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Registering feeding pigs in group-housing

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Abstract

A High Frequency Radio Frequency Identification (HF RFID) system was designed for registering feeding pigs. The system consists of transponders, antenna(s) and reader(s). The RFID antennas were installed on commercially available round feeders for growing-finishing pigs. Eight of these feeders were placed in four pens with partially slatted floors. In each pen 59 growing-finishing pigs were housed with an RFID transponder in their ear. In one pen, RFID ear tag transponders were inserted in both ears of the pigs. When a pig's transponder comes close to the RFID antenna and thus to the feeder, the transponder's unique identification code is registered. The RFID reader ensured data communication between the RFID system and the PC and decoding of the transponder messages. It was determined whether the system was able to discriminate between pigs that were feeding and pigs that were not feeding. This was done both online (using feeding pigs) and offline (using stationary transponders). For the online validation 20 pigs (from the pen with 2 transponders per pig) were marked and observed during 11.5 hours. The percentage of RFID registrations within observed feeding visits was 77.11 % and 92.23 % of the RFID registrations occurred within 10 s from a feeding visit. The percentage of feeding visits containing RFID registrations was 89.17 %. To investigate the possible causes for the missed feeding visits an offline validation was performed where stationary transponders were placed in several orientations and on several heights under the antenna. The range of the RFID system was measured. The range of the system covered the feed trough well. However, the orientation of the transponders relative to the antenna had an influence on the registrations and for some orientations, the registration range was small. From this observation, it was inferred that the movement of the pigs' ears during feeding can bring the transponders out of the registration range, thus creating irregular gaps between registrations. However, this problem can be solved by proper data-analysis where the RFID registrations are clustered into feeding visits and meals to determine the feeding patterns of the pigs. By clustering the registrations using a time window of 9 s, the sensitivity and specificity of the system were 88.58 % and 98.34 %, respectively. Changes in feeding patterns can then be used to signal problems with the pigs' health, welfare and productivity in an online way.

Keywords: radio frequency identification, pigs, feeding, validation, range measurement

1. Introduction

The feeding pattern of growing-finishing pigs is an important health, welfare and productivity indicator. Feeding is not only highly related to growth, an ill or lame pig will also lack feeding motivation (Weary et al., 2009). A pig under welfare constraints will not be able to maximize its growth potential. A low ranked pig in a pen with limited feeding places will not be able to feed at a desirable frequency or duration (Nielsen, 1999). Despite the importance of the feeding pattern for the pigs and the farmer, not many systems exist that can measure this for group-housed pigs.

Some electronic feeding stations are commercially available for growing-finishing pigs (Bruininx et al., 2001; Faltys et al., 2014). These are single-spaced feeders with head and neck protection (or full body protection) that provide a record of the timing of feeding and the feed disappearance. A Low Frequency (LF) Radio Frequency Identification (RFID) antenna is incorporated in the feeder to allow identification of the feeding pig based on its RFID ear tag. These systems are mainly used for research and by genetic companies for breeding decisions.

For feeders used on-farm, two systems have recently been developed and validated. The first incorporates LF RFID antennas in a rectangular multi-space feeder (Brown-Brandl and Eigenberg, 2011). The disadvantage of using LF RFID is that the data transfer rate is low and anti-collision algorithms have not yet been elaborated. This means that no simultaneous readings of multiple transponders are possible and more than one transponder in range of the antenna thus leads to data collisions and missed readings. For multi-space feeders this would mean that one LF RFID antenna would be needed per feeding place and that interference of the antennas should be avoided. For animal identification, LF RFID has been the standard for many years (ISO 11784/5). However, applications where multiple transponders can be in range of the antenna (or multiple pigs can be feeding from the same feeder without distinct feeding places) ask for a different type of RFID system. The second system developed for commercial pig feeders, which is the system presented here, is therefore a High Frequency (HF) RFID system with anti-collision algorithms (Reiners et al., 2009; Maselyne et al., 2014a; Maselyne et al., 2014b).

Prior to the development of an early warning system based on the RFID system its accuracy in registering feeding patterns should be properly validated. The reading range should be sufficiently accurate to discriminate feeding pigs from non-feeding pigs under variable conditions. Therefore, the goals of this research were to 1) validate the system online using feeding pigs and 2) offline using several transponders, in order to find an explanation for the results of the online validation.

2. Materials and methods

2.1 RFID system

An RFID system consists essentially of a transponder attached to the object to be identified and a fixed antenna and reader. The transponder contains a world-wide unique ID code, which can be picked up by the antenna and decoded by the reader. The reader can then be connected to a PC for continuous data-acquisition. The HF RFID system (ISO 15693, 13.56 MHz, custom-made by DTE Automation GmbH, Enger, Germany) that was developed for a commercial round multi-space feeder (Swing MIDI, Big Dutchman Pig Equipment GmbH, Vechta, Germany) is shown in Figure 1.

Eight feeders were equipped with the system. The 8 antennas were connected 4-by-4 to a multiplexer and a reader, so that each antenna was addressed sequentially with a cycle time of 2 ± 1 s (mean ± standard deviation (SD)). Communication between reader and PC was through an RS232/USB convertor. Specialized software was installed on the PC for data-acquisition.

The transponders (IN Tag 300 I-Code SLI tags, HID Global Corporation, California, USA) carry no batteries, meaning that it is a passive RFID system. Passive HF RFID is based on the principle of inductive coupling, both the transponder and the antenna have an antenna coil that is tuned to the right frequency. When the coupling between transponder and antenna is strong enough, the transponder can be powered up by the electromagnetic field of the antenna and send its unique ID code back to the antenna. This is done by amplitude or frequency shift keying. The coupling between transponder and antenna depends on the relative positions and orientations of both. Also other influences can be present such as metal, water or other transponders in the neighborhood of the antenna.

2.2 Online validation

As there can be multiple influences on the performance of the RFID system, a thorough validation is necessary. This was done using video observations on feeding pigs (Hybrid sow x Piétrain boar) at one feeder during 11.5 hours (between 7:00 and 18:30). Twenty focal pigs in a pen of 59 were selected and marked. The pen was with partially slatted floor (40 % slatted concrete, 60 % solid concrete), automatic ventilation and feed supply, 4 nipple drinkers and 2 feeders equipped with the HF RFID system. Supplied pellets were *ad libitum.* Age of the focal pigs was 16.5 ± 1 weeks and weight was 40 ± 5 kg (mean ± SD). The pigs had 2 transponders, one in each ear. Feeding visits of the pigs were scored using The Observer 5.0 (Noldus Information Technology, Wageningen, The Netherlands). The barn was located at ILVO's experimental farm (Institute for Agricultural and Fisheries Research, Melle, Belgium).

The timing of the RFID registrations of the pigs were compared to the timing of the observed feeding visits. Synchronization between both systems was ensured by logging both on the same computer. Per-second agreement, sensitivity and specificity of the raw RFID registrations were calculated.

2.3 Offline validation

To evaluate the effect of position and orientation of the transponders on the achieved registration range, an offline validation has been performed. A wooden test set-up was constructed to allow placement of stationary transponders at fixed positions around the feeder. Seven heights of the transponders were possible (15, 20, 25, 30, 35, 40 and 45 cm, with the antenna at 50 cm). Forty-eight tags were placed on the board with 10 cm distance in-between. Seven different orientations of the tags were possible (1 at 0° versus the horizontal plane, 2 at 90° and 4 at 45°). An example of such a set-up can be seen in Figure 2.

For all orientations and heights, the transponders were placed in the test set-up during 10 s. Five different random distributions of the transponders on the board were used to eliminate the effect of the transponder. Each test was repeated 5 times. The optimal registration range would be that all transponders that are inside or above the feeder trough are registered, while all other transponders are not.

3. Results

3.1 Online validation

In total, 14,070 RFID registrations were logged of the focal pigs during the observation time. Observed feeding duration was 9.7 h. The percentage of RFID registrations within observed feeding visits was 77.11 %, while 92.23 % of the RFID registrations occurred during or within 10 s from a feeding visit. The percentage of feeding visits containing RFID registrations was 89.17 %. The per-second agreement between RFID and video was 96.61 %. Specificity of the RFID registrations was 99.58 %, but despite these high numbers sensitivity was only 33.91 % for the raw data.

The timing of an observed feeding visit of a pig and the registrations of the 2 transponders of that pig are shown in Figure 3. This figure illustrates that despite the good timing of the RFID registrations, the registrations are not continuous (explaining the low sensitivity). This can be explained partially by the use of multiplexers. If a transponder would be registered every cycle of the multiplexer while the pig is feeding, one would expect a registration of both transponders every 2 ± 1 s (mean ± SD). This is not the case, however, and the reason was found during the offline validation (as can be found in the next section).

3.2 Offline validation

From the performed tests, the range of the RFID system could be constructed for different heights and orientations. The percentage of successful readings outside the feeder trough was generally very low, explaining the high specificity during the online validation. The percentage of successful readings inside or above the feeder trough can be found in Table 1.

It is clear that the reading range is influenced by the position and orientation of the transponders. The fraction of successful readings inside or above the trough varies between 0 and 100 %, with an average of 57.59 %. This explains the low sensitivity and the gaps between the registrations of a feeding pig. A pig moves while feeding and the position and orientation of the transponders change as a consequence. The RFID system has a different reading range dependent on the orientation of the transponders, due to the principle of inductive coupling. Overall, the constructed range covered the feeder trough well.

4. Discussion

Overlap between feeding and registrations, per-second agreement and specificity were very good. However, the sensitivity of the RFID system was quite low as the readings inside or above the feeder trough depend heavily on the position and orientation of the transponders. This is due to the need of good coupling between transponder coil and antenna coil.

To improve the sensitivity, it is recommended to change the height of the RFID antenna throughout the fattening period. For small pigs, the antennas can be lowered to 46 cm. For larger pigs, the antenna has to be placed at a height of at least 50 cm to allow them to eat comfortably. Due to the use of a multiplexer and the missed registrations due to changes in position and orientation of the transponders during feeding, the RFID registrations should be clustered into more robust features representing feeding behavior. By clustering the registrations using a time window of 9 s the sensitivity and specificity could be improved to 88.58 % and 98.34 %, respectively (Maselyne et al., 2014a).

Increasing the reading range by increasing the power to the antenna might also be possible. However, this would decrease the specificity as more pigs that are around the feeder will be registered erroneously, while the lack of coupling for specific orientations will not be solved. Since pig pens can be crowded, the option of data clustering is preferred.

For any RFID system used for measurements of animal behavior, an online and offline validation is recommended. Sensitivity and specificity should also be calculated separately in the online validation, since measures such as agreement or accuracy can give a distorted (generally positive) picture due to the low duration of a certain behavior (in this case feeding) during an entire day. For the offline validation, orientation influences the reading range. Therefore, tests with only the transponder parallel to the antenna do not give results on the full reading range. It is crucial to know that for systems with inductive coupling, with some orientations of transponders it is very difficult to detect the transponder (Maselyne et al., 2014b).

5. Conclusions

An HF RFID system for registering feeding pigs was validated offline and online. The tests revealed the good performance of the system with the current settings. RFID registrations are not continuous during feeding, so data-analysis is necessary for clustering these registrations in feeding visits. Specificity and sensitivity of the raw RFID registrations were 99.58 % and 33.91 %, respectively. Clustering of RFID registrations could improve specificity and sensitivity of the RFID system to 98.34 % and 88.58 %, respectively.

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Figures and Tables

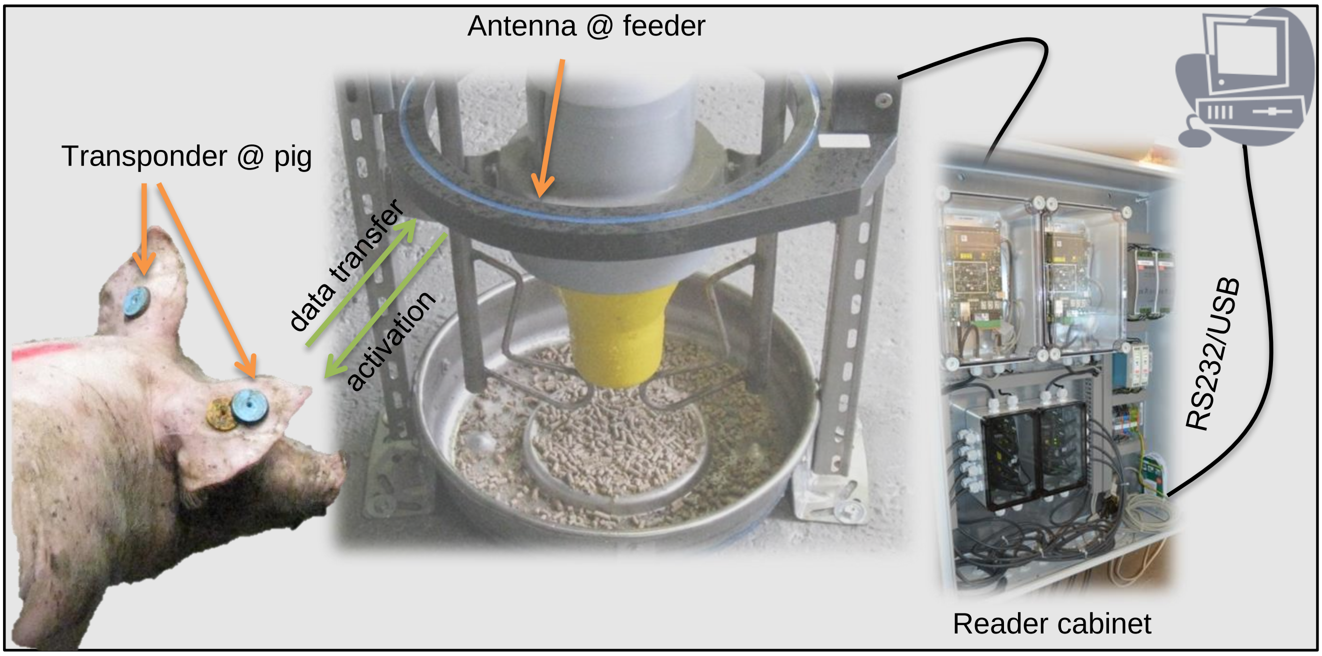

Figure 1: Overview of the different components of the passive High Frequency RFID system.

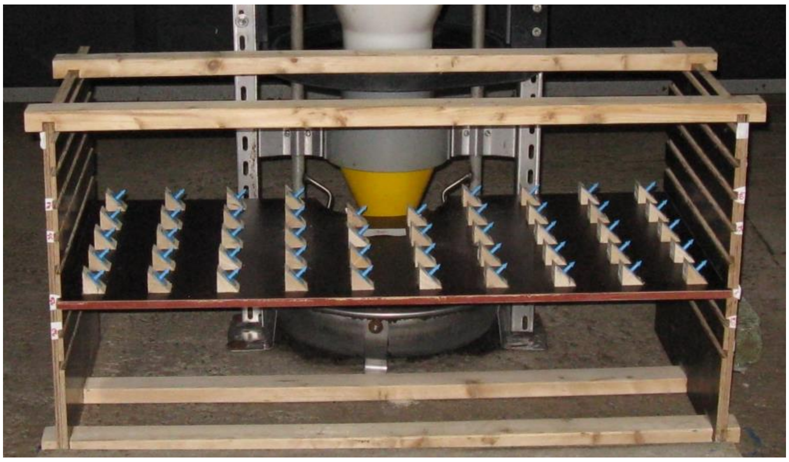

Figure 2: Test set-up for the offline validation, using this board transponders could be placed under an angle of 45° with the horizontal.

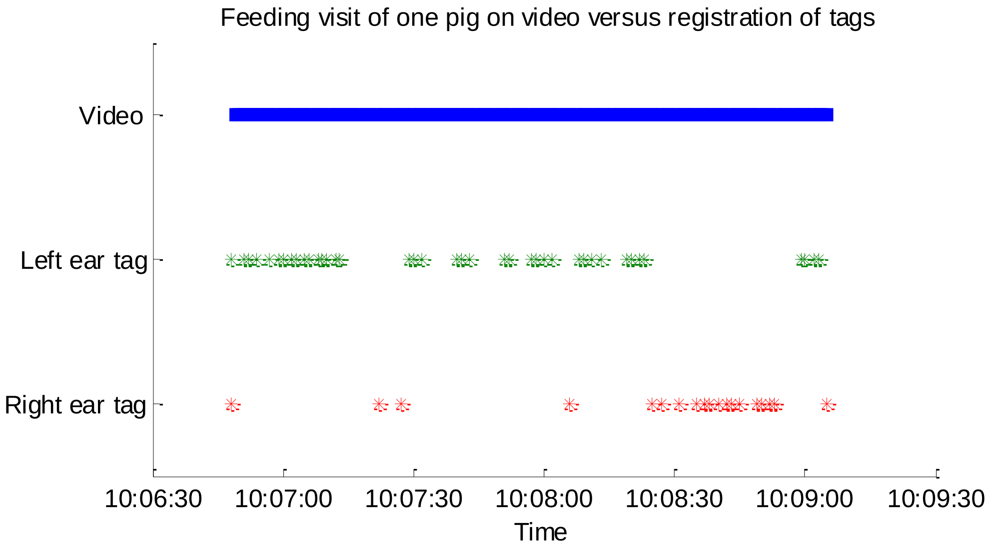

Figure 3: Feeding visit of one pig on video with the corresponding RFID registrations of both transponders.

Table 1: Percentage of successful readings inside or above the feeder trough, for every height and orientation tested.

(%)	Height (cm)							Average
Orientation	15	20	25	30	35	40	45	
0°	0	26.67	66	70	66.67	66.67	92	55.43
90° (1)	14.67	38.67	86.67	100	100	100		73.33
90° (2)	0	25.33	53.33	74.67	100	100		58.89
45° (1)	33.33	100	100	100	100	96		88.22
45° (2)	0	0	0	2.67	66.67	66.67		22.67
45° (3)	33.33	53.33	100	96	100	100		80.44
45° (4)	0	0	0	0	33.33	56		14.89