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Opinion Paper: Digital Animal Monitoring – What is on the Horizon?

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With the advancing digital transformation in society as a whole and in agriculture in particular the use of digital animal monitoring in livestock farming is steadily increasing. Since the introduction of the first automatic systems in the 1980s many monitoring approaches have been developed. However, adoption and diffusion of the systems vary, and uptake is often slow.
Of course, all new developments bear challenges, risks and opportunities. We herein summarise the expected prospects and developments as perceived by stakeholders by using discussions in focus groups to collect the information. Therefore, a stakeholder workshop on the topic of animal monitoring and digital transformation in livestock farming was held in November 2017 in Kassel, Germany, with 30 invited participants from a range of stakeholder groups. We identified four key messages: 1. Health and welfare of livestock can be improved by optimised process control using objective real-time data without replacing human judgement; 2. disruptive processes can result in new farming models and markets; 3. different personalities and highly qualified workers might enter the agricultural businesses, and 4. small farms could profit from digital transformation.
Our findings highlight the importance of providing possibilities and reducing barriers for agricultural development so that disruptive technologies and new people and ideas have a chance to grow sustainably. Policymakers need to develop suitable regulations for data security and protection to safeguard a fair workplace and market for the involved stakeholders.

Keywords
Digital transformation, livestock farming, opportunity, risk, challenge

The development of civilisation is closely intertwined with the development of agriculture. Without efficient agriculture, more people would need to work on farms and fewer could pursue other professions. The word agriculture, containing the word culture, indicates this symbiosis. As a more recent achievement of cultural development, rooted in mathematics and electronics, information technology has gained more and more importance in everyday life. The associated digital transformation is a powerful driver of the processes in industry, society and farming. This development entails opportunities, obstacles and fields of action alike (Bundesministerium für Ernährung und Landwirtschaft 2017). Looking at the recent history of automation in farming, Jungbluth (2011) pointed out that the foundation of sensor-based monitoring systems was laid with the introduction of the first commercially available electronic identification systems for dairy cows in the 1980s. During that period, the first automated heat detection systems for dairy cows were developed and the first reasonably priced home computer, Sinclair ZX80, was introduced.

Even in robot development agriculture did not lag behind. A prototype of a milking robot was first presented in 1989 by the company Düvelsdorf (Düvelsdorf Handelsgesellschaft mbH, Ottersberg-Bhf.,

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Germany) at the Agritechnica (a leading trade fair for agricultural technology). With the entrance of milking robots on the horizon, the advancement of automated mastitis detection was pushed because it was necessary for compliance with rules and regulations. Since then, many monitoring approaches and systems have been developed, but their adoption and diffusion vary and uptake is often slow.

The objective of this paper is to present the outcome of a stakeholder workshop held by the Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL e.V., Association for Technology and Constructions in Agriculture; hereinafter: KTBL e.V.) in November 2017. We aimed at gathering information about the opinions of different stakeholders on opportunities, risks and challenges of digital animal monitoring. Furthermore, key messages were extracted from the collected statements to collate information on how this development should be promoted to support the interests of farmers, industry, consumers and, last but not least, the animals.

Status quo of animal monitoring

Applications such as livestock monitoring systems or animal-related indicators have been implemented to varying degrees depending on animal species. Many systems are now already commercially available to measure aspects of animal behaviour, activity or other physiological parameters such as rumen pH or body temperature in cattle (Rutten et al. 2013). The detection of heat, the measurement of rumination or the automatic detection of calving are some examples that have been the subject of research but also have been put into practice very successfully (Chanvallon et al. 2014, Saint-Dizier and Chastant-Maillard 2015, Zehner et al. 2017). Besides some systems developed around electronic feeding stations for gestating sows, only a few technologies exist for monitoring pigs. The same is true for monitoring poultry. In many cases, these systems monitor groups and not individual animals (Van Hertem et al. 2017).

The systems developed for all three species have a common shortcoming: most of them are offered as isolated solutions that are not communicating or cooperating with other software, such as herd management systems. Here, the development is often slowed down because manufacturers prefer to market their products independently of competitors and thus delay the development of interfaces between systems. Cross-industry standards have not been successful so far (Kuhlmann et al. 2009). However, initial approaches, for example, the integration of production data, veterinary treatments, slaughterhouse data or milk control data, in pig and cattle farming are being tested, and some companies offer tools to exchange data between different systems (Pressler 2018).

Materials and methods

A stakeholder workshop (“KTBL Fachgespräch”) on the topic of animal monitoring and digital transformation in livestock farming was held in November 2017 in Kassel, Germany. Thirty invited participants from a range of interest groups attended the workshop. The selection of participants was done by an organising committee, which consisted of six scientists who are experts in the field of Precision Livestock Farming. The stakeholder groups involved comprised open-minded personalities and early adopter farmers (3), scientists (10), lawyers (1) and people working in the farming tech industry (12), tech industry (2) and advisory services (2). The selection of the potential participants was based on their experience and involvement in processes, research or business related to digital transformation.

During the workshop the participants were split into six focus groups. The discussions were organised following the method of a “World Café” (Brown and Isaacs 2005). As far as possible, each group contained an equal number of scientists, industry representatives and other interest groups. The topics 'opportunities', 'risks' and 'challenges' of digital animal monitoring were debated in three separate 30-minute sessions with one of the organising experts as a session chair who documented the outcome of the discussions. Each topic was discussed in two groups in parallel, i.e. within each session two groups discussed 'opportunities', two groups discussed 'risks' and two groups discussed 'challenges'. After each session the participants were allocated to new topics and new groups so that the topics were always discussed by newly assembled groups. Each participant discussed each topic only once and in random order.

After each session a ranking was done by the group members on the issues which had been worked out during the session. After finishing the discussions the two session chairs for each topic summarised the issues discussed in a short talk, which was followed by a final plenary discussion of the results.

For this article, the main topics discussed during the sessions were sorted into the categories 'technical aspects', 'biological aspects', 'legal aspects', 'work-related aspects', 'qualification', 'social aspects', and 'economic aspects'. Some rather detailed aspects were summarised under more general topics to focus on the main aspects of the discussions. Because many topics were discussed as 'opportunity', 'risk' and/or 'challenge' simultaneously, a corresponding categorisation of the topics was added to the results.

Results

Opportunities, challenges and risks of monitoring systems and digital approaches

Within the groups, we observed very different dynamics in the discussion. Between the groups, there was a high congruence in terms of topics discussed, ranging from technical to legal, from ethical to personal and organisational topics in all of the groups. The main discussed topics can be found in Table 1. Many of the topics can be seen as opportunities as well as challenges and risks.

Table 1: Overview of topics discussed within the focus groups

Topic	Opportunity	Challenge	Risk
Technical aspects			
Process security and process control	x		
Objective data and real-time information	x		
Correct interpretation of data		x	x
Accuracy and reliability		x	x
Usability, user-friendliness		x	
Robustness and durability		x	x
Technical reliability		x	x
Compatibility and interoperability		x	x
Broadband performance and coverage		x	
Traceability	x	x	x

Table continues on next page

Topic	Opportunity	Challenge	Risk
Biological aspects			
Animal health and welfare	x	x	x

Early detection of illness, less use of medications	x		
Human–animal relationship		x	x
Ethical issues of (invasive) technologies		x	x
Legal aspects			
Transparency and traceability	x	x	x
Improved governmental and administrative control	x	x	x
Data protection and security		x	x
Data usage and rights		x	x
Sustainability and recapturing of sensors		x	x
Work-related aspects			
Reduction of administrative burden	x		x
Occupational safety	x		x
Work load, availability 24/7	x	x	x
Dependency on technology		x	x
Qualification			
Focus change from manual labour to management	x	x	x
New requirements for staff		x	x
Training of farm staff	x	x	
Finding qualified personnel		x	
Provision of jobs for non-educated staff		x	
Loss of skills		x	x
Changing image of work-place	x		x
Social aspects			
Increased work-place quality	x		
Change of personality types attracted to farming	x		x
Decreasing number of farm workers		x	x
Acceptance by society	x	x	x
Economic aspects			
Development of new farming systems and markets	x	x	
Slowing down of structural change	x		
Data as an additional source of income	x	x	
Dependence on system providers		x	x
Cost-benefit ratio	x	x	x
Increased efficiency	x		

Technical aspects

On top of the list of technical aspects was the possibility of an increase in process security and process control. Linked to this top opportunity, the acquisition of objective data and real-time information was debated. The participants agreed that sensor-based data acquisition is a must for improving process control.

The reliability of systems also played a role in all group discussions, with two main aspects: On the one hand, the stakeholders saw the risk of technology failure associated with data security. On the other hand, they were concerned about the reliability and accuracy of information and assertions provided by monitoring systems. Users might draw wrong conclusions by data inaccuracy, error tolerance and missing context or just by lack of transparency and awareness of the strengths and weaknesses of various methods. The stakeholders also debated how user-friendly the systems are regarding not only data analysis and software but also durability, robustness and animal-friendliness of the hardware.

The participants pointed out that investments in monitoring systems were hampered by lack of compatibility and interoperability of systems and by missing standards. Furthermore, the missing interoperability of systems could hinder further development of holistic decision support models to a certain degree. The question arose if this issue will be dealt with on a political level to improve utilisation of different data streams.

Additional technical aspects discussed were the availability of broadband connections and traceability. Especially in very rural areas, broadband access still is a major issue on some farms because the operation of cloud services and remote maintenance completely rely on internet access. Here, policymakers are asked to promote progress.

Traceability not only relies on internet access but also is challenging because of other technical aspects such as continuous tracing of bulk goods. The participants agreed that digital technologies provide very detailed product data, and they pointed out the opportunities in terms of product security and quality associated with improved traceability. In this context, the risk of fraud was also discussed.

Biological aspects

As the main biological aspect, the stakeholders expected an increase in health and welfare of farm animals. This is a subsequent result of the improved process security and control through animal monitoring leading to early detection of diseases and a reduction in the use of medication as it has been described by many authors (Rutten et al. 2013). On the other hand, the use of automated monitoring systems could lead to less visual observations of the animals and, thus, to a less close human-animal relationship. This development could impair animal welfare. Furthermore, if sensors are invasive, ethical issues may arise not just regarding the animals but also for the recycling and re-capturing of sensors in slaughterhouses. This aspect is not only an ethical issue but also has to be considered a legal challenge of animal monitoring.

Legal aspects

The legal aspects discussed involved data protection, data security and utilisation or rights of utilisation as well as the setting of standards. This complex issue is probably the highest rated challenge for digital farming.

An opportunity mentioned several times was the increasing transparency and traceability, which can be considered as positive, along with the aspect of automating administrative tasks and documentation. This change may lead to the desired reduction in administrative burden. Although transparency was seen as an opportunity, it was also perceived as a threat and challenge. This perception was linked to the acceptance of farming practices by the general public and the notion of a negative image. This is a conflict, which has been described as 'the two faces of modernity' by Boogaard et al. (2011).

Closely related to these topics is the aspect of data protection and security. It relates to both legal and technical risks. These risks were discussed in all groups and must be countered by appropriate measures. An increasing documentation and disclosure obligations toward customers and authorities are associated with an increasing dependency on data and appropriate processing systems to gain market access. As a consequence, the farmer is forced into using such systems, which adds an additional risk factor to the farm business. Inherent weaknesses in data protection and security can also bear financial risks due to potential punitive reinforcement of data protection offenses. Heterogeneous regulations and new legal requirements were also mentioned as challenges for investment security.

Work-related aspects and qualification

Digital transformation can reduce the physical workload because the focus is changing from manual labour to management tasks. In consequence, the operation of technology requires new qualifications, some of which are not available to the farmers or their employees. This aspect, therefore, has to be considered both in the recruitment of farm personnel and for future training. From a personal and organisational point of view, training of farm staff is crucial for the success of utilisation. Finding qualified personnel is not easy, and maybe the requirements will increase with an increase in digital transformation. On the other hand, some skills, especially manual and animal-related ones, could be lost due to systems taking over the monitoring and care of the animals. This is a risk strongly related to ethical aspects and animal welfare.

Aspects of occupational safety were also mentioned. For example, the distraction of smartphone use increases the risk of accidents, so that some farms with relevant negative experience have already banned the use of these devices in certain areas.

A high degree of automation on farms may also have some repercussions because the dependency on technology will be increasing and the number of tasks and animals supervised by each individual worker might rise. This change might cause stress and could negatively affect the quality of life and mental health of farmers and farm personnel.

Social aspects

A very interesting point with regard to social aspects was the exchange of opinion to improve workplace quality. This point was seen as a burden as well as a bonus. However, this perceived duality means that the image of the workplace ‘farm’ is changing. Some people will be attracted by the new image, whereas others might be deterred because they prefer physical labour. This dynamic may lead to a change in personality types who will be attracted to the farming profession in the future. Additionally, an increasing automation might reduce the amount of farm labour and the number of jobs for non-educated personnel. This development will influence social structures.

A great social opportunity of digital animal monitoring could be an improved acceptance of animal husbandry by society due to increased animal welfare and transparency in production. Good communication is necessary to achieve societal acceptance of digital animal monitoring, and the participants agreed on a possible risk of misperception of this very ‘technical’ form of animal care.

Economic aspects

The participants deliberated that new technologies could be disruptive and may lead to new farming systems, which could increase animal welfare but also competitiveness in livestock farming. As with all new technologies, new utilisations could arise from their use and provide new sources of income for farmers. Particularly noteworthy is the aspect of slowing down the structural change in farming. Although many people still assume that farms will continue to grow and therefore stimulate automation, digital transformation also offers a chance for maintaining smaller farms by providing new markets and increased efficiency.

The last point to mention here is the increase in competitiveness and efficiency, which can be a consequence of the already mentioned opportunities but can also be linked to new markets opening up. It is already noticeable that global players are interested in agriculture. This interest could result in strong new impulses from outside in the coming years, but of course also in great dependence on these system providers. Examples of global players include IBM, Microsoft and Airbus. The reason for their involvement is the accumulation of large amounts of data, which are of great importance in the course of world food supply. The workshop participants mentioned the development of large networking portals, the use of high-performance computing for processing of big datasets and new methods for data processing as key competences of these new players. For example, the use of non-relational databases or methods of machine learning offers potential to enhance the use of large amounts of highly variable data on animal behaviour. Farmers, as producers of these data, could well benefit from this new market. The real added value is created through the connection of datasets and analysis, which generates the actual knowledge. Other markets that are associated with the production of high-quality products or offer landscape conservation are also conceivable.

The costs of sensor technologies and of additional services will be crucial for the uptake and success of adoption and diffusion of digital monitoring systems in the farming sector. The cost-benefit ratio must be in a range that is economically viable and delivers added-value either economically or socially.

Discussion and Conclusion

The stakeholders participating in the workshop generally expressed a positive outlook on the utilisation of new technologies in agriculture. However, the herein identified challenges and risks need to be addressed. Some of the challenges affect not just the farming community but society as a whole. Policymakers are asked to find solutions for data protection and security and to promote as possible organisational and educational changes in the training education systems for farmers.

The development of digital monitoring systems must be tailored to the needs of the farmers. However, the systems also need to be animal-friendly for ethical reasons and for the acceptance of farming practices by society. In addition, some farmers seek help by using technology as a tool to overcome management issues. It must be clearly communicated to these farmers that good farming practice is the basis for the use of new technologies, that human judgement cannot be replaced and that the ultimate ethical authority needs to remain in the hands of qualified stock personnel.

Looking at the required changes in skills and capabilities induced by new technology, it can be envisaged that the future farming industry will attract different types of people who are highly qualified. In the poultry industry, first data analysts have been recruited to monitor poultry barns across the world (e.g. www.optifarm.co.uk).

With larger quantities of data being generated in the future, the value of this 'farming by-product' needs to be investigated. Farmers, as producers of these data, could well benefit from this new market. However, data, as a quasi-synonym for information, are simply raw material. The real added value is created through knowledge generated by analysing data and possibly by connecting datasets. This necessity has an important effect on data value.

Many people assume that the access to the latest technologies may remain restricted to big and industrialised farms (Walter et al. 2017) and could further lead to continued growth and concentration driven by mechanisation and automation. However, digital transformation could well be a way to slow down structural change in farming, offering a chance for smaller farms to remain viable (Finger et al. 2019). A reliable animal monitoring system could for example support part-time farmers. Furthermore, compact, fully automated units might prove to be economically advantageous. Furthermore, disruptive processes can result in new farming models and markets. As much as mobile phone technology has revolutionised our daily lives, as much can new technologies open up new opportunities and markets.

It has to be noted that this study can only give an overview of how stakeholders see the opportunities, risks and challenges of digital animal monitoring technologies today. In conclusion, it will be important to observe how new developments and innovations (e. g. micro/nano sensors for monitoring physiological parameters in animals), further emerging players (especially in global and developing markets such as China) or the propagation of the 'Internet of Things' will change the perception of digital transformation in livestock farming. We expect that additional new opportunities, risks and challenges will always arise in the future.

Our findings highlight the importance of providing possibilities and reducing barriers for agricultural development. New disruptive technologies must have a chance to be implemented and find a route to market. Policymakers need to provide regulations regarding data security and protection to ensure a fair workplace and market for all involved stakeholders.

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