the same way humans do [21]. Moreover, different animal species may not have the same conceptual view of the world. As a consequence, animals from distinct species will not behave similarly given the same scenario. This affects several design decisions in the construction of interfaces and interactive systems targeted at animals: from the way in which they will be encouraged to play to the reference health values the system will use to create a physical activity. Consequently, the intelligent playful environment can be designed specifically for a single animal species or it can be designed to recognize the animal's species and adapt itself to it.
- *Human participation (participant vs. non-participant).* Humans may or may not take part in the playful activity. In the former case, the system will only react to animal interaction. In the latter, it will respond to both human and non-human actions.
- *Human presence (physical vs. virtual).* If humans tak.e part in the playful experience they can either be physically present in the environment or participate remotely. The remate participation may encompass a wide range of scenarios, from pet owners in their spare time at work to child patients in hospitals, seeking amusement and distraction.
- *Control.* The intelligent features and reasoning engine of the playful environment can learn and take decisions autonomously, i.e. without human intervention, or they can be guided by explicit human knowledge. The latter idea implies that IPE4As can provide mechanisms to allow human users to define explicit behavioral patterns the system must follow. For example, if a zoo worker wants the activity to be paused every day at midday to feed the animals and resumed after all the animals have finished, she should be able to easily program the system with such desired behavior.
- *Jnformation acquisition.* The system inputs can be gathered by different technologies: wearable devices, sensing (motion sensors, pressure sensors, etc.), video and audio recordings, etc. In all cases, the selected capturing devices should be non-obtrusive and ensure the animals' safety and comfort.
- *Learning inputs.* Both humans and animals can coexist within the playful environment, interacting with the system as well as with each other. The design phase of the environment has to establish which of these interactions will serve as learning inputs for the intelligent system. It also has to be decided ifonly animal interactions will be included or if human inputs will a1so be considered. In sorne cases, human interactions with their pets could provide very valuable information to the learning system. As an example, pets are not able to verbally communicate when they are bored, but their owners can recognize their mood and start playing with them. The system could therefore learn which activity raises the pet's mood by looking at the owners interactions with the animal.

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Requirements	Features
Playfulness	Number of participants
lntelligence	Participants' species
Reactivity and interaction	Human participation
Animal-centered design	Human presence
	Control
	Information acquisition
	Learning inputs
	Types of stimuli
	Single-purpose vs. multi-purpose activities

Table l.Requirements and features of future intelligent playfal environments for animals.

- *Types of stimuli.* Since distinct species may behave differently in the same context, their preferences and motivations may also differ. Sorne species might therefore feel more attracted by visual stimuli such as lights or mobile mechanisms (e.g. cats), while others would respond more eagerly to olfactory clues (e.g. dogs). Inorder to use the proper actuators and devices to capture the animal's attention. IPE4As should rely on the most suitable stimuli for each animal species in a given context.
- *Single-purpose vs. multi-purpose activities.* Playful activities created by the environment can be focused on solving just one issue of animal well-being, i.e. a game which only fosters physical activity. On the other hand, more complete activities covering several issues can also be created, i.e. a game which includes a training element at the same time as physical activity is being monitored and fostered by the system.

Table 1 summarizes the list of requirements and features presented above in order to clarify the concepts and provide a schematic view for future references.

BENEFITS OF PE4A

In order to develop successful and profitable IPE4As, the scenarios in which these systems can be deployed have been analyzed and the benefits they can bring to the community in different domains are presented here.

Mental Well-being

Not only humans but also animals need to socialize. However, domestic pets are left at home during the greater portion of the day while their owners are working, without any possibilities of interacting with their human friends. Even when the owner is at home they may not receive all the affection they need. Similarly, zoo animals live inside a restricted ecosystem, sometimes as the only ones of their kind and without the possibility to interact directly with humans on the other side of the glass. These animals can suffer from isolation, sadness and anxiety [2,27,28], far from achieving a fully happy existence. An intelligent playful environment could detect whether an animal is becoming bored or stressed, and if the context is considered appropriate, initiate a playful experience to stimulate and entertain the animal, keeping its mind active. The environment should therefore study the best moment and way to create those fun activities. For this purpose, the intelligent environment should have previously learned the animal 's favorite games and interactions and the most effective sensorial clues to attract its attention. However, the system has to prioritize the animal's welfare. These kind of playful activities, the moment when they are conducted and the consequences on the animal's well-being should be studied in depth in order to avoid behavioral problems or causing stress.

Physical Activity

Another key to animal well-being is physical activity, which has to be stimulated in cases such as the ones described above. If an animal does not receive al1 the required attention, nor any external stimuli for long periods of time, or is feeling depressed, it would not likely initiate any physical exercise. Animals living in shelters are one of the most harmed groups because of limited physical activity. In this case, the environment could capture the animal's attention and engage it in playful activities to encourage it to perform physical exercise. The system could adapt the exercise to the animal's physical attributes and habits in order to create a healthy and amusing routine. Other variables to be tak:en into consideration should be the frequency, duration and time when the activity tak:es place. The potential improvements the environment could bring on animals' welfare should therefore be studied.

Training

Playful environments can also be an enjoyable way of fostering training activities without overloading the animal with strict orders. Tough training and repetitive actions can cause loss of attention and refusal to participate in the training. By transforming the learning activity into a garne, it will be understood as a playing exercise and not as a rigorous activity. Consequently, animals should be more inclined to participate. The environment should support two training modalities, depending on whether a human tak:es part in the training or not. If a human acts as a trainer, the bonds between the animal and the human would be reinforced. On the occasions when humans are unable to mediate the training activity, the environment should leam the best way to introduce a new order to the animal according to its preferences and adapt the training to its learning pace and motivation.

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Therapy

Animals can help in the rehabilitation of people recovering from illnesses or disabilities [12,14]. Interactions with animals can reduce patients' anxiety [3] or help children with autism in socializing tasks [29]. In situations where the animal cannot be physically present with the subject 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 non-verbal communication could emerge between humans and physically distant animals, originating an enriching experience for both sides.

CONCLUSIONS ANO 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 provide intelligent adaptation to the animals' behaviors and needs, creating playful activities to overcome possible issues such as isolation, poor physical condition, repetitive training exercises or remote digital interaction with human-beings. A conceptual taxonomic framework has been laid down for the future design and development of these environments. Severa] applications have been outlined, highlighting the benefits of applying intelligent playfulness to animals' interactions with digital ecosystems.

Future work essential for the successful construction of IPE4As includes the definition of a formal development methodology covering the aforementioned features and requirements. Each of these features should be carefully studied in order to determine how they will affect the construction of the environment and the users' well-being, and whether they should eventually be taken into consideration in the development process regarding the specific circumstances.

Hence, we are defining in our on-going work a flexible intelligent behavior-management system for reactive environments. It will leam from the users' habits and preferences, extracting behavioral rules to create engaging playful activities capable of evolving over time. The human end-users of the system would also be allowed to define their own personal behavioral rules and incorporate them into the playful environment [8,25]. The behavior-management system will therefore combine two ways of incorporating behavior: based on automatically acquired knowledge, as well as explicit knowledge specified by humans. This powerful combination will allow the development of playful environments able to adapt themselves to a wide range of scenarios more effectively, without having to develop a custom system for each one.

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