Dina Workshop:
Sequential Monitoring in Animal Husbandry:
Controlling Error Rates

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This report is also available as a PDF file on World Wide Web at
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1 Introduction

Within animal production, the possibilities of using information from automatic sensors are increasing. From a decision support point of view this offers the advantage of a detailed monitoring of the individual animal as well as the different physical units where the animals are housed.

Techniques for quality monitoring are well-known from industrial production, and recently techniques for troubleshooting in complex domains have been introduced. It is obvious to implement these techniques within animal production.

When constructing monitoring systems within animal production, it is important to make trade-offs between three factors: 1) The risk of false positive, 2) The risk of false negative, and 3) The timeliness of the alarm.

The intention of the workshop is to gather researchers with experience from different domains, in order to present different approaches for handling these trade-offs.

Monitoring of animal production differs in important aspects from traditional industrial production monitoring. First of all, the monitoring covers many diverse units with a wide biological variation. Secondly, the biological processes are dynamic, and varies over time, eg. growth, diurnal and seasonal variation, oestrus cycles. Finally, the production process is closely monitored and controlled by the farmer. The observations, decisions and actions of the farmer is seldom registered, leading to a selection bias in the data, that is hard to remove.

More positive aspects are the possibility of using information from other production units, (animals, herds), and a traditional willingness to share the information between herds.

In many cases, it is extremely important to react without delay, eg. an animal in oestrus should be detected and mated within a few days for a few days, a diseased animal should be treated or removed before it infects other animals.
2 Program

9:45 10:00 Coffee

10:00 10:20 Opening and Introduction.  
*Nils Toft*, Institute of Animal Science and Animal Health,  
Royal Veterinary and Agricultural University

10:20 10:50 Sequential monitoring in Animal Husbandry  
*Erik Jørgensen*, Biometry Research Unit,  
Danish Institute of Agricultural Sciences

10:50 11:00 Short Break

11:00 11:40 Statistical Quality Control  
*Søren Andersen*, Novo Nordisk A/S

11:40 12:20 State space models for filtering and monitoring of processes  
*Flemming Skjøth*, Department of Cattle Husbandry,  
Danish Agricultural Advisory Centre

12:20 12:30 Discussion

12:30 13:30 Lunch

13:30 14:20 Trouble shooting techniques  
*Marta Vomlelová*, Department of Computer Science,  
Aalborg University

14:20 15:00 Integrated Management System (IMS) for pig production  
*C. P. Schofield*,  
Silsoe Research Institute, UK

15:00 15:10 Coffee

15:10 15:40 Herd Analysis: How to find the needle  
*Carsten Enevoldsen*, Department of Clinical Studies  
Royal Veterinary and Agricultural University

15:40 16:00 Discussion
3 Abstracts

3.1 Sequential monitoring in Animal Husbandry

*Erik Jørgensen*

Biometry Research Unit,  
Danish Institute of Agricultural Sciences

Within animal production, the possibilities of using information from automatic sensors are increasing. From a decision support point of view this offers the advantage of a detailed monitoring of the individual animal as well as the different physical units where the animals are housed.

The purpose of this presentation is to illustrate the theme of the workshop. The potential of monitoring is presented using three cases from animal production, oestrus detection, disease detection, and epidemiological monitoring.

Techniques for quality monitoring are well-known from industrial production, and recently techniques for troubleshooting in complex domains have been introduced. It is obvious to implement these techniques within animal production.

However, monitoring of animal production differs in important aspects from traditional industrial production monitoring. First of all, the monitoring covers many diverse units with a wide biological variation. Secondly, the biological processes are dynamic, and varies over time, eg. growth, diurnal and seasonal variation, oestrus cycles. Finally, the production process is closely monitored and controlled by the farmer. The observations, decisions and actions of the farmer is seldom registrated. This leads to a selection bias in the data. The bias is hard to remove.

Thus, it is important to identify the areas where direct technology transfer may be made from monitoring of similar industrial production processes, and where a further development of methods are necessary to address the problems within animal production. Hopefully, this workshop will be a step in that direction.

3.2 Statistical Quality Control

*Søren Andersen*

Novo Nordisk A/S

Basic concepts from univariate statistical quality control, Shewhart charts with different run rules are presented and illustrated with examples. Group control charts for multiple-stream processes are discussed and illustrated, and general multivariate control methods are presented.
### 3.3 State space models for filtering and monitoring of processes

*Flemming Skjøth*
Department of Cattle Husbandry,
Danish Agricultural Advisory Centre

For the processing of signals State space models is a classical approach. By utilizing the Kalman filter to estimate an latent process, which is believed to covern the observed process, a very flexible class of models is available. Some examples and techniques for process monitoring and the detection of alterations in the underlying process is given from agriculture.

### 3.4 Trouble shooting techniques

*Marta Vomlelová,*
Department of Computer Science,
Aalborg University

Troubleshooting looks for an optimal sequence of steps (actions and questions) to solve a given task in a probabilistic domain.

Troubleshooting problem incorporates a list of causes (underlying issues or possibilities), actions (solutions or suggestions), and questions (gathering additional information). The problem domain is represented by a Bayesian network.

A solution of the troubleshooting problem is an optimal ordering of steps (actions and questions), taking into account the probabilities and cost factors (risk, money, time, etc.).

The problem is NP-hard therefore an approximate method must be used. We developed the SACSO methodology that performs well for troubleshooting of printers, it may be used also other areas (prediction, brokering, etc.). Since Bayesian network methodology requires deep understanding an intuitive front-end tool was developed that does not mention a Bayesian network at all and it is easy to use also for non-skilled domain experts.

### 3.5 Integrated Management System (IMS) for pig production

*C. P. Schofield*
Silsoe Research Institute
UK

A revolutionary pig feeding management system based on actual measurements of animal size, shape and performance is being developed. This will increase production efficiency by improving pig performance, controlling live pig and carcass quality and uniformity and reducing environmental pollution without compromising pig welfare.

Traditionally, weight has been used to measure pig performance because of the difficulty of
making any other measurements of live animals. However, Video Image Analysis (VIA) can measure area and linear dimensions and estimate volumes quickly, frequently and accurately. VIA measuring systems developed at Silsoe Research Institute offer near real time objective assessment of the size, shape and hence growth of individual pigs. Our research has shown that measurements from the top view image of a growing pig correlate closely to its weight, and indicates that other measured dimensions enable a good assessment of lean meat and fatness to be made. A commercial version of the Silsoe VIA system for estimating the weight of pigs is now available from Osborne (Europe) Ltd.

By integrating the VIA data into a management system (IMS) comprising suitable nutrition models and feed control mechanisms, we can increase the efficiency in the animal performance - feed requirement cycle. More accurate provision of an ideal diet to individual or groups of pigs can then be managed by measuring dimensions relating to their actual condition, rather than estimates from weight or age.

Integrating pig growth models into the production management and control system will enable an advanced control engineering approach to be applied. This involves measuring process output (for example pig growth rate derived from video images) and feeding this into a process controller which calculates the difference between actual (measured) and optimal (calculated from a model) growth, enabling the feed input to be altered to minimise the error. Information will be available from the shape and size data, which will enable diets to be formulated to improve pig quality and uniformity. This will reduce the time that key farm staff spend on decision making about feed provision, and will enable them to concentrate on important issues such as pig health and general welfare. The improved dietary control offers significant potential for keeping nitrogen excretion to a minimum.

**Sponsors**

DEFRA, MLC, P.I.C. UK Ltd, BOCM PAULS Ltd and Osborne (Europe) Ltd.

**Research Participants**

University of Edinburgh, University of Bristol, ADAS Terrington Pig Unit and Silsoe Research Institute.
3.6 Herd Analysis: How to find the needle

*Carsten Enevoldsen*
Department of Clinical Studies
Royal Veterinary and Agricultural University

Efficient tools for data filtering and monitoring has been available to farmers and consultants for decade. However, these tools are rarely used in practice. Often sequential monitoring is based on crude means per time unit that does not take into account very well known covariates. Sometimes occurrence of events is monitored without taking into account the population at risk. The purpose of this presentation is twofold:

- To present possible reasons for this seemingly paradoxical situation. Maybe the decision maker does not need the available tools. Maybe they are not efficient. Maybe the problems that are monitored are not the real problems.

- To describe the complexity of trouble shooting in a dynamic dairy herd with numerous measurements at several organizational levels. How do we define the problem? Which tools are available? Which tools have not been utilized?

The presentation will focus on the lactation curve. Most studies have focussed on the individual cow but including between cow and between herd variability as well can reveal important aspects of herd management. In the dairy herd seasonal aspects are of particular relevance. Numerous biologically relevant profiles ("needles" - basically latent variables) are of major interest.
## 4 Participants

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