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Pushing Boundaries of RE: Requirement Elicitation for Non-Human Users

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Abstract—With the advance of modern technologies, computer-based systems for animals are gaining popularity. In particular, there is an explosion of products and gadgets for pets: wellness monitoring applications (e.g., FitBark and PetPace), automatic food dispensers, cognitive enrichment apps, and many more. Furthermore, the discipline of Animal-Computer Interaction has emerged, focusing on a user-centric development of technologies for animals, making them stakeholders in the development process. Animal-centric technologies have already been developed to support activities of rescue and assistance dogs, to provide environmental and cognitive enrichment for animals in captivity, and to support conservation and animal behavior research. Going beyond human stakeholders poses new exciting challenges for requirement engineering and can be used to significantly expand its boundaries under broader theoretical and methodological frameworks. This paper highlights these challenges and proposes a research agenda for developing methodologies for requirement elicitation and analysis for a user-centric development of computerized systems for non-human users.

I. INTRODUCTION

I used to look at my dog and think "if you were a little smarter, you could tell me what you were thinking," and he'd look at me like he was saying "if you were a little smarter, I wouldn't have to."—-Fred Jungelaus.

Animals have been active users of technology for many decades, wearing tracking devices in conservation research, working with operant chambers in scientific experiments, etc. With the advent of big data, ubiquitous computing and other new technologies, there is an explosion[1] of software-enhanced products for animals, such as applications for wellness monitoring [1] and entertainment [2], automatic feeders [3], etc. However, the real paradigm shift has been marked by the emergence of the multi-disciplinary field of Animal-Computer Interaction (ACI) ([4], [5]) which takes a *user-centric* approach, placing the animal in the center of an interactive development process. Examples of animal-centered technologies include various systems for supporting the activities of working dogs and assistance dogs ([6], [7], [8]), providing environmental and cognitive enrichment for pets ([9], [10], [11], [12]) and zoo animals in captivity ([13], [14]); or technologies for conservation and other animal research ([15], [16], [17].

[18] argued that the emerging discipline of ACI has the potential to significantly expand the boundaries of Human-Computer Interaction by focusing on users who require interfaces that do not assume what we call 'language', and whose cognitive characteristics and natural behavior place hard methodological constraints on the design and evaluation of such interfaces. We believe that an even stronger claim applies to the discipline of RE. Indeed, the summary of the First International Workshop on Research Methods for ACI ([19]) held earlier this year, explicitly calls for refining and extending frameworks and methods for requirement elicitation to the context of non-human users. But not only the ACI community can benefit from expanding RE to the realm of non-human users. This can also lead to the fertilization of the discipline of RE, providing new insights into existing requirement elicitation techniques, which are completely human-oriented. If we lift the assumption that our users are human, that they can describe what they need and provide feedback, that we understand their behavior as that of our own species, what RE frameworks and methodologies still apply, and which can be revised and adapted?

The aim of this paper is to argue that it is both fascinating and worthwhile to explore the interrelations between RE and ACI, and to take a closer look at what is required for extending RE methodologies to the realm of non-human users. We believe that the explosion of products for animals in the market, and ACI growing more mature as a scientific discipline[2] make it a timely moment to raise these issues. We start by considering the notion of stakeholders in RE, which is almost exclusively human-focused. We then review RE techniques for requirement elicitation, and demonstrate their use in the context of animals. Finally, we propose a research roadmap to systematically extend RE methods to the realm of non-human users.

II. GOING BEYOND THE HUMAN STAKEHOLDERS

Requirements elicitation is the process of seeking, uncovering, acquiring, and elaborating requirements for computer based systems [20]. The process of requirements elicitation is generally accepted as one of the critical activities in the

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[1]Remarkably, at the Crufts exhibition in 2015, Samsung unveiled the world's first futuristic smart kennel for dogs, featuring a paw-operated snack dispenser and a treadmill and a tablet at the cost of 20,000 GBP.

[2]This is witnessed, e.g., by the Third International ACI conference taking place in Milton Keynes, UK in 2016 for the first time as an independent event, co-located with the First International Workshop on Research Methods in ACI [19].

RE process, and the selection of appropriate elicitation techniques is a critical factor for the success of the requirements elicitation. [21].

To elicit requirements, we need to approach stakeholders: those entities that have an interest in the development of the system. The fact that requirement elicitation methodologies are human-oriented is strongly reflected in assumption made the RE literature that stakeholders are human. [20] writes: "Stakeholders are *people* who have an interest in the system or are affected in some way by the development and implementation". While restricting users/customers to human beings only, [22] further extends the scope of this notion: "The stakeholders not only refer to *human being*, such as end users, customers, decision-makers or developers, but also refer to the physical, organizational, or legislation environment where the desired system is to be used".

[23], [24] have criticized the tendency to see stakeholders as almost exclusively human and proposed the inclusion of 'non-human nature', that is, the natural environment, as an equal stakeholder type. The focus on humans is attributed there to the traditional framing of discourse on stakeholders in political and economic terms, with humans being perceived as the only entities capable of having political and economic power, or stakes. [23]. Animals, however, and in particular, pets are a growing economic power (e.g., according to [25], industry of pet-related products and services has increased 10 times since the late 1990s).

Until the emergence of the discipline of ACI in recent years ([4]), animals have not yet received much attention as stakeholders in the development process. A cursory literature search on "animal stakeholders" points indeed towards stakeholder discourse *on* animals (e.g., farm animal breeding, animal welfare), but little work on attempting to analyze animals' point of view. A recent article [26] discussed the way in which frogs could become (unwitting) stakeholders in a development project, although their focus was on project temporalities and avoiding the way in which an aspect of the natural environment (e.g., the existence of some animals on a building plot) could impact development.

However, as the ACI manifesto [4] emphasizes, taking a user-centric approach in the design of animal technologies can have many benefits for both animals and humans. It could support dogs with occupations on their missions, such as search and rescue ([27], [6]) and seizure alert ([28]). It could lead to further insights into animal cognition, for example, by informing the design of interactive technology for behavioral studies that affords optimal usability and creative appropriation for the animals ([29]). It could support conservation efforts, for example, by informing the design of monitoring devices that produce minimal impact on the animals [30], while maximizing the quality and reliability of the data gathered through them [16]. It could improve the economic and ethical sustainability of food production, for example, by informing the design of technology that affords farm animals more freedom and autonomy, reducing their stress levels and susceptibility to illness without recourse to drugs, increasing their productivity

and improving the quality of their produce [31], [32], [33].

[4] poses crucial questions the ACI discipline needs to tackle: How do we elicit requirements from a nonhuman stakeholder? How do we involve them in the design process? To some extent, standard requirement elicitation techniques can be applied with the animals' representatives - owners, keepers or handlers. However, animal behavior literature warns against using reports from non-experts, who may misinterpret the needs and the behavior of animals. It is therefore no longer the case that "techniques for requirements elicitation are derived mostly from the social sciences, organizational theory, group dynamics, knowledge engineering" [20]. One immediate consequence of going beyond human stakeholder is the need to make reference to a huge body of knowledge of biology, animal behavior, applied ethology, etc, including also animal experts as stakeholders.

III. REQUIREMENT ELICITATION TECHNIQUES AND THEIR SUITABILITY FOR NON-HUMAN USERS

In what follows we review the existing elicitation techniques[3] in RE [22], [20] focusing on their suitability in the context of animals, providing examples from the literature of ACI.

A. Observational techniques

Observational techniques in RE usually include social analysis, protocol analysis, observation and ethnographic study [22], [20]. *Ethnography* is the study of 'people' in their natural setting, methods for systematically eliciting ethnographic data have been successfully used for both non-human [34] and non-sentient entities [35] have been proposed in literature. *Observation* is one of the most popular ethnographic techniques, where the analyst observes the actual execution of existing processes by the users without direct interference. Depending on the kind of end-users, involvement of specific behavioral experts are needed, making this technique even more expensive to perform than in human settings, where it already is noted to require significant skill and effort on part of the requirements analyst [20].

The concept of *multi-species ethnography* is discussed in [36], [37]. As highlighted by [37], it is "a project that seeks to understand the world as materially real, partially knowable, multicultured and multinatured, magical, and emergent through the contingent relations of multiple beings and entities. Accordingly, the nonhuman world of multi-species encounters has its own logic and rules of engagement that exist within the larger articulations of the human world, encompassing the flow of nutrients and matter, the liveliness of animals, plants, bacteria, and other beings." In the context of ACI, [38] discuss the challenges of multi-species ethnography in the context of dog technologies, and propose an interspecies semiotics to support the integration of direct animal observation with and animal researchers' accounts into ethnographic observation.

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[3]Analytic techniques such as requirements re-use and documentation studies are not discussed because of their limited use so far in our context due to limited pre-existing knowledge bases.

The authors discuss how the accounts of human participants, evaluated in relation to the accounts of canine behavioral researchers, can contribute to the ethnographer's observations.

[39] suggests to extend the ethnographic approach to the context of non-human users by combining it with quantitative methods from ethology, proposing to coin the new method 'ethographology', a blending of techniques from ethology and ethnography, which may then be applied to the study of human and non-human users.

B. Conversational techniques

Conversational techniques for requirement elicitation include interviews, outside facilitators, the holding of workshops, focus groups or brainstorming sessions. While these methods, relying on the use of language, cannot be applied directly with non-human users, they have been shown useful with respect to owners, keepers, handlers and animal experts. In an early requirement elicitation [34] for smart kennels, semi-structured interviews of carers included questions about the wellbeing and behaviour of dogs, carers and dogs daily routines and activities, information recorded and methods of recording and managing it, perceived potential roles and benefits of technology for dogs and carers, etc.

Semi-structured interviews with search and rescue experts were used in [27] for the development of a wearable computer interface for working search and rescue dogs that communicates with their handler via a mobile application.

Role-play and design focus groups have also been explored in the context of non-human users. [40] explores methodologies for participatory research with non-human users. Based on these ideas, design workshops[4] called 'Conversations with animals', with dogs and bees as active participants have been organized, attended also by animal experts to bridge interspecies barriers.

C. Synthetic techniques

One of the most promising synthetic techniques in the context of animals is prototyping. Providing stakeholders with prototypes of the system to support the investigation of possible solutions is an effective way to gather detailed information and relevant feedback [20]. Developing new ways of getting feedback from non-human users is acknowledged as one of the key questions facing the ACI community in [19]. However, physical prototyping has already been used, e.g. for eliciting requirements for interfaces for diabetes alert dogs [28] and cancer detection dogs [41], for gouging interest and finding preferences for smart entertainment of captive elephants [42].

IV. A ROADMAP OF RE FOR NON-HUMAN USERS

As we have seen above, many requirement elicitation methodologies from RE are already being applied in the context of non-human users. However, currently, they are mostly applied in an ad-hoc way which is not properly documented, which limits their replicability and potential re-use.

[4]Further details can be found at http://www.morethanhumanresearch.com/conversations-with-animals.html.

An even more critical issue is the need for a stronger involvement of animal experts in the requirement elicitation processes. Below we propose some directions for extending RE techniques to the realm of non-human users. While specific analysis of animal experts is needed for each particular case, species-specific physical characteristics useful for requirement elicitation can be collected. Almost every technology makes use of the animal's senses, such as vision, hearing and touch. Understanding the mechanisms behind these senses is pivotal for requirement elicitation. For instance, human eyes have circular pupils, but a great many animals have pupils that are oval or slit-shaped. These slits or ovals may be oriented vertically (as in crocodiles, vipers, cats and foxes), or horizontally (as in some rays, flying frogs, mongooses and ungulates such as sheep and hippopotami). The form of the pupil, as well as its orientation greatly affect they way displayed images are perceived by the animal [43]. Another example is the flicker frequency of a film: while humans need 16-20 images per second to perceive what we see as continuous film, dogs need about 70 images per second [44]. Interestingly, for many years scientists believed dogs do not perceive TV images, until modern TVs with a high-enough flicker rate emerged. A dog-centric study of attention to audio and video stimuli from TV has been carried out in [45].

Dogs are one of the most well-studied animals in animal science, as well as the most frequent users of technological products available on the market. Moreover, most of ACI research carried out up to date has focused on dogs. However, information on dogs physical characteristics, behavioral traits and cognitive abilities is scattered across veterinary science, biology and ethology, and is usually written in language not accessible to developers and ACI researchers (see, e.g., [46]). Developing an accessible body of knowledge directly relevant for dog-centered technologies could be a useful starting point.

Such efforts would be of strong benefit for RE, as a more complete accessible body of knowledge would make it possible to use analytic techniques which have so far remained out of scope due to the lack of established knowledge, data, and re-usable documentation in animal and other non-human user development projects. Thus, it would be of interest for RE to further establish systematic structures to capture information relevant for the re-use of non-human stakeholder requirements.

Another direction to target is receiving and analyzing user feedback, which is instrumental in synthetic elicitation techniques, such as prototyping. The main way in which one can learn about an animal's perception of technology is by observing and analyzing its behavior. As in the previous case, collaboration with animal experts becomes crucial in this time-consuming task. In this context automatic analysis of animal behavior seems particularly promising [29], [11], [47].

Animal welfare is another issue that needs to be taken in consideration. Animal welfare science is the scientific study of the welfare of animals as pets, in zoos, laboratories, on farms and in the wild. Although it has been in the center of public attention for many years, the investigation of animal welfare using rigorous scientific methods is a relatively recent

development. The world's first Professor of Animal Welfare Science, Donald Broom, was appointed by Cambridge University in 1986. In his keynote talk at the International ACI conference earlier this year, he emphasized the potential of the use of technologies to create a significant impact on the welfare of animals, stressing in particular farmed animals. He urged ACI researchers to explore the requirements of animals in the context of welfare.

As emphasized in [19], we have a moral obligation to 'build only what they want and need'. [48] argue that most technology currently being designed for use by pets is exploitative and entangled in human-centric values. An illustrative example is the use of tablet games for pets, which is a wide-spreading phenomenon: numerous mobile applications for pets have hit the market; thousands of YouTube videos can be found; several dog training centers were reported to open classes teaching dogs to use tablets. Pet owners may think their pets are bored, and provide them with digital entertainment, however recent studies on dog interaction with tablets warn about its potential dangers [49], [50]. RE practices and techniques can help accommodate the above mentioned moral obligation. Just as the natural environment stakeholder is recognized in RE literature as imposing a moral obligation on developers [23], [24], this view can be extended and adapted to non-human stakeholders.

Other directions for the promotion of RE for non-human users are:

- Developing guidelines for elicitation technique selection and application.
- Increasing the awareness of the ACI community and developers of products for animals to available RE techniques for requirement elicitation.
- Documenting case studies and industrial experience reports on successful and failed projects in which requirement elicitation techniques were systematically applied.
- Exploring how requirements elicitation activities relate to new fields, such as cloud computing and big data. For instance, FitBark uses data collected by the sensors to learn more about the needs of its users (breed-specific energy consumption, times of rest and activity).

V. Summary

In this paper we have argued that exploring RE techniques in the context of technologies for animals is beneficiary, interesting and timely. The lack of exchange of information between animal scientists and developers of animal technologies seems to be a critical issue in ACI in general, and for extending RE techniques to the realm of animals in particular. Animal experts tend to be suspicious of new technologies and of their developers' understanding of animals needs and reactions. This, however, has been changing with the emergence of the discipline of ACI, which puts the animal's needs in the center of attention. The change is witnessed by several experts from animal science, animal welfare and applied animal behavior attending the ACI conference and engaging in fruitful dialogue with ACI researchers [19]. The increasing interest of animal

experts in technologies for animals makes it a timely moment to establish a dialogue between the disciplines of RE, ACI and animal science.

In [51], Recker warns against paradigmatic research thinking, suggesting that "the best pathway toward an exploration of the unknown is by moving from the known knowns to the known unknowns the areas where we already know that we dont know enough (or nothing at all). From there, it is hopefully only a small step to explore the areas that we cant even anticipate yet". Extending RE for more types of users and stakeholders may just be that "known unknown", which can push the boundaries of the discipline and shed light on the known from a different perspective.

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