Computers and Electronics in Agriculture 142 (2017) 473–484

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

Original papers

Accuracy of a real-time location system in static positions under practical conditions: Prospects to track group-housed sows

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ARTICLE INFO

Keywords:
Real-time location system
Indoor sow tracking
Data filtering
Wavelet
Accuracy

ABSTRACT

Social interaction between animals may influence disease transmission paths. Therefore, the usage of real-time location systems gains in importance for livestock farms and research institutes as this technology helps to simultaneously obtain positions of a large number of animals and to evaluate them automatically. Thus, the aim of the project was to specify the accuracy of the real-time location system under practical conditions with regard to a possible future application. In practice, ear tags have proven their worth because pigs manipulate and therefore destroy other objects applied to them in the long term. Therefore, a real-time location system was used providing the sending unit integrated in an ear tag. Ear tags were tested in a sows' gestation stall in static positions. Measuring took place for 5 min per static position, whereas data was transmitted once per second (1 Hz) which led to 300 data points per position. Metal pen equipment led to lost or noisy positions. On average, 9% of data losses occurred and were inserted for the following data evaluation. A Haar wavelet was applied to reduce the noise. Filter settings were rated with the help of an error size consisting of the Euclidean error and an error for the variance of the filtered signal. An optimal filter setting could be achieved when only the 29 largest coefficients for the X axis and 20 largest coefficients for the Y axis were kept while all others were set to 0. Additionally, a *t*-test was performed to test whether an averaged number of coefficients over all ear tags and an optimal individual filtering of each single ear tag resulted in a significantly different filter result. P-values of the *t*-test were 0.15 (X coordinate) and 0.18 (Y coordinate) and therefore not significant. Thus, an averaged filter setting can be applied to all ear tags. The median accuracy of measured data described as Euclidean distance was 2.7 m before filtering and improved to 2.0 m after filtering. Considering the results of this system investigation, it shows that the system may be helpful for ensuing studies regarding e.g. animal behaviour, movement profiles, or social networks to uncover possible transmission paths for diseases.

1. Introduction

Infectious diseases in livestock spread on various pathways such as animal trade (van Duijkeren et al., 2008) and direct contacts (Morris, 1993). Among other influencing factors, contact structures determine the occurrence and dynamics of infectious diseases to a great extent. Especially, network analysis (Newman, 2010) helped to uncover transmission paths and advanced the development of adjusted epidemiological models, which were used to improve disease management. Patterns of pig trade have been widely analysed using network analysis (Lentz et al., 2011, 2016; Büttner et al., 2013a, 2013b; Ciccolini et al., 2012; Bigras-Poulin et al., 2007) but little is known about disease spread at pen level. This may be due to the fact that the contact structure of pigs is hard to capture. As a result, homogenous mixing is still assumed to predict disease spreading on pen level. In order to aim at an improvement of this situation, a real-time location system was tested for its applicability to reflect locations of sows and subsequently their proximity to each other.

Location systems have increasingly been gaining in importance for farms (Banhazi et al., 2012; Wathes et al., 2008). Especially in animal husbandry, technical solutions have become more meaningful due to growing stock sizes and declining employment rates (Frost et al., 1997). Matthews et al. (2016) gives an overview of automation in the pig industry. Of special interest are e.g. oestrus (Ostersen et al., 2010; Freson et al., 1998; Bressers et al., 1993) and lameness detection (Scheel et al., 2017; Traulsen et al., 2016; Pluym et al., 2013) as well as other health

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http://dx.doi.org/10.1016/j.compag.2017.09.020
Received 24 February 2017; Received in revised form 18 July 2017; Accepted 14 September 2017
Available online 02 October 2017

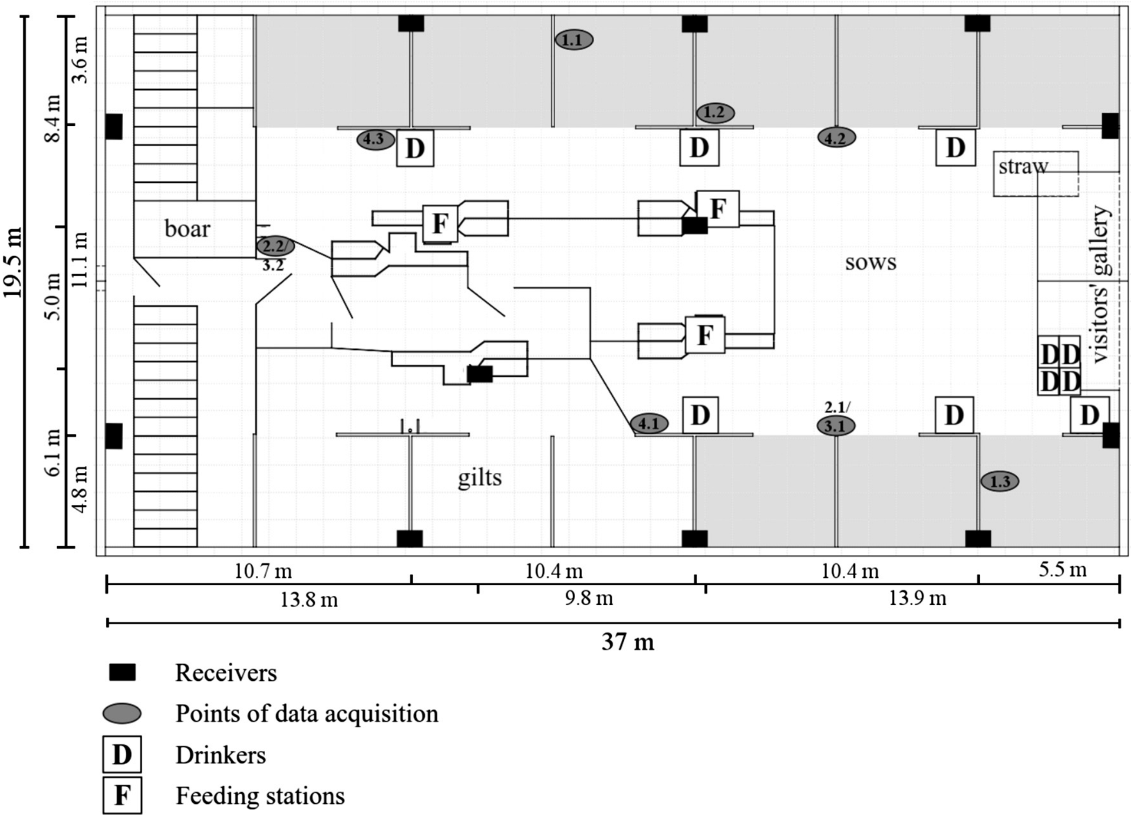

Fig. 1. Floor map of gestation stall in Futterkamp with receivers, points of data acquisition, drinkers, feeding stations, and resting areas (light grey areas). Points of data acquisition according to the different test designs used (see Fig. 2): 1.1: positions P. 01 – P. 03; 1.2: positions P. 04 – P. 06; 1.3: positions P. 07 – P. 09; 2.1: positions P. 19 – P. 22; 2.2: positions: P. 23 – P. 26; 3.1: positions P. 27 – P. 30; 3.2: positions: P. 31 – P. 34; 4.1: positions: P. 10 – P. 12; 4.2: positions: P. 13 – P. 15; 4.3: positions: P. 16 – P. 18.

or welfare issues (Kruse et al., 2011; Reiner et al., 2009; Exadaktylos et al., 2008; Ferrari et al., 2008). Also, scientists have demonstrated a growing interest in this new technology as it may help to analyse e.g. animal behaviour (Oberschätzl et al., 2015; Georg et al., 2012; Cornou et al., 2011), animal networks on pen level (Büttner et al., 2015a, 2015b), and the spreading of diseases (Chen et al. 2014, 2013). Additionally, technical solutions may be helpful to draw conclusions on animal welfare (Reimert et al., 2013; Špinka, 2012). As stated by Gygax et al. (2007), animals influence each other regarding their social interactions. Samarakone and Gonyou (2009) pointed out that sows may change their social behaviour according to group size. Hence, simultaneous recording of all herd members may be preferable but also challenging (Gygax et al., 2007). Until now, studies applied video recording and analysis or direct observations to obtain behavioural data. These techniques are time-consuming, lavish, and costly and therefore only practical for small herd sizes (up to 20 animals) (Gygax et al., 2007) or short periods of time. This is why high numbers of animals or a 24 h observation period require technical solutions.

Location systems comprise receivers and senders. Most systems work with senders attached to a neck collar (Ubisense, GEA, LPM). One system, however, uses transponders included in ear tags (SmartBow GmbH). Especially when working with swine, ear tags are more suitable and the only practicable solution so far, as pigs are very curious and show strong exploratory behaviour (Fraser et al., 1991). Practice has shown that other objects such as neck collars attached to sows are more likely to be chewed on and consequently are destroyed or lost more often. A further advantage of ear tags is that they are securely fixed to the ear of the animals so they cannot slip out of place like a transponder worn around the neck (Gygax et al., 2007; Rose, 2015).

Currently, tracking systems are predominantly used in cattle stock (Porto et al., 2014; Chen et al., 2013; Gygax et al., 2007; Pourvoyeur et al., 2006). One study has focused on goats (Georg et al., 2012). Studies with pigs are rare. Porto et al. (2012) investigated the technical possibilities of localising pigs with an active RFID system. Scheel et al. (2017) and Traulsen et al. (2016) worked with the acceleration data of the Smartbow system to detect lameness. Studies with swine may be rare because only ear tags can be used. Other transponders such as neck collars get easily chewed on and destroyed by pigs due to their exploratory behaviour (Fraser et al., 1991). The advantages of the Smartbow system compared to systems used earlier in pigs (Porto et al., 2012) are the small ear tag size, the low weight, and the higher operating frequency band. Further, the system transmits the 2-D position as well as the 3-D acceleration. This allows a wider range of application.

However, in practical application, technical solutions face some challenges. For example, electric signals may suffer from distraction by metal pen equipment and water (Deak et al., 2012; Maalek and Sadeghpour, 2013; Rose, 2015). Water sources can be drinking troughs or the animals themselves. This signal distraction is called noise and might lead to a longer signal runtime due to signal reflection or position losses due to signal absorption. The system interprets a longer runtime as a position more distant from the receiver. This leads to jumpy position changes even if the animal does not move. Noise complicates the correct detection of a target (Maalek and Sadeghpour, 2013) and therefore must be reduced with an additional application of a filter.

Under practical conditions, accurate localisation is challenged by this noise and signal absorption. This leads to the aim of the present study which was to specify the accuracy of a real-time location system under practical conditions to track group-housed sows in later epidemiological and behavioural studies. Prior to system operation in sows, the accuracy must be evaluated. Thus, the system was tested in a sows' gestation stall of a conventional farm under practical conditions. The ear tags were placed in static positions within the pen to obtain position data for accuracy testing. Especially epidemiological studies consider the contact intensity as it is an indicator for disease transmission. Sows