Responsible ACI: Expanding the Influence of Animal-Computer Interaction

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With emerging technologies powered by AI and IoT affecting animals in unprecedented ways, a question for the ACI community is how to expand the field's influence so that the computing interactions to which animals are exposed do not harm but benefit them. This position paper proposes that more ACI work could: focus on the risks that technology poses for animals and the impacts of technology that does not necessarily target them, as well as on the benefits of technologies that target them; re-frame human-centric ethical frameworks produced by governance bodies from a multispecies perspective against which to foreground impacts of technologies on animals; explicitly relate ACI work to global societal priorities set by governance bodies against which to highlight how an animal-centred perspective can support those. The paper encourages researchers to take responsibility for the challenge of giving animals representation amongst anthropocentric pressures and, despite necessary compromises, to continue to push for animal-centred technological innovation.

CCS CONCEPTS • Insert your first CCS term here • Insert your second CCS term here • Insert your third CCS term here.

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1 INTRODUCTION

Increasingly pervasive and powerful technologies such as the Internet of Things (IoT), Machine Learning (ML) and Artificial Intelligence (AI) are regarded both with optimism, as essential tools to achieve global Sustainable Development Goals (SDGs) [e.g. 2], and with caution, as potential threats to our species' survival [e.g. 21]. In order to address concerns over the impact of emerging technologies, governance bodies, such as the European Union, have issued ethics guidelines for responsible innovation [1], which have been broadly subscribed to by major corporations in the sector [e.g. 22, 42]. Academic researchers are also increasingly exploring ethical questions and responsible approaches to the development and deployment of these emerging technologies [e.g. 14; 51]. Within the mainstream discourse, almost invariably, proposals for responsible technological innovation have been concerned with protecting and benefitting humans. However, recently,

leading bioethics researchers [54]' calls for considering the impact of AI on animals have attracted the attention of global governance bodies such as the International Telecommunications Union (ITU) and the United Nations Environmental Programme (UNEP) [31].

Within the Animal-Computer Interaction (ACI) community, ethical concerns relating to the effects of technological developments on animals have been integral to the disciplinary discourse for over a decade [e.g. 40], particularly regarding the engagement of animals in computing research [e.g. 39, 62], the design of technologies targeted to animals [e.g. 49, 65] and the wider implications of ACI projects [e.g. 23, 37]. Furthermore, consistent with ACI's disciplinary values, a wide range of research has addressed theoretical [e.g., 4, 63], methodological [e.g. 9, 67] and technical [e.g. 35, 41] aspects of designing and developing animal-centred technologies. In other words, the idea of responsible technological innovation has, at least in principle, informed ACI research and practice from early on. However, outside the ACI community, awareness of this work seems to be still limited, which in turn is likely to limit the impact that, as a field, ACI could be having on such innovations, helping to maximise benefits and minimise harms for animals, consistent with its disciplinary aims.

As the ACI community celebrates the 10th edition of its International Conference, this position paper proposes that, to expand the influence of the field, more ACI work could:

- focus on the risks that technology poses for animals and on the impacts of technology that does not necessarily target them, as well as on the benefits of technologies that target them (section 2)
- interpret human-centric ethical frameworks produced by governance bodies - such as the European Commission's *Ethics Guidelines for Trustworthy AI* - from a multispecies perspective against which to foreground impacts of technologies on animals and raise related ethical concerns with those stakeholders (section 3)
- explicitly relate contributions from ACI work to global societal priorities set by global governance bodies - such as the United Nations' Sustainable Development Goals - against which to highlight how the animal-centred perspective championed by the ACI community, together with the expertise of its members, can support those stakeholders' priorities (section 4).

2 EXTENDING ACI'S REMIT: CASTING A WIDER NET

Researchers have recently begun to raise concerns over AI's impact on animals [e.g. 7, 54, 69]. In particular, Singer and Tse [54] have called for greater consideration, in the mainstream discourse, for the impact of AI technologies that are specifically designed to interact with animals (e.g. robotic milking systems), that are not designed to interact with animals but do so accidentally (e.g. self-driving cars) or that do not interact directly with animals but influence human behaviour towards them (e.g. algorithms selecting social media content). Along these lines, Coghlan and Parker [10] have conducted a systematic review of how AI technologies may harm animals. Building on Fraser [17]'s categorisation of anthropogenic threats to animal welfare, the authors propose a framework that accounts for intentional, unintentional, direct and indirect harms, with a focus on the practical impacts of AI systems. In the authors' analysis, AI systems may be specifically designed (e.g. AI-enabled drones developed by poachers to track and kill endangered animals) or deliberately misused (e.g. drones used in conservation being hacked by ill-intentioned individuals) to cause *intentional harm* to animals in ways that are socially *condemned*; or they may be designed to support activities that cause intentional but socially *acceptable* harm to animals (e.g. precision farming technologies enabling further farming intensification; novel brain-computer interfaces being developed through invasive animal tests; AI-enabled drug discoveries leading to more animals being used in experiments). AI systems may also have *unintentional* harmful impacts on animals, whether *direct* (e.g. self-driving cars not being designed to recognise small animals, or malfunctioning and thus failing to recognise them) or *indirect* (e.g.

proliferation of AI systems damaging animals' habitats; AI systems use in husbandry practices resulting in animal neglect; algorithmic bias reinforcing anthropocentric prejudice). In addition, the authors point out that harms may ensue when AI systems, which could benefit animals (e.g. for veterinary medicine), are not developed or deployed (e.g. due to lack of funding); they refer to these as *forgone benefits*.

Although Coghlan and Parker [10]'s considerations focus on AI systems, the concerns they raise are relevant to the development of computing technologies more broadly and, indeed, over the years similar concerns have been addressed within the ACI community. For example, researchers have highlighted risks of *intentional harms* such as cyberpoaching [48] or increased animal exploitation [64] deriving from the use of tracking technologies and of the data collected through them. Researchers have also pointed out *unintentional harms* that technology may have, for example, when wearables physically injure animals or disrupt activities that are essential for their survival, or for the survival of other individuals or groups within their ecosystem [49]. Concerns over other *indirect unintentional harms* have been raised, for example, regarding the use of technologies designed to care for companion animals, which may result in them being neglected as their guardians delegate responsibility [23]; or regarding the use of quantifying technologies, which may lead to an incorrect interpretation of and response to their welfare needs, as well as to a weakening of the human-animal bond [34]. Further concerns over indirect unintentional harms have been raised by researchers noting how classification models trained on large amounts of web-scraped data suffer from human bias attributing negative behavioural traits to animals based on superficial characteristics, such as coat colour [16]. More generally, ACI researchers have been mindful of the interspecies differences, communication barriers [33] and power dynamics [19] which characterise human-animal relations and which are likely to result in technologies that serve the interests of humans rather than those of animals.

However, while the above contributions demonstrate ACI researchers' awareness of and concern over technology's potential to harm animals, work in the field has generally concentrated more on realising technology's potential benefits for both animals and human-animal relations. At the same time, concerns over potential harms have mostly related to applications specifically targeting animals rather than computing applications more broadly. In this regard, researchers have proposed guiding principles, tools and strategies to ensure that technologies targeting animals are designed from an animal-centred perspective and, thus, benefit them. Work in this area includes, for example, guidelines [e.g. 28] and protocols [e.g. 39] for the ethical treatment of animal participants, and tools for supporting researchers self-reflection and decision-making [e.g. 52] during research; design guidelines [e.g. 61] and frameworks [e.g. 65] to inform the development of technologies that enhance animal welfare; as well as concepts and strategies to help researchers deal with the wider implications of ACI projects and how these may affect animal dignity [e.g. 63] and justice [e.g. 37].

Overall, researchers' prevailing concentration on realising potential benefits is, of course, not surprising. Nevertheless, at a time when technologies of increasing power and reach are encroaching on both managed and free-living animals in unprecedented ways, there is arguably a need for more ACI work to:

- focus on the risks of harm that technology poses for animals and related ethical implications (as well as working towards the realisation of its potential benefits)
- pay more attention to the impacts of and ethical implications for technology that does not necessarily target animals (as well as addressing technology that specifically targets them).

In other words, to adequately reflect its animal-centred perspective on the study and design of computing technology, there is arguably a need for ACI to increasingly address the full breadth of impacts that emerging, increasingly powerful and pervasive, technologies may have on animals as well as the ethical implications of those impacts. In this regard, a key question is how to engage stakeholders, such as governance bodies, to create opportunities for debate and conditions for influencing policies that could eventually reflect ACI's ethos and maximise ACI's benefits for animals and society more

broadly. The following sections address this question by making two complementary proposals (sections 3 and 4 respectively).

3 FROM HUMANS TO ANIMALS: RE-FRAMING ANTHROPOCENTRIC ETHICAL FRAMEWORKS

To engage governance bodies, researchers could reinterpret human-centric ethical frameworks produced by those very bodies, to reflect a multispecies perspective against which to foreground impacts of technologies on animals and raise related animal-centred ethical concerns. This could be helpful for three reasons: ACI researchers' work that addresses the impacts of computing technologies on animals is arguably more likely to engage governance bodies, if it is framed in terms of those bodies' existing policies; examining technology's impacts against the frameworks that underpin those policies could make ACI researchers' work more relatable for a range of other stakeholders (e.g. non-governmental organisations, media, general public) interested in the public discourse on emerging technologies and familiar with related policies; examining impacts on animals through the lens of human-centric frameworks could highlight implicit (e.g. socially ingrained) anthropocentric bias inherent in computing systems and inform debate on the importance of considering animals' interests in the development of policies that regulate technological innovation.

As an illustrative example, the European Commission's High-Level Expert Group on Artificial Intelligence has produced *Ethics Guidelines for Trustworthy AI* [1]. These provide a framework comprising: four ethical principles for the development, deployment and use of AI; seven key requirements for realising ethical AI; and an assessment list to operationalise the requirements in specific cases. Of particular interest here are the four foundational ethical principles: *respect for human autonomy*; *prevention of harm*; *fairness*; and *explicability.* In relation to these, the guidelines stress the need to: "*…pay particular attention to situations involving more vulnerable groups such as children, persons with disabilities and others that have historically been disadvantaged or are at risk of exclusion, and to situations which are characterised by asymmetries of power or information…*" (p. 2). It will not be lost on ACI researchers who subscribe to a non-speciesist [40, 66] point of view that animals are precisely among those "others that have historically been disadvantaged", given their subordinated position within human legal and socio-economic systems [37]; "or are at risk of exclusion" from receiving AI's potential benefits and from being protected from potential harms, given the "asymmetries of power and information" characterising human-animal relations [19].

The *Guidelines*' ethical principles are grounded in international human rights law, which underpins European Union's legislation and reflects what the Expert Group terms a "*human-centric approach*". Given the absence of equivalent international animal rights law, applying the four ethical principles to nonhuman animals might seem unfeasible. However, recent work [56] has examined human rights jurisprudence to establish whether some human rights (e.g. right to dignity and respect; right to privacy; right to freedom from slavery, servitude and forced labour) might also apply to nonhuman animals. Although the investigation was in the context of a legal judgement in a future court of law (ruling whether a high-welfare smart farm of the future might breach any of the rights in question), the authors found that already existing legal instruments do allow the application of those rights to nonhuman animals. These findings contribute to work which has long contested the exclusion of animals from fundamental legal entitlements [e.g. 55] and are consistent with multispecies political philosophies of justice, such as Nussbaum [46, 47]'s Capabilities Approach, which has underpinned proposed notions of animal-centredness within ACI [37]. This is based on the recognition that all those who share the condition of *animality*, who have an ability to feel and a perspective on the world, strive for *capabilities* that are important for their flourishing - i.e. *life*, *health* and *bodily integrity*; using their *senses*, *imagination* and *thought*; making meaningful *choices* and *plans*; forming relevant *affiliations*; *playing*; having *control* over their environment [46, p. 102] - which they are entitled to have the opportunity to pursue as *autonomous* agents endowed with intrinsic *dignity* [47].

On the grounds of such cross-species commonalities, it is not unreasonable to reinterpret the four ethical principles of the European Commission's *Guidelines* from a multispecies perspective, against which to foreground impacts of AI systems on animals and related ethical concerns.

A multispecies interpretation of the European Commission's *Ethics Guidelines for Trustworthy AI*

Below the Guidelines' four ethical principles are summarised and minimally rephrased so they could refer to both human and nonhuman animals (for comparison, the *Guidelines* can be downloaded from the European Commissions' website). Subsequently, two examples of AI-enabled systems are discussed, in which ethical concerns are considered against the multispecies principles.

Respect for autonomy. Those interacting with AI systems must be able to keep full and effective self-determination, and co-shape processes that influence their life. AI systems should not unjustifiably subordinate, coerce, deceive, manipulate, condition or herd individuals, but rather augment, complement and empower individuals' capabilities, leaving meaningful opportunity for choice, and supporting and creating meaningful work.

Preventing harm. AI systems should not cause nor exacerbate harm, nor adversely affect individuals, by protecting their mental and physical integrity, and dignity. AI systems and the environments in which they operate must be safe and secure. Vulnerable individuals should receive greater attention and be included in the development, deployment and use of AI systems, particularly where adverse impacts may result from power or information asymmetries. [1]

Fairness. AI systems must be fair, ensuring that benefits and costs are equitably and justly distributed, and that individuals and groups are free from unfair bias, discrimination and stigmatisation. AI systems should never deceive or unjustifiably impair freedom of choice; and should carefully balance competing interests and objectives. Individuals should be able to contest and seek redress against decisions informed by AI systems.

Explicability. AI systems' processes should be transparent, their capabilities and purpose openly communicated, and decisions explainable to those directly and indirectly affected, so decisions can be contested. Where outputs cannot be explained, other explicability measures may be required, provided the system respects fundamental rights. The degree of explicability required depends on the severity of the consequences of erroneous outputs.

Example 1: Considering precision farming systems against the multispecies principles

According to Coghlan and Parker [10]'s classification, AI applications used within precision farming may cause *intentional harms* to animals (e.g. leading to further intensification), which are *legal or generally regarded as acceptable* in the name of efficient and profitable food production.

Precision farming involves the application of intelligent systems to monitor animals' physiology and behaviour (e.g. temperature, locomotion), to infer production process requirements (e.g. detection of oestrous), to optimise husbandry practices (e.g. feeding regimes) and to automate production processes, some of which are partly delegated to the animals themselves (e.g. robotic milking). While smart farming is deemed to have potential for improving welfare [36], researchers

[1] In the original version, the text ends with "*Preventing harm entails consideration of the natural environment and all living beings*". However, later in the document it transpires that this consideration refers to environmental impacts such as energy usage and pollution related to the development and use of AI systems. In any case, here the statement is subsumed by the multispecies interpretation of the principle.

[11] have pointed out that this will depend on what definition of welfare will be built into these systems, and whether they will correctly and accurately recognise relevant welfare indicators. Additionally, researchers [36] have highlighted how, to yield welfare benefits, these systems would need to be designed taking a human- and animal-centred approach so as to afford good utility and usability for both farmers and farmed animals. Furthermore, beyond welfare on the farm, other considerations may determine how farmed animals are affected by precision farming systems.

Below are examples of ethical considerations that the four multispecies principles could help foreground for the eventual attention of governance bodies regulating the development of precision farming systems:

Respecting autonomy. While, within precision farming systems, animals may have greater choice as to when to undertake some production activities, their autonomy may nevertheless be significantly limited, as the technologies that these systems employ make it possible to control almost every aspect of the animals' life (e.g. what and when they eat, where they go and who they socialise with, when and how they reproduce and die) ever more effectively, thus making it impossible for them to self-determine (e.g. artificial insemination has significant welfare implications for farmed animals, yet they have no saying on the matter). Researchers [36] have proposed that the development of precision farming systems could employ a participatory approach enabling farmed animals to inform these systems' design. However, beyond simply affording usability for animals, these systems may not enable individuals to freely engage in activities that are important to them (e.g. motherhood) and to make meaningful choices (e.g. whether to be inseminated).

Preventing harm. Precision farming systems that malfunction or afford poor usability or wearability for animals may cause frustration and even injury [36] (e.g. wearable devices developed to detect oestrous in cows may obstruct blood circulation in the tail causing severe injury and even requiring amputation). Data leakages in systems may render the animals vulnerable to external malicious attacks (e.g. sabotage of feeding regimes or animal husbandry equipment). Precision farming may afford the intensification of farming practices whereby more crowded living conditions might make it impossible for animals to properly manage their interactions, with more vulnerable individuals succumbing to warped group dynamics [48]. The use of animals' data (which the animals themselves will not have access to) to control their biological functions (e.g. reproductive cycle, social interactions) may be incompatible with respect for their dignity [63].

Fairness. Although precision farming systems may significantly improve the welfare of farmed animals in specific cases, they may pose indirect risks to the welfare and dignity of those individuals who are classified as such. In particular, the 'incorporation' of farmed animals in highly technologized production systems may reinforce societal perceptions of them as 'stock' and further legitimise their commodification; at the same time, ironically, the perceived 'dignification' of animals when they interact with technology (e.g. 'the clever cow who uses a computer to milk herself') may increase the acceptability of such commodification. Given the incommensurate power asymmetry between farmed animals and farming industry, the balance of interests built into precision farming systems may not be in the animals' favour (unless consumers and policy makers were to demand it) and their resistance to unwanted practices resulting from decisions made by these systems (e.g. scheduled exclusions from certain resources) may easily be ignored.

Explicability. Precision farming systems may afford a measure of transparency for animals through associative learning (e.g. understanding what a robotic milking machine does) during physical and cognitive interaction with their interfaces, if these are appropriately designed. However, animals have no way of understanding the implications of processes outside their sensory and cognitive experience (e.g. why a cow has an object attached to her tail and what that does), such as the collection and processing of their own data, and use of information extracted from it, which may have significant consequences for them but which they cannot object to (e.g. a recommendation to send a cow to slaughter because the system detects a decline in milk production). Farmers may understand the implications of these processes and endeavour

to leverage them to benefit their animals to an extent but, given the requirements of the farming process, they may not prioritise the animals' interests and, thus, may not adequately represent the animals [37].

Example 2: Considering (anthropocentric) smart cities against the multispecies principles

Anthropocentric smart cities illustrate what Coghlan and Parker [10] term *forgone benefits* of AI, whereby systems that could benefit animals are not being developed because the prospective benefits are not deemed worth investing on. At the same time, urban smart systems that are being developed may harm animals if they are not designed for them.

To ensure that the needs of a growing urban population [59] are met with equity and inclusion [32], smart sustainable cities are expected to leverage big data analytics and context-aware computing for activity monitoring, data analysis, service provision, and urban planning purposes [8]. However, although urban expansion is increasingly encroaching on natural habitats and forcing wild animals to move into cities, their needs are still largely disregarded [3] and smart city visions still fail to represent them [2]. While some species manage to live within urban environments, these are often inhospitable, by indifference (e.g. glass-fronted buildings against which birds crash) or by design (e.g. spikes fitted on buildings' edges to prevent birds from perching) [6]. Urban wild animals are welcomed, tolerated or persecuted, depending on whether they are seen as benefitting or damaging human interests [30]. In contrast, many are arguing that smart cities should be designed for multispecies cohabitation [25]; specifically, some argue that smart cities should endeavour to meet, with *equity* and *inclusion*, the needs of both animal and human dwellers as a matter of *justice*, by providing intelligent and adaptive environments where animals could "*make sense of their urban surroundings and interact with them effectively to achieve biologically relevant goals*" [38]. While the *multispecies smart city* concept is yet to inform urban development agendas, below are examples of ethical considerations that the multispecies principles could help foreground for the attention of governance bodies regulating the development of smart cities:

Respecting autonomy. Animals living in cities have relative autonomy as they move across the urban space to explore territories, seek resources, and maintain social interactions. However, human infrastructures and practices constrain their autonomy by limiting their movements (e.g. impervious fences blocking access to gardens, extensive paving where vegetation that once provided safe cover can no longer grow), their ability to find necessary resources (e.g. due to loss of vegetation where food and shelter might be found) and to maintain social interactions (e.g. finding mates, raising offspring), in an environment fundamentally controlled by humans. Smart cities will pose similar and, even greater, limitations to animals' autonomy, unless their design accounts for animals' needs (e.g. intelligent fences responding to the approach of individuals needing access), enabling them to make meaningful choices, undertake meaningful activities when it matters to them, and interact effectively with the urban environment [38].

Preventing harm. Urban environments pose many dangers for animal dwellers, which threaten their integrity and even life (e.g. busy roads on which they are hit by speeding cars when crossing, glass-fronted buildings with which they collide when flying, structures in which they become trapped when seeking shelter). When they succumb, their bodies may be discarded like rubbish or trampled with indifference (e.g. by moving vehicles), which demeans them and reinforces perceptions of them as entities that do not matter and that can be treated with disregard or even recklessness. Smart cities will not be safer and more dignifying places for wild animals unless they are designed, for example, to significantly reduce hazards, by providing them with relevant information (e.g. glass-fronted buildings' glass walls that change reflectivity throughout the day to always be perceivable) and by safely managing physical interactions with them (e.g. intelligent vehicles that choose to avoid small animals [7]).

Fairness. Cities do not currently provide an equitable and fair distribution of benefits and costs between humans and other dwellers, or among different species of animals. For one thing, humans have most of the advantages; for another

thing, while some animals are welcomed and cherished as enhancing humans' aesthetic experience (e.g. pretty song birds) others are repelled and persecuted as pests (e.g. pigeons, rats), usually with deadly consequences. Smart cities will not reduce discrimination and stigmatisation of animals unless they are designed to value the unique worth of different species, delivering design solutions that mediate and balance different species' needs with a view to maximise benefits for the most disadvantaged ones, and fostering attitudes of respect, appreciation and care [38].

Explicability. Urban phenomena can be hard to interpret for animals (e.g. road traffic), even though many learn how to negotiate and exploit them (e.g. visiting rubbish bins outside restaurants). When they cannot do so, the consequences may be dire. In contrast, smart cities designed also for animal dwellers could make the urban environment easier to read for them (e.g. signalling in a species-appropriate way where resources could be accessed). Although animals would not be able to understand the inner functioning of the smart city (e.g. how data is collected and processed, how the information extracted from it is used), their interaction with the intelligent urban environment, and the data it produced, could feed into an iterative development cycle that gradually informs the multispecies city's development [38].

4 FROM ANIMALS TO HUMANS: FRAMING ACI'S POTENTIAL FOR GLOBAL PRIORITIES

As exemplified above, a multispecies interpretation of human-centric ethical principles could help to foreground animal-centred ethical concerns related to various impacts of technology (in this case, AI systems) on animals [37]; and, in this regard, drawing on frameworks developed by governance bodies may make it easier for the ACI community to engage those stakeholders in much needed discussions on the importance of considering animals' interests when regulating the development of emerging technologies. While this paper leverages the ethical principles underpinning the European Commission's *Ethics Guidelines for Trustworthy AI* [1] as an example, other relevant frameworks could be similarly useful.

However, for the ACI community to engage governance bodies and, thus, extend the influence of ACI onto any regulated settings where animals and computing technologies might come into contact, arguably ACI researchers would need to show the relevance of their work to the societal priorities set by those governance bodies. Specifically, researchers would need to show how the animal-centred perspective championed by the community (along with the expertise of its members) could support (and be key to) the pursuit of those priorities. In this regard, it is hard to think of more ambitious priorities than the United Nations (UN)' Sustainable Development Goals (SDGs) [57], which were adopted in 2015 "*as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity*", balancing "*social, economic and environmental sustainability"* by leveraging "*creativity, knowhow, technology…from all of society*" [57]. The abovementioned European *Guidelines* [1] themselves state that AI systems can "*help to facilitate the achievement of the UN's Sustainable Development Goals, such as promoting gender balance and tackling climate change, rationalising our use of natural resources, enhancing our health, mobility and production processes, and supporting how we monitor progress against sustainability and social cohesion indicators*" (p. 4).

While the relevance of emerging technologies to the SDGs' agenda is widely acknowledged, the overall perspective on their potential is, unsurprisingly, decidedly anthropocentric (just as it is in the European *Guidelines*). So, the challenge for the ACI community is to articulate how its work - the result of its members' "creative thinking, technical knowhow and technological innovation" - can contribute towards realising a global sustainable future; and how, to this end, ACI's animal-centred perspective is key to achieving a balance between "social, economic and environmental sustainability". There are signs that global governance bodies are becoming more receptive to the idea that human, animal and environmental wellbeing are interconnected and that a purely anthropocentric approach does not have the potential to deliver a sustainable future for humanity. As a case in point, in 2022, the United Nations Environment Assembly of the UN's Environment Programme adopted a historical *Resolution* recognising, for the first time ever, the nexus between animal welfare,

environment and sustainable development. The *Resolution* makes repeated reference to *One Health* [43], "*an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems*". Co-sponsored by the Food and Agriculture Organization (FAO), the World Organization for Animal Health (OIE), the United Nations Environment Programme (UNEP), and the World Health Organization (WHO), the approach "*mobilizes multiple sectors, disciplines, and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems*" (p. 2) with a view to enabling sustainable development.

There is no reason why ACI should not be one of the "sectors, disciplines and communities" that are "mobilized" to foster multispecies well-being towards global sustainable development; and by engaging more explicitly with global governance agendas, such as the UN's SDGs, the ACI community could demonstrate the relevance of its work and, importantly, the value of its animal-centred perspective on the study, design and deployment of computing technologies. There are several ways in which ACI could support these goals, but some seem particularly obvious:

- designing, deploying and evaluating technologies for monitoring, analysing and interpreting animal-related phenomena in different settings (e.g. presence, behaviour, wellbeing and needs of species, groups, individuals) ensuring that the design of monitoring tools and protocols is informed by animal-centred frameworks
- designing, deploying and evaluating technologies that afford animals effective interactions with their environment (e.g. enabling meaningful choices, autonomous access to relevant resources, management of social relations) maximising, not only utility and usability, but also compatibility with animals' *capabilities* and minimising human-animal conflicts
- designing, deploying and evaluating animal-centred technologies that engage different human communities in the monitoring of and providing for animal wellbeing (e.g. raising awareness of human activities' impact on some animals, highlighting the human-animal wellbeing nexus, coordinating collective animal care activities), fostering attitudes of understanding, respect and safe interspecies relations.

Connecting animal-centred technological interventions to Sustainable Development Goals

ACI researchers could establish explicit links between the kind of interventions mentioned above and the UN's SDGs, which include: 1) *no poverty*; 2) *zero hunger*; 3) *good health and well-being*; 4) *quality education*; 5) *gender equality*; 6) *clean water and sanitation*; 7) *affordable and clean energy*; 8) *decent work and economic growth*; 9) *industry, innovation and infrastructure*; 10) *reduced inequality*; 11) *sustainable cities and communities*; 12) *responsible consumption and production*; 13) *climate action*; 14) *life below water*; l5) *life on land*; 16) *peace, justice and strong institutions*; 17) *partnerships for the goals*. Although, to different degrees, ACI is likely to be relevant for many of these, its relevance seems particularly salient for some of them. These are discussed below to exemplify areas for technological intervention that seem particularly relevant to them and where ACI researchers could establish explicit links to SDGs when they conceive, produce and disseminate their work.

Good health and well-being. This goal aims to tackle leading causes of death and disease, and increase life expectancy for people across the globe, accounting for "*economic and social inequalities, rapid urbanization, threats to the climate and the environment*" and leveraging "*multisectoral…approaches*" to build good health for all.

The nexus between human and animals health and wellbeing is well-established and has many facets. For example, it is believed that human-animal interactions can be beneficial for both human and animal [15]. Thus, technologies that educate people on the value of human-animal relations, that enhance understanding of and empathy for animals, and that foster human respect for and positive interactions with animals have the potential to advance human as well as animal well-being [60]. Additionally, assistance animals play a vital role for some of the most vulnerable people, who are often among

the more disadvantaged, not only physically or mentally, but also socially and economically [50]. Thus, technologies that can help charitable organisations to find appropriate occupations for assistance animals according to their capacities and aptitudes [68], as well as technologies that provide animal-centred tools to support animals in their assistive activities [18] can benefit the animals' welfare, reduce costs associated with their training and enable them to work more effectively, thus helping them to reduce the impact of health and socio-economic inequalities that afflict some people. Moreover, it has been amply demonstrated that animal welfare compromises, typically within the farming industry, can lead to the development of deadly pathogens and zoonotic diseases transmissible to humans [12]. Thus, animal-centred assessments of the impacts of technologies used within the farming industries, as in the case of precision farming discussed above, are highly relevant here; equally relevant is ensuring that technologies such as precision farming systems are designed from an animal-centred perspective (as far as possible), to ensure that monitoring methods are minimally intrusive and that the animals' environment supports as many of their capabilities as possible, for example by enabling meaningful choices, autonomous access to relevant resources, and effective management of social relations.

Sustainable cities and communities. This goal is about "*creating career and business opportunities, safe and affordable housing, and building resilient societies and economies*" by "*investing in public transport, creating green public spaces, and improving urban planning and management in participatory and inclusive ways*".

As discussed above, rapid urbanisation is a major challenge for animals, whose habitats are being progressively eroded and who often encounter inhospitable conditions when they move into densely developed urban environments. However, urban development can also be a challenge for human inhabitants, where the crowded, unsanitary and deprived living conditions of mega-cities can negatively affect physical, mental and social wellbeing. While, as discussed, smart cities are expected to address this kind of issues through intelligent planning and equitable provision of services, researchers have warned that smart cities are set to become *ecocidal* places, if their development continues to be informed by a solely anthropocentric perspective [26]. Access to nature is considered important for human wellbeing but, for many people, the only chance to access nature is within cities. Where they exist, green spaces attract wild animals whose presence can enrich human experience, if people can learn to appreciate and live with them safely [6]. Thus, technologies which take an animal-centred approach to help citizens explore and appreciate the unique characteristics and ecological value of different species, and learn how to interact safely with wildlife, have the potential to foster positive attitudes towards animals and reduce discrimination against them, whilst fostering a sense of pride in people's local multispecies communities [13]. Aside from augmenting people's urban experience, such projects have the potential to provide opportunities for citizens to participate in the planning and management of urban spaces [5] by sharing their wildlife experiences and perhaps becoming wildlife advocates, thus enabling resident animals to participate in urban planning, so to speak, by human proxy [38], while at the same time fostering people's inclusion and political agency. This use of technology has the potential to also help increase social cohesion and resilience, through the sharing of enriching activities, thus helping to create safer urban communities for both animals and humans.

Life below water and ***Life on land.*** These goals aim to "*sustainably manage and protect…ecosystems, enhancing conservation and the sustainable use of…resources*" (SDG 14) and to "*reduce the loss of natural habitats and biodiversity which are part of our common heritage and support global food and water security, climate change mitigation and adaptation, and peace and security*" (SDG 15).

As urbanisation continues to expand, cities have an increasingly important role to play in the conservation and promotion of biodiversity. In this regard, as discussed above, the design, deployment and evaluation of animal-centred

technologies for monitoring urban wildlife, for supporting animals' interactions with the urban environment, and for engaging people in wildlife care and conservation activities within urban spaces have significant potential to enable smart cities to become healthy and biodiverse multispecies ecosystems [38]. At the same time, research that addresses, from an animal-centred perspective, the trustworthiness of intelligent systems to which animals may be exposed within urban settings or to which their management and care may be (partly or entirely) delegated [53] has an important role to play in ensuring that the design and deployment of those systems have a positive impact for animal dwellers. Outside the city's boundaries, technologies designed and deployed to study the presence, behaviour and needs of animals continue to be highly relevant to inform strategies for the conservation and sustainable management of natural habitats. Particularly, but not only, within natural habitats that are home to vulnerable species, an animal-centred approach to technological interventions can ensure that these do not unduly interfere with animals' bodily health, habitual behaviour and daily activities [49], and that data collection, transmission and use does not compromise their safety and security [20], which is essential for the success of conservation initiatives, which also depends on the protection of individual animals' welfare [44]. Taking holistic approaches that include an animal-centred perspective to the design of technology-aided solutions for managing human-wildlife conflicts [24] is also important to ensure that animals are not penalised as a result, particularly where they are already suffering the consequences of human encroachment, including the loss of resources and migratory routes.

The above examples are by no means comprehensive but simply aim to point out the relevance of ACI research to some of the goals of global governance agendas; and most of them correspond to work that the ACI community is already undertaking. While the UN's SDGs are ultimately human-centric, explicitly engaging with them in their work could help ACI researchers to demonstrate how taking an animal-centred approach to the development, deployment and use of relevant technologies could significantly facilitate the pursuit of those goals.

5 CONCLUDING REMARKS: TAKING RESPONSIBILITY

Some have argued that ACI researchers should develop only technologies that animals need and want [45] while others have cautioned against the risks of developing animal technologies that end up being exploitative of or that disregard animals, or that is mindful of animals but not animal-centred [63]. This author agrees with these positions wholeheartedly. However, emerging technologies of growing power and reach are affecting animals in unprecedented ways, producing equally unprecedented impacts; and it is likely that, for the foreseeable future, this trend will continue. Therefore, a key question for the ACI community is *how* to ensure that the multiplicity of computing interactions to which animals are being increasingly exposed are consistent with the animal-centred ethos of ACI.

Amongst its members, the ACI community holds a strong intellectual capital, in terms of technical knowledge, methodological experience, creative thinking and ethical reflection. However, while some governance bodies are starting to take an interest in the impacts that emerging technologies, such as IoT and AI, may have on animals, in the mainstream discourse awareness of relevant ACI work is still relatively limited, particularly at governance levels. In turn, this is bound to limit the influence that, as a field, ACI could be having to help minimise harms and maximise benefits for animals. The 10th anniversary of the community's International Conference seems a good time to reflect on how the community might extend its influence. In this regard, this position paper has proposed that more ACI work could: focus on the risks that technology poses for animals and the impacts of technology that does not necessarily target them, as well as on the benefits of technologies that target them; interpret human-centric ethical frameworks produced by governance bodies from a multispecies perspective against which to foreground impacts of technologies on animals; and explicitly relate ACI work

to global societal priorities set by governance bodies against which to highlight how the animal-centred perspective championed by the ACI community can support those. These approaches could help the community to engage powerful stakeholders in much needed discussions on the importance of considering animals' interests when regulating the development, deployment and use of emerging technologies. Although, engaging with the anthropocentric ethical frameworks and political agendas of those stakeholders may be challenging, it still provides the opportunity to bring ACI's animal-centred perspective to those agendas, helping to promote animal capabilities and to normalise respect for animal dignity, in turn supporting the development of an inclusive and sustainable multispecies society.

Ultimately, this author suggests, responsible ACI means *taking responsibility* for, and indeed leadership on, addressing the challenge of giving animals representation in the face of enormous anthropocentric pressures, and ensuring that, despite the many ethical compromises we may have to make along the way, we do all we can to steer technological innovation in the right direction for animals.

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