Posture analysis

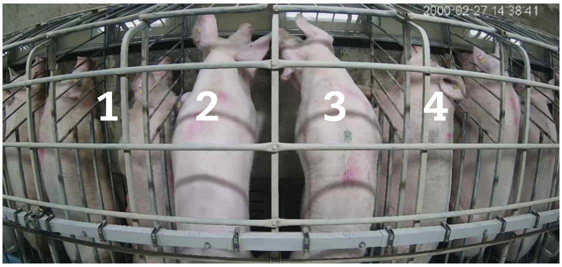

Figure 6. Sample image used for testing the algorithm

Figure 6 presents an example of an image that was used for testing the algorithm. This image was never used for training the model. The posture of the four sows shown in Figure 6 were correctly classified by the model (sows 1 and 4 as lying, sows 2 and 3 as standing).

Table 2. Confusion matrix for the pig posture classification algorithm

	Lying	Standing	Sitting	Kneeling
Lying predicted	9,969	324	64	72
Standing predicted	112	2,383	16	89
Sitting predicted	35	27	75	10
Kneeling predicted	7	3	1	0

The algorithm was tested using images in which four sows in individual stalls were targets for the analysis of posture. Table 2 is the confusion matrix obtained from the predictions of our algorithm. From this matrix, we can see that the algorithm correctly identified the posture of 12,427 sows and was wrong for 760 sows on a total of 13,187 sows. Table 3 shows the sensitivity, specificity, and precision for the four postures.

Table 3. Sensitivity, specificity and precision for the four postures

	Lying	Standing	Sitting	Kneeling
Sensitivity	98.5%	87.1%	48.1%	0.0%
Specificity	85.0%	97.9%	99.4%	99.9%
Precision	95.6%	91.7%	51.0%	0.0%

From Table 3, we can see that our algorithm performs well at the task of differentiating between standing and lying sows. We see that the natural imbalance of the data gives to the algorithm a natural tendency to classify more sows as lying. Future work will address this imbalance of the data to improve sensitivity for the standing posture and specificity for the lying posture. Our algorithm clearly lacks sensitivity and precision for identifying sitting and kneeling sows. In fact, these postures are very rare with 1.2% and 1.3% of occurrence for sitting and kneeling, respectively. Therefore, it is very hard to balance the training dataset for a good identification of these postures. Future work will include training the algorithm with more occurrences of these postures.

Our results suggest that our algorithm can identify very well the standing and lying postures of sows in images and that this can be used as a metric for behaviour analysis. Future work will aim at evaluating the precision of posture analysis for pigs housed in groups. Posture is an important behaviour metric that has the potential to be used in multiple ways such as predicting the onset of farrowing (Cornou *et al.*, 2011), detecting lameness, predicting piglet crushing (Mainau *et al.*, 2009), or detecting the onset of estrus. Posture – as detected from the developed algorithm – is currently used in Ro-Main's smaRt Breeding system as one of the variables used to predict the best timing for insemination based on behaviour. The resulting precision breeding system analyses time series composed by the posture of individual sows housed in stalls to predict an optimal timing for insemination.

Conclusions

Our real-time individual pig tracking and behavioural metrics collection system can generate valuable group or individual behaviour metrics that can, in turn, be used to automate tasks, raise alerts, or help pig producers make better and faster decisions. It can also help the research community to better understand pig behaviour and equipment companies to better evaluate their products with respect to animal behaviour. Moreover, it can be used by veterinarians as a diagnosis tool or by engineers as a ventilation calibration tool.

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Developing sensor technologies to inform breeding approaches to reduce damaging behaviour in laying hens and pigs: The GroupHouseNet approach

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Abstract

The European COST Action GroupHouseNet aims to provide synergy for preventing damaging behaviour in group-housed pigs and laying hens. One area of focus of this network is how genetic and genomic tools can be used to breed animals that are less likely to develop damaging behaviour directed at their pen-mates. Reducing damaging behaviour in large groups is a challenge, because it is difficult to identify and monitor individual animals. With the current developments in sensor technologies and animal breeding, there is the possibility to identify individual animals, monitor individual behaviour, and link this information to the genotype. Using a combination of sensor technologies and genomics enables us to select against damaging behaviour in pigs and laying hens.

Keywords: damaging behaviour, genetic selection, automatic tracking

Introduction

The European COST Action GroupHouseNet (www.grouphousenet.eu) aims to provide synergy for preventing damaging behaviour in group-housed pigs and laying hens. One area of focus of this network is how genetic and genomic tools can be used to breed animals that are less likely to develop damaging behaviour directed at pen-mates. The behaviours we are focussing on are feather pecking in laying hens (Rodenburg *et al.*, 2013) and tail biting in pigs (Valros *et al.*, 2015). As both animal species are kept in groups, identifying actual performers of this behaviour (peckers and biters) at the individual level remains challenging. At the same time individual tracking is pivotal for breeding approaches. Using traditional behavioural observations is possible, but time consuming and costly. Here, we propose that a combination of sensor technologies and genomic methods should be used as a more feasible strategy to select against damaging behaviour in laying hens and pigs (Rodenburg *et al.*, 2017a). We compare different sensor technologies that can be used to identify individual animals for breeding, discuss the identification of indicator traits using data from sensor technologies, and discuss applications to animal breeding.

Sensor technology

With the current developments in sensor technologies, breeding for laying hens and pigs that show less damaging behaviour by selecting animals using sensor data might offer solutions to these welfare challenges. We propose using a combination of sensor technology and genomic methods to solve this issue (Figure 1).

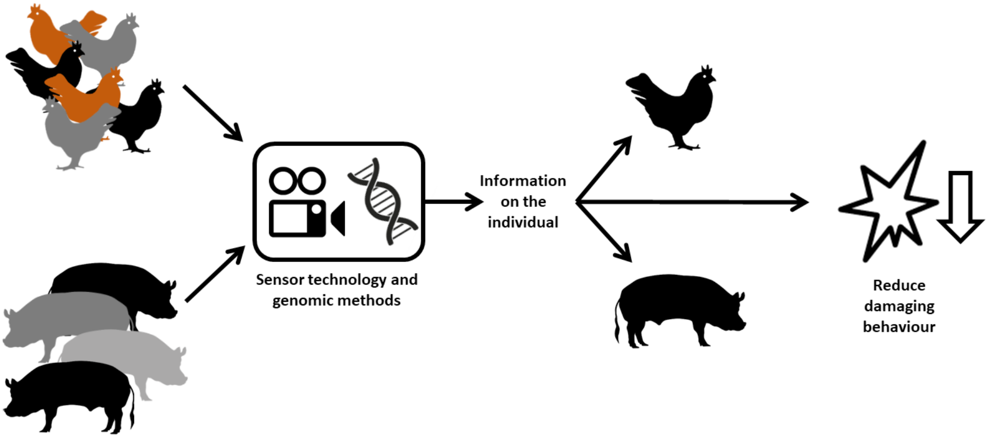

Figure 1. Overview of the approach to derive individual sensor and genomic data from group-housed pigs and laying hens and then combine this information to develop a genomic profile of individuals with the desired behavioural phenotype

We compare different sensor technologies (like ultra-wideband, RFID, computer vision) that can be used for detection of damaging behaviour or related behavioural traits (proxy measures). In laying hens, using video tracking and computer vision is challenging, given the small size of the animals and the large similarity between animals. When evaluating the sensor technologies used to this point, for laying hens RFID (Richards *et al.*, 2011) and accelerometer-based (Quwaider *et al.*, 2010) approaches seem most promising. Using UWB tracking, a specific type of RFID tracking using active tags on the animals, it was possible to distinguish feather peckers from non-feather peckers based on activity levels (Rodenburg *et al.*, 2017b). In pigs, computer vision is already used to record technical performance and there seems to be potential for expanding this approach to the recording of damaging behaviour (D'Eath *et al.*, 2018; Mittek *et al.*, 2018). Using computer vision, one of the main challenges is to link the correct identity to each individual and to maintain this link between identity and video image throughout the tracking period. Here, a combination between video tracking and passive RFID systems seems promising, as the RFID system can be used to re-assign the correct identity to individual animals. If sensor signatures and genomic fingerprints of individual animals can be combined, this would greatly improve our possibilities to reduce damaging behaviour through genetic selection.

Linking sensor information to genetic information

We are now at a point where both sensor technology and genomics approaches have the potential to provide a large amount of data at the level of the individual animal, which can be used to understand and selectively breed against damaging behaviours, such as feather pecking (FP) in laying hens. For example, the high and low FP lines (Kjaer, 2017), selected on whether they show high or low FP behaviour, have been characterised in genomic and transcriptomic studies. These studies have added to our knowledge of the mechanisms underlying FP behaviour and can also be used to record genomic profiles of individual birds. Similarly, using sensor technology, we can now record detailed information on hens from the lines, creating an individual behavioural profile, describing a hen's activity, location and proximity to other individuals (Rodenburg *et al.*, 2017b; Rufener *et al.*, 2018). If we use both sensor and genomic technological approaches in a breeding population, we can link the genomic data to the behavioural data, and define the genomic profile of individuals that show the desired behaviour (for example, low or no damaging behaviour). As a prerequisite, however, we need to determine genetic parameters for each indicator trait derived from sensor data, especially the genetic correlations between indicator and target trait. Once thought impossible, this approach may now be feasible, because breeding companies have begun to genotype their breeding stock routinely and they are also investing in methods for automatic phenotyping. Once the desired genomic profile has been defined, we can test whether selecting for this profile will reduce damaging behaviour by breeding a next generation based on genomic selection and then phenotyping this generation with the same tools that were used to phenotype the parent stock. We feel that a combined sensor and genomics approach has great promise to select against complex behavioural traits that involve multiple individual animals in a group, such as damaging behaviour in pigs and laying hens.

Conclusions

Reducing damaging behaviour is an important goal for commercial poultry and pig production. The current developments in animal breeding and Precision Livestock Farming offer solutions to reduce damaging behaviour. We argue that a combined sensor and genomics approach has great promise to select against complex behavioural traits, especially when combining sensors like computer vision and RFID tracking.

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