Precision Livestock Farming

Use of technologies to optimize animal production

Tomas Norton

M3-BIORES KU Leuven
Measure, Model & Manage Bio Responses

Livestock Forum
27 April 2017
Overview

• Challenges for Livestock Production
• What is PLF?
• Basic principles of PLF
• Examples of PLF systems
• Using PLF to monitor the mental state of animals
• Conclusions
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Measure, Model & Manage BioResponses

M3-BIORES
Real-time modelling of individuals
- 3 professors, 4 Post Docs
- 25 – 30 Ph d students
- 20 – 25 Mastertheses/year

2016
M3-BIORES ➔ A2H-Health
Physiology – immunology - genetics
- 7 professors
- 60 Ph d students
- 40 mastertheses/year

FEED THE FUTURE.
LIVESTOCK PERFORMANCE

273 A-Publications
389 Conference papers
48 contracts with international research partners

17 products
2 spin-off companies
15 patents
2 spin-off companies

2016
M3-BIORES ➔ A2H-Health
Physiology – immunology - genetics
- 7 professors
- 60 Ph d students
- 40 mastertheses/year

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Challenges for livestock production
Problem of monitoring animals

- Livestock farming in the past ...

Farmer had the time to use audio-visual scoring
Numbers of animals ↔ Numbers of farmers
High number of animals per farm
Less available time per individual animal
More welfare and other problems
3 approaches in Europe with focus on the animal
First approach: Iceberg Indicator (1)
Second approach: Welfare Quality (2)
Europe has invested in a methodology to quantify Animal Welfare

“Welfare Quality”

Procedure: Experts do audio-visual scoring by visiting farms and looking to (behaviour) of animal.
Automated Systems (3)

Technology can help to quantitatively measure behaviour, health and performance of animals.
Welfare Scoring/Monitoring

Welfare Quality (2) once a year

Iceberg indicators (1)

slaughterhouse

PLF-Continuous animal based management during growth period (3)
What is Precision Livestock Farming (PLF)?
Management of livestock by continuous automated real-time monitoring of production/reproduction, health and welfare of livestock and environmental impact.
7 European PLF Conferences

4 Smart Sensors Workshops

EU Projects:
- Bright Animal
- ALL-Smart-Pigs
- BioBusiness
- EU-PLF

EC-PLF
CIGR
ASABE
EurAGENG
ISAH
...
The basic principles of PLF
Model-based Monitoring/Improvement of Bioresponses (1991)

- **Micro-environment**
- **Measure**
- **Algorithms**
- **Feedback**
- **Controller**
- **Desired process output**

**Dynamic Bioresponse**

**Process**

1. **Measure**
2. **Algorithms**
3. **Feedback**
A living organism is a CITD system
A living organism:

Complex

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A living organism:

**Identical**

**Individually different**
A living organism:

Complex

Individual

Heartbeat (bpm)

Time (s)

Time (s)

Heartbeat (bpm)
A living organism:

- Complex
- Individual

Time

N

δ Individual

Individual

δ population

Av. population

Response variable

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A living organism:

- Complex
- Individual
- Time-Varying

Example: Heat production of broiler chickens

5 days old

30 days old

Example: Heat production of broiler chickens,

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A living organism:

- Complex
- Individual
- Time-Varying
- Dynamic

Living organism = CITD - system

1. Measure
2. Model
3. Manage & Monitoring

In an on-line way

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Examples of PLF Technology: What is possible today?
Example: Infection Monitoring by On-line Pig Sound Analysis

i.c.w. University of Milan, SoundTalks NV, Fancom BV
Health monitoring by on-line sound analysis:

On-line cough recognition algorithm in pig stables
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NETWORKING DAY
EXHIBITION + CONGRESS

10 MAYO 2016
27 ABRIL 2017
MAYO 2018

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PCM: Results

- Pigs ill upon entering
- Animals treated
- Pigs ill again
- Animals again ill

Cough Index (# coughs / 24h)

Time (day)


Animals treated

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Example: Real time monitoring of problems in a broiler house

i.c.w. Fancom BV
eYeNamic monitor tool

- Farm manager
- Camera network
- Farm network
- Monitoring software

Image pre-processing

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Experiment’s ground plan

Camera

63.5 m

21 m

21 m

19.8 m

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Farmer logbook and manual video observation as references
Event detection

Feeder line
Normal situation

Defect Feeder line
Problem in feeding lines

Measured values
Smoothed values within 25% range
Smoothed values out of 25% range
Predicted values

Distribution (%)

Date (dd/mm)

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Detected events in the validation experiment over 42 days

**Conclusion:** Events in a broiler house could be detected using top-view image analysis with an accuracy of 95.24%.
Continuous automated monitoring of intake

Feed/Water (time) → Process
Monitoring of drinking behaviour in pigs (i.c.w. Ughent, Fancom BV)

- Monitoring water usage as indicator for health status
- Estimate hourly water use in a pig pen by analysing hourly duration of drink nipple visits
Model-based monitoring of water use

Water flow measured

Water use from water meters

Compare

Water use estimated from image

Transfer function modelling

Images

Detection of visits

Duration of visits
Model-based detection of visits

Drink nipple

\[ \Delta T = \text{duration of the visit} \]
Hourly water use can be estimated with an accuracy of 92% or 200 ml over 13 days.
Example: Continuous automated monitoring of feed intake of broilers by sound technology
Continuous recording of sounds (top) and individual pecking sounds (bottom) as extracted by the algorithm.
## More Results

<table>
<thead>
<tr>
<th>Chickens</th>
<th>Exp.</th>
<th>Minutes</th>
<th>Number of peckings per experiment</th>
<th>feed uptake per experiment (g)</th>
<th>Feed loss per experiment (g)</th>
<th>Feed intake per experiment (g)</th>
<th>Feed Intake Per Pecking (Mean±Std)</th>
<th>Feed loss per experiment (%)</th>
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</table>
FEED THE FUTURE.
LIVESTOCK PERFORMANCE

FEED UPTAKE PER EXPERIMENT (g)

NUMBER OF PEEKINGS PER EXPERIMENT

R² = 0.9858

R² = 0.9856

0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00

0 500 1000 1500 2000

0.00 5.00 10.00 15.00 20.00 25.00 30.00 35.00

0 500 1000 1500 2000

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Model based aggression management

Aggressive behaviour → Process → Normal behaviour
Example: Monitoring and reducing aggressive interactions in pigs using image analysis in collaboration with TIHO, UMIL, Fancom bv
Pig aggression monitoring installations

- 2 Farms:
  - Ruthe, Germany (Experimental farm)
  - Madou, The Netherlands (Commercial farm)
- Rounds: 5
- Round: 3 hours per pen per day / 2 days
- Hours of recording: **60 hours**
- Aggressive events: **228**
Labelling Aggression

Labelled variables:

- Duration of aggression (start-finish time)
- Time of feeder activation
- Aggression interrupted/not interrupted

- Type of aggressive interaction
- Aggression initiator and receiver
- Individual reaction to feeder activation
Results

Sensitivity: 88 %
Specificity: 89 %
Accuracy: 89 %
“Stress@work”: positive – negative stress

burn-out = no return from distress zone when stressor is gone!
Focus zone
Future prospects in PLF

“Animal Welfare”

Published Article
Web of Science Core Coll

1990 = 43 papers
2015 = 780 papers
Last 5 years = 44% increase

Trending topics - Focused

<table>
<thead>
<tr>
<th>Search Term</th>
<th>Publications % change 2011 to 2015</th>
<th>Citations % change 2011 to 2015</th>
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<td>AW + Cortisol</td>
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<td>AW + Play</td>
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<tr>
<td>AW + Heart rate variability</td>
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<tr>
<td>AW + Technology/Automation</td>
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</table>

Marchant-Forde (2016)

2/12/2016

PLF vision: research & teaching
**Objective:** Quantification of mental status (fear) of a horse in a non-invasive and continuous way during physical exercise

**Experimental design**

```
walking 5' 5' 1' 4' 1' walking
trotting
```

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• **Prediction**

![Diagram showing activity, heart rate, and model error over time during different phases of motion: walking, trotting, walking.](image)

*Activity [counts]*

*Heart rate [bpm]*

*Model error [bpm]*

Time [s]: 600, 700, 800

**Course:** M3-BIORES KU LEUVEN - PLF

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Remarkable result:

- Activity (counts) vs. Time [s]
- Heart rate [bpm] vs. Time [s]
- Model Error [Bpm] vs. Time [s]
Real-time stress monitoring for livestock

Existing BioRICS Stress Level Monitoring

Existing Sensixa eAr-sensor

New technology Delivers:
• Real Time Stress Level Monitoring
• Real Time adaptive Algorithms
• Wireless connection & recharging
Vision for PLF in the worldwide livestock sector
What is the opportunity for Europe?

Real-time modelling/management of bio-responses

M3-BIORES is a leading group

Precision Livestock Farming (PLF)
EU is leading!

New high tech sector to attract young people

Export PLF technology to China, India, Brazil....

Cost effective PLF technology for family farms

Technology from cutting edge research and development in PLF
Global sustainable Livestock Production

- Nutrition
  - Multi-national feed companies
  - Research groups
  - Innovative SMEs

- Animal Health
  - Multi-national pharma company
  - Farm Technology Companies
  - Farmers cooperative
Conclusions

• PLF offers fully automated continuous real time detailed monitoring and management of animals in the livestock sector.

• PLF brings the farmer to the individual animal that needs his/her attention, active management tool.

• PLF is a tool that helps farmers and stakeholders.

• PLF allows sustainable livestock production.

• Worldwide implementation of PLF needs a collaboration model between industry, researchers, farmers and stakeholders.

• Development of PLF products benefits from long-term strategic collaborations between academy and industry.
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The views expressed in this presentation are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Commission.
Thanks for your attention!
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