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Classifying sows' activity types from acceleration patterns An application of the Multi-Process Kalman Filter

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Abstract

An automated method of classifying sow activity using acceleration measurements would allow the individual sow's behavior to be monitored throughout the reproductive cycle; applications for detecting behaviors characteristic of estrus and farrowing or to monitor illness and welfare can be foreseen. This article suggests a method of classifying five types of activity exhibited by group-housed sows. The method involves the measurement of acceleration in three dimensions. The five activities are: feeding, walking, rooting, lying laterally and lying sternally. Four time series of acceleration (the three-dimensional axes, plus the length of the acceleration vector) are selected for each activity. Each time series is modeled using a Dynamic Linear Model with cyclic components. The classification method, based on a Multi-Process Kalman Filter (MPKF), is applied to a total of 15 times series of 120 observations, which involves 30 min for each activity. The results show that feeding and lateral/sternal lying activities are best recognized; walking and rooting activities are mostly recognized by a specific axis corresponding to the direction of the sow's movement while performing the activity (horizontal sidewise and vertical). Various possible improvements of the suggested approach are discussed.

Keywords: Group-housed sows; Body activity; Dynamic Linear Models; Multi-Process Kalman Filter

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1. Introduction

When sows are group-housed it can be difficult to gain access to individual animals. Often this leads to serious management problems. The development of sensor technology (Eradus and Jansen, 1999) opens up new possibilities for monitoring single animals within a group, and current automation systems aim to facilitate 'management by exception' by drawing the farmer's attention to particular individuals.

A large range of automation systems for animal husbandry are based on Dynamic Linear Models and the Kalman Filter (Kalman, 1960). Thus in pig production it is possible to monitor the condition of young pigs via their drinking behavior (Madsen et al., 2005); and in group-housed sows it is possible to monitor estrus via individual body activity (Cornou and Heiskanen, submitted for publication). A similar approach has been described for monitoring milk quality in dairy cattle (Thysen, 1993), and de Mol et al. (1999) suggest a method of this kind for detecting estrus and diseases. Finally, an application for use in poultry production is presented in Roush et al. (1992).

The behavior of the individual sow can be affected both by its physiological state and by illness: body activity tends to increase at the onset of estrus (Cornou and Heiskanen, submitted for publication; Freson et al., 1998; Geers et al., 1995; Serlet, 2004); nest-building behavior is performed at the approach of farrowing (Jensen, 1993) lameness mainly influences the sow's walking activity, while other diseases may affect specific behaviors such as feeding (Forbes, 1995). Automated monitoring of the activities of an individual group-housed sow would therefore help the farmer to detect deviations from normal behavior and provide information about the specific state of the animal.

The objective of this study is to develop a method for automatically classifying particular activities that group-housed sows perform. The method tracks acceleration measurements. An accelerometer, fixed on individual sows, allows activity data to be recorded at any time. The modeling of activity patterns could allow the individual animal to be monitored for the full duration of its reproductive cycle, i.e. from the mating section to the farrowing house. Other applications, such as monitoring animal welfare, can also be foreseen.

The following section describes the collection of acceleration measurements and the five types of activity selected. Section 3 sets out the methods used to model and classify the activity types. Section 4 presents and evaluates the results. Section 5 further discusses the results; it explores perspectives for improvement and suggests new applications of the classification method presented.

2. Time series of accelerations and activity types

2.1. Collection of acceleration measurements

The time series of acceleration measurements referred to in this article are extracts of data collected from five group-housed sows in a production herd in Denmark over a period of 20 days during March 2005. The sows were fed *ad libitum*; they had access to two electronic sow feeders (ESF) and three nipple drinkers. Resting areas were straw-bedded and activity areas had plain or slatted floors. Acceleration data were measured in three dimensions using a digital accelerometer (LIS3L02DS from STMicroelectronics) four times per second, 24 h a day. A box containing the accelerometer and the battery package was fitted on a neck collar which was put on the experimental sow. The neck collars tended to loosen after few days. However, the weight of the