Advantages of individual feed consumption and weight monitoring of growing finishing pigs

A. Peña Fernández¹, T. Norton¹, A. Youssef¹, C. Bahr³, E. Vranken¹,², D. Berckmans¹

¹Department of Biosystems, Division M3-BIORES: Measure, Model & Manage of Bioresponses, KU Leuven, Kasteelpark Arenberg 30, 3001 Heverlee, Belgium.

²FANCOM B.V., Research Department, P.O. Box 7131, 5980 AC Panningen, The Netherlands

³Agrifirm Innovation Center B.V. Landgoedlaan 20, 7302 HA Apeldoorn
Introduction

Large farms of more than 400 fattening pigs represent more than 90% of the industry in Europe (Marquer et al., 2014).

Feeding represents up to 70% of production costs in pig farming (Woyengo et al., 2014) and it is a fundamental way of influencing the feed efficiency of pigs and thus the overall efficiency of pig production (Gaines et al., 2012; Douglas et al., 2015).

Today’s commercial feeding strategies are set at group level and the growth-stage related nutrient demand is managed using feeding curves that adjust feed ration during either 2- or 3- phase feeding programs (Cloutier et al., 2015).

Conventional feeding strategies do not account for the variation of nutritional requirements among individual pigs, maximizing the performance of individual pigs and thus the efficient use of feed on the farm is not possible with these strategies (Andretta et al., 2014; Mayer et al., 2013).
Introduction

However, pigs are living organisms, the efficiency to convert nutrients into lean meat can vary between individual pigs during their growing and fattening periods (Brossard et al. 2009, Brown-Brandl, T.M. et al. 2013). Thus, pigs should be considered as Complex, Individually different, Time-varying and Dynamic (CITD) systems (Berckmans, 2004).

Living organism = CITD - system

Mechanistic models: Schinkel and De Lange, 1996; Green and Whittemore, 2005; Strathe et al., 2009; Wetten et al., 2011; Nitikanchana et al. 2015)

Grey-box models are used to estimate daily nutrient requirements for each individual pig according to their actual growth and feed intake patterns (Hauschild et al., 2012)

1. Measure
2. Model
3. Manage = Monitoring

- Continuously
- Fully Automated
- In Real-Time

M3-BIORES
Precision Feeding project

Hypothesis:
Optimal feed amount and composition can be determined for each individual pig in the batch to optimize their growth.

Objective:
Develop a real-time model to forecast the right amount and composition of the feed for an individual pig according to its growing pattern.
Experimental setup

80 growing-finishing boars (Pietrain x Topigs 20)

4 pens (67 m x 6.26 m; 16.71 m², effective 16.14 m², 0.81 m² per animal), partially slatted floor and situated in a room with computer-controlled heating and mechanical ventilation systems.

2 Schauer feeding stations per pen

Ad libitum feed and water
Experimental data

Each pig shows an individual, time-variant, feed consumption and weight development when following the same feeding strategy.
Experimental data

<table>
<thead>
<tr>
<th>Treatment1</th>
<th>Treatment2</th>
<th>Treatment3</th>
<th>Treatment4</th>
</tr>
</thead>
<tbody>
<tr>
<td>InitialWeight</td>
<td>FinalWeight</td>
<td>InitialWeight</td>
<td>FinalWeight</td>
</tr>
<tr>
<td>Average [kg]</td>
<td>21</td>
<td>118</td>
<td>21</td>
</tr>
<tr>
<td>SD [kg]</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
Experimental data

These graphs are an example of the input (left graph) and output (right graph) data which will be used in the system identification process to determine the model structure suitable for the process.
Time-invariant TF model

- Model the dynamics of the pig response to a change in the Feed supply

\[
I/O \text{ Model } \rightarrow \quad y_t = \frac{b_0 + b_1 L + b_2 L^2 + \cdots + b_n L^n}{1 + a_1 L + a_2 L^2 + \cdots + a_n L^n} u_{t-k} \quad \text{with} \quad L^j y_t = y_{t-j}
\]

Model Order = [na nb nk 0]
Results Time-invariant TF

Model Output vs Weight for Pig 158320820

- Weight
- Model
- HW
- Steps

Input - Feed consumption (FD) Daily

- EC
- FD
- LysC
- Ratio
- Steps
Results Time-invariant TF

- Discrete-time transfer function (TF) models
- Single-Input Single-Output (SISO)

\[ y_t = \frac{B(L)}{A(L)} u_{t-k} = \frac{b_0+b_1L+b_2L^2+\cdots+bnL^n}{1+a_1L+a_2L^2+\cdots+a_nL^n} u_{t-k} \quad \text{with} \quad L^j y_t = y_{t-j} \]

Model: \([1 \ 1 \ 0 \ 0]\)  
\[ W_t = \frac{b_0}{1+a_1L} FD_t \]

**Group level:** Average value of \(a\) and \(b\) parameters from all pigs

\[ W_t = (0.990 \pm 0.006)W_{t-1} + (0.6 \pm 0.3)FD_t \quad R_T^2 = (60 \pm 30)\% \]

**Individual level:** \(a\) and \(b\) parameters are estimated individually for each pig \(R_T^2 = 94.3\%\)
Biological insight

Time-invariant parameters: $b_0$ should be the average value of pig’s feed efficiency

Solution: Time-variant parameters
Time-variant TF model

- Model the dynamics of the pig response to a change in the Feed supply

\[ W_t = c_{1,t} + c_{2,t} \cdot F_{D_t} \]
FORECASTING DLR

<table>
<thead>
<tr>
<th>Time Window</th>
<th>Prediction Horizon</th>
<th>MRPE [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Days</td>
<td>1 day</td>
<td>1.0 ± 0.4</td>
</tr>
<tr>
<td>7 days</td>
<td>7 days</td>
<td>3.3 ± 1.3</td>
</tr>
</tbody>
</table>
Biological insight

Relation between feed efficiency and $c_2$, DLR parameter

Coefficient of correlation $\rightarrow r = (0.9 \pm 0.2)$
Biological insight

Nutrient or fat deposition??
Conclusion: Individual management of feeding strategies may enhance pig’s performance and overall productivity
Thanks for your attention!!

Questions?