75. Do we improve any aspects of animal welfare by implementing Computer Vision in livestock farming?

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Abstract

Computer Vision technology has been developed recently as a tool for measuring behaviour on the individual level in group housed livestock. This form of digital agriculture or precision livestock farming has the potential to answer to public concerns on farm animal welfare by using the data to reduce the risk of harmful social interactions such as tail biting in pig production and severe feather pecking in laying hen production. Computer Vision, however comes with changes to livestock farming and therefore can lead to new moral questions. Currently it has not resulted in much public debate. We argue that this is not to be understood as a sign that there are no societal and ethical challenges, but that – as part of responsible research and innovation – this is an important moment to explore and analyse the potential societal and ethical issues. In this paper we aim to explore the moral dimensions of the use of Computer Vision in livestock farming with a special focus on poultry. We analyse the moral dimensions from an animal welfare perspective. Although introduced to prevent welfare risks or improve the welfare status of animals, this innovation can lead to welfare questions depending on one's concept of animal welfare.

Keywords: animal welfare, computer vision, ethics

Introduction

Have you ever tried to follow one chicken around in a flock of thousands? The movement, behaviour and interactions of livestock animals provide important indicators of animal welfare. Following the general trend in western countries towards improved livestock welfare in intensive systems, understanding and managing animal behaviour has become of high priority. Phenotypic measurements such as egg quality or feed conversion have been implemented at different levels in the livestock industry, measurements on behaviour mostly rely on observations by a researcher in a study on traditional small groups and (individual) cage housing. These measurements do not reflect the commercial practice. Taking the laying hen industry in the Netherlands as an example, public concern for animal welfare and ecological footprint have caused a shift from cage housing in small groups to flocks of tens of thousands in mostly aviary systems. This setup increases the risk of harmful behaviour such as severe feather pecking which is causing injuries and mortality on a large scale. Measurements on this behaviour could improve the prevention and reduction of harmful social behaviour via management solutions and changes in breeding. Management solutions have been studied based on group behaviour and individual measurements could help create effective management solutions. The implementation of social behaviour as a phenotype into breeding practices could significantly improve animal welfare of livestock on a global level. Breeding for improved animal welfare has therefore been described by Fernyhough *et al.* (2020) as the moral responsibility of the breeding companies. The current inability to include direct measurements of social behaviour into genetics programmes reduces the effectiveness of implementing breeding for improved animal welfare. Animal welfare is a multifactorial phenomenon and monitoring of it is not an easy task. It requires insight in a broad range of parameters, preferably in many occasions and over a longer period. This makes animal welfare monitoring not only time consuming, but raises also issues of feasibility if the aim is to monitor many hundreds or even thousands of animals. Technology can

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play an important role in this case. Currently used technologies such as RFID, ultra-wide band tracking and accelerometers do not provide information on social behaviour but have been used for monitoring animal health and welfare by enabling to collect data on activity and location on the individual level. This contributes to the automatic assessment of animal health, welfare, the spatial distribution and behaviour of animals (Ellen *et al.*, 2019). However, the collection of data on social interactions between animals in groups has not been feasible by these technologies. This is problematic, because individual welfare is also influenced by social behaviour and group interactions. Furthermore, animal welfare does not only raise questions at the level of the individual but also at group level. Therefore the introduction of Computer Vision seems promising, for it has the ability to measure social behaviour in groups of livestock by constructing meaningful descriptions of physical objects from images. For example the use of Computer Vision technology allows for measuring and acting upon tail biting in pig production and feather pecking and smothering in groups of laying hens.[18] Next to detecting such problems, the ability to aggregate and process large amounts of data also enables to prevent such problems with the help of early detection markers. Computer Vision has a huge potential but is still in development (Guo *et al.*, 2022). This includes a number of technical challenges next to more societal and ethical dimensions. In this paper we focus on these later aspect for three reasons. First, Computer Vision is not a stand-alone technology in livestock farming. It fits in developments of data driven farming, digital agriculture, smart farming and Precision Livestock Farming (PLF). At the same time Computer Vision adds functionalities to existing technologies of which the effect has not been studied before. Also, the requirements for Computer Vision include big data processing and therefore could strongly enhance the shift towards data driven farming. Therefore, it is important to reflect on the potential impact of Computer Vision as part of the increased use of technology in livestock farming for all involved stakeholders. Second, in line with the striving for responsible research and innovation, it is important to reflect on the societal and ethical dimensions of this innovation during the process of development rather than focusing on risks in terms of increasing acceptance (Klerkx *et al.*, 2019; Wathes *et al.*, 2008). The third reason for the focus on the societal and ethical dimensions of Computer Vision may sound paradoxical: lack of explicit public debate or broadly identified moral dilemmas. In comparison to, for example the use of modern biotechnology in breeding, digitalization and automation in livestock do not yet result in much public debate. This is not to be understood as a sign that there are no societal and ethical challenges, but that – as part of responsible research and innovation – this is an important moment to explore and analyse the potential societal and ethical issues. In the remaining of this paper we explore the animal welfare related moral dimensions of the use of Computer Vision in livestock farming.

Computer Vision in livestock and animal welfare

Developing Computer Vision applications in the livestock production sector can be understood as a result of recent public concern for livestock welfare in western societies. The ability to monitor individual as well as group behaviour with Computer Vision enables to better assess welfare and recognize (group) behaviour that indicates welfare risks or positive interactions amongst the animals. However, to assess whether this innovation is effective or desirable directly leads to well known discussions on the concepts of animal welfare. If one starts with Ohl and Van der Staay (2012) stressing the importance of positive welfare, the adaptive capacities of animals and the dynamic character of this concept, one would focus on different parameters in using Computer Vision than if one would take the Five Freedoms as a start. Such conceptual differences are not only rooted in biological views on welfare, but also link to ethical views on what makes animal welfare morally important. Therefore, to explore the animal welfare related moral dimensions of Computer Vision we do not have a 'one size fits all' approach and have to take the various views on welfare into consideration. For this paper we use the three views as defined by Fraser (2008): basic health and functioning; affective states; and natural living.

[18] These are also the case studies from the Imagen research project (NWO, 2020) that this paper is part of.

Basic health and functioning

The domain of basic health and functioning is what Computer Vision mainly aims to improve. The current level of injuries and mortality cause a major animal welfare issue. One target harmful behaviour is severe feather pecking behaviour, which is causing injuries and mortality in laying hen production systems. Feather pecking is the pecking, pulling out and eating of feathers of conspecifics. This behaviour is separate from aggressive pecking, which is linked to establishing hierarchy in small groups. The motivation of laying hens in large groups for severe feather pecking could best be described as redirected foraging behaviour and the problem has been found to be multifactorial. The behaviour spreads through the flock and can lead to cannibalism (Cronin and Glatz, 2021; Rodenburg *et al.*, 2013). Another type of behaviour which causes mortality and harm in laying hen production is the smothering or the suffocation of hens due to crowding and piling. Our understanding of this specific behaviour is limited and additional detailed research is needed (Gray *et al.*, 2020; Winter *et al.*, 2021). These harmful types of behaviour could be found in all housing systems and are more prominent in large groups of hens (Lay *et al.*, 2011). Current methods of measuring behaviour rely on individual data of location or on group level continuous monitoring. Computer Vision could provide a new method to directly measure these behaviours on the individual level. From this perspective, Computer Vision mainly enables to address welfare problems and does not raise serious concerns about wider ethical concepts such as animal integrity and the impact on the human animal relationship. The ethical discussion seems to be limited to the requirements of Computer Vision for using of markers on birds and the effects these wearables may have on bird behaviour and welfare.

Affective state

From the perspective that animal welfare is about subjective experiences, Computer Vision can be an interesting innovation. For instance, social interactions provide an indicator for positive welfare. All livestock species are social animals to some extent. The time individuals spend together and the interactions they have will provide insights into their emotional state. Therefore the use of Computer Vision for measuring social interactions will improve our understanding of individual affective states. In the example of laying hens, severe feather pecking behaviour has been found to be positively correlated with time spend foraging and negatively correlated to dust bathing behaviour (Newberry *et al.*, 2007). Dust bathing behaviour in laying hens is strongly related to a positive affective state and by measuring this behaviour through Computer Vision, positive welfare could be studied. By studying the relation between different types of behaviour through modelling of behaviour on the individual level, the affective state of animals and factors of influence could be determined in both directions.

From this perspective, Computer Vision can be promising since it enables to take affective states, both positive and negative in to account. The main concern would be that it will be used only in a rather limited way focusing on reducing morbidity and mortality, for instance to prevent production loss. This would not do justice to the wider dimensions of welfare.

Natural living

The natural living view stresses the ability of animals to 'live reasonably natural lives by carrying out natural behaviour and having natural elements in their environment'. (Fraser, 2008, p. 3). From this perspective, Computer Vision could have added value. The ability to measure the expression of natural behaviour allows for deeper understanding of these natural behaviours and effect of environmental stimuli. Computer Vision could for instance measure the range use of an animal to a (semi-)outdoor environment, which is a natural living demand incorporated into some labels for animal welfare. Adaptations to the livestock industry towards natural living could be offered to farmers by using a direct implementation on farm or by offering products based on measurements of natural living via research on animal management and breeding. However, in order to use Computer Vision, the technical requirements pose conditions which are not in line with the domain of natural living. Markers or tags on the animals need to be used in order to link measurements of behaviour to the correct individual. These wearables might interfere with the ability to perform natural behaviour, as for instance a backpack on a bird makes feather grooming more difficult. The type of environment suited for Computer Vision should reflect the environment to which the algorithm was developed. Placing cameras in a strongly controlled environment allows for a more straight forward implementation. Natural elements such as rain and large plants provide natural conditions but reduce the required visibility, making implementation more difficult. Also, the required internet connectivity for Computer Vision services during the developmental phase could more easily be found in urban areas, reducing the possibilities to outdoor access. Still one could argue that most of these concerns can be addressed in the course of the development of this technology. However, there are also some more principled points of concern that the technology takes current systems and infrastructure as the default. For instance, the target species also has to resemble the breed used in the training images, which excludes breeds with a different morphology. For instance a Computer Vision algorithm built for commercial broilers might not be applicable to dual-purpose hens of which more natural behaviour could be expected. Lastly, the investment costs of Computer Vision might cause a shift away from natural living. The system might only be affordable to large production units and leave out small family farms. The costs per animal will also be lower in an intensive system compared to a system in which more space is given to each animal, for less video frames need to be analysed. The technical requirements of Computer Vision thus negatively affect natural living.

Conclusions

In this paper, we aimed to map the implications of the current introduction of Computer Vision technology from the perspective of the three animal welfare dimensions: basic health and functioning, affective states and natural living. We conclude that this form of digital agriculture or Precision Livestock Farming has many applications. The greatest potential of the technology and our primary focus is in its ability to measure social interactions on the individual level in group housed livestock. Harmful social behaviour of livestock such as severe feather pecking in laying hens and tail biting in pigs have been one of the major negative influences on animal welfare in group housed livestock. The entire topic of measuring social behaviour in livestock using Computer Vision has, in spite of its potential impact, not resulted in much public debate. From the view on welfare as a dimension of basic health and functioning this lack of debate should not come as a surprise. The potential for Computer Vision to improve welfare is significant, and concerns seem to arise only regarding the technical requirement of animals wearing markers or sensors. This conclusion is already different from the perspective of the affective state view. This perspective will consider Computer Vision promising as it enables assessing these affective states. However, the risk lies in using the existing data in a shallow way and thus one should be cautious to use this potential not only to prevent mortality and production loss, but also to do justice to the broader dimension of welfare and enable positive affective states. Regarding the perspective of natural living, Computer Vision can provide insights into natural behaviours and the environmental conditions that enable these behaviours. However, one would expect much more debate, because the technology requires the use of wearables that might interfere with the animal's physical ability, is currently not developed to function in free-range systems and might take current breeds as the default in developing a Computer Vision algorithm.

This analysis shows that a mere reference to animal welfare in the ethical assessment of Computer Vision is not sufficient. The multi-layered character of this concept entails that we have to be as explicit as possible in explaining what we mean with welfare and why this is important in the context of Computer Vision. Otherwise a false clarity will frustrate the ethical evaluation. This need for clarity is especially important because the morally relevant dimensions of Computer Vision go beyond of the field of animal welfare. This technology for instance strongly pushes the market further towards data driven agriculture and may be particularly suitable in intensive environments and raise questions of justice and privacy for farmers. Furthermore, it has an impact on the human-animal relationship. These dimension need to be further addressed elsewhere, but also emphasize the need to be as precise as possible when one refers to the animal welfare dimensions of Computer Vision.

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