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INTEGRATED MANAGEMENT SYSTEMS FOR PIGS - INCREASING PRODUCTION EFFICIENCY AND WELFARE

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SUMMARY

Integrated management systems (IMS) for pig production will enable the industry to meet tight product specifications whilst satisfying society's demands to reduce the environmental impact of livestock production and improve animal welfare. An IMS is based on modern theories of process control that have been proven in other industries but have yet to be applied to pig production. Initial applications (described here) consider managing the growth of the finishing pig, and will be developed to include management of the gestating sow. In the longer term, control of environmental processes within pig housing with IMS will also be considered. These developments will undoubtedly reveal - and provide the opportunity to resolve - the conflicts between financial and environmental pressures in modern pig production. Other applications are envisaged and include active control of pig behaviour as well as disease.

Keywords: environment, integrated management systems, pigs, process control, sustainable production

INTRODUCTION

Current systems of management are often unable to assist livestock producers to satisfy his/her customer's specifications for livestock products. The producer must also meet increasingly stringent regulations on farming methods that aim to diminish the environmental impact of livestock production, and provide a higher standard of animal welfare, for example. He must balance society's view on what constitutes acceptable agricultural practice against the need to produce animals cheaply and efficiently. Resolution of the various conflicts that arise in livestock production requires integrated solutions if potentially competing demands are to be satisfied.

This paper discusses how the development of integrated management systems can help us to progress towards improved production and environmental management of pigs by allowing many potential conflicts to be identified and, hopefully, resolved.

PIG WEIGHT, SIZE AND SHAPE

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, offering near real time, objective assessment of the size, shape and hence growth of individual pigs (Marchant and Schofield 2001). Measurements from the top view image of a growing pig (Figure 1) show a linear relationship with its weight (Figure 2), so W = a + bX, where W is live weight and X is the plan surface area, and where the s.e. of a is 0.63, that for b is 3.5, and that for the prediction less than 0.5 kg. The difference between VIA predicted weight and mechanically determined weight was less than 3 %; that is, no different from the expected difference between two determined weights, given the influences of change in intestinal and bladder content, and the accuracy of mechanical weighing systems (Whittemore *et al.* 2001). A commercial version of the Silsoe VIA pig weighing system is available from Osborne (Europe) Ltd.

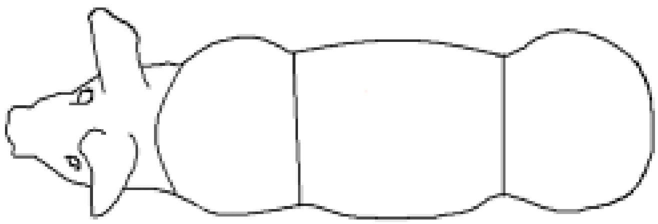

Figure 1. Overhead plan view of the pig as monitored by the imaging system. The A4 plan area includes the three body segments, and excludes the head.

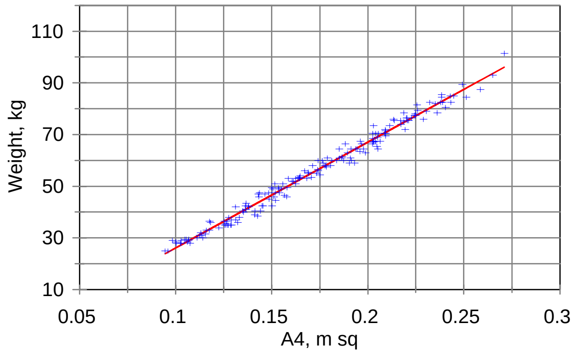

Figure 2. Pig live weight as a function of the A4 plan area measured by the VIA system.

In a recent experiment (Henderson and Schofield, unpublished) a pilot set of 59 pigs was weighed frequently over a period of one month to give same-day comparisons of 851 weighings from the load cell weigher (W) and those predicted from the VIA A4 data stream (VIAW). After removing outliers, the data set comprised 56 pigs and 807 comparative values. Pigs averaged 35.1 (∓SD 7.34) kg for this trial, ranging from 13 to 56 kg. Regression of VIAW on W (standard errors for the coefficients, the constants and the overall equation are in brackets) gave:

VIAW (kg) = 0.959 (0.0122) W + 1.42 (0.439) (2.55) (n=807)

Both the coefficient and the constant were significant (P<0.01). The more close to zero the constant and the more close to unity the coefficient, the more similar the VIAW and W measurements of weight may be considered to be. The regression equation for values of W yielded estimates that might be considered as within expectation of that for two weighings undertaken for a single pig with the same machine at two different times of day.

Figure 3 demonstrates how the VIA system can provide weight-related information from individually identified pigs within a production pen. These sample data are from a 90-day trial in which 20 pigs were monitored during growth from 25kg with some reaching over 100kg. Weight was measured using the Silsoe VIA system, and a load cell platform under the feeder race. The inset graph separates one lame pig's data from the group, and clearly demonstrates that the VIA derived weight matches, and indeed emphasises the weight loss recorded using conventional methods.

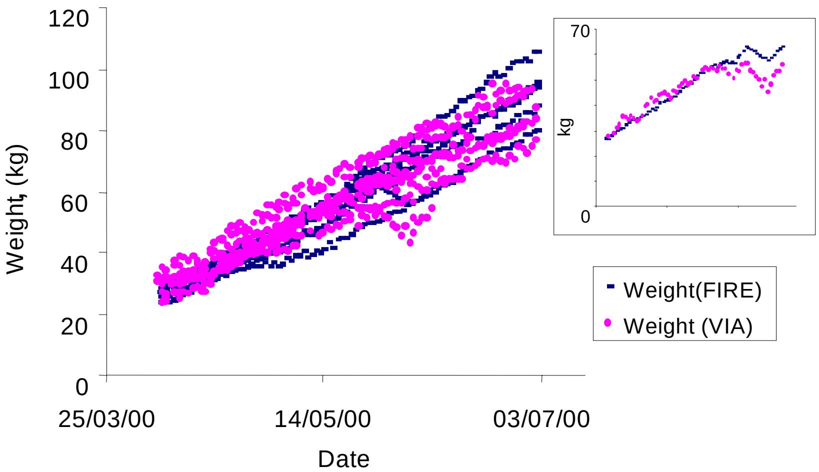

Figure 3. Changes in VIA-predicted weight and conventionally measured (FIRE) weight over time for 8 pigs. Inset demonstrates recorded drop in weight for a pig with a leg infection.

Whittemore and Schofield (2000) argue that changes in pig shape parameters (composition) are likely to be more effective than weight, if used as a control input for managing the nutrition of growing pigs. They claim that post-weaning and during the reproductive cycle, shape (condition) change is a better indicator of metabolic activity than weight change. Also, at slaughter, carcass value is more closely related to the size and shape of cuts for sale, hence of the shape of the joints from which they arose. It is specific muscle volume that gives a better prediction of carcass value than lean tissue weight.

INTEGRATED MANAGEMENT SYSTEMS

Basic Concepts

Sustainable livestock production requires producers to satisfy many environmental and economic demands that may conflict. The product must meet target quality specifications whilst the production process must be profitable and acceptable environmentally. Current systems often fail to satisfy even the basic requirement of acceptable quality. In the UK only 48% of pork carcasses met requirements for fatness and conformation in 1998 (MLC). The diminishing supply of skilled stockmen has made livestock management difficult and the traditional solution has been to automate. Whilst this has been possible with many environmental variables, the production process itself is still controlled by the farmer. In an integrated management system, the production of livestock is treated as a process that can be managed using process control techniques such as those used in other industries. The initial application for an IMS is likely to be management of the primary output, i.e. meat, but once this has been achieved attention can turn to other outputs, such as the emission of pollutants or disease.

Many livestock production processes operate as an open-loop control system (Figure 4). In the case of rearing animals for meat, the input is a desired growth rate: the controller is the farm manager; the actuator is the nutrition supply system, which is operated by the manager; the process is the animal; and the output is the resulting growth rate.

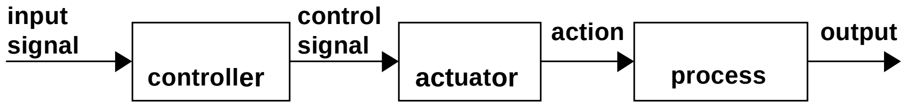

Figure 4. Open-loop control system.

Open-loop nutrition control is prescriptive, in that the diet to be fed at any time is calculated in advance. The producer will subject the animals to a nutritional regime that has been designed in the expectation that it will produce the required result. In a well-managed enterprise the nutritional regime will be based on some form of growth model. Growth models enable the nutritional inputs (protein and energy) required by an animal to realise its growth potential, to be calculated. However, there are many factors (e.g. disease, or unfavourable environment) which may prevent the animals from achieving their potential. The solution lies in model-based control system (Figure 5).

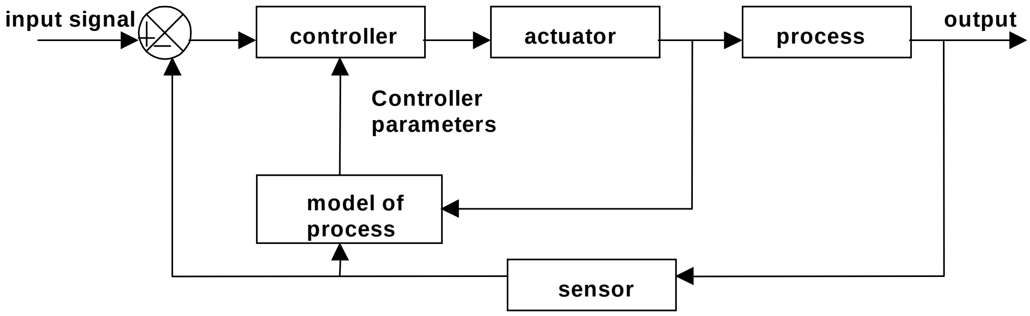

Figure 5. Model-based closed loop control system for daily nutrient intake.

Developing an Integrated Management System for Pigs

Silsoe Research Institute is working with the Universities of Edinburgh and Bristol and commercial partners to integrate VIA into a management system. This will comprise nutrition models and feed control mechanisms and aim to increase control of the animal performance efficiency - feed requirement cycle (Whittemore *et al*. 2001). The approach being applied involves measuring process output including pig growth rate derived from video images. This is fed into a process controller that calculates the difference between actual (measured) and optimal (calculated from a model) growth, enabling the feed input to be altered to minimise error. When controlling diet, the main inputs are energy and amino acid intake. The IMS takes direct control of these inputs on a daily basis, and delivers instructions to manage provision of nutrient supply. More accurate feeding of individual or groups of pigs can thus be managed by measuring their actual condition, rather than estimating from weight or age. The IMS aims to provide an ideal diet at all times, so allowing better control of pig growth, composition and quality, reduced environmental pollution and improved welfare.

The development of this IMS requires research on sensors, process models and actuators. Frost *et al* (1997) conclude that current developments in sensor technology will lead to a surge in information relevant to monitoring animals and their environment. Sensor systems are available to identify and weigh animals (e.g. Geers 1994; Marchant *et al*. 1999) and should become available to monitor physiological variables, such as body temperature and heart rate, hormones and metabolites in milk and other secretions (Mottram 1997) and body composition (Fisher 1997). Process models range from mechanistic to empirical, the latter being more common in livestock production. An empirical model has no prior knowledge of the underlying structures or processes in the modelled system. It may be of value where the process is poorly understood, e.g. multi-factorial respiratory diseases in pigs (Wathes 1998) in which the underlying environmental determinants are numerous and the interactions unknown.

IMS and environmental processes

New legislation will restrict annual emissions of ammonia, dust and odour from pig houses (Wathes 1998). The farmer must still provide pigs of the correct weight on the agreed date **-** he will be penalised if the weights are outside the tolerance limits, but now he must also ensure that the pollutant emission rates are at or below his target, otherwise face hostile action against his business. So he must manage both the meat production process and the environmental processes occurring within and outside the buildings. The relationship between these processes is complex. The farmer needs to understand the inter-relationships between pig growth, nutrient supply and utilisation and pollutant emissions. There is a need for integration in management of both the production process and the animal's environment.

CONCLUSIONS

In the future, housing design and management for livestock must integrate the management of production and environmental processes. Modern livestock production comprises a complex set of physical, biological and economic processes, and the margin of error in their management is shrinking because of the tighter specification for the products and the dismantling of barriers to international trade in livestock products. Additional constraints arise from the growing shortage of skilled labour and reduced profits for investment in new technology. Pollutants from livestock production have a negative impact on local, regional and national environments. Legislation (e.g. IPPC) to limit and reduce pollutant emissions has been introduced in Europe while local communities in North America and Europe have become increasingly intolerant of odour emissions from livestock facilities. The development of integrated management systems for livestock production should resolve the conflicts that face producers.

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