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THE INTELLIGENT PIG BARN

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ABSTRACT

Until now, production monitoring in pigs has mainly focused on growth, reproduction, feed consumption and mortality. However, in the daily management, pig producers also rely on additional observations related to animal behavior, e.g. in relation to climate regulations, and early intervention in case of productivity and welfare related problems, such as diarrhea, tail biting and fouling. In the ongoing PigIT research project it is hypothesized that a systematic placement of cheap sensors and cameras in the production pens combined with methodological developments to integrate the information from these sensors will enable automatic detection of behavioral patterns reflecting impaired production and welfare.

INTRODUCTION

As it is stated in the project description of the PigIT project[1], the major welfare problems affecting the productivity of growing and finishing pigs are intestinal (i.e. diarrhea, affecting mostly weaners) and respiratory (affecting mostly finishers) diseases. Other major welfare issues are tail biting and undesired excretory behavior (fouling) with sudden appearance of filthy floors.

Until now, computer based production monitoring in growing pigs has mainly focused on growth, feed consumption and mortality. However, in the daily management, pig producers rely on additional observations related to animal behavior, e.g. in relation to climate regulations, and early intervention in case of economic and welfare related problems, such as disease and tail biting. These behavioral observations also serve as early indicators in case of feed and growth related problems.

Several research projects described in the literature have tried to develop methods for automatic monitoring in pig production. Previous efforts in Denmark have (with a few exceptions) been focused on monitoring sows, but in the PigIT project, the ambition is to adapt their methodology to growing pigs and to go a step further and integrate the monitoring methods in active decision support and regulation.

It is the hypothesis of the project that a systematic placement of cheap sensors in the production pens combined with methodological developments to integrate the information from these sensors will improve the production process and thus add significant value to investment in the sensor technology. The potential benefit will be seen in productivity as well as in the welfare of the animals in the systems.

SENSORS AND DATA

In the PigIT project, the strategy is to rely on vision technology and cheap standard sensors installed in and around the pens (no sensors are positioned on the pigs). The aimed observational unit is a pen of weaners or finishers.

1 www.pigit.net

Figure 1 illustrates the sensor infrastructure of a project herd with sensor based measurement of temperature, water consumption and feed intake at pen level. Furthermore, cameras installed above the pen allow for vision based assessment of activity and live weight of the pigs. At section level, temperature and humidity are monitored by data retrieved from the climate computer in the herd. In addition to the automatic registrations, farmers record cases of tail biting, diarrhea and fouling.

Figure 2 shows sensor data collected in two pens (a double pen as illustrated in Figure 1(b)) over a week in February 2015. Water consumption is aggregated per hour and shows a clear diurnal pattern. Feed consumption is extracted from the feeding computer and is shown as kg feed per feedstuff per day (including water since it is a liquid feeding system). Whereas the water consumption reflects the behavior of the pigs, the amounts fed are basically decided by the farmer and controlled by the feeding computer.

The pen level temperature plots show that the local temperature fluctuates over time and varies considerably (2–4 ° C) between the two positions in the pen (see Figure 1(b)). For the week shown, it seems that the local temperatures measured close to the aisle correspond quite well to the temperature measured at section level, whereas the temperatures measured at the drinking nipple at the back of the pen are higher. The section level temperature and humidity shown at the bottom of the figure are controlled by the climate computer and they will to a large extent reflect decisions made by the farmer.

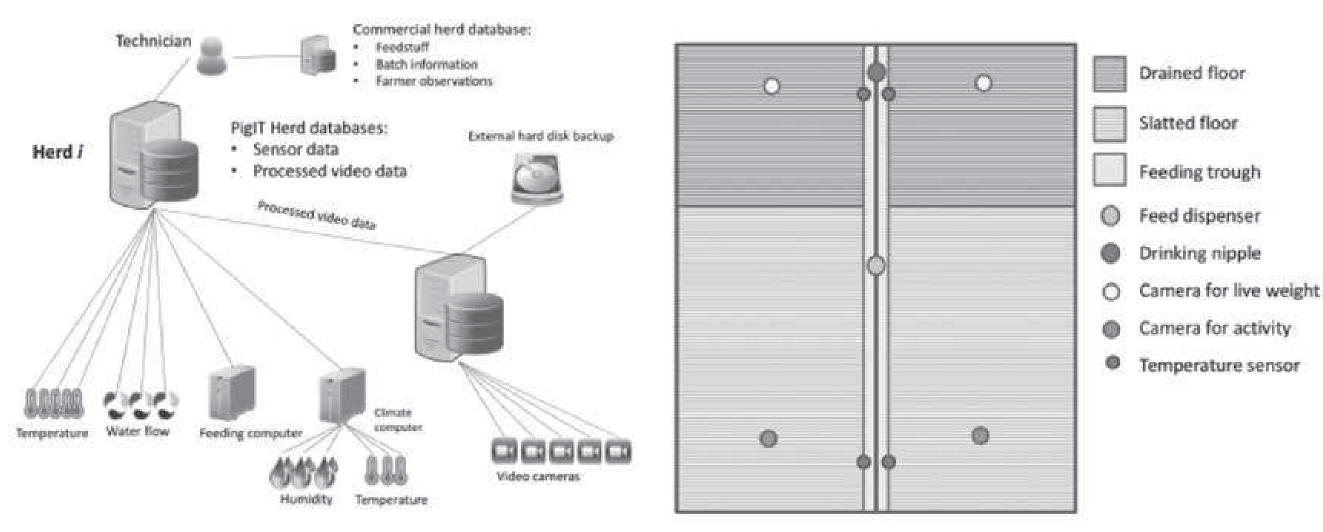
Vision data from the cameras (not shown) are used for live weight estimation and activity monitoring. In some herds, data from manual weighings of the pigs are also available. In addition to the sensor data, farmer observations of fouling and diarrhea are also shown in Figure 2.

DATA FILTERING AND EARLY WARNING

The idea of an early warning system is to automatically detect patterns in data reflecting impaired production or welfare. Welfare problems are primarily expected to influence the behavior of the pigs as expressed by the activity level and the drinking pattern. Other kinds of data as for instance the humidity, the local temperature or the feed allocation may serve as explanatory variables or risk factors.

Several methods like hidden Markov models (Aparna et al., 2014; Udupi, 2014) or state space models (Madsen et al., 2005; Cornou and Lundbye-Christensen, 2012) may be applied in the detection of impaired welfare.

In the PigIT project, a state space model in terms of a multivariate dynamic linear model is applied



(a) Data infrastructure (b) Sensors and pens

Figure 1. The sensor and data infrastructure of the herds of the PigIT project. Data on humidity and temperature from the climate computer are at section level. All other information is at pen (or double pen) level.

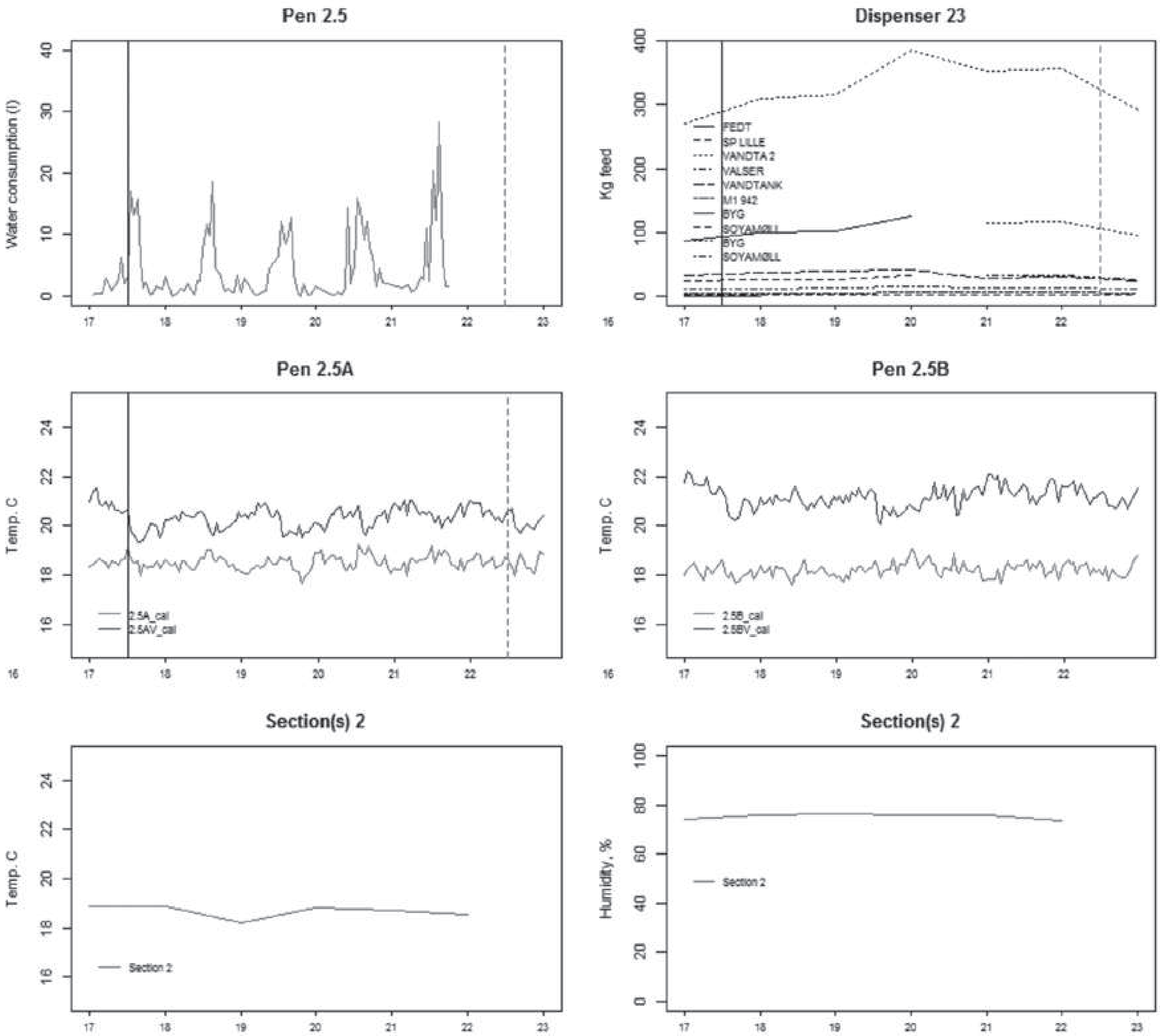


Figure 2. Sensor data collected over a week in February 2015 for the double pen 2.5A/2.5B in Section 2 of a herd. Upper panel: Water consumption per hour (left) and feed intake (liquid feed) per day (right). Middle panel: Local temperature at the drinking nipple (dark grey) and at the aisle (light grey) for both pens. Lower panel: Temperature (left) and humidity (right) at section level. On the 17th, fouling is observed in Pen 2.5A (black vertical line) and on the 23rd, diarrhea is observed in the same pen (black vertical dashed line).

for detection of fouling and diarrhea in a pilot study by Jensen et al. (2015). The basic idea behind the use of such a model for early warning is that as long as production and welfare remain at the same level, the model will be able to provide unbiased (and rather precise) forecasts for the next observations, whereas systematic forecast errors (over or underestimation) are taken as an indication of an out-of-control situation. In the following a short summary of the results from Jensen et al. (2015) is given.

The data applied in the study were water intake, feed allocation and manually collected live weight observations. The multivariate approach enables us to combine information from (in this case) three different data sources and take their interconnectedness into account.

An observation is a vector holding three elements (water intake, feed allocation and average live weight) and it is described by an observation equation linking the observation to an underlying unobservable parameter vector which evolves over time according to a system equation. Both equations include random terms of which the variance components are estimated from data. For more information about the

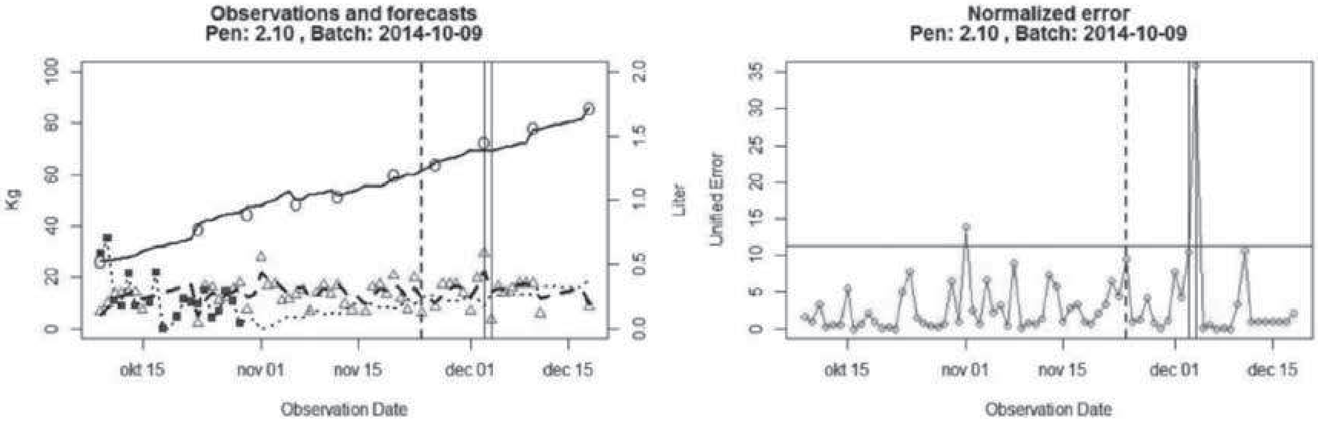


Figure 3. Example from Jensen et al. (2015). Left panel: The observed values of mean live weight (circles), feed allocation (triangles) and water flow (solid squares) per pig in a batch. In addition, the filtered mean values, estimated by the model, for live weight (solid line), feed allocation (dashed line) and water flow (dotted line). Right panel: The unified forecast errors corresponding to the observations depicted in the left panel. Vertical lines indicate cases of diarrhea (dashed) and fouling (solid).

modeling approach, reference is made to West and Harrison (1997).

The early warning system is based on a sequential comparison of the forecasted observation at time t (given all observations until time t –1) and the actual observation at time t. In case of a significant deviation between the forecast and the observation, a warning is given as illustrated in Figure 3.

As it is seen in the figure, diarrhea is observed on the 23rd of November (dashed vertical line) and fouling is observed on the 3rd and 4th of December (solid vertical lines). The right panel shows the unified forecast error with a threshold for warnings. Whereas no warning is given for the diarrhea, a clear warning is raised for the fouling. Several reasons can be given for the missing warning for the diarrhea: missing water flow data at the time of the event, insufficient calibration or simply the fact that no automatic warning system will be perfect.

PERSPECTIVES

As it is said in the project description, the main novelty of the PigIT project is the systematic and intensive use of sensor data combined with video surveillance for monitoring based on advanced data filtering techniques. It is expected that this will help the farmer to monitor welfare and productivity related issues on his farm, and more importantly, to help him make timely interventions in order to avoid problems arising.

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