Animal-Computer Interaction: Animal-Centred, Participatory, and Playful Design

Patricia Pons[1], Ilyena Hirskyj-Douglas[2], Anton Nijholt[3] and Adrian D. Cheok[4]

[1]ISSI Research Group, Department of Information Systems and Computation, Polytechnic University of Valencia, Valencia, Spain, ppons@dsic.upv.es
[2]Department of Computing, University of Central Lancashire, Lancashire, England, ihirskyj-douglas@uclan.ac.uk
[3]Human Media Interaction, University of Twente, Enschede, The Netherlands and Imagineering Institute, Iskandar, Malaysia, a.nijholt@utwente.nl
[4]Imagineering Institute, Iskandar, Malaysia and City University, London, UK, adrian@imagineeringinstitute.org

Introduction

This introductory paper presents the field of Animal Computer Interaction (ACI) and the work that is being presented at the ACI Symposium at Measuring Behavior. In recent years there has been growing interest in developing systems to improve animal's wellbeing and to support the interaction of animals within the digital domain. The field of Animal-Computer Interaction considers animals as the end-users of the technology being developed for them, orienting this process by the needs and characteristics of its non-human stakeholders. Although animals have interacted with technology long before the emergence of the ACI field [12, 18], usually their behaviors were typically anthropomorphized with their needs not being fully understood. Instead, ACI research adopts an animal-centred approach and aims to understand technologically mediated interaction of animals from their perspective. In this way, the technology and systems being developed could be adapted properly towards the non-human animal user. This is in a similar way that Human Computer Interaction (HCI) has done with human-being users.

Growth of Animal-Computer Interaction Research

The scientific aims, methodological approach and ethical principles of ACI were defined in Mancini's manifesto [9] in 2011 following on from the notable work of Resner [16]. Since then the ACI community has been growing and sparking the interest of more researchers diversifying into different focus areas such as zoo, pet and farming ACI, among others. This field has culminated into the first and second International Conferences on ACI, in 2014 and 2015 respectively, and an upcoming Third International Conference during 2016. There have also been several ACI workshops within computing and animal behavioral conferences, which has helped to spread the importance of this field to researchers of other areas. This diversifying is essential as when undertaking research within ACI there is need to provide knowledge from many different areas, ranging from computer science to animal behavior as well as ensuring all aspects of animal welfare.

There are many subfields within ACI holding notable works. A major area of ACI is to support animal welfare [15, 19], for example through devices such as automated kennels [11] or playful environments [13] in order to avoid stress or isolation problems. Similarly to Computer Science, the advancements in tracking technology have also been involved in ACI: from automated facial recognition for dogs [6] to body posture recognition in cats [14]. Game studies field has also approached animal play with cats [20], pigs [1], dogs [2], chickens [8], orangutans [21 and elephants [5]. Humans have also benefitted from ACI through systems which allow animals to assist them, usually through service dogs. We can also mention the development of interactive devices for aiding the detection of cancer with detection dogs [10], devices that support diabetes alert dogs when they need to alert their owner, or even emergency services [17]. Wearable technology has also been developed to facilitate remote communication between humans and dogs with occupations. These technologies include search and rescue dogs, allowing dogs to communicate using gestures which are detected by the wearable device [3]. More recently technology has been developed for zoo Animal-Computer Interaction, with a SIG (Special Interest Group) meeting being held at the 34th International Conference on Computer Human

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Interaction (CHI'16) to discuss on how to provide suitable technological enrichments for these animals [4].

Animal-Computer Interaction and Measuring Behavior

Due to the nature of the field and the uniqueness of its end-users, ACI researchers have to face several difficulties when designing for and with animals. One key difficulty is designing for non-verbal users, which HCI also faces. It is in this way that ACI and HCI share similar methods at gathering requirements and creating interactions. These methods, however, must be adapted towards the end user [7]. As animals mainly express themselves through non-spoken language, understanding and measuring their behavior is fundamental for the development of ACI research and methodologies. This assessment of behavior can be supported through other requirements gathering techniques such as biometric feedback, chemical analysis and owner evaluations. However, as the Internet of Things (IoT) increases into the everyday habits that we share with animals, systems that are able to automatically recognize, and more importantly react, to animal behavior are being built.

Collaboration of Animal Computer Interaction and Measuring Behavior

If we want to develop suitable technology for animals following a user-centered approach, our target users should be involved in all the stages of the design and development process. Hence, analyzing and evaluating their behaviors and responses towards the technology allows animals to be involved in the design process. Using this method, the two fields of animal behavior and computer science collide to create informative ACI. In this regards whilst ACI takes from animal behavior, ACI can also help inform animal behaviorists on working with technological systems and animals. In this way discussions will be had upon the methodological, theoretical, theme-based and focused-based approaches taken by the authors. The two fields through their exploration of how to measure animals' behavior can strengthen together. Whilst systems are being built that are able to measure animals' behavior it is only through correct interpretation that real meaning can be drawn from such interactions and thus analyzed by a system. From the above discussion it is clear that the interactions with technology so far remains interdisciplinary and needs input from a range of different fields (such as humanities, games studies, design research, animal sciences, social sciences to name a few). Through this symposium it is hoped to explore the relationship between ACI and animal-behavior. A possible research agenda for collaboration during and beyond this Symposium could be the following:

- First, a systematic review of existing literature in the field of measuring behavior regarding technological methods and approaches could be drawn with the help of experts in this field.
- Second, an evaluation of existing methods and work within ACI for measuring behavior could be assessed by experts in animal behavior, outlining potential pitfalls as well as strong points.
- Third, researchers in both fields could collaborate together to come up with areas in which measuring behavior by means of technological artifacts could be improved and/or provide benefits for the animal.
- Fourth, researchers could discuss which methodologies are used in their own area of expertise and whether or not these methodologies could be transferred from one field to another or redesigned following an animal-centred perspective.
- Fifth, discussion could be held to determine the extent to which technological artifacts could be a viable way of measuring behavior: how the technological artifacts might affect the interaction, how to interpret data into meaningful behavior, how autonomous could this behavior recognition process be, etcetera.

The aims of this Symposium are twofold. Firstly, we want to introduce the topic Animal-Computer Interaction in the Measuring Behavior community with the assumption that there can be fruitful interaction between these

two communities. Secondly, we aim at contributions that address methodological questions. How to conduct user-centred design in Animal-Computer Interaction or in computer-mediated human-animal interaction? Which methodologies from HCI can be adapted to ACI? Clearly, in this emerging field of research case studies can help to give answers to these questions as well.

The main topics that have been mentioned above also appear in the papers that have been accepted for this symposium. The papers and presentations address participatory and animal-centred design of playful and social interfaces for animals, the use of wearables (sensors) to monitor animals, technology that allows natural interactions, investigation animal preferences, trying to understand how animals experience and understand audio-visual stimuli, validating results of experiments, developing social relationships, et cetera. We present short summaries of the papers accepted for this workshop, emphasizing how they contribute to these issues.

Participatory design of interfaces to control playful applications is reported in "Playful UX for Elephants" by Fiona French and collaborators. Their research aims at implementing interactive toys and adaptive systems for captive elephants. Designed interfaces allow for shower control, audio control and musical instrument control. Issues that are investigated are interest, motivation and playfulness, and usability. This latter involves 'natural' control of applications using natural trunk movements and trying to discover an elephant's preferences, for example the kind of haptic feedback to the trunk. In general, what kinds of systems have elephant appeal? Detecting trunk proximity (in order to allow trunk control of buttons) is one of the many technical challenges.

Explicit ethical guidelines for dog-computer interaction are discussed in the paper "The Ethics of How to Work with Dogs in Animal Computer Interaction" by Ilyena Hirskyj-Douglas and Janet Read. The guidelines follow from various case studies on Animal-Computer Interaction and animal centered and participatory design approaches, often done with dogs, including studies by the authors. The guidelines address issues such as consent, safeness and comfort, and avoidance of stress. Underlying the guidelines are insights and changing attitudes to cognitive and emotional capabilities of dogs, and comparisons with views held by HCI researchers on experiments with children. Within this paper, it is mentioned that a dog can never fully consent to take part within a study. One question that leaps out is whether a non-harm approach is always possible.

Naohisa Ohta and his co-authors discuss their ideas and research plans for investigating whether and how animals can collaborate with artificial presences or with humans through such presences in the contribution "Animal-Human Digital Interface: Can Animals Collaborate with Artificial Presences?". It is argued that a multisensory approach with active agent functions is needed. More concrete research plans are mentioned. One of them is about the effect of including depth perception in artificial visual stimuli. In addition, there are plans to investigate whether social cues provided by robots can be understood and can help to develop social relationships between robots and animals. This will become an important issue when social and assistive robots become part of people's and animals' everyday life.

In the contribution "Animal-Computer Interaction (ACI): An analysis, a perspective, and guidelines" Egon van den Broek describes his experiences while reading the current ACI literature and his viewpoints on issues that should play a role in discussions on the methodological foundations for ACI research. Ideas follow from robot researcher Rodney A. Brooks' views on the role of interaction and context in the development of artificial intelligence, and previous research on interactions between humans and artificial animal agents. Apart from this historical reflection and a subsequent emphasis on context-aware computing, van den Broek surveys approaches to validation of experimental results and the 'triangulation' techniques for validation that have emerged in the social sciences.

The paper "Towards a Wearer-Centred Framework for Animal Biotelemetry" by Patrizia Paci and co-authors focuses on how to design and use sensor technology in an animal-centred way. Body-attached sensors can track an animal's activities (movements, body postures, absolute and relative positions) and provide physiological information. However, they can also interfere with the phenomena being studied. Sensors should conform to the wearer's naturalistic setting and behavior. Otherwise there can be negative effects on the validity of the recorded data or the animal's welfare. The authors have developed an animal-centred framework for designing wearable

sensors with sensory imperceptibility, physical unobtrusiveness and cognitive acceptability as main parameters. In addition, it takes into account that such sensors can disturb natural interactions with other members of the same social group.

There are various ways to observe animal behavior. Indeed, we can use body-attached sensors as discussed in the Paci paper mentioned above. In "Detecting Animals' Body Postures Using Depth-Based Tracking Systems" Patricia Pons and co-authors refrain from accelerometers and gyroscopes attached to a dog's or cat's collar and instead use computer vision techniques (depth-based tracking using Microsoft Kinect) to distinguish locations and body postures (sitting, walking, jumping, et cetera) of a cat. It is preliminary work, presently with good results on cats, and the authors expect that more postures and behavior can be detected using machine learning algorithms and that the work can be extended to other animal species.

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In this introductory paper to the Measuring Behavior Symposium Animal-Computer Interaction we introduced the main topics of research on ACI: anticipatory and animal-centred design of playful and social interfaces for animals, the use of wearables (sensors) to monitor animals, technology that allows natural interactions, investigation of animal preferences, trying to understand how animals experience and understand audio-visual stimuli, validating results of experiments, and understanding the development of social relationships. We think it is useful to introduce these issues in the Measuring Behavior community, find more interest and look for cooperation. It is expected that this Symposium will allow for fruitful collaboration between researchers from both areas as well as to provide insightful ideas for both the presented articles as well as for the future of the ACI and the Measuring Behavior communities.

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