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From MilkingBots to RoboDolphins: How AI changes human-animal relations and enables alienation towards animals

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Technologies, especially disruptive technologies, have a great potential to change and reshape human-human as well as human-technology relations. This creates various ethical challenges that need to be addressed. However, technologies also have great potential to change human-animal relations. Since this aspect is underexplored in the academic debate on technologies' impact on relations, we believe that it is important to (1), descriptively, study how new and emerging technologies impact human-animal relations, and (2), normatively, to enrich the debate with a non-anthropocentric perspective that recognizes that human-animal relations also have moral significance. Therefore, in this paper we investigate how artificial intelligence (AI) technologies and robotics impact human-animal relations, and we discuss the moral significance of these changes. AI technologies change human-animal relations due to, first, *automation*, and second, *replacement* processes. Automation processes mainly take place in the animal agriculture sector, and the replacement of biological animals with artificial AI-driven animals mainly in the context of zoos, companion animals and laboratories. We address both processes (automation and replacement), thereby providing an overview of how the use of AI technologies will—or can—change human-animal relations, at both the individual and societal levels. While doing so, we highlight the morally significant aspects that come along with such changes and provide first thoughts on which uses of AI are welcomed from a perspective of human-animal relations.

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Introduction

Technologies, especially disruptive technologies, have a great potential to change and reshape human-human as well as human-technology relations. This comes with various ethical challenges that need to be addressed from within different disciplines. However, technologies also have great potential to change human-animal relations. This aspect is widely underexplored in the academic debate on technologies' impact on relations. Research on how technologies influence relations currently comes with a strong anthropocentric tailoring. There is rather little literature on human-animal relations within philosophy of technology (for exceptions cf., e.g., Coeckelbergh 2011; 2023). Research from other disciplines that study human-animal relations, such as psychology (Adams, 2018; Wells, 2019), animal welfare science (Raut et al. 2020), or animal ethics (Crary, 2010; Diamond, 1978; Palmer, 2010), rarely link their investigations to technological issues, and clearly have no focus on technologies.

This research gap is problematic since human-animal relations matter morally (a brief argument follows in the next section), and technologies have various impacts on them. With this paper, we aim at filling this research gap by giving answers to the overarching questions of *how* technologies affect human-animal relations, and what follows from it ethically speaking. In doing so, we aim to contribute to the ethical discussion about how AI can be developed and used in an ethically responsible way.

Therefore, we investigate how artificial intelligence (AI) technologies and robotics impact human-animal relations and discuss the moral significance of this. This focus was chosen for two reasons. First, we address *human-animal relations* instead of animal-technology relations because it requires fewer demanding premises. An examination of how human relations to animals are changed using technology can also build upon approaches that locate morally significant relations only in the human realm. It does not necessarily build upon the assumption that animals themselves can have morally significant relations at all. We think they can (cf., e.g., Bekoff, 2003), and we also hold it to be important to overcome anthropocentric perspectives. However, for the sake of convincing also those who are skeptical about animals' (or robots') capacities to build morally significant relations to engage with the topic, it seems promising to first investigate the research gap of technologies' impact on human-animal relations and leave a comprehensive investigation of animal-technology relations for future research. Second, we focus on AI technologies, because firstly AI is one of the most important technologies of our time. Moreover, using a concrete technology as example instead of discussing technologies in general enables us to discuss concrete potentials for changing relations and to ethically evaluate these changes.

For investigating how AI technologies (may) change human-animal relations, we focus on automation (Automation processes) and replacement processes (Replacement processes). While there may be other social practices and processes that alter human-animal relations, automation and replacement are the most prevalent. We discuss different examples where AI technologies are applied on animals or affect animals and what follows from this regarding (qualities of) relations, referring to individual relations to animals, as well as to human-animal relations on a more abstract level of society. We then elaborate on how these changes should be morally evaluated. The examples we discuss by no means constitute an exhaustive discussion of how AI is impacting human-animal relations. However, we believe we have selected the most pertinent and relevant cases because AI is currently being increasingly used in animal agriculture and the animal entertainment industry, and both industries, especially global animal agriculture, are huge, multi-billion dollar global industries. Following this, we briefly discuss if in some cases a shift in the perception of animals may have initiated the development of replacement AI technologies in the first place, posing the 'chicken and egg' question (3).

AI's (potential) impact on human-animal relations

Within (animal) ethics, there are different approaches to arguing for the moral significance of human-animal relations. Wittgensteinian philosophers Cora Diamond (1978) and Alice Crary (2010) argue that what is morally significant about other animals is not some kind of capacity they possess – and that humans share with them – but that we have moral relations with them. From these relations, we can derive answers to the question of how we should treat animals that are not 'constructed' in an abstract way but are consistent with our lived morality. Diamond thus rejects the relevance of moral status ascriptions. Another route to take is to uphold the relevance of moral status ascriptions, but to argue that they should not be based on capacities or properties, but on relations, as Mark Coeckelbergh and David Gunkel (2014) call for. Furthermore, with their relational approach, they also suggest that the very project of moral status ascription is problematic from a power/authority perspective: it assumes that humans have and should have the power and authority to confer moral status upon non-humans, creating and consolidating a hierarchical relation between humans and non-humans. At the very least, they urge to be careful when ascribing moral status to non-humans, given that we know so little about them; the epistemological situation is problematic.

And a third way to account for the moral significance of human-animal relations is to retain a property-based approach to moral status, but to argue that specific contexts, such as relations, must count morally in cases of conflict, when it is necessary to prioritize certain individuals, or to argue for special duties toward certain individuals. Such approach is favored, e.g., by Clare Palmer (2010). She takes a sentientist approach, meaning that for her sentience is a necessary and sufficient condition to be directly morally considerable. However, she argues for special duties toward those (sentient) animals with whom humans have relations—duties that do not exist toward (sentient) animals with whom no such relationships exist. These morally significant relations vary in their form, and range from sharing the home with animals, sharing living space such as gardens with them, or encountering animals in the wild. The more intense these relations are the more special duties they generate according to Palmer's account. A compatible argument for moral status based on cooperation with animals has been made by Coeckelbergh (2009).

These three approaches differ partly significantly in their philosophical arguments. But they have in common that they all account for the moral significance of humans' relations to other animals.[1] And AI technologies change such human-animal relations, thereby affecting something that is of moral importance. They change them on individual levels as well as on more general levels of societal relations to animals. Most of these changes occur due to, first, automation processes, and second, replacement processes.

Human-animal relations come in many forms and are very diverse. We therefore refrain from a general description or definition of a morally significant human-animal relation. We will briefly describe what kind of relation we are talking about, and how AI changes it, when we discuss the examples below.

Automation processes. AI-driven automation processes in the animal context mainly take place in the agricultural sector. Using technology to make animal agriculture more efficient is often

referred to as "precision livestock farming" (PLF; Bos et al. 2018; Tuyttens et al. 2022), so, many AI uses are discussed in the context of PLF. There are already a variety of AI applications within animal agriculture. Robots are used for milking, herd management, or deboning in processing plants. Other robots drive through poultry houses and collect eggs that are not placed in designated nest boxes. AI systems are deployed for fattening control, feed optimization and automated feeding.[2] One of the most common fields of application is using AI technologies as early warning systems to automatically detect or predict diseases as early as possible, such as, e.g., mastitis, lameness in cows or avian influenza (for many cf. Walsh et al. 2019; Zhang et al. 2023). Surveillance cameras, computer vision methods, and predictive imaging tools are used to track farmed animals and analyze their behavior to detect deviations from expected animal behavior. In the context of disease prevention, using AI for facial recognition of individual animals is commonly envisaged (Roberts, 2023). While such applications are still mainly in pilot phases, they will likely be used increasingly (Simoneau-Gilbert and Birch, 2024), and often aim at automated pain detection, which then could be followed by an automated dispensing of medicine without veterinary intervention (Coghlan and Parker, 2023). Most (if not all) of these applications are aimed at fully automated, continuous monitoring or handling of farmed animals without human observation or intervention.

While these efforts are often well-meant, they do not change the basic situation that technologies here create and maintain a situation of *alienation* between humans and animals. Technology is a condition of possibility (Coeckelbergh, 2012) for this alienation. On the contrary, the technological interventions lead to even greater alienation of animals used for agricultural purposes, with several morally relevant aspects. To be sure, alienation from farmed animals occurred and occurs even without the use of AI technology, as industrialized animal agriculture has moved far away from the idealized relations of care supposedly found in 'traditional' pastoral animal agriculture, where the farmer cares for individual animals and their well-being to 'receive' their flesh, milk, eggs. However, the form of individual human-animal relations at stake in industrialized contexts (which also involves relations of care, with the farmer and farm workers as caregivers and the animals as care recipients) is further disturbed by the use of AI in the industry, as the human caregiver is completely replaced by a machine. As Simoneau-Gilbert and Birch (2024) point out, "AI threatens to make genuine care even more difficult to achieve" within the field of animal agriculture, as it eliminates remaining interactions between humans and farmed animals. Relations of care between farmers and animals, as they may exist in small-scale, less automated agriculture, get eroded *even more* if the entire process, from breeding to killing the animals, including medical care, is adopted by machines that fully replace human caregivers.[3] As this not only concerns farmers, but also the farmers families, farm workers, veterinarians, butchers, and others, it is interlinked with other human-animal relations on a broader, societal level. On this level, an increase of alienation between farmers and their farmed animals creates *an even greater* distance between consumers and the animals raised for food. Further AI-enabled automation leads to a greater invisibility of what happens in animal agriculture as well as to an even greater loss of relations consumers have to what they eat. Again, this already occurs in modern societies without the use of AI in agriculture. However, this 'alienation through AI-driven automation' process is accompanied by the risk of making societal transformations towards more respectful and care-full animal agriculture, in which human-animal relations of care are at least as important as profit, *even harder* to achieve. And despite the use of PLF is often promoted as an animal welfare measure (cf. Kim et al. 2023), there is a risk that the removal of human expertise will rather have a negative impact on animal welfare (Bos et al. 2018). While veterinarians should be trained to recognize individual aspects of discomfort, AI systems are rather trained on general signs. As Birch (2023) warns: "We will see misleading rhetoric about "automated welfare monitoring", when in reality the sensitivity has been deliberately tuned down to a very low level."

Alienation processes occur not only using technological systems, but on many levels, such as, e.g., the linguistic level: the way we talk about animals implicitly brings in biases and helps to maintain alienation. Language co-creates realities, and as some philosophers and eco-linguists point out, it is therefore a powerful tool for creating and maintaining the human-animal dualism and the belief in human superiority over animals (Coeckelbergh, 2012: 79; Trampe, 2018). In many languages it is common to use different terms for animals and humans, even when addressing the same biological processes or body parts. For example, the English language offers terms such as paws and claws for animals but arms and hands for humans. And by calling a cow a "cow" when it is regarded as a living (particular) animal but "cattle" when it is farmed and "beef" when it is dead meat for food consumption, language contributes to alienation between humans and animals, enabling bad treatment, slaughtering, and consumption of animals. Here, at the level of the more general societal relation to animals, the most dominant perspectives on animals prevalent in a society are supported by a specific language use that increases the alienation (e.g., seeing pigs as food and dogs as family members). AI comes with the potential to either perpetuate this linguistic alienation or to overcome it. AI-based large language models (LLMs) use our human language. Regarding animals, they currently represent our societal biases towards different animal species (e.g., providing users with recipes to cook pigs, while refusing to do so for dogs; cf. Hagendorff et al. 2022). In principle, large language models could also be programed in a way that avoids perpetuating these societal biases and point towards a different perspective on the animals that are currently mostly used as means towards human interests (Ghose et al. 2024). The LLMs could in principle be mobilized as an educational tool to overcome a perspective on animals that is ethically problematic, thereby potentially altering societal human-animal relations towards a less instrumental view on these living beings.

To briefly sum up, AI systems can promote or at least perpetuate the concealment and the justification of the treatment of animals in animal agriculture by enabling an ever-increasing automation of the industry and by perpetuating a language that support distant and instrumental human-animal relations. This creates an even greater alienation towards animals both on individual levels of farmers and farm workers – leading to even fewer or worsening relations of care –, and on a societal level when it comes to how humans relate to the animals' humans they raise for food. While we have no doubt that agricultural AI systems can be used in ways that benefit the welfare of individual animals (Bossert, 2023; Coghlan and Parker, 2023), we argue that the risk of further alienating humans from farmed animals should be taken seriously as a moral challenge.

Replacement processes. Another use of AI systems that can impact human-animal relations is the replacement of biological animals with artificial AI-driven animals, so, the use of zoomorphic social robots. Social robotics includes robotic systems that 'imitate' or engage in social interaction and/or are designed to look and behave like living entities. Zoomorphic social robots are designed to look and behave like biological animals, therefore

'imitating' or generating human-animal relations. The application of zoomorphic social robots mainly takes place in the context of (i) zoo animals and the entertainment industry and (ii) companion animals. In this section, we first discuss replacement processes by social robots. Afterwards, we briefly address another field where replacement of animals by AI technologies take place, namely in the laboratory context.

In the zoo and entertainment context, the most prominent example are RoboDolphins. California-based Edge Innovations[4] develops artificial animals by combining live puppetry, programmed behavior, and artificial intelligence to "reimagine the entertainment, educational, and business potential of the marine animal industry" (endnote iv). They aim at allowing people to interact with dolphins—and other marine mammals as well as sharks—without having to keep biological animals in captivity. Therefore, this development is advertised as animal welfare measure.

As a replacement for biological companion animals, social robots are often used for therapeutic reasons, e.g., in elderly care to prevent loneliness. The most prominent example is Paro, a robotic baby seal that is often used in the care of dementia patients to engage them emotionally (Pu et al. 2019). JustoCat is a robotic cat developed to replace biological therapy cats. Other examples, such as Sony's Aibo and the dogs, cats, and birds by RoboPets,[5] are AI-driven companion robots that serve the function of a 'common' companion animal at home. In these examples, the biological animals are replaced by artificial ones and thus, human relations to biological individuals are replaced by relations to artificial entities. In case of companion animals, the relations at stake are often very close, caring, and intimate ones, as companion animals are often seen as family members. Of course, this is not necessarily so. Whether a certain relation is mainly one of human love and friendship toward the animal, or mainly one of domination and oppression, varies from case to case. (Note also that companion animals could feel positive or negative emotions toward humans; the human-animal relation could also include love and affection or fear and anger from the animal toward the human.)

In other cases, AI does not replace the individual that is giver and receiver of the relation (the relata), but the (type of) relations themselves. For example, drones are available that take dogs for a walk.[6] While the dog 'owners' who use these drones may still relate to their dogs in different ways and feel close to them, the human-companion animal relation is at least changing in a way that basic tasks of care are being taken over by technologies. If the care tasks are increasingly handed over to AI-driven machines and automated, this could create the risk of seeing companion animals as means to serve human interests, rather than as vulnerable, living, and sentient beings that need to be cared for to serve *their* interests. To avoid such consequences, these ethical issues must be addressed, both within the AI ethics literature and within the media and public discourse on applying such AI systems to animals.

Note that in the canine context, one also finds examples of robotic dogs in industry robotics next to social robotics, such as Boston Dynamics' well-known legged robot Spot. Spot can be used to provide data-intense insights into routine operations, improve site health, or perform in hazardous situations.[7] Here, a third form of replacement takes place, the replacement of human labor in dangerous, monotonous, or overwhelming situations. However, as Spot is not developed to take the social role of a companion or zoo animal, the robot does not look and behave as dog-like as, e.g., the robotic dolphins look and behave dolphin-like. While the question why such multifunctional industrial robots are designed rather zoomorphic than anthropomorphic is worth investigating, in this paper we do not discuss industrial robots such as Spot. We suppose they have a rather low impact on social human-animal relations because they are not easily confused with a biological animal.

Morally evaluating these replacement processes reveals a complex and nuanced 'picture'. We address some of the morally relevant aspects that come along with these processes (additionally to the ones already mentioned), however, we do not claim to grasp all of them. The human-animal relations that are at stake in a zoo context are quite different from the ones in the context of sharing a home with animals. Therefore, they need to be discussed separately.

Regarding human-robot relations a broadly discussed aspect is the one of (potentially lost) reciprocity (van Wynsberghe, 2022). Addressing the individual level of human-animal relations in the zoo context, the loss of (a certain kind of) reciprocity when replacing biological animals with artificial ones needs not to be feared. Captive whales and dolphins, often forced to perform entertainment programs untypical for their species, cannot be said to engage in reciprocal human-dolphin relations worth losing. Interaction with captive dolphins is not what the interaction with a dolphin in her natural habitat would be like. So, the interaction with a robotic dolphin seems to be more realistic in that sense that it does not pretend to allow for 'getting to know' biological dolphins.

On a broader level of societal human-animal relations, zoos, and similar institutions convey the idea that animals are available for us to marvel at and are for our use, thereby perpetuating a morally problematic perspective on animals (as also discussed in section 2.1). Even if it is advertised with good intentions such as species protection or environmental education, the permanent availability and utilization of the animals in these contexts is undeniable and morally problematic since it once again instrumentalizes the animals. To the extent that visiting a zoo indeed promotes a more respectful perspective on animals, it may change the perception of animals, thereby potentially changing societal human-animal relations in a positive direction. However, this is very controversial; it is questionable whether the confinement of other living beings for human entertainment or other purposes actually demonstrates and promotes respectful perspectives and relations. It is certainly possible to keep animals in a way that treats them respectfully. However, this requires so much refuge space for animals that they are often not encountered, making a visit to the zoo less attractive.

Thus, no morally valuable aspects of human-animal relations get lost by replacing biological animals in zoos with artificial ones. For larger animals with large space requirements and complex social lives it is advantageous not to live in captivity (Marino et al. 2019), what also applies to the dolphins replaced by RoboDolphins. So, the beneficial aspects of such replacements seem to overweight in terms of human-animal relations.[8] Note that with this conclusion, we do not want to perpetuate a simplified perspective on AI-driven robots. If robots take on the same social role that animals have had in the past, this is morally significant, and so are the resulting relations between humans and other entities. To treat robot animals badly creates the wrong kinds of relations – regardless of the properties of the robot. But whatever may be the case for human-robot relations, we think that harmful, violent, or disrespectful relations harm animals anyway, given what we know about them. Animals have a very rich emotional life and various, complex social structures (Bekoff, 2003; Whitehead, 1997). A deprivation of their social structures or constant experience of negative emotions frustrates them and can be seen as harmful in a way that does not apply to robots, as the latter lack such rich emotional life and complex social structures. So, the establishment of respectful, non-violent relations may benefit animals more than robots.

The relations between humans and their companion animals are different. In principle, respectful relations as (almost) equals are possible. In the case of companion animals for whom robot substitutes exist, such as dogs and cats, humans have more power and responsibility than the animals. Accordingly, as in other asymmetrical relations, it is up to the human to create a relation that is either respectful or violent. In this respect, whether the replacement of a biological companion animals by artificial ones can prevent (biological) animals' abuse depends on the individual case.

Regarding human's wellbeing, many studies reveal that sharing a home with animals and being surrounded by animal companions increase human physical and mental health (Matchock, 2015; Wells, 2019). Companion animals, amongst other effects, reduce fear, pain, and feelings of depression and foster relaxation. If robotic, artificial companion animals in 'common' home settings have the same beneficial impact on an everyday level needs far more empirical studies.[9] Also, examinations of how such uses of AI affect human-animal relations are still a research gap. If they will be filled, it foremost addresses the individual level of benefits or harms that may result from human-companion animal relations on both sides, the human, and the companion animal side. As the mentioned health benefits demonstrate, there may be various benefits and harms that are morally significant. Here, we do not want to engage with the human health and human elderly care related aspects of human-animal and human-robotic animal relations that are discussed in medical ethics (cf. Preuß and Legal, 2017 for a brief overview, as well as the references in endnote ix). We want to shed light on a few aspects that are currently underrepresented in the academic debate.

In addition to the potential positive impact of AI-driven companion robots being able to prevent animal abuse,[10] there is a risk that they will perpetuate a perspective on animals that needs to be overcome to build truly respectful human-animal relations. With this, we address as much the societal level of human-animal relations as the individual level. As Preuß and Legal (2017: 408) point out, „[t]he pet robot is always available without any behavioral irregularities." As with zoo animals, the permanent availability of another entity does not have a place in relations among equals. The moral significance of this aspect depends on humans' capacity and willingness to differentiate between biological and artificial entities. If people are able and willing to reflect on the difference between biological and artificial animals (cf. Matthias, 2015: 185) there is rather no moral problem from the perspective of human-animal relations (there may still be a challenge from the perspective of respectful human-robot relations). What remains in any cases, however, is – again – some kind of alienation from the biological animals that also occurs in cases of replacement. A robotic animal is a robot, not a biological animal, even if it looks and sounds like one. How much of morally valuable relational aspects get lost through this form of *alienation* – again – depends on the kind of relation and if it is rather characterized by respect or suppression. This alienation also enables stereotypes about animals to persist, which can again harm animals. There is a risk that animals are seen as a kind of robots.[11]

AI and shifting perspectives on animals

With some of the uses of AI technologies in the animal context, the question arises whether the development and use of these technologies lead to a shift in the human-animal relations as described above, or whether an already existing shift in human-animal relations caused the development and use of the technologies. As Bovenkerk and Boersma (2023) point out in the conservation context, technologies can also be an indicator for an already existing shift in human- animal (or human-nature in the conservation context) relations. We do not see such a prior existing shift in the context of automation processes with AI systems, as these processes rather perfect animal use instead of reacting to a requested change. However, the cases of replacing laboratory animals or zoo animals (or animals for food production) with AI technologies may indicate such a prior existing shift in societies perspective on animals. The assumed need to, e.g., develop robotic dolphins that replace biological ones in zoos represents an already existing shift in the human-dolphin relation and the way we value them. So, in such cases the AI-driven innovation can also be seen as a reaction on a change in the relation additionally to causing further (potential) change.

When new technologies are introduced, then (for example in agriculture or in other relevant contexts), it is thus best to carefully study the human-animal relations that are shaped by these technologies, focusing especially on the *changes* these technologies create.

Furthermore, this attention to shifts and changes in relations is important to take into account in the moral evaluation of human-animal relations: if these relations are dynamic and changing, both historically and today, then this should make us even more cautious about ascribing moral status to animals based on properties, since these properties tend to be perceived differently across time, depending on the development of (new) human-animal relations. A precautionary approach, as also already argued for by Coeckelbergh, is then most adequate: in case of doubt, it is better to err on the side of caution and (too much) protection of animals.

Conclusion

In this paper, we have investigated some human-animal relations and the ways in which they may be impacted by new technologies, with a focus on AI and robotics. We have also discussed the moral significance of these relations. AI systems impact human-animal relations especially through processes of automation and of replacement. While automation processes mainly need to be evaluated negatively, ethically speaking, with regard to their impact on human-animal relations, replacement processes can benefit animals as well as human-animal relations. Therefore, it is crucial to note that AI can not only be detrimental but also beneficial for animals and our individual as well as societal relations to them.

During our investigations, we came across an interesting theme that may help to further discuss these matters: alienation. It seems that many of our current human-animal relations are plagued by alienation. This alienation is made possible by our use of technologies, next to for example our use of language to talk about animals – which then is embedded in AI technologies – and to justify our practices, e.g., in agriculture.

Such alienation, however, is perhaps not a necessary feature of how technologies shape human-animal relations. In principle, we can try to imagine advanced technologies that help us to shape our relations to animals in morally better and morally more acceptable ways. More research is needed in this direction, preferably in an interdisciplinary way that connects technical development with (post-)humanities. Currently many humanities scholars are sympathetic to questioning anthropocentrism. There is also an increasingly long tradition of animal ethics and animal rights, with calls for changing our practices in ways that do not harm animals or at least cause less harm. However, unless we investigate the precise human-animal relations in different contexts and the myriad ways in which they are impacted and changed by new and emerging *technologies* (next to language), such calls risk remaining ineffective and empty.

Data availability

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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Notes

1 One could also argue that even in very 'classical' property-based approaches such as utilitarianism, relations can have – indirect – moral weight if the deprivation or establishment of relations affect the wellbeing of individuals (leading to the suffering or happiness of an individual). This, of course, requires many empirical studies that prove how relations influence happiness or cause suffering (cf. Raut et al. 2020).

2 For example, echo sounder technology in aquaculture facilities can detect when caged fish are swimming near the surface of the water and use this as a signal for feeding times. For more detailed examples cf. Bossert and Hagendorff, 2021: 4, as well as Roberts, 2023.

3 In such cases "[t]he 'farmer', who was already a (production) manager, now becomes a user, a webmaster and a system supervisor, a system controller. The consumer 'downloads' milk or meat from the system; newborn animals are 'uploaded' to the system. The status of humans is always coupled with the status of animals: both statuses evolve simultaneously." (Coeckelbergh, 2012: 142).

4 https://www.edgefx.com/real-time-animatronics (accessed 10/24/2023).

5 https://www.robicare.de/produkt/justocat/; https://us.aibo.com/; https://www.robopets.co.uk/ (accessed 10/24/2023).

6 https://www.dronesdirect.co.uk/p/walkiesdogdrone/proflight-walkies-dog-drone (accessed 10/24/2023).

7 https://bostondynamics.com/products/spot/ (accessed 10/24/2023).

8 Note that a thorough ethical evaluation of these replacement processes is more complex and involves more morally significant issues. For example, replacing biological animals with artificial ones may perpetuate the view of animals as captive for human entertainment. While biological animals in zoos often develop behavioral disorders that, at least in theory, any visitor can critically reflect upon, artificial animals are designed to always appear content (thanks to an anonymous reviewer for pointing this out). While all of the multifaceted issues of such replacement processes should be further investigated and human-robot relations raise their own ethical issues, we believe that, at least in the short term, these replacements are promising since they benefit animals and human-animal relations because of their potential to 'liberate' captive animals and to raise awareness of the moral challenges of keeping biological animals for human entertainment.

9 For their use in hospitalized settings and elderly care, especially with dementia patients, several studies have been conducted, cf. Gustafsson et al. 2015; Heylen et al. 2012; Moyle et al. 2015; 2016; Pu et al. 2019; Sharkey and Wood, 2014.

10 This argument of avoiding abuse of animals by means of artificial replacement also reminds of the case for replacement of a great number of animals in animal testing, in which AI can play a role (Hartung, 2016). AI's ability to make sense of huge amounts of data could reduce the number of animals used for toxicity testing (Luechtefeld et al. 2018) and the development of AI-connected human organoids might have the same potential. Provided that AI-based experiments can deliver the same or even better testing than animal models, few will oppose this development. Even most proponents of animal experimentation acknowledge that it is morally problematic but see it as a necessary evil for human benefit. If technology can achieve the same or greater benefit, this needs to be welcomed. For human-animal relations, it means that scientists would no longer 'have to' perform invasive experiments on animals (which often is a rather burdensome situation), and therefore animals are no longer instrumentalized or seen as available for human purposes. The very same argument can support 'replacing' animals raised for food with AI systems that allow to produce cultured meat (including fish meat), cultured dairy products, or cultured eggs, even though this is a very indirect form of replacement.

11 We do not discuss the issue of alienation in the context of zoo animals. While this is a complex topic, we think that, broadly speaking, the very existence of zoos reflects a form of alienation towards the nonhuman world that comes along with a lack of empathy towards animals, especially the big animals that have large spatial requirements and the more intelligent animals. Whether the replacement of biological zoo animals with artificial ones can alter this, is an interesting, open research question to be investigated.

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Both authors jointly discussed the topic of the paper. LB wrote the first draft of the paper; MC revised it thoroughly.

Competing interests

The authors declare no competing interests.

Ethical statements

This article does not contain any studies with human or animal participants performed by any of the authors.

Informed consent

As no studies with human participants have been performed for this article, no informed consent was needed.

Additional information

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