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Implementation of a sow stance information system (SowSIS) in electronic sow feeders

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Abstract

Lameness in sows not only poses a health and welfare concern, but also leads to considerable economic losses for the farmer. The disease condition increases labour and treatment costs and leads to premature culling and euthanasia of sows. Since the obligation to house sows in groups in the European Union in 2013, an increase in lameness prevalence is seen. It is therefore essential that lameness is detected accurately and at an early stage. Visual detection of lameness is a subjective technique, usually only detecting severe lameness cases. Visual detection of lameness becomes even more difficult due to the group-housing of sows and the increase in farm size. Recently, at ILVO SowSIS (Sow Stance Information System) was designed and validated for objective lameness detection in sows. SowSIS performs automatic force measurements and additionally generates visual stance variables using a transportable device with four load cells (one for each leg of the sow) and a camera arm. A sow is guided into the device and the force exerted by each of the four legs is measured. Using the camera, a lateral digital image can be taken of the hind legs. An adapted version of the SowSIS system has now been implemented in four electronic sow feeders (ESF), using only the force stance variables. The aim is to validate this adapted system for individual online and repeated measurements of group-housed sows, without interfering with their daily routine. A trigger is used to start the measurements automatically while a sow is feeding. The sow is automatically identified at the trough. Due to the asymmetric design of the ESF (feed trough in the left or right front corner of the ESF), a correction for the uneven balance of the sow is necessary. Measurements are performed in four pens on ILVO's experimental farm. Sows will be followed-up throughout time to validate the adapted system and its ability to detect changes in the force stance variables related to lameness development. When the system has been validated, the automatically gathered data can be used to signal the farmer when a lameness case is arising. The SowSIS implementation in ESF thus aims at early detection of lameness cases and possible prevention of economic losses.

Keywords: Sow, lameness, SowSIS, electronic sow feeders

1. Introduction

Lameness in sows poses a health and welfare concern (Heinonen et al., 2013). Lame sows are often in pain and have a reduced motivation to eat, drink and walk. They have trouble competing with others for resources and can suffer from social pressure in group-housing (Cornou et al., 2008). This, together with their long resting times, can in turn be a factor in the development of other disease conditions.

Lameness also concerns the farmer. Prevalence of lameness in group-housed sows can be high: on average 10 % prevalence has been reported (Pluym et al., 2011). Lameness increases labor and treatment costs, but can also lead to production losses due to early culling or euthanasia of sows and possible effects on (re)productive results. Lameness was found to be the second most important reason for culling, and sows culled for lameness were younger than sows culled for other reasons (Pluym et al., 2013c).

With the obligation to house gestating sows in groups in the European Union since 2013, an increasing importance of lameness prevention and detection is expected (Pluym et al., 2013a). In group-housing, prevalence increases and the detection becomes more difficult – the latter especially in large groups of sows. Detection of lameness is currently performed by visual observations of the sows. Visual observations are time-consuming and prone to errors however.

Recently, an automatic, transportable device for lameness detection was developed: SowSIS (Sow Stance Information System) (Pluym et al., 2013b). The device consists of an aluminium box that can be dismounted into several pieces for easy transportation to farms. A sow can be lead into the device and using load cells, the force exerted by each leg can be measured (force stance variables). Weight shifts and kicks were found to be promising indicators for lameness detection. With the device visual stance variables can be derived using a camera arm and image processing.

This paper describes the implementation and first result of an adapted version of SowSIS in electronic sow feeders. The aim is continuous monitoring of (group-housed) sows on-farm. This could then provide the basis of a tool for early detection of lameness cases, thereby preventing economic losses.

2. Materials and methods

2.1 Animals and housing

The experiments were performed at ILVO's experimental farm (Institute for Agricultural and Fisheries Research (ILVO), Melle, Belgium). Gestating sows (hybrid, Ra-Se genetics) were housed in four groups of 19 sows each. The barn was automatically ventilated and pens had partially slatted floor and a concrete lying area. Each pen was equipped with an electronic sow feeder (ESF, Nedap, Groenlo, the Netherlands).

Sows were allowed to enter the ESF freely, but were supplied with a limited ration of dry food per day. Each sow was equipped with a Radio Frequency Identification (RFID) transponder and was identified near the feed trough. Water was available *ad libitum* at two drinker devices per pen.

2.2 SowSIS hardware

The original, transportable SowSIS is described in Pluym et al (2013b). The version for implementation in the electronic sow feeders is shown in Figure 1. Four single point load cells (AP 635, SCAIME, Juvigny, France) were installed in an aluminium frame and covered with an aluminium plate each. Size of the plates was 63.5 by 23 cm for the hind legs and 63.5 by 23 cm with a corner of 37 by 21 cm removed for the front legs. A ridge in the middle prevented the sow from lying down. A gradual slope was used for the sow to mount the device and a staircase was used for the sow to dismount the device before exiting the ESF. In the ESF, the sow had to eat either on the left or on the right side at an angle of 45° (as in Figure 1).

The load cells were connected to the power grid for voltage input and to a NI USB 6211 data-acquisition card (National Instruments, Austin, Texas, USA) for sensor output. The NI USB 6211 card was in turn connected to a desktop PC using a 35 m USB 2.0 Active Extension Cable (StarTech.com Limited, Northampton, United Kingdom).

2.3 SowSIS software

Data-acquisition software was written in LabView (National Instruments, Austin, Texas, USA). Start and stop of measurements were determined by the automatic locking of the entrance gate of the ESF. This gate was locked until 30 s after entrance if the sow did not receive feed (because she consumed her daily portion already in a previous visit) or until 3 min 20 s after delivery of the last feed.

During the measurements, data from the four load cells was acquired at 10,000 Hz and averaged to 10 Hz. Using calibration parameters specific to each load cell the voltage output of the sensor was transformed to weight exerted on the force plate. The plates were calibrated with weights of 0, 5, 10, 20, 40, 60 and 75 kg. The recorded force exerted on each plate could be visualized in a Graphical User Interface and was logged at 10 Hz to a data file. The maximum duration of measurements was set to 1800 s.

Identification of the sow within the feed trough of the ESF can be logged and linked to the corresponding measurement of the SowSIS. This data was not yet logged at the time of the measurements.

2.1 Data processing

For data-processing, several steps were undertaken, using MATLAB R2010b (The MathWorks, Inc., Natick, Massachusetts, USA). First, all the measurements that lasted longer than 5 minutes were filtered out for further data-processing. For those measurements, the measurement points for which the sum of the weights exerted on the four load cells was smaller than 50 kg were removed. The measurements start as soon as the entrance gate locks, but the first few seconds the sow still has to mount the device, so this data must be removed. Then, also the measurement points for which the sum of the weights deviated more than 20 kg away from the mean sum were removed as these were likely erroneous measurements. To remove the data points where the sow was not standing on all four force plates, all measurement points were removed where there was one load cell that gave a measurement of less than 10 kg for longer than 10 s. Only the measurements that had a total duration of 5 min or longer (after the previously mentioned filtering steps) were used for the analysis.

For each remaining measurement, force stance variables were derived as in Pluym et al (2013b). The mean absolute and relative weight exerted on each force plate was calculated. Also the mean relative weight on left, right, front or back side was calculated. Number and mean duration of kicks was calculated for each leg, scaled to a 5 min measurement. A kick was defined as lifting a leg so that the absolute weight falls below 10 kg. Number, mean duration and mean magnitude of weight shifts between each combination of two legs was also considered, scaled to a 5 min measurement. A weight shift was considered when the shift of absolute weight for each of both legs differed more than 10 kg from the mean weight of the leg during the whole measurement. For the total of all measurements, the mean and the coefficient of variation (standard deviation divided by the mean, expressed in percentage) of each variable were calculated (Pluym et al., 2013b).

3. Results

Seven days of measurements in one pen (with one ESF, with the feed trough at the right side of the sow, and one SowSIS) were considered. Of the 1285 times that the entrance gate locked, 145 measurements were longer than 5 min (four days with 20 measurements, two days with 21 and one day with 23 measurements). After removal of the points where the sum of weights was lower than 50 kg or further than 20 kg from the mean, 139 measurements were longer than 5 min (so 96 % remaining). After removal of measurement points where one leg was below 10 kg for more than 10 s, only 111 measurements remained (so 77 %), leaving two days with 14 measurements, two days with 16 measurements and three days with 17 measurements. After the filtering steps, average duration of the measurements was reduced from 20.6 min to 15.6 min.

An example of a measurement is shown in Figure 2. At the start of this measurement some data had to be removed due to the sum of weights being lower than 50 kg or further than 20 kg from the mean (sow was still mounting the device).

Another example is shown in Figure 3. As mentioned earlier, the feed trough in the ESF was located at the right side of the sow. The sow sometimes moved her right hind leg to the left hind load cell for a couple of minutes during measurement. As it is not possible to distinguish between the hind legs in this case, these data-points were removed. Also a couple of times the sum of the weights differed more than 20 kg from the mean. Thus, either the sow was not with all four legs or her entire weight on the load cells or these were measurement errors.

For each remaining measurement after the filtering steps, force stance variables are derived and averaged across the measurements for analysis. Mean relative weight on the right front leg (closest to the trough) is a bit higher than on the left front leg and the left hind load cell also recorded a bit higher loads than the right hind one. There is, as expected, a slightly uneven balance (3 - 4 percentage points) of the sow due to the position of the trough in the ESF. Relative weights on left, right, front and back side remain approximately equal to those in Pluym et al. (2013b), however. Number and duration of kicks also remain in the same order of magnitude. Duration of weight shifts is slightly shorter and the number of weight shifts in the diagonal direction was also less during these measurements. Magnitude of the weights shifts was about the same as in Pluym et al. (2013b). The absolute and relative weights have a moderate coefficient of variation (≤ 20 %), while the variables related to kicks and weight shifts show a high coefficient of variation (> 20 %) (except the magnitude of weight shifts, these have a coefficient of variation around 20-30 %).

4. Discussion

Implementation of SowSIS in electronic sow feeders could allow logging daily measurements of force stance variables of sows in group-housing. Some preliminary results were shown in this paper. The ESF used had a trough at the right side, so the sow was with her head at an angle of 45° during feeding and during the measurements. Some problems were anticipated with this design. First, the sow would have an uneven balance with more weight on the front leg closest to the feeder trough. This was confirmed with the results presented here, although the difference was minimal. The right front leg carried on average 4 % more weight (% of the total sum of weights) than the left front leg for an ESF with the trough at the right side of the sow. This uneven balance might also depend on the sow or the measurement (see Figure 2 and 3 for example). Second, if the sow prefers a straight feeding position, it is possible that she would prefer to put both hind legs on the same force plate to obtain this position. Indeed, it was seen that sometimes no force was exerted on the right hind load cell, but instead the left hind load cell measured a higher force (see Figure 3 for example). Probably the sow was standing with both hind legs on the left hind load cell in that case.

After the appropriate filtering steps, 77 % of the measurements remained. It remains to be investigated whether the dataset consists of frequent measurements of each sow, or whether some sows can be linked to frequent measurement errors. A visual check of the actual position of the sows during the measurements could provide extra information to validate the performed filtering steps.

The variables related to the absolute and relative weight and the kicks and weight shifts are on average similar to those of the original SowSIS reported in Pluym et al. (2013b). The coefficient of variation was larger for most variables. In Pluym et al. (2013b) there was a distinction between within and between-sow coefficient of variation however. Sow identification is foreseen to enable calculation of the within and between-sow coefficient of variation separately. Further work will focus on incorporating the sows' ID in the measurements and doing a visual check of the sows' positions. Frequent (daily) measurements of sows will be available then, so we can investigate whether lameness detection (in an early stage) is possible with the SowSIS implemented in the ESF.

5. Conclusions

An adapted version of SowSIS, using only the force stance variables, was implemented in electronic sow feeders. Using four load cells, the force exerted by each of the four legs of the sow could be measured. Due to the feed trough being at one side of the sow, an uneven balance of the sows is seen. Sows can also prefer to stand with both hind legs on one load cell to obtain a more straight feeding position. These measurements can be removed by appropriate filtering steps. After these steps, 77 % of the original measurements remain longer than 5 minutes. Measurements with the SowSIS will continue and identification of the sow will be incorporated. The daily measurements of the sows will then be used to evaluate the system for the application of (early) lameness detection.

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Figure 1: SowSIS installed in an electronic sow feeder.

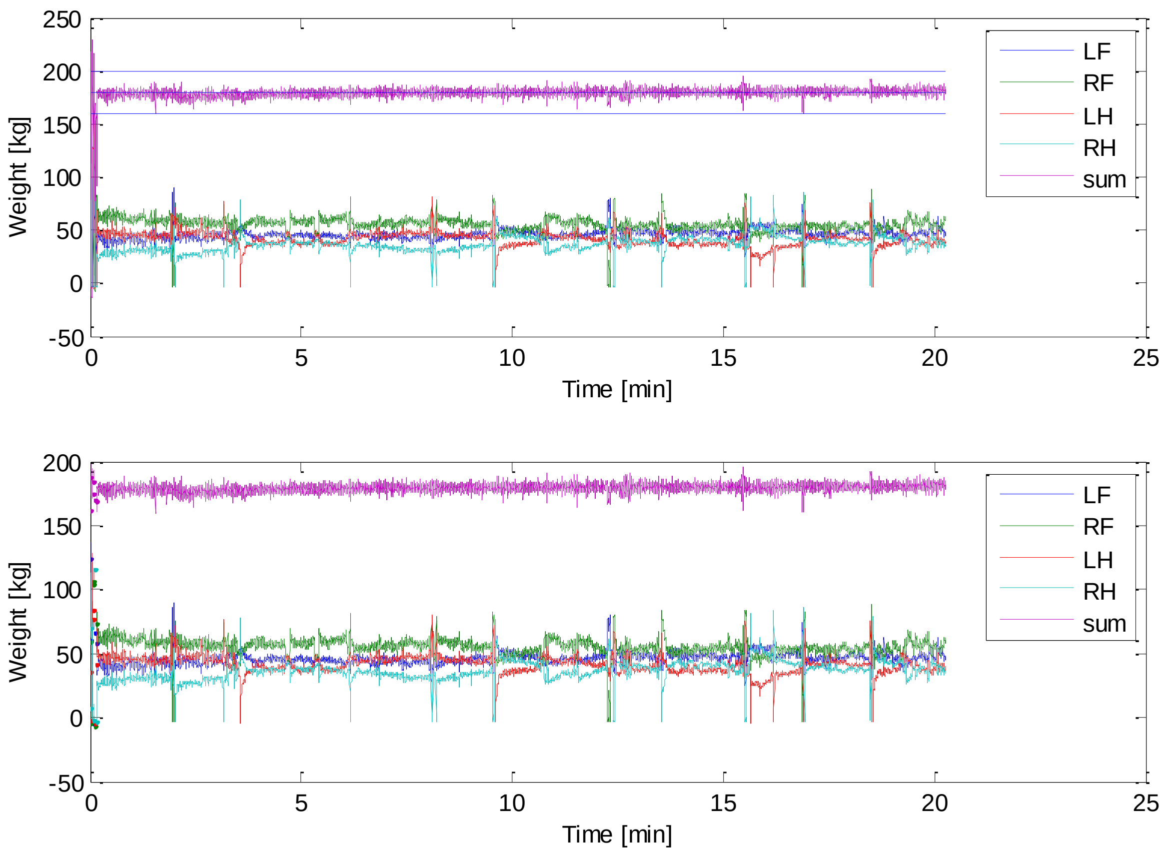
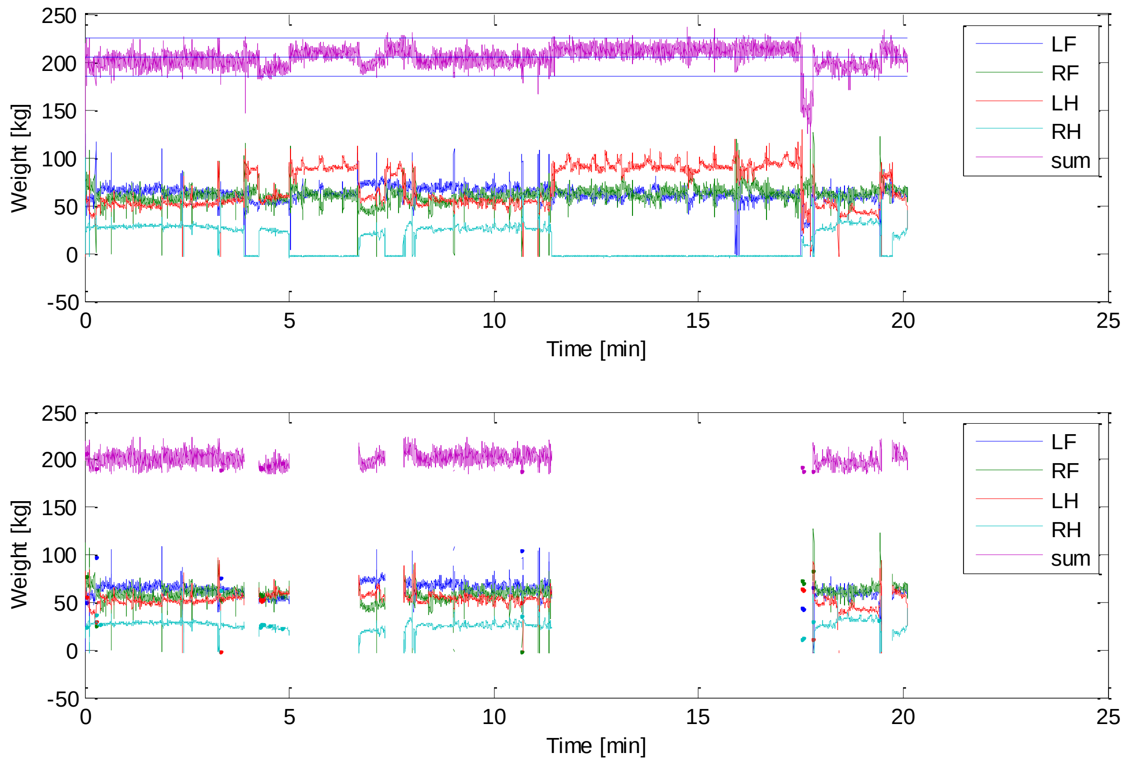


Figure 2: Overview of a measurement of one sow, top: original data, bottom: filtered data.



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