Big Data and Robotics for Precision Farming:
creating value with sensor data

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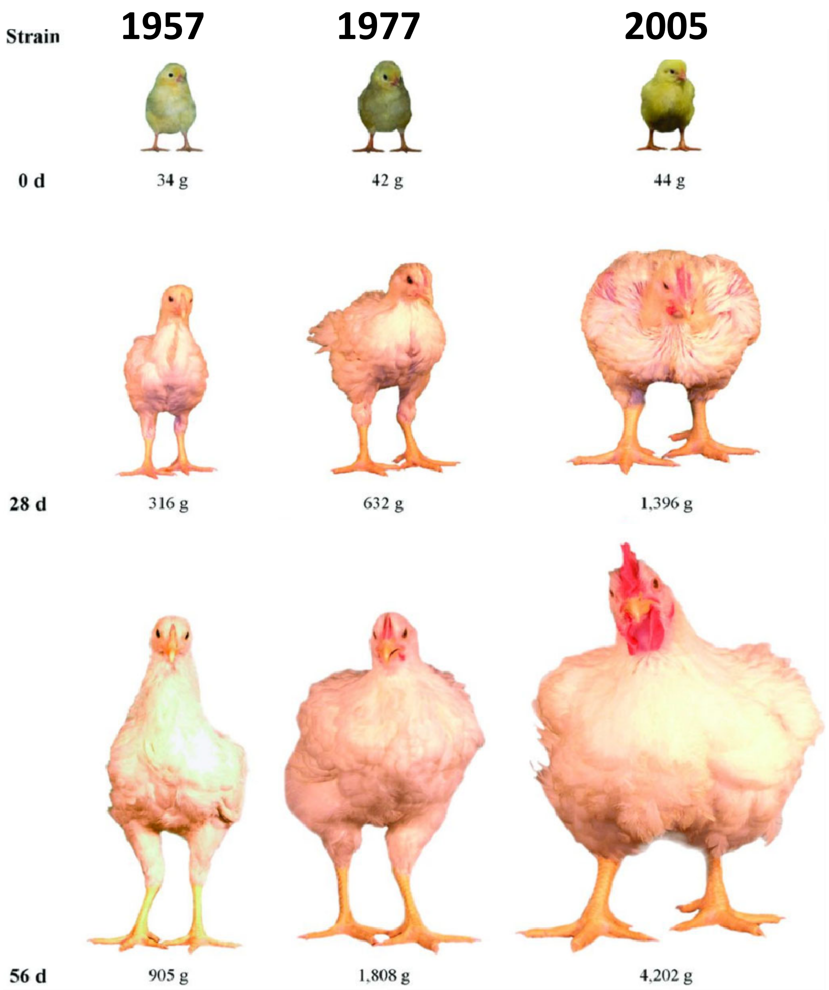
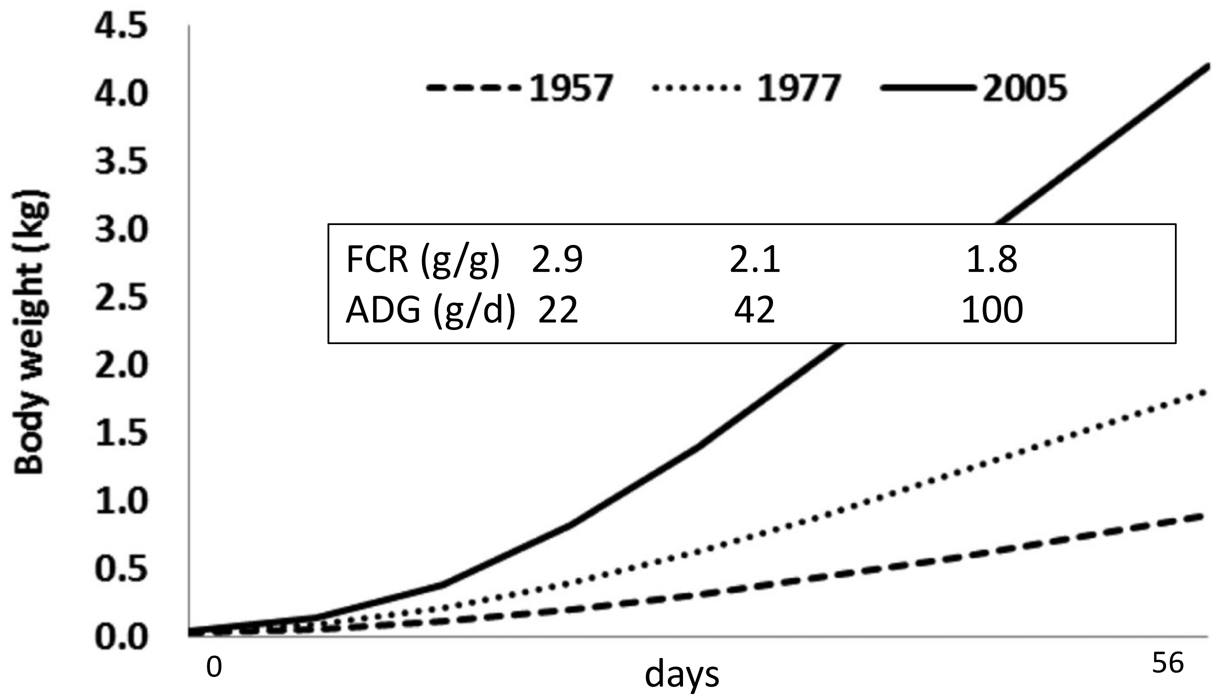
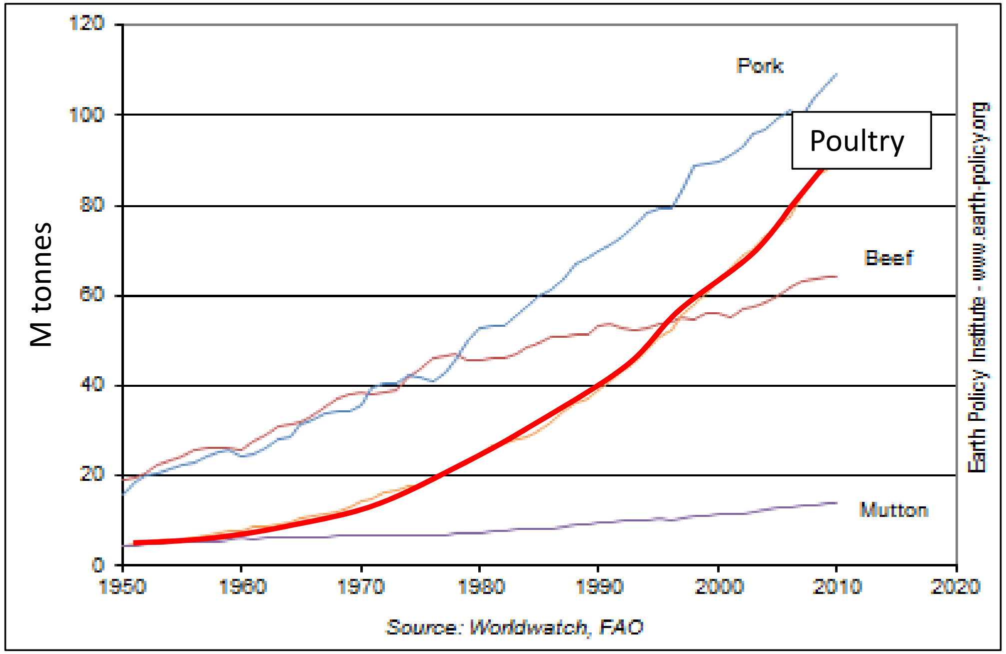
The evolution of the animal engine 57→77→05

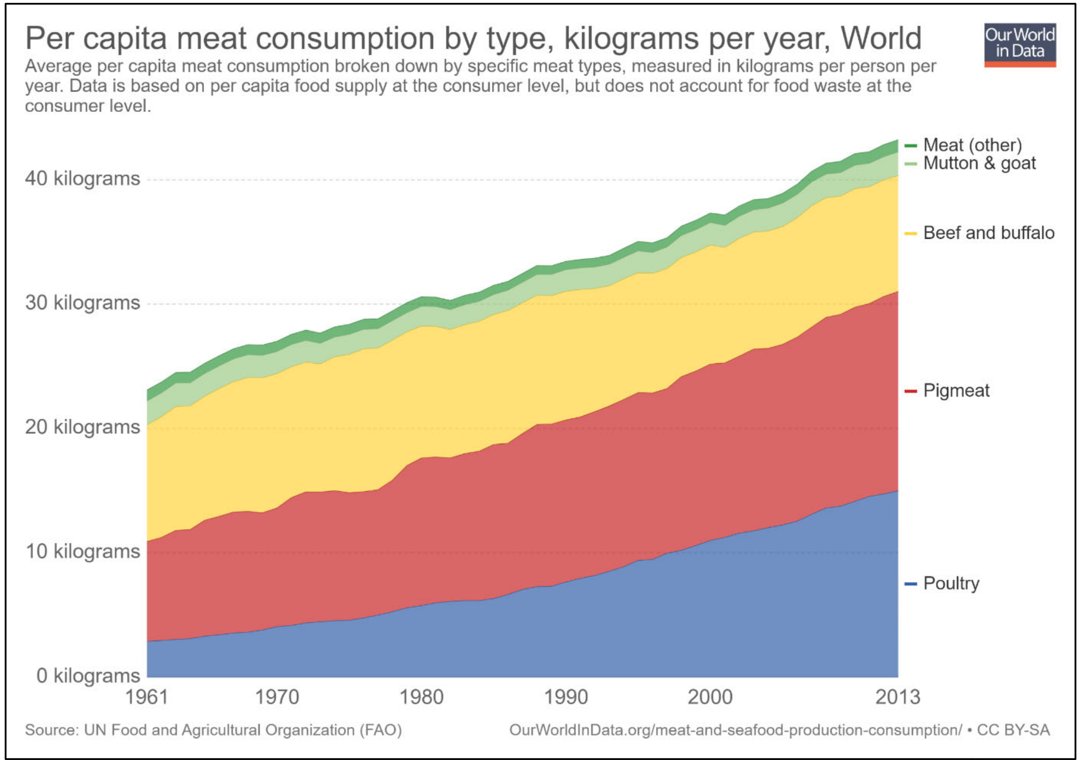




Zuidhof et al. (2014) Poultry Science

Evolution of meat protein production/consumption

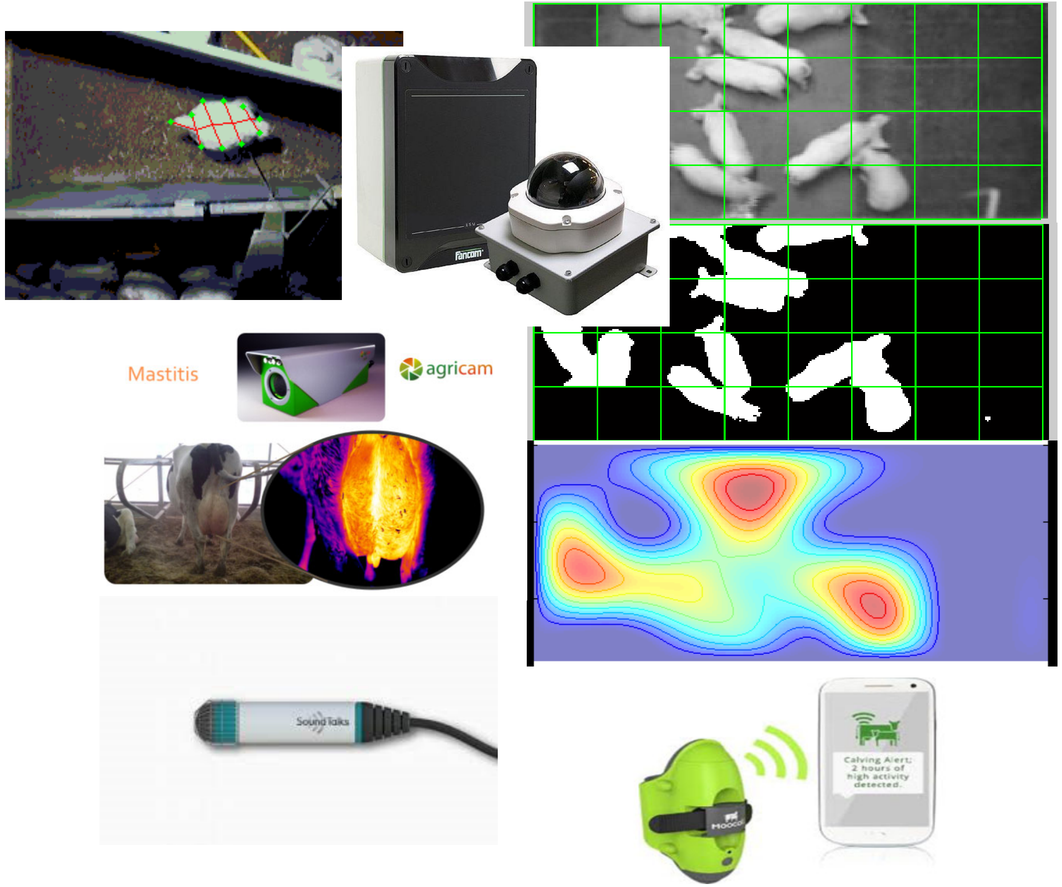




Precision livestock Farming

Precision livestock farming (PLF), can be defined as the management of livestock production using the principles and technology of process engineering.

(Wathes et al., 2008)



Who is Precision livestock Farming for?

Farms today face a big challenge: <u>too many animals too few staff</u>

→Increasing hard to get good people

→Animals are more efficient but also more "sensitive"

For the farmer who:

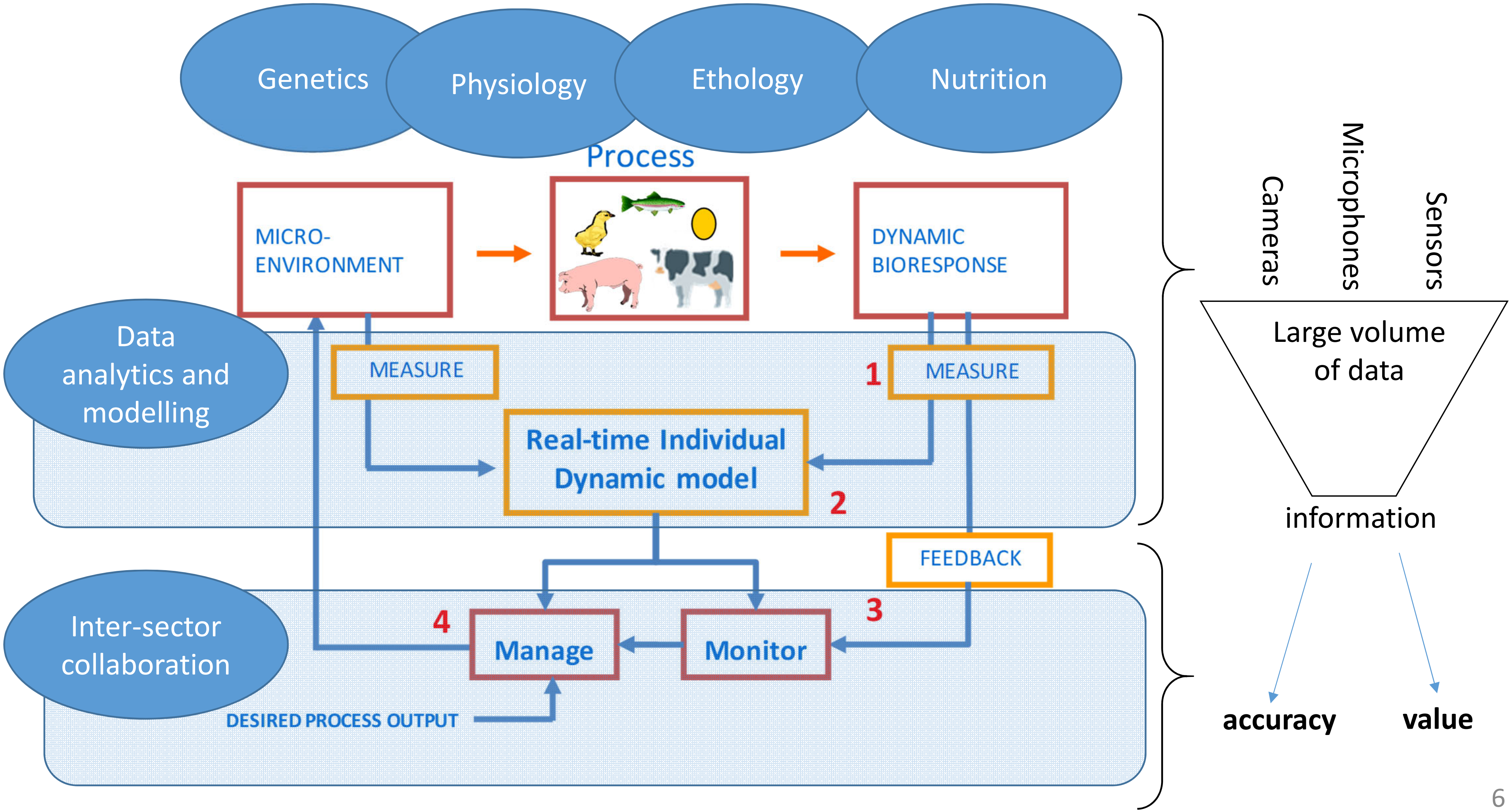
- is seeking to be resource efficient
- is conscious of animal health
- is conscious of animal welfare

PLF is still emerging in many livestock production sectors!

ww. Landbouwleven.be

Source: www. farmersweekly.co.uk

Principles of PLF

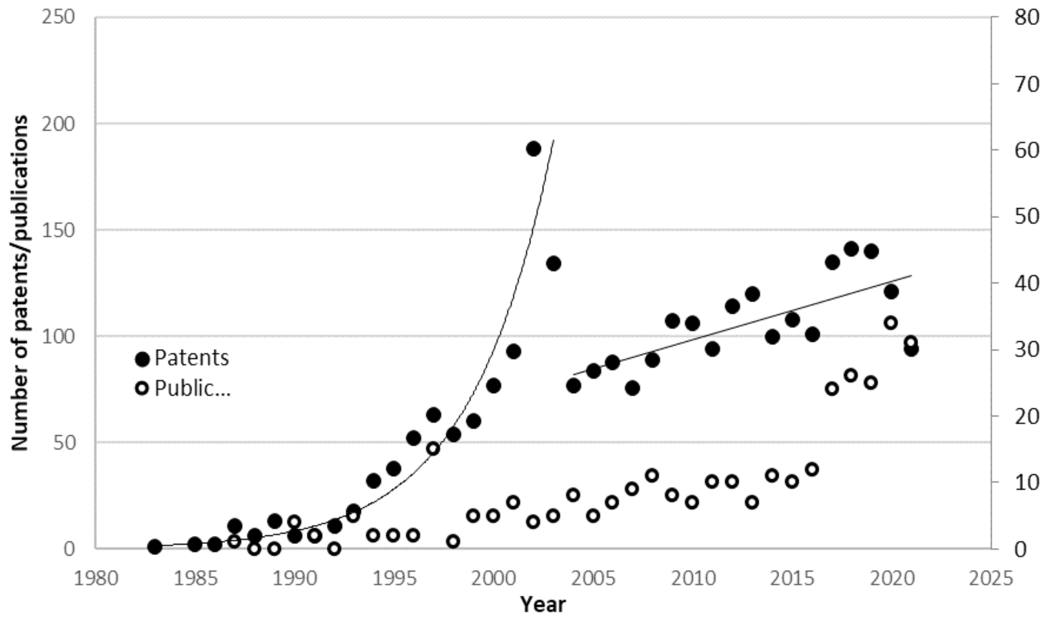


PLF: a lot of technical progress since the 80's

Precision Livestock Farming was first used in a publication by Christopher Wathes (Wathes, 2003).

Since 2009, there have been 15 large European Research projects (FP7, H2020) containing PLF (50% after 2019)

United States Department of Agriculture started on PLF since 5 years:
2014 → FFAR programme set-up
2018→ Food and Ag. Cyber Informatice
2019→ Interdisciplinary Engagement in Animal Systems



Norton, Brown-Brandl et al., 2022

The gap between research and application!

What the literature shows is possible:

- Weighing broilers from sound
- Counting broilers from video
- Stress monitoring from video/sound
- Respiratory health monitoring from sound
- Estimating lameness from video

What is available:

- Weight monitoring
- Environmental monitoring
- Simple behaviour indicator monitoring from video
- Litter monitoring

Remainder of this talk

Developing Automated Monitoring solutions:

- Basic animal monitoring: what is the current limitation?
- How to improve: target specific application
- Combining multiple technologies (weighing)

- Development Automated Management solutions:
  - High value potential of robotics

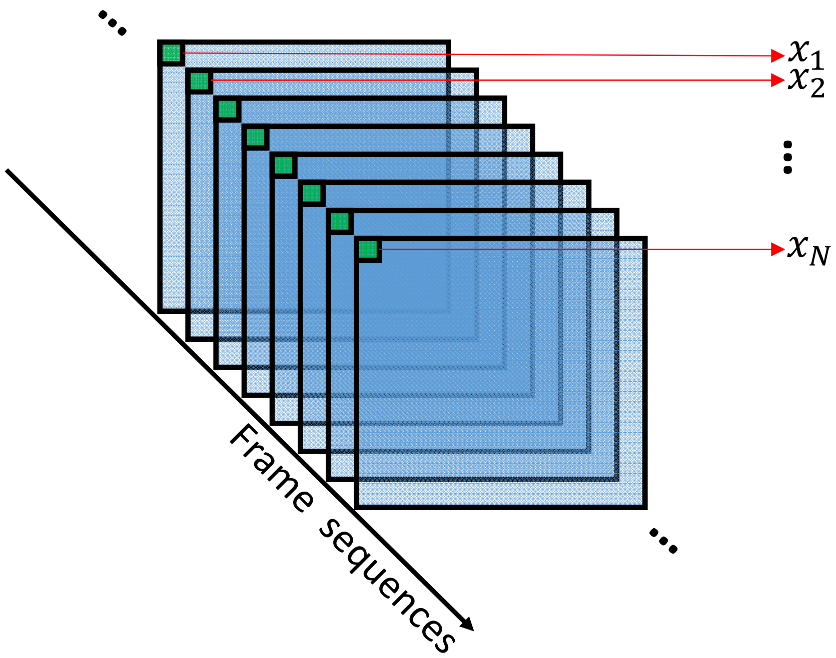
Development of automated monitoring technology

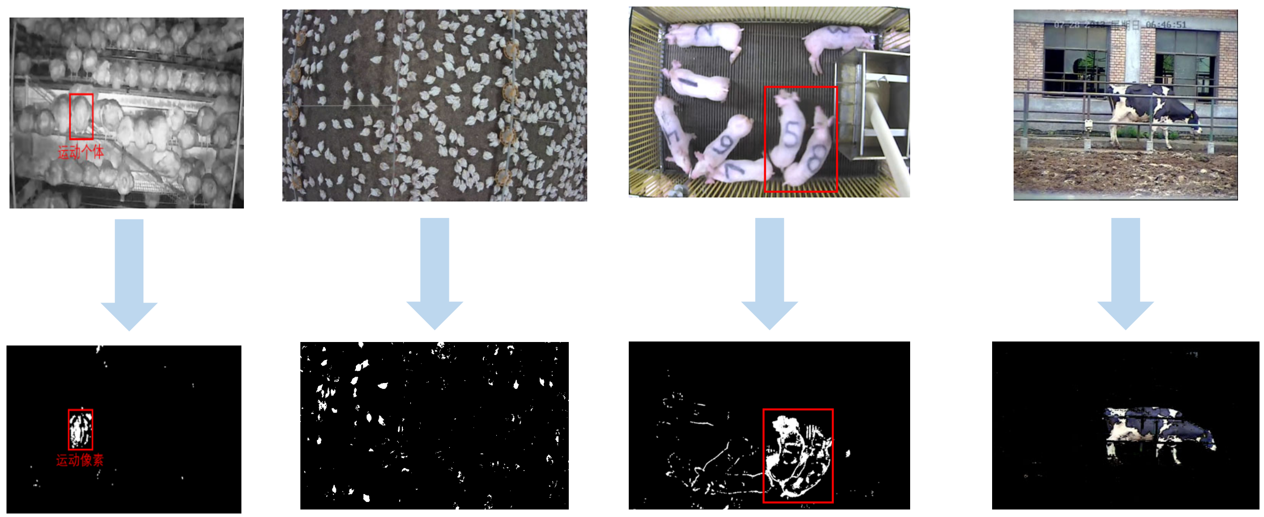
Calculating animal response indicators from video data

Basic image processing methodology for behaviour monitoring

Parameterizing the background by distribution $p(X|\theta)$, and estimating θ via observed data

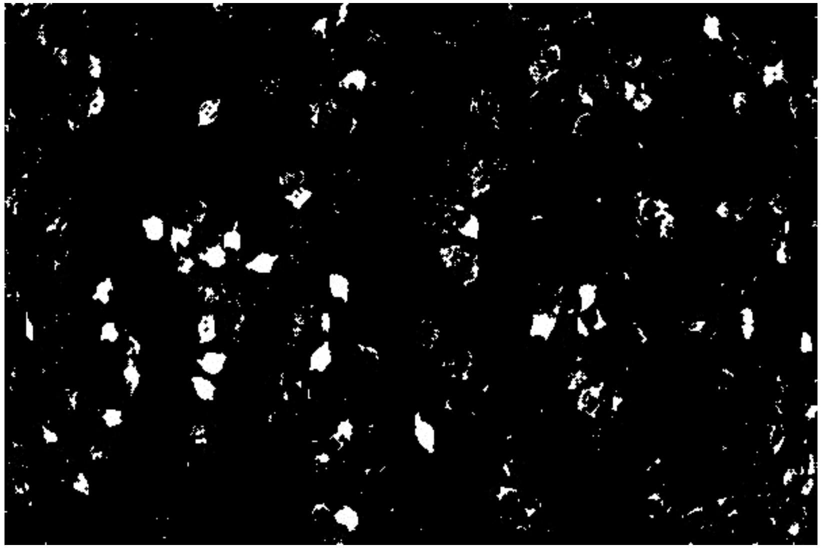
- If new observed data obey this distribution → output 0 (static background)
- Otherwise→ output 1 (moving animal)
- Updating model parameters θ



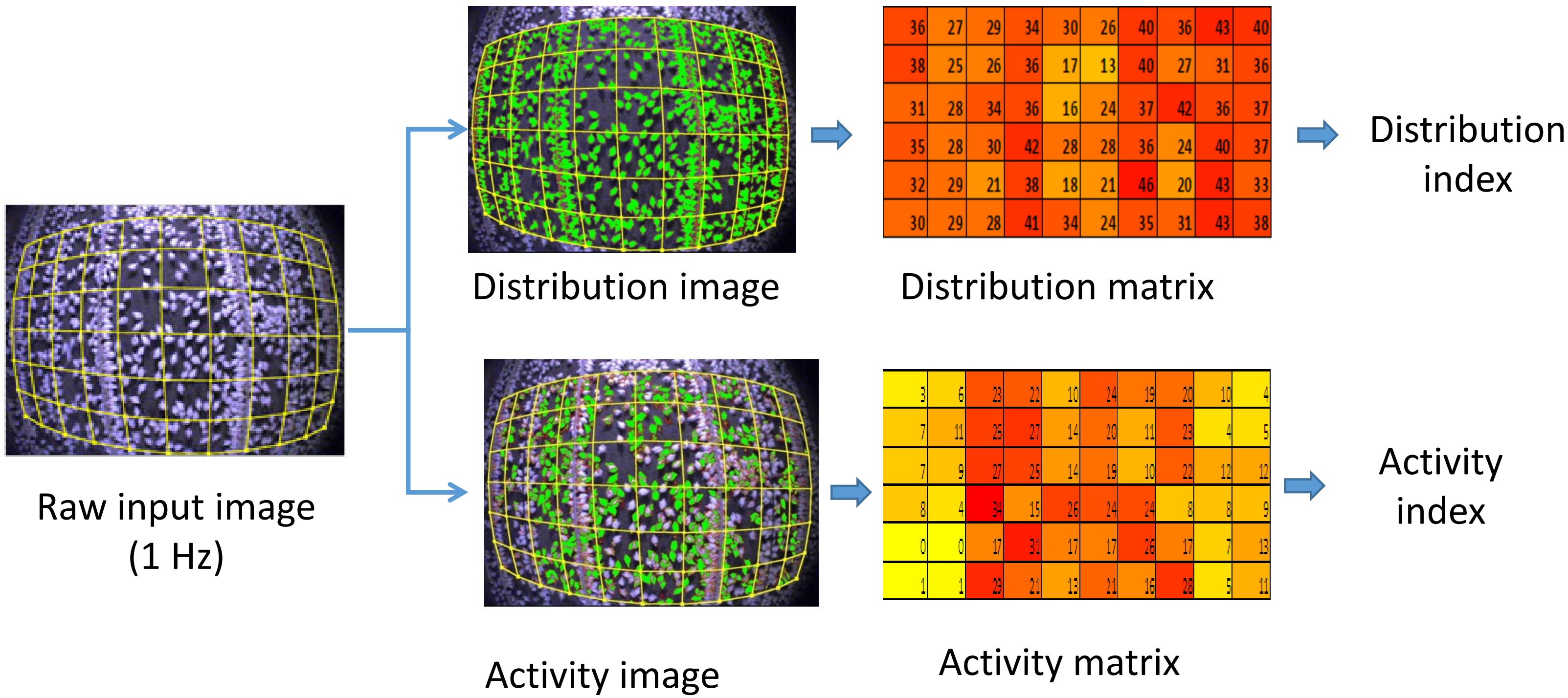


Technical attributes

- Only sensitive to activated broilers (neglect the static ones)
- Light weighted (~30fps @AMD Ryzen 4880H CPU)
- Robust to dynamic environment



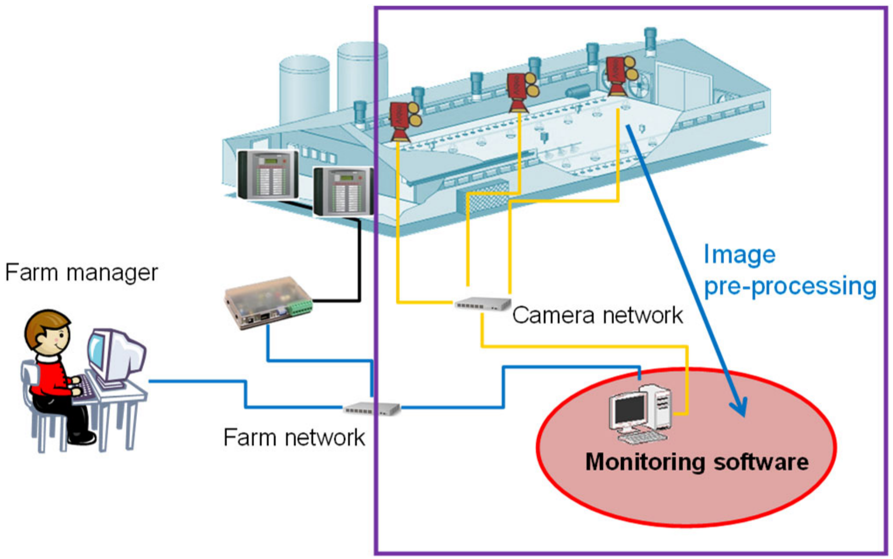
Bio-response quantification by computer vision

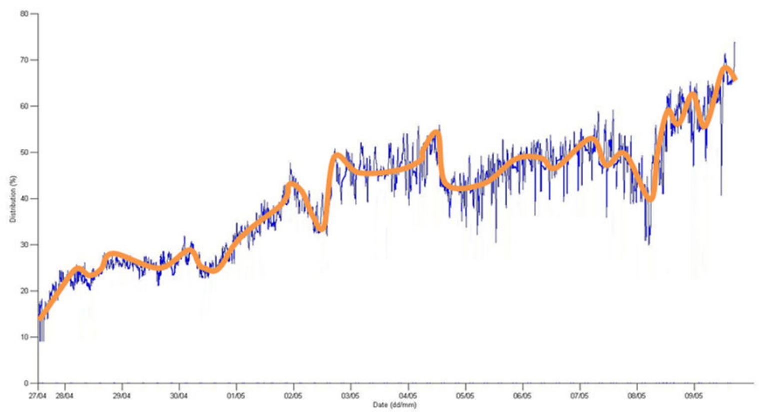


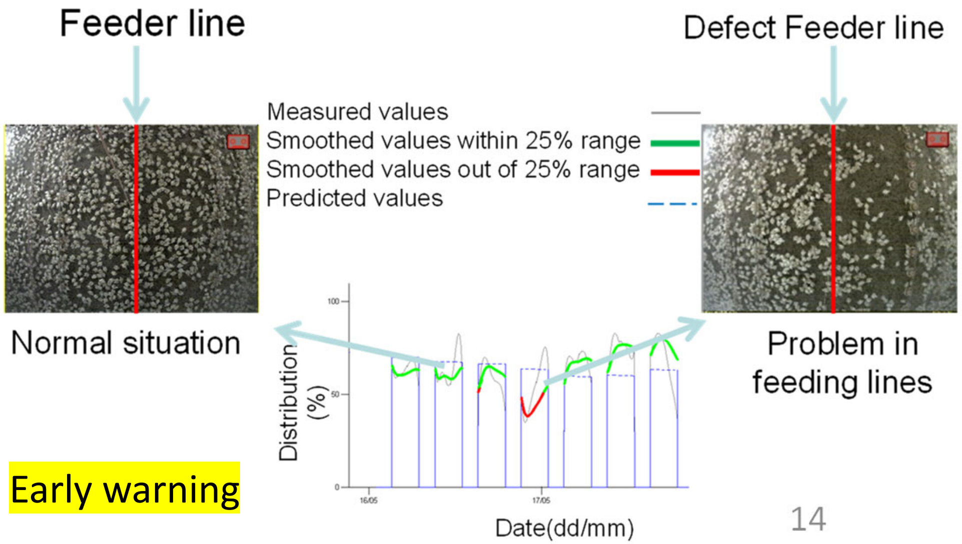
- **Activity/Unrest index**: the variation of pixel intensity due to poultry activity
- **Occupation/cluster index**: measure the degree of agglomeration

- Detecting malfunctioning in broiler houses
- Produce alarms in real-time when malfunctioning happens
(in feeder or drinker lines, light, climate control, etc.)

eYeNamic monitor tool (Fancom/KU Leuven)

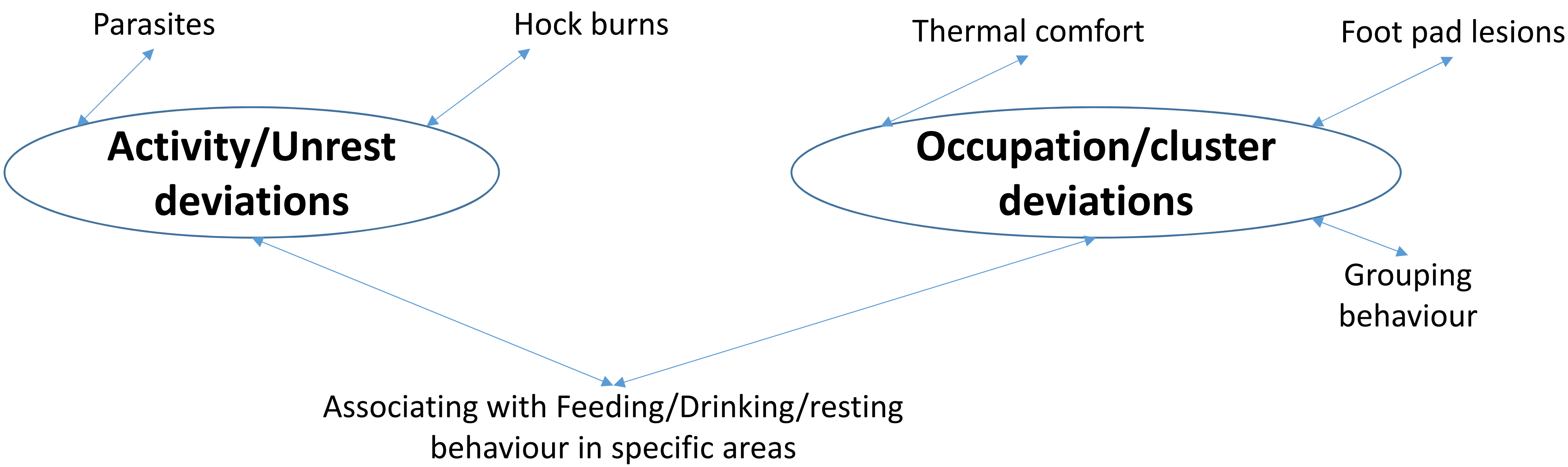






Early warning

Associating image indicators with animal welfare indicators

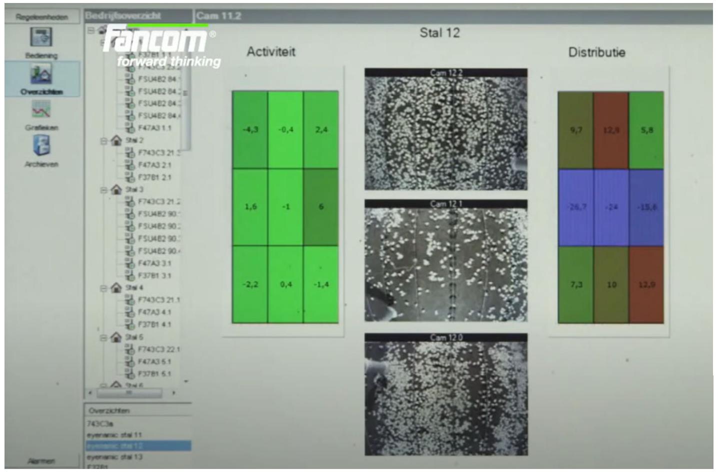


- Fernandez A P, Norton T, Tullo E, et al. Real-time monitoring of broiler flock's welfare status using camera-based technology[J]. Biosystems Engineering, 2018, 173: 103-114.
- Pereira D F, Lopes F A A, Gabriel Filho L R A, et al. Cluster index for estimating thermal poultry stress (gallus gallus domesticus)[J]. Computers and Electronics in Agriculture, 2020, 177: 105704.

eYeNamic on the market

forward thinking

2012



now

Biometrics for broilers

- Automatic animal weighing system
- Water monitoring for automatic water consumption registration

Possible reasons:

1. Value of activity and distribution is limited

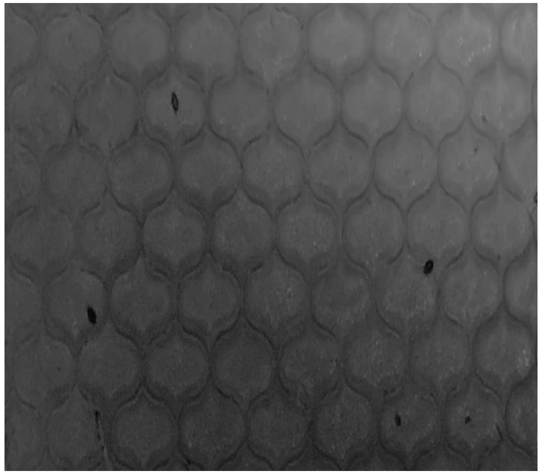
2. Early warning not enough information for the farmer

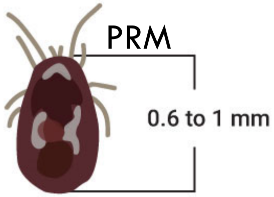
Going beyond the baseline PLF behaviour monitoring

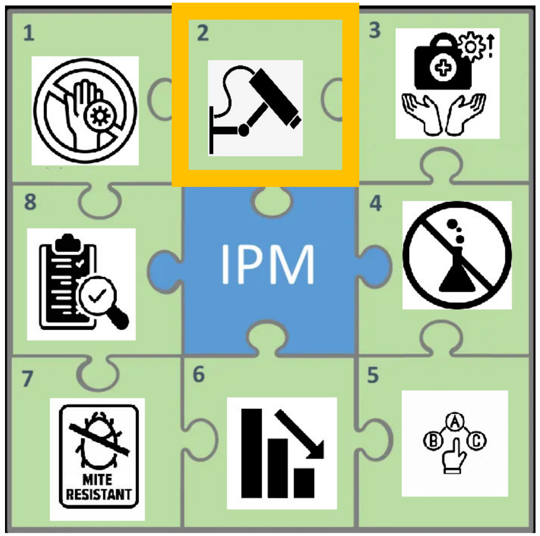
Targeting a specific application

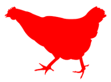
Monitoring of Red-Mite Infestation

The province of Antwerp
EXPERIMENTAL POULTRY CENTRE







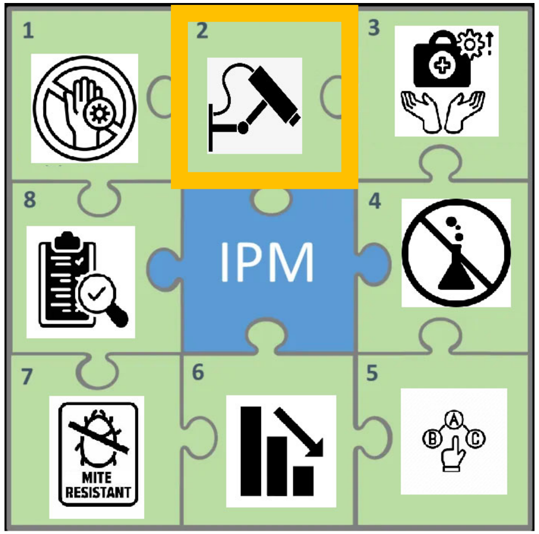


Negative welfare

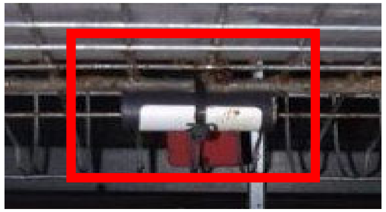
100 million €

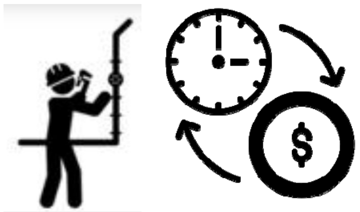
Approach followed

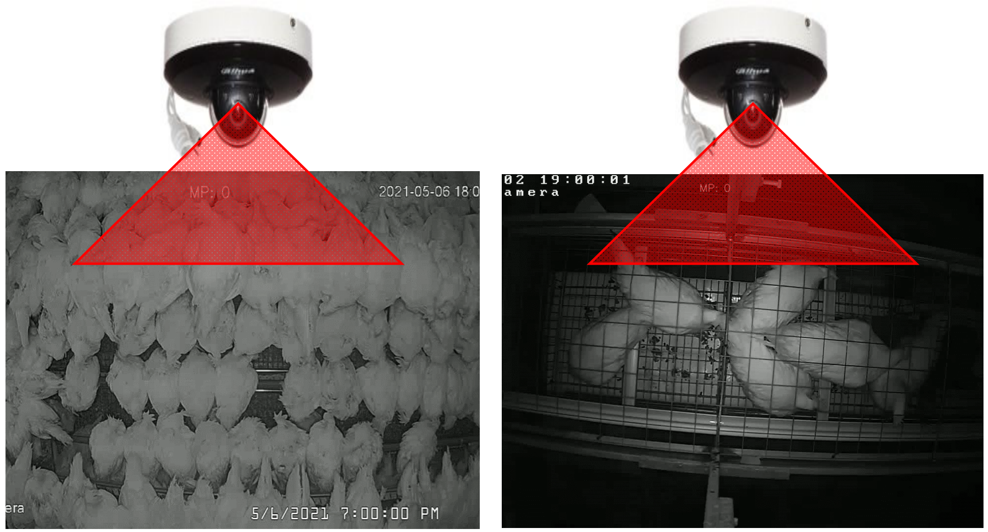
Hypothesis: General nighttime activity of laying hens increases with increasing PRM



Gold standard



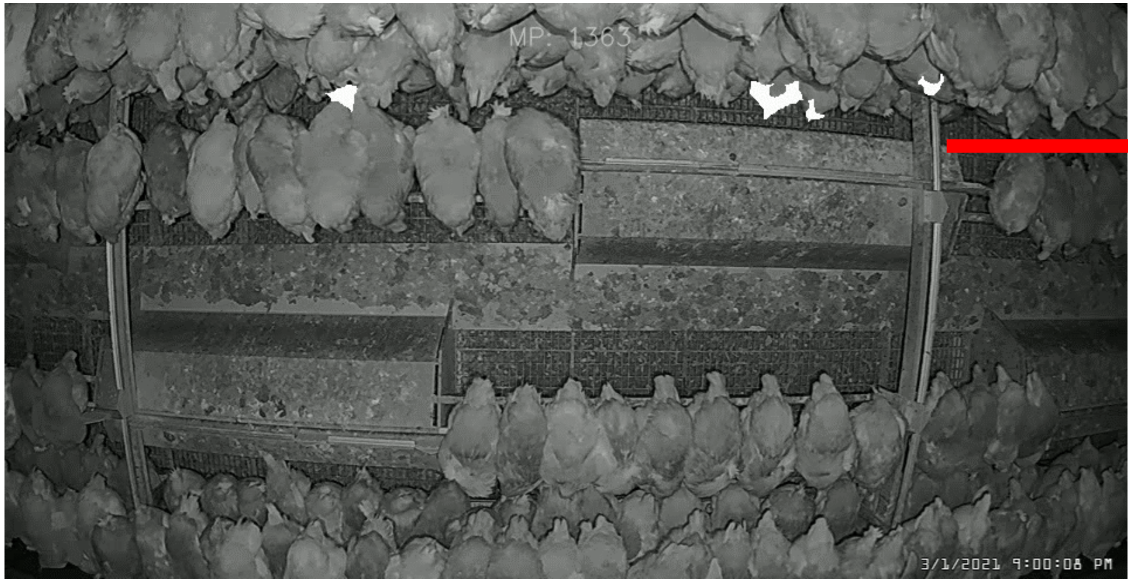




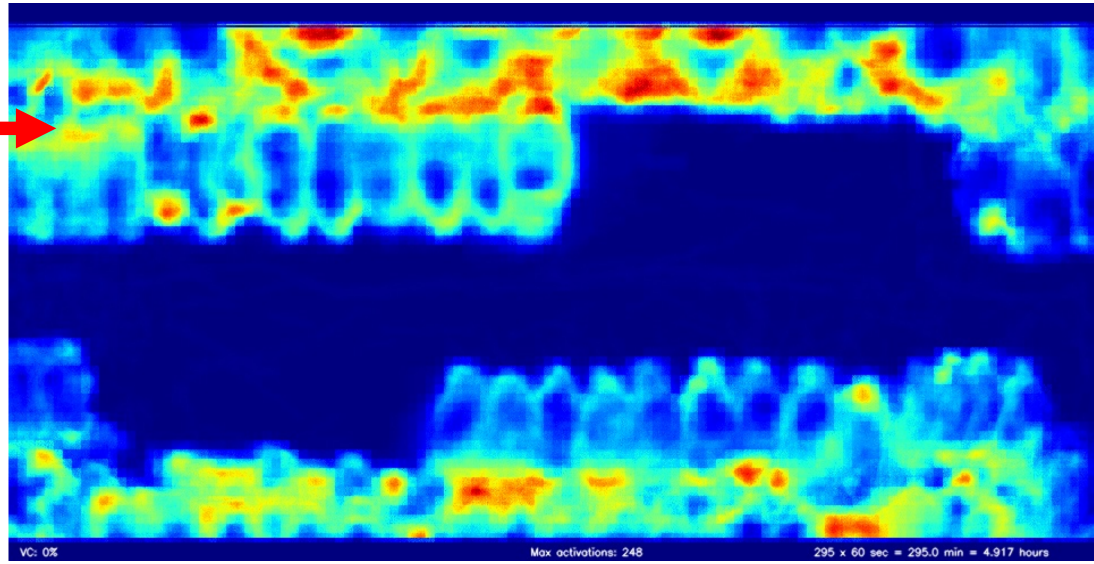
Capturing nighttime activity of hens and link to PRM → Early warning!

Sleep monitoring method

MOVEMENT MAP IS CREATED.



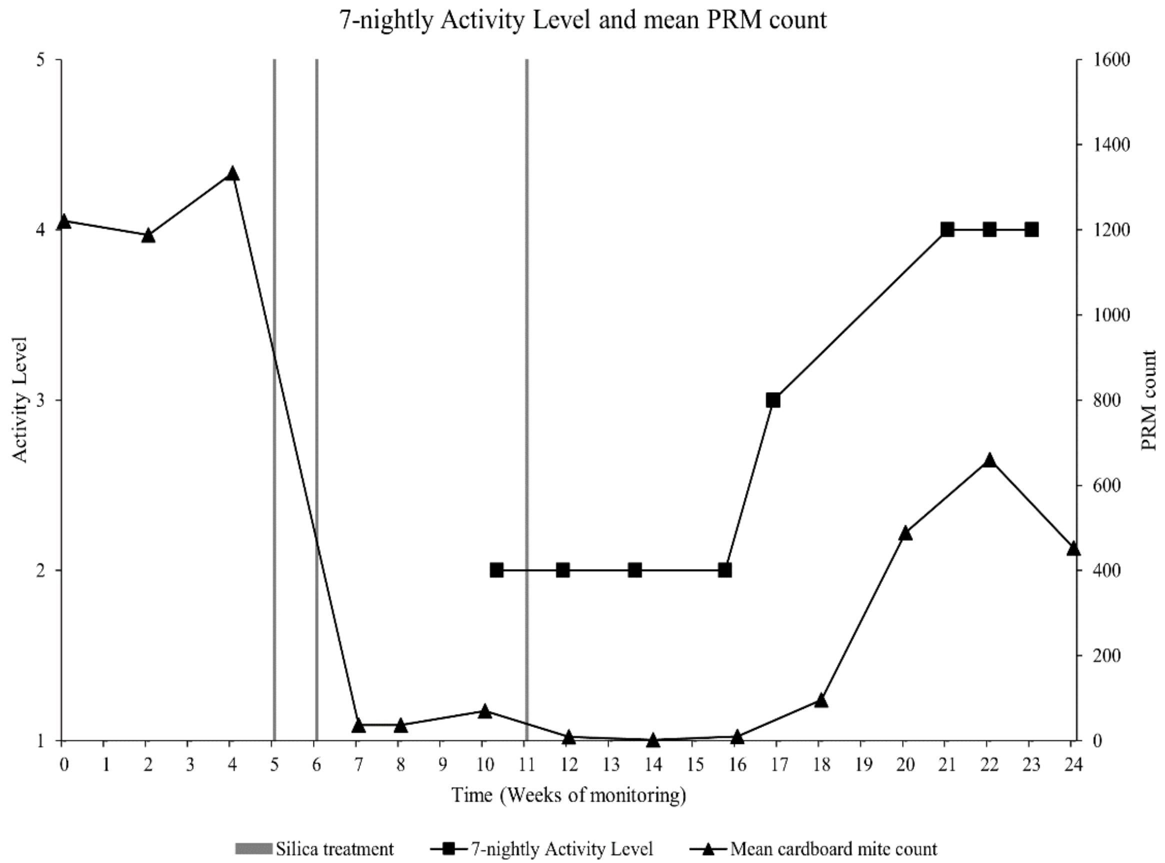
HEATMAP: TOTAL NIGHT



Willems et al (2022)

Restlessness indicator!

Results



__Advantage__

Activity level clearly represents the restlessness of the birds during the dark period

Clear meaning for an early warning system

__Disadvantage__

Needs more effort for clear value for farmer – likely need more monitoring functionality to be useful

Improving beyond the baseline PLF monitoring (weighing example)

Combining data from different devices

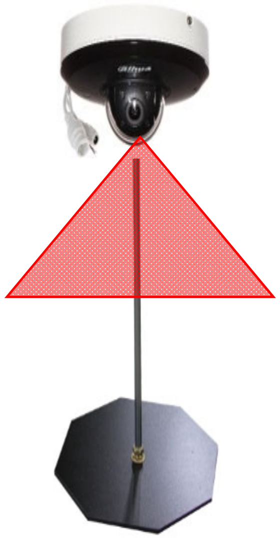
Improving the broiler-breeder weighing?

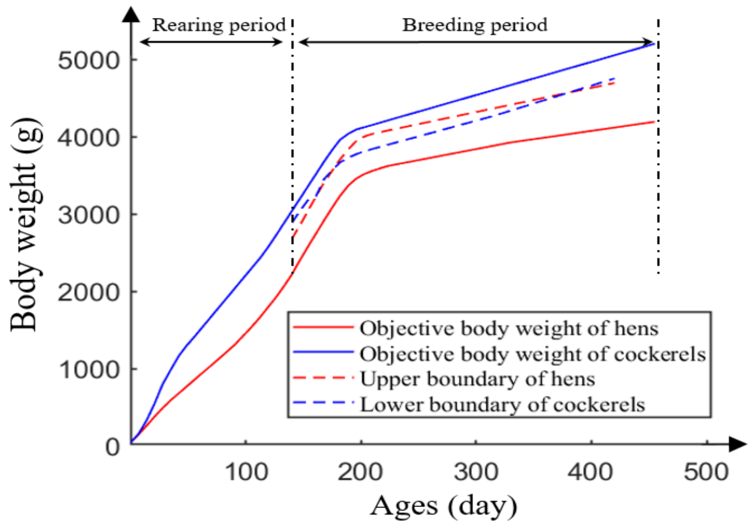
Motivation

- Breeding in a ratio of 10:1 (female: male) with different food supply
- Make rooster/hen follow empirical growth curve to maximum fertile eggs
- Non-uniform growth causes overlap

Objective

- Find more robust feature to separate rooster and hen

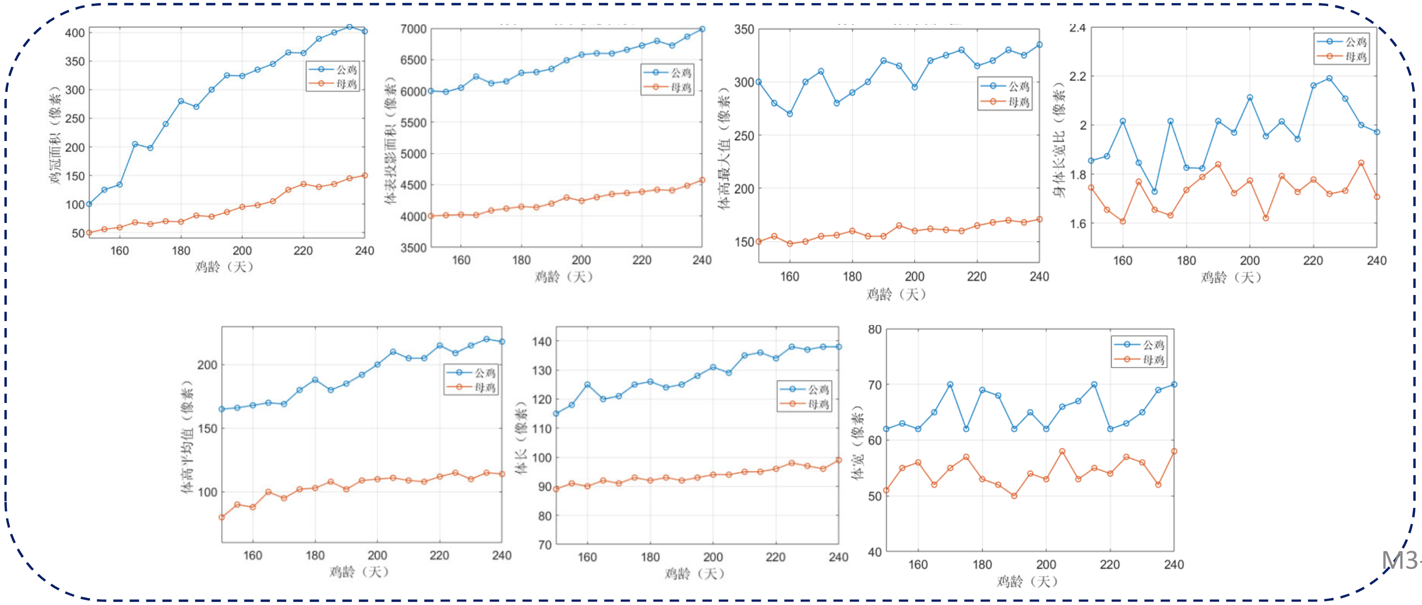


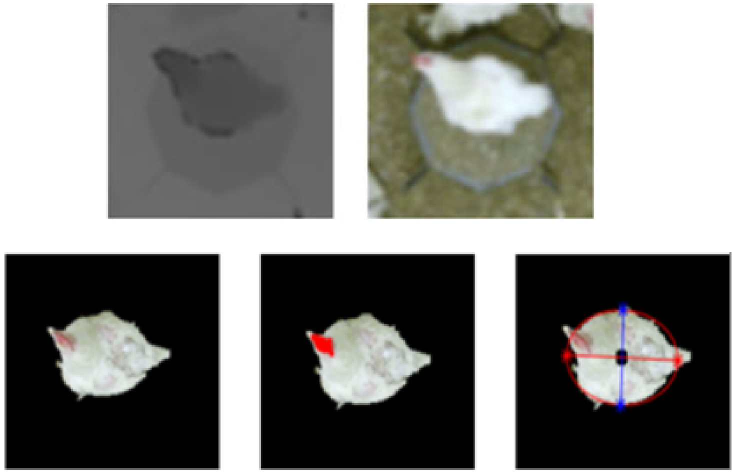


Time spent in the laboratory…

Features:

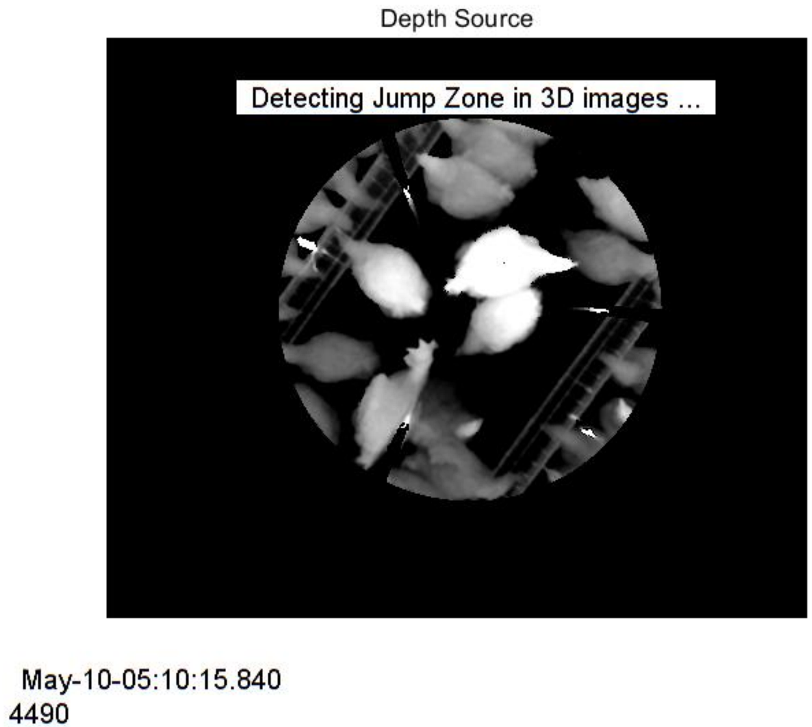
- Body area
- Body height (max&mean)
- Body length
- Body width
- Body ratio (height/width)
- Comb size





Liu et al. (2020)

Time spent in the field…

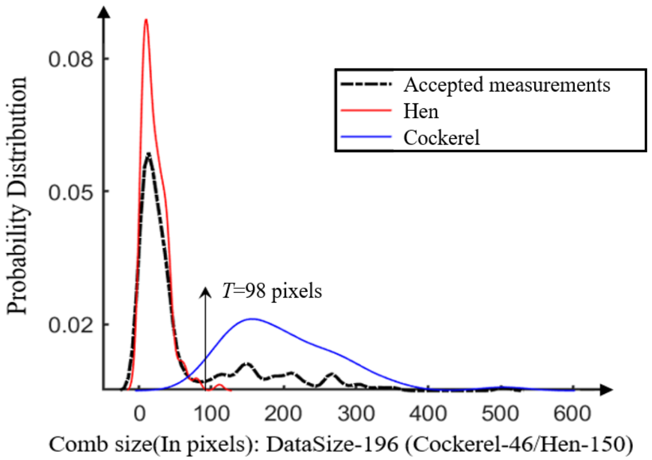


- Jumping action pattern (frame-wise rising)

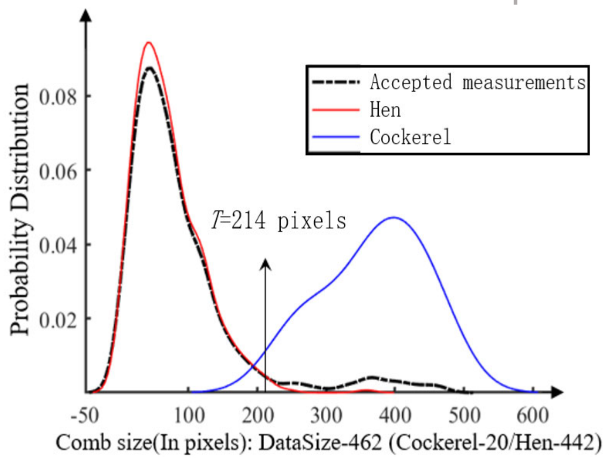
Result

Camera+weight

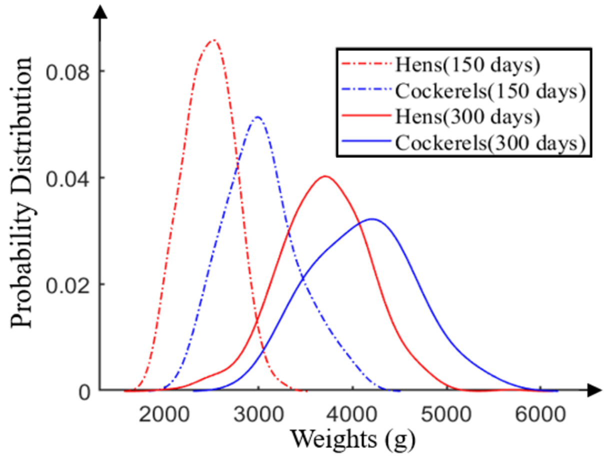
Weight alone



150-day-old



300-day-old



Weight

Liu et al. (2020)

Technical Outcome

- Science based
- Validated in the field
- Technology available

Real Impact

- Expensive: limited appeal to industry
- Results published

Development of Automated Process Management solutions

Application of Robotics

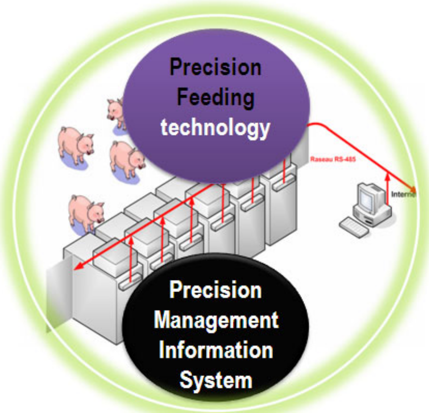
Robotics has already infiltrated

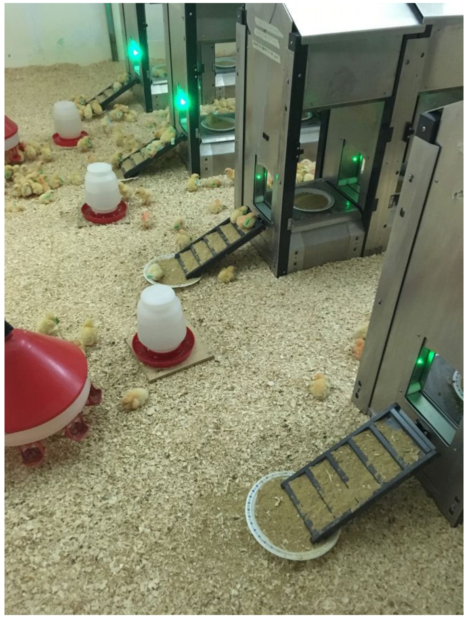
- Robotic milking is a success
- But is there a <u>killer application</u> for other sectors?
- Need to do more than just replace the farmer?

Sophisticated robotics are needed for precision feeding

Business arguments for individual feeding

- Group-fed animals = feed high loss
- Oversupply of nutrients





https://www.feedstrategy.com

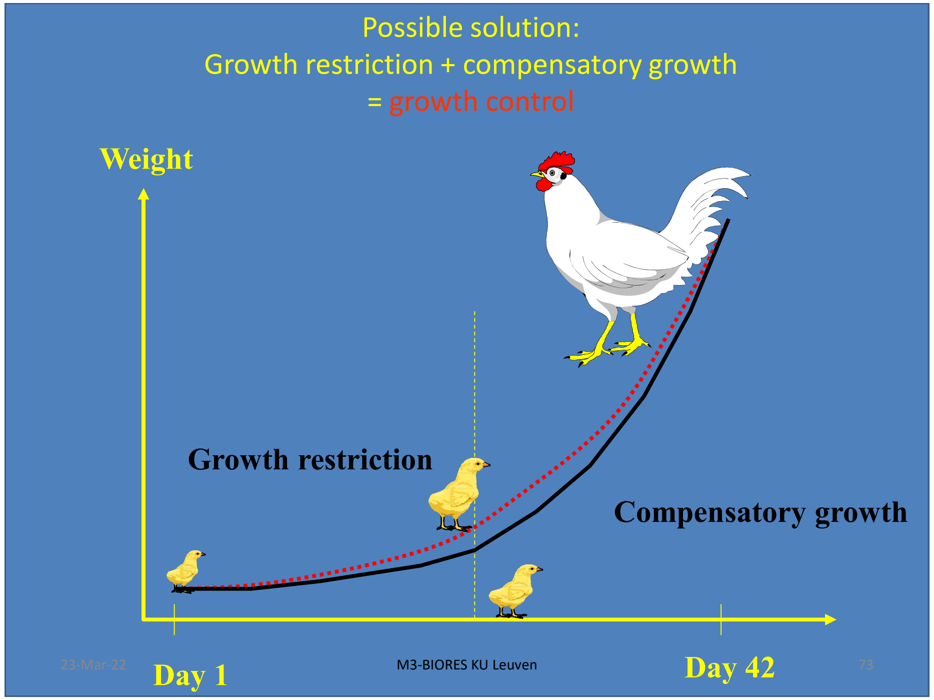
Components of precision feeding are available:

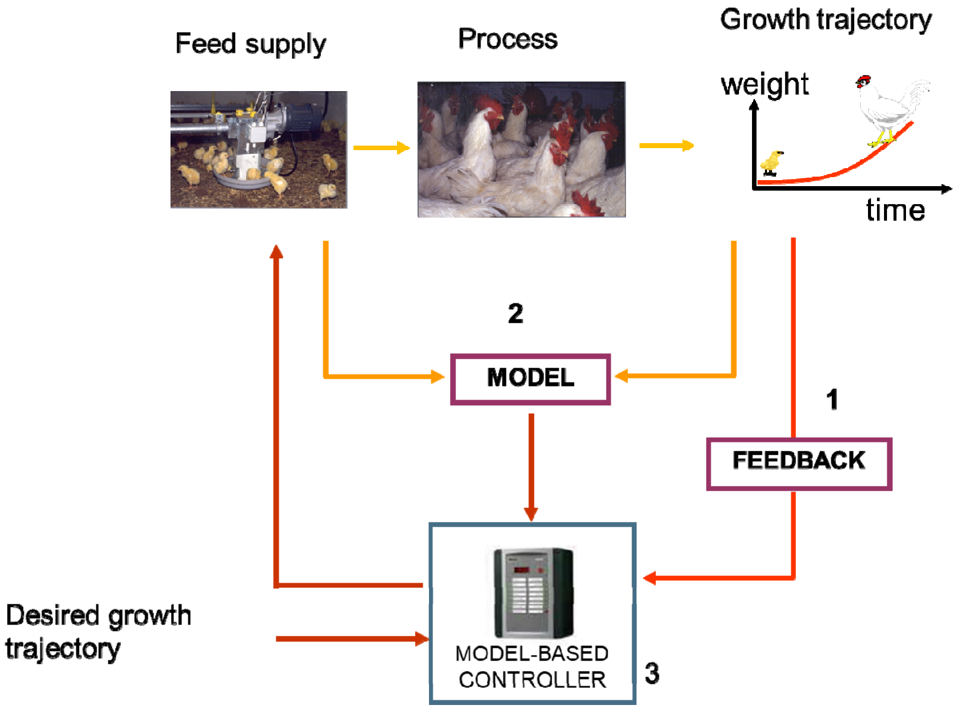
- **Measuring devices** (scales for body weight and feed)
- **Real-time models** (e.g., estimating real-time nutrient requirements, etc.)
- **Actuators** (e.g., Intelligent feeders, etc.)

	Precision *vs.* Conventional feeding	
Variable	**Trial 1**	**Trial 2**
Feed intake	n.s.	n.s.
Weight gain	n.s.	n.s.
Protein deposition	n.s.	n.s.
Lipid deposition	n.s.	n.s.
Protein intake	**< 16%**	**< 16%**
Lysine intake	**< 27%**	**< 26%**
Nitrogen excretion	**< 22%**	**< 30%**
Feeding cost, $/pig	**< 8%**	**< 10%**

Haushild et al. (2014); Pomar et al., (2014, 2016)

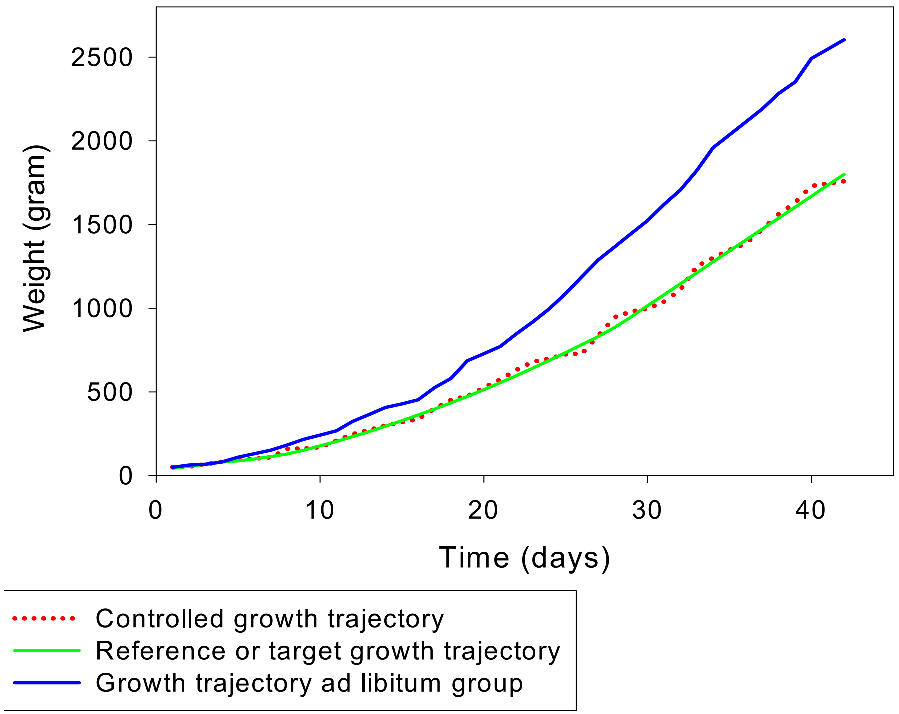
More sophistication = more risks



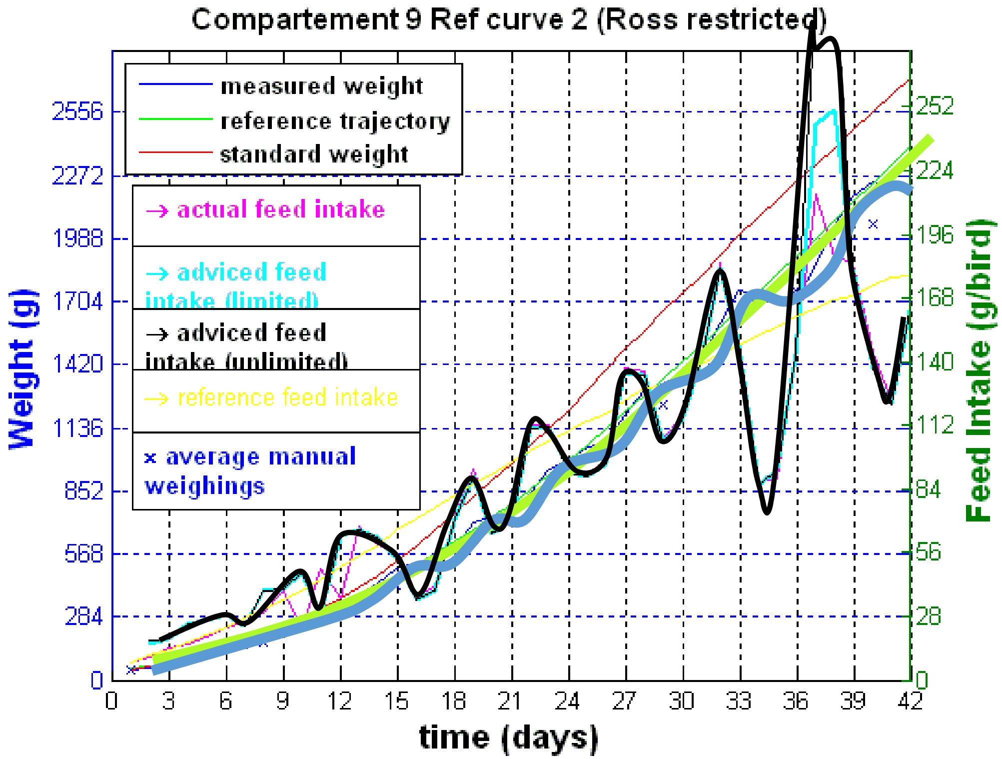


Cangar et al. (2008)

More sophistication = more risks going from lab to field



In the laboratory



In the field

Risk in bringing tech early the market

- Flockman – science based technology
- 15% of the market initially
- Teething problems are High Risk

Wathes (2010)

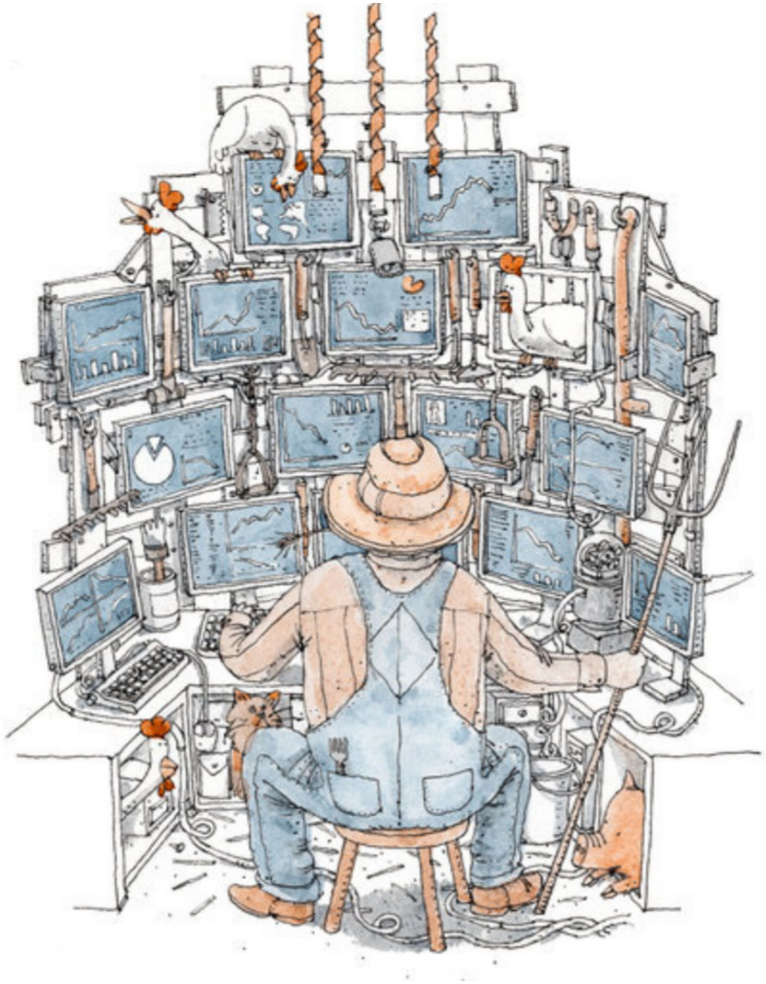
PLF adoption is about more than technology

a. Commercial potential needs to justify development:
   - Depends on the stakeholder: genetics/health/productivity

b. Farmers need to be willing to take up the solution:
   - Early warning versus advice

c. Business models should be clear:
   - Market driven
   - Incentivised

What we need to avoid!



Take home messages:

1. Coarse indicators of behaviour change from PLF technology are of limited value to farmers. More interesting to target on important applications where value is clear

2. Combining technology are more accurate but additional hardware costs

3. Robotic solutions to achieve precision feeding can be of high impact but requires accurate sensing solutions and confident market introduction

What is certain!

- Faster implementation of PLF needs collaboration between researchers, farmers, industry and other stakeholders!

Thanks for your attention

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Find out more about us at: www.m3biores.com

Acknowledgements

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FANCOM
forward thinking

Funders

AGENTSCHAP INNOVEREN & ONDERNEMEN

SEVENTH FRAMEWORK PROGRAMME

KU LEUVEN

Interreg North-West Europe
EUROPEAN UNION
MiteControl
European Regional Development Fund