The PigIT Closing Conference

Book of Presentations I

Tuesday, November 13th, 2018, University of Copenhagen

PigIT Report No. 10 • November 2018

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This note is also available on www at URL:
http://www.pigit.net/publications/PigIT-Report10.pdf

Centre for Herd-oriented Education, Research and Development
Department of Veterinary and Animal Sciences
University of Copenhagen

Contents

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Affiliate partners of PigIT:

Supported by:

Chapter 1

The Closing Conference

1.1 Welcome

It is a great pleasure to welcome our international and Danish connections from science and industry to this event where we share the results and experiences of the seven year research project within the field of precision pig farming.

The PigIT project, with the full title *Improving welfare and productivity in growing pigs using advanced ICT methods*, is a strategic research alliance supported by the Danish Council for Strategic Research. It was initiated in 2012 and was, originally, planned to run for five years. It has later been extended by two years.

The partners of the alliance are University of Copenhagen, Aarhus University and the Danish Pig Research Centre. The private companies TNM A/S, Skov A/S and AgroSoft A/S (from 2014) have been affiliated partners.

The scientific objectives of the project have been to develop and improve methods for

1. Model based production and welfare monitoring, and

2. Model based decision support

The themes of the program reflect those two objectives, and the day concludes with perspectives for the future.

1.2 Program

1.2.1 Arrival and registration

The registration desk opens at 9:30 where also a cup of coffee is served.

1.2.2 Theme 0: PigIT - motivation and core concepts

Chair: *Lene Juul Pedersen*

10:00 The ideas behind the PigIT project. *Anders Ringgaard Kristensen*, University of Copenhagen

1.2.3 Theme 1: Model based production and welfare monitoring

Chair: *Lene Juul Pedersen*

10:30 A dynamic approach to monitoring of growth in finishers. *Anna Helena Stygar*, University of Copenhagen (present affiliation: Luke, Finland)

10:50 Automatic learning and pattern recognition using sensor data. *Dan Børge Jensen*, University of Copenhagen

11:20 Coffee break

1.2.4 Theme 1 (continued): Model based production and welfare monitoring

Chair: *Dan Børge Jensen*

11:40 Spatial modeling of drinking patterns as a tool for reducing alarms in pig production. *Katarina Nielsen Dominiak*, University of Copenhagen (present affiliation: SEGES, The Pig Research Centre)

12:10 Behavioral changes preceding tail biting and pen fouling in slaughter pig pens. *Lene Juul Pedersen*, Aarhus University

12:30 Using machine learning to predict tail-biting, fouling and diarrhea in pigs. *Yuvraj Domun*, Harper-Adams, United Kingdom

12:50 Lunch

1.2.5 Theme 2: Model based decision support

Chair: *Anders Ringgaard Kristensen*

13:50 Models and methods for optimization of pig production in a stochastic environment. *Reza Pourmoayed*, Aarhus University (present affiliation: Grundfos)

14:20 From raw data to optimal sow replacement decisions - an integrated solution. *Jeff Hindsborg*, University of Copenhagen

14:40 Coffee break

1.2.6 Theme 3: Where to go from here

Chair: Nils Toft

15:00 The IQinAbox project. *Thomas Nejsum Madsen*, Nejsum Aps

15:20 Ambitions for machine vision. *Dan Børge Jensen*, University of Copenhagen

15:40 Plenary discussion. *All presenters*

16:00 Closing

Chapter 2

Book of presentations I

2.1 Theme 0: PigIT - motivation and core concepts

Chair: Lene Juul Pedersen

2.1.1 The ideas behind the PigIT project

Presentation by Anders Ringgaard Kristensen

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Kick-off seminar, March 8th 2012

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The PigIT alliance 2012 – 2018, who are we?

A strategic research alliance entitled:

- PigIT - Improving welfare and productivity in growing pigs using advanced ICT methods

Strategic vision:

- To create the strongest possible Danish alliance within the field of Precision Livestock Farming (Pigs)
- An internationally leading centre for PLF

Partners:

- University of Copenhagen, Department of Veterinary and Animal Sciences
- Aarhus University, Departments of Animal Science and Economics and Business
- Pig Research Centre

Associate partners:

- TNM A/S
- Skov A/S
- AgroSoft A/S

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Phe PigIT alliance 2012 – 2018, who paid?

Source	DKK[1]	EUR[1]
The Danish Council for Strategic Research	20.0	2.67
University of Copenhagen	3.2	0.43
Aarhus University	2.7	0.36
SEGES, Pig Research Centre	4.4	0.59
Companies	0.8	0.11
Total	**31.0**	**4.13**

[1] Millions

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Background

Finisher production in Denmark is under pressure - Increasing export of live piglets to Germany, Poland and other countries

For the Danish finisher production to regain its competitiveness, drastic changes are expected:

- Much larger units
- Less labor input

A consequence will be an increasing number of pigs per employee leaving less time for direct (human) observation of the pigs

Welfare and productivity will be challenged

Smart continuous monitoring by sensors might be one of the ways to go!

Hypothesis: It is the hypothesis that

- a systematic placement of cheap sensors in the production pens
- combined with methodological developments to integrate the information from these sensors will improve the production process.
- The potential benefit will be seen in productivity as well as in the welfare of the animals in the systems.

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PigIT

The PigIT alliance: Societal objectives

The societal objective of this alliance is to contribute significantly to the competitiveness of the Danish slaughter pig industry while still ensuring a satisfactory level of animal welfare.
This will provide a basis for future commercial products with an international market perspective.

The work packages!

- Growth and feed consumption
- Tail biting
- Diarrhea
- Pen fouling
- Optimal feeding and marketing

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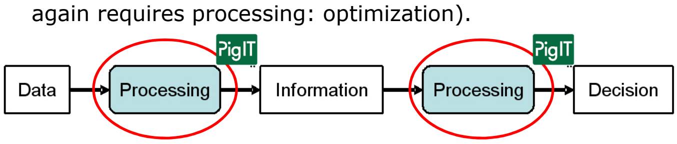
PigIT

From data to information to decision

- We refer to a collection (typically in a database) of registrations of the same kind as *data.*
- We don't use data directly for decision making (huge amounts of data).
- Before we can use data we need to reduce it through some kind of processing.
- The resulting information is used for decision making (which again requires processing: optimization).



- Most PLF projects only address the first part of the path from Data to Information (early warning systems, **monitoring**)
- The ambition of PigIT is also to cover the last part of the path from Information to Decision (optimization, **decision support**).

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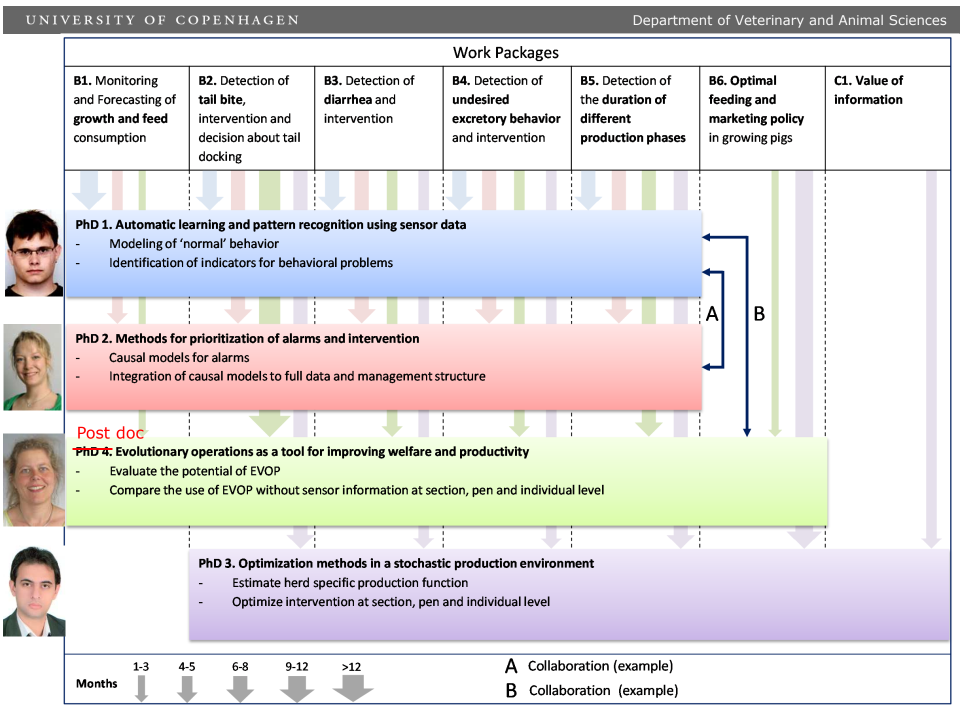
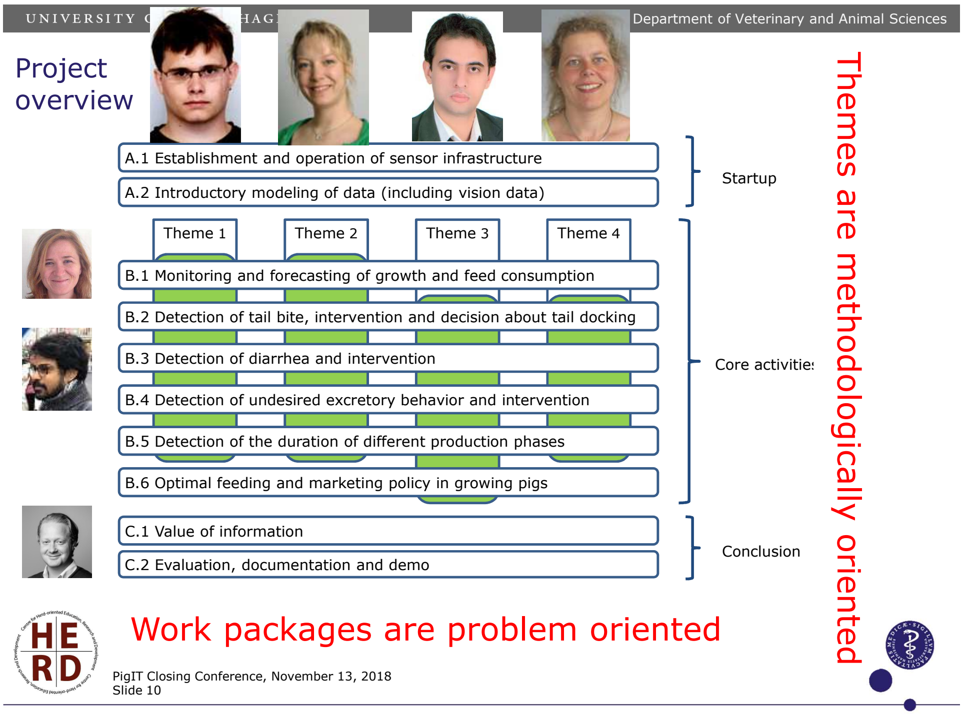
The PigIT alliance: Scientific objectives

The primary scientific purpose of the alliance is to develop and improve methods for

1. Model based production and welfare monitoring by,
   a) Optimizing the use of automatic measurements based on sensor technology.
   b) Improving links between data from different animals and different parts of the herd.
   c) Enhancing the early prediction and identification of reduced welfare and productivity.
2. Model based decision support by,
   a) Improving integration of data in the decision process by
      i. learning parameters from data and
      ii. implementing industrial methods for process design, control, and development.
   b) Ensuring optimal decisions by integrating indicators of animal welfare and productivity.
   c) Developing optimization algorithms, which can handle multiple decision criteria and multiple levels.

Slide 8 **The methodological themes (PhD projects)**





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Data and herds

The PigIT project has collected data in several herds:

- Finishers
  - An experimental herd at Research Centre Foulum, Aarhus University
  - An experimental herd owned by the project partner SEGES, Pig Research Centre, at Grønhøj (Central Jutland)
  - A private herd in Thy (North-Western Jutland)
  - A private herd in Southern Jutland.
  - A private herd with large pens and automatic weighing in Central Jutland
- Weaners
  - An experimental herd at Research Centre Foulum, Aarhus University
  - An experimental herd owned by the project partner SEGES, Pig Research Centre, at Grønhøj (Central Jutland)
  - A private herd in Southern Jutland.

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Types of data in the PigIT project – pen level

Sensor data:
- Temperature
- Water ”consumption”

Feeding system (often two-pen level):
- Feed intake by feedstuff per day

Processed video data:
- Weight assessment
- Activity

Unprocessed video data

Farmer: Supplementary observations
- Diarrhea
- Tail biting
- Pen fouling
- Pigs inserted/removed
- Manual weighing (selected pens)

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Types of data in the PigIT project – other levels

Section level
- Climate system:
  - Temperature
  - Humidity

Technician
- Supplementary observations
- Text based logbook

Herd database (“commercial”)
- Batch information
- Feedstuff “analysis”

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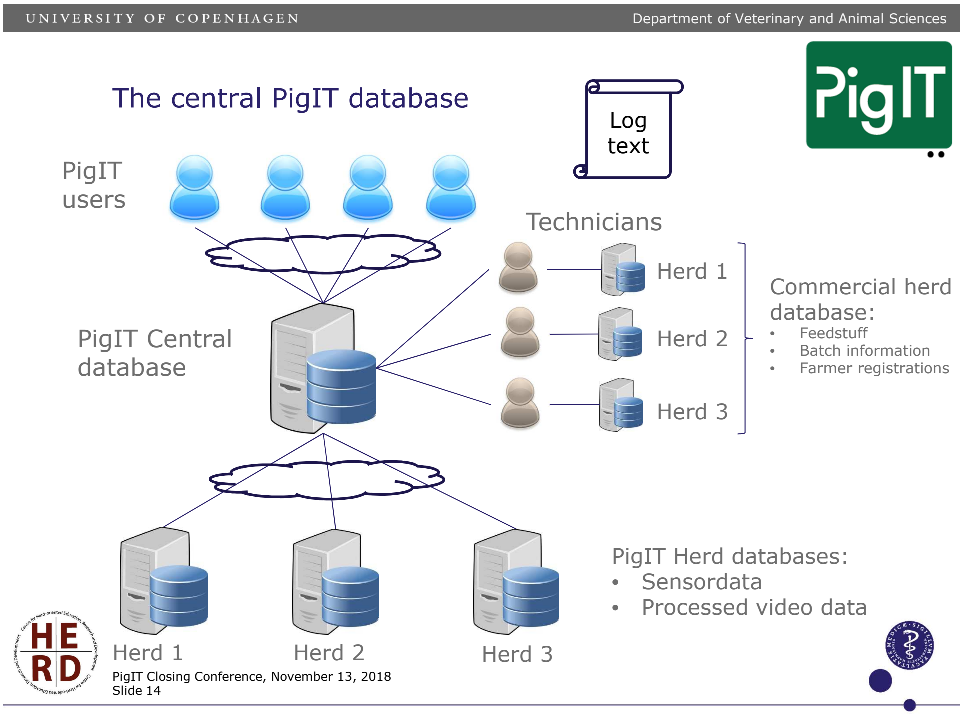
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The central PigIT database
Log text
PigIT
PigIT users
Technicians
Herd 1
Herd 2
Herd 3
Commercial herd database:
Feedstuff
Batch information
Farmer registrations
PigIT Central database
PigIT Herd databases:
Sensordata
Processed video data
Herd 1
Herd 2
Herd 3
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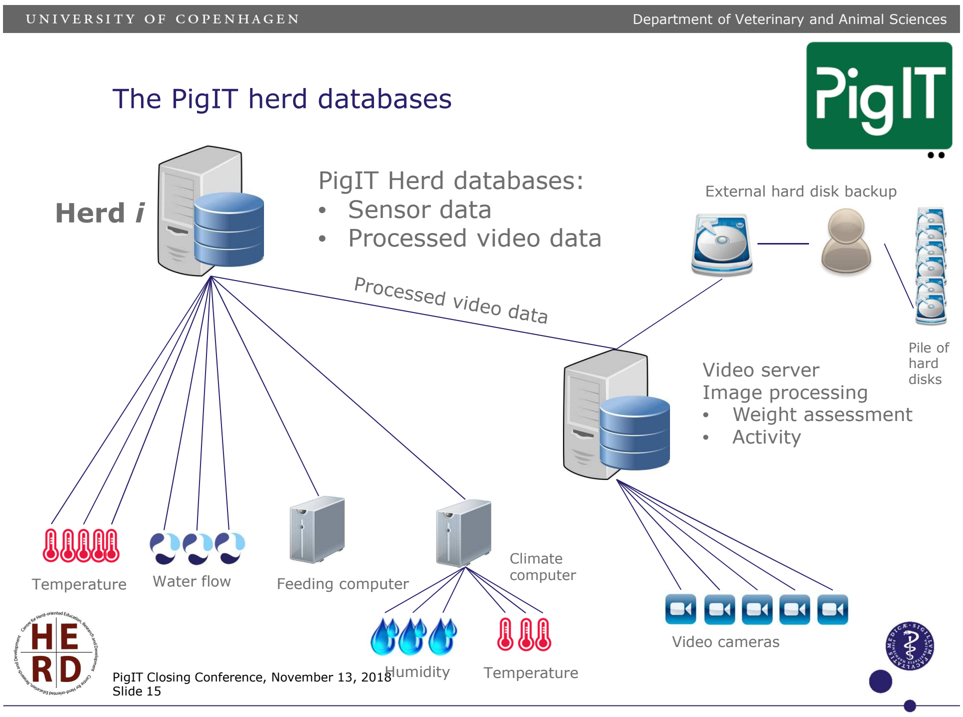
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The PigIT herd databases
PigIT
Herd i
PigIT Herd databases:
Sensor data
Processed video data
External hard disk backup
Processed video data
Pile of hard disks
Video server
Image processing
Weight assessment
Activity
Temperature
Water flow
Feeding computer
Climate computer
Humidity
Temperature
Video cameras
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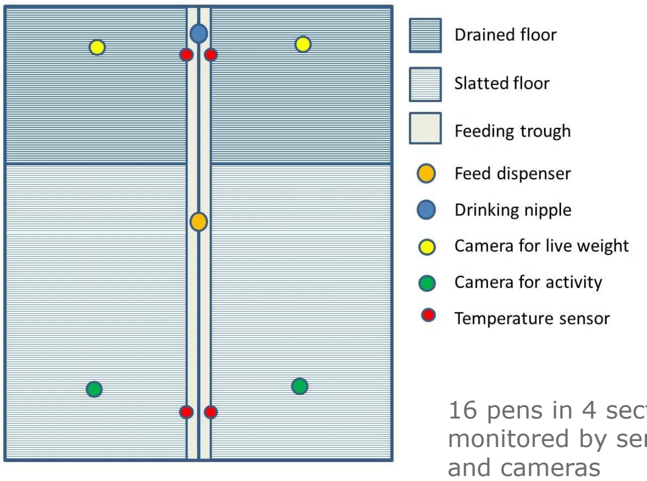
Sensors as installed in two experimental pens



16 pens in 4 sections are monitored by sensors and cameras

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A dynamic approach to monitoring of growth in finishers

Presentation by Anna Helena Stygar, post doc in PigIT.

Work package:
B.1:Monitoring and forecasting of growth and feed consumption.

Contribution to scientific objectives:

1. Model based production and welfare monitoring by,
   a) Optimizing the use of automatic measurements based on sensor technology. Automatic weighing system.
   b) Improving links between data from different animals and different parts of the herd. Herd, batch and pig level
   c) Enhancing the early prediction and identification of reduced welfare and productivity. Reduced productivity

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Automatic learning and pattern recognition using sensor data

Presentation by Dan Børge Jensen, PhD student, post doc and assistant professor in PigIT.

Work packages:

B.3: Detection of diarrhea and intervention

B.4: Detection of fouling and intervention

C.1: Value of information

Contribution to scientific objectives:

1. Model based production and welfare monitoring by,
   a) Optimizing the use of automatic measurements based on sensor technology. Multivariate framework: Water, feed, temperature, humidity ….
   c) Enhancing the early prediction and identification of reduced welfare and productivity. Diarrhea and fouling

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Spatial modeling of drinking patterns as a tool for reducing alarms in pig production

Presentation by Katarina Nielsen Dominiak, PhD student and post doc in PigIT.

Work packages:

B.2: Detection of tail biting, interv. and dec. about tail docking

B.3: Detection of diarrhea and intervention

B.4: Detection of fouling and intervention

Contribution to scientific objectives:

1. Model based production and welfare monitoring by,
   a) Optimizing the use of automatic measurements based on sensor technology. Water monitoring
   b) Improving links between data from different animals and different parts of the herd. Herd, batch and pen level
   c) Enhancing the early prediction and identification of reduced welfare and productivity. Tail biting, diarrhea and fouling

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Behavioral changes preceding tail biting and pen fouling in slaughter pig pens

Presentation by Lene Juul Pedersen, professor at AU.

Work packages:
B.2: Detection of tail biting, interv. and dec. about tail docking
B.4: Detection of fouling and intervention

Contribution to scientific objectives:

1. Model based production and welfare monitoring by,
   c) reduced welfare and productivity. Does behaviour change when tail biting and fouling occur?

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Using machine learning to predict tail-biting, fouling and diarrhea in pigs

Presentation by Yuvraj Domun, Harper-Adams University, visiting PhD student in PigIT

Work packages:
B.2: Detection of tail biting, interv. and dec. about tail docking
B.3: Detection of diarrhea and intervention
B.4: Detection of fouling and intervention

Contribution to scientific objectives:

1. Model based production and welfare monitoring by,
   a) Optimizing the use of automatic measurements based on sensor technology. Water monitoring, temperature etc
   c) Enhancing the early prediction and identification of reduced welfare and productivity. Tail biting, diarrhea and fouling

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Models and methods for optimization of pig production in a stochastic environment

Presentation by Reza Pourmoayed, PhD student in PigIT

Work package:
B.6: Optimal feeding and marketing policy in slaughter pigs

Contribution to scientific objectives:

2. Model based decision support by,
   a) Improving integration of data in the decision process by
      i. learning parameters from data and Learning growth and feed intake
   b) Ensuring optimal decisions by integrating indicators of animal welfare and productivity. Productivity
   c) Developing optimization algorithms, which can handle multiple decision criteria and multiple levels. Herd constraints

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From raw data to optimal sow replacement decisions - an integrated solution

Presentation by Jeff Hindsborg, research assistant in PigIT

Work package:
C.2: Evaluation, documentation and dissemination

Defined deliverables from work package:

a) Visual prototypes of a monitoring and decision support system. Not just a prototype but a working software tool due to a separate grant from a levy foundation

b) Closing conference where the most important results of the activities are presented – That's why we are here

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The future – where to go from here

Two presentations:

1. IQinAbox – presentation by Thomas Nejsum Madsen. Implementation an commercialization of scientifically based monitoring methods
2. Ambitions for machine vision presented by Dan Børge Jensen, the CYBELE project

Discussion

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PigIT

Thank you to:

Those who helped us:

- The involved farmers and their staff
- The technicians from SEGES Pig Research Centre
- The technical staff at Aarhus University
- The international Advisory Board

Those who paid:

- The Danish Council fort Strategic Research
- SEGES Pig Research Centre
- University of Copenhagen
- Aarhus University

The Danish Council for Strategic Research

Our affiliate partners:

- TNM A/S
- Skov A/S
- AgroSoft A/S

And last, but not least, to

Those, who did the work:

- The PigIT project group

All of you for listening!

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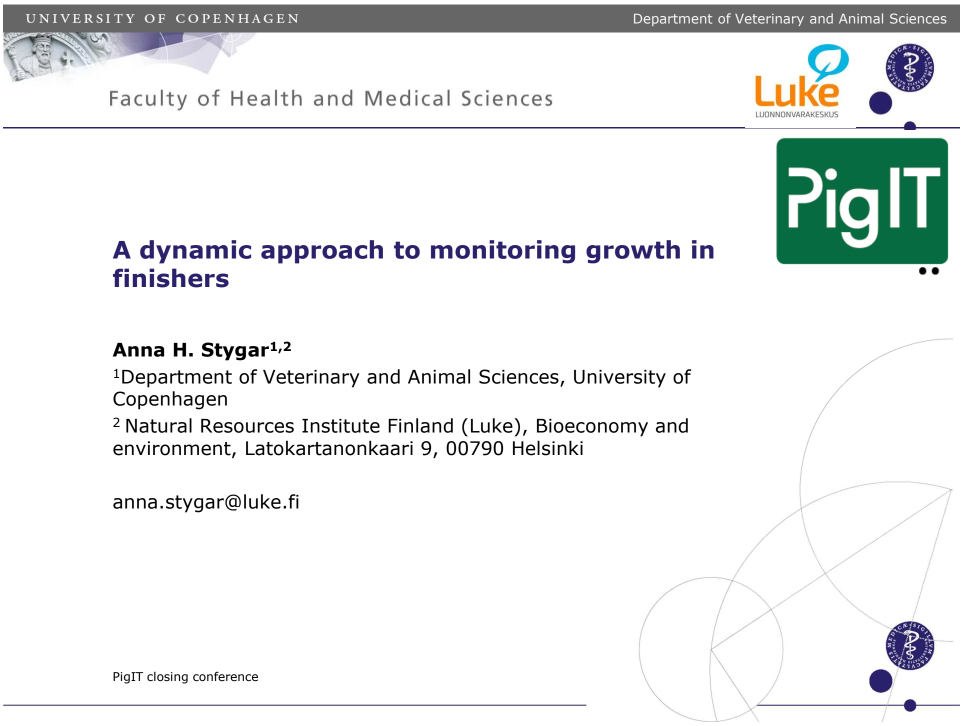
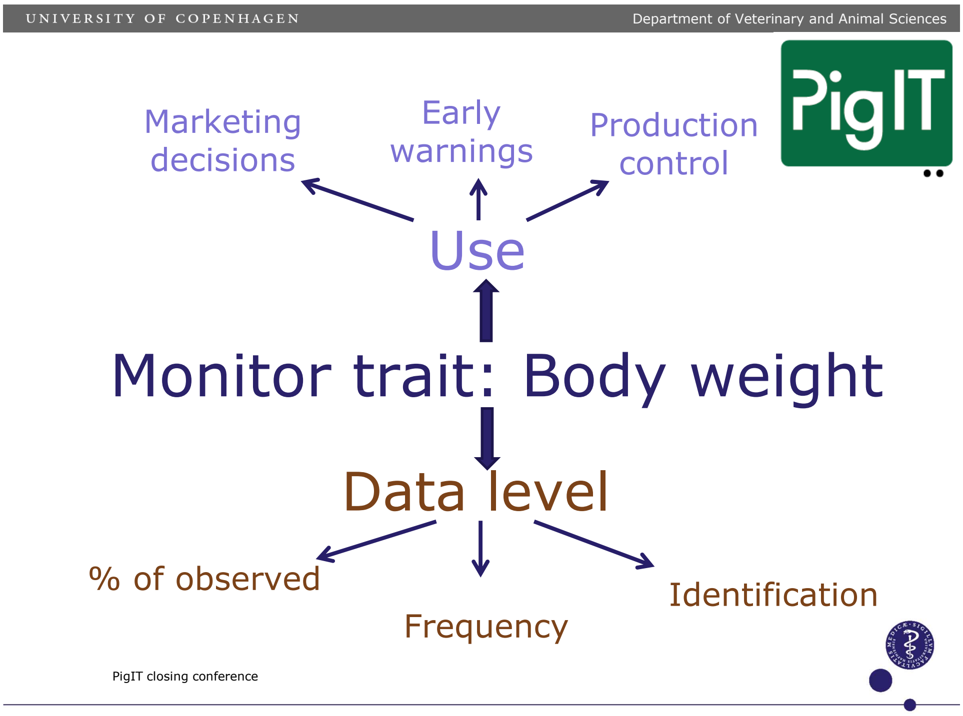
2.2 Theme 1: Model based production and welfare monitoring

Chair: Lene Juul Pedersen and Dan Børge Jensen

2.2.1 A dynamic approach to monitoring of growth in finishers

Presentation by Anna Helena Stygar





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Objectives of this study

- To construct models for growth monitoring and forecasting for finishers using:
  - ❑ the data from traditional BW monitoring based on selected group of pigs (Study 1)
  - ❑ the data from frequent BW monitoring (Study 2)
    - ➢ Individually identified pigs (alarms for the whole batch and individual pigs)
    - ➢ Unidentified pigs (raising alarms for the whole batch)

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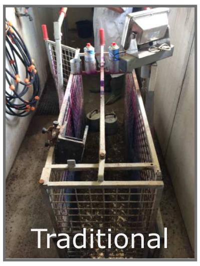
Material and methods

- 2 farms



- Nr of pigs 12,568
- Nr of observations: 397,157

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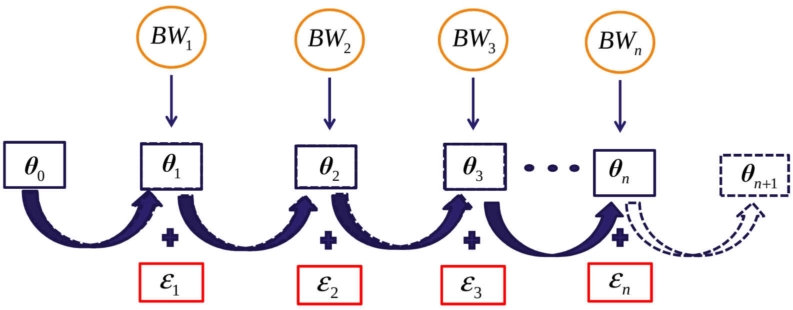
Material and methods

Dynamic linear model (DLM)



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Study 1

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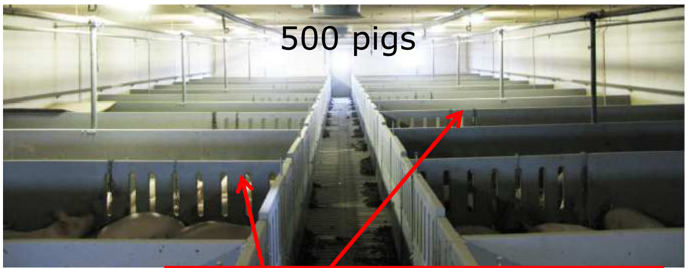
Study 1



15% of pigs in a control group

- ~ 600 BW observations
- 1 BW/pig from selected group/week
- **growth control and delivery strategy**

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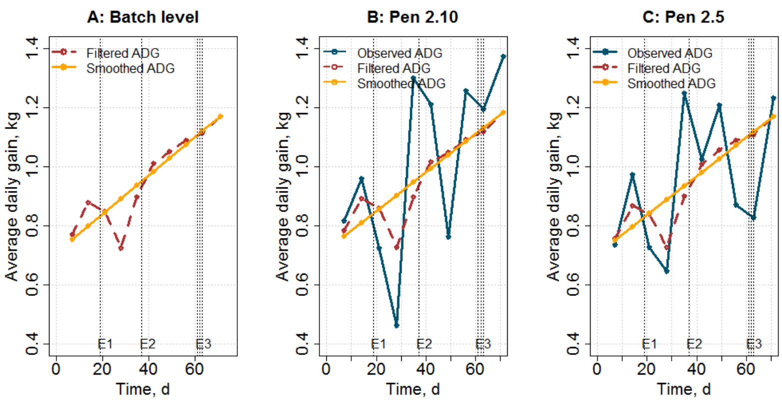
Study 1 - results

DLM for production control at batch and pen level



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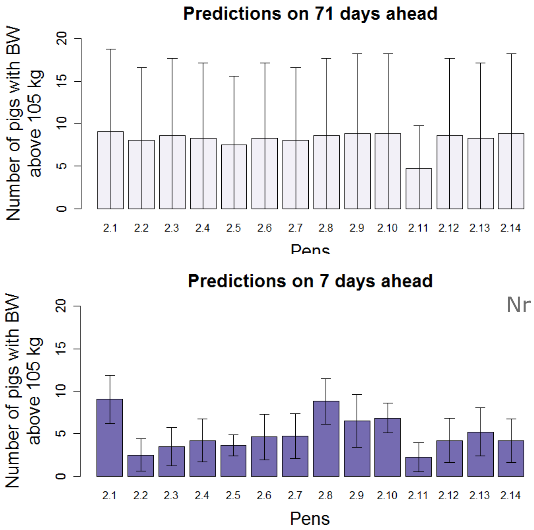
Study 1 - results

DLM for predicting the number of pigs ready to market



Nr of BW observations= 0

MAD=3.6 pig
CV = 102%

Nr of BW observations ~ 1100

MAD=1.6 pig
CV = 24%

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PigIT

Study 2

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Study 2

PigIT

- 40,000 -60,000 BW observations
- 3.1 -4.5 BW/pig/day
- currently provides delivery strategy

Growth alarms for identified and unidentified pigs?

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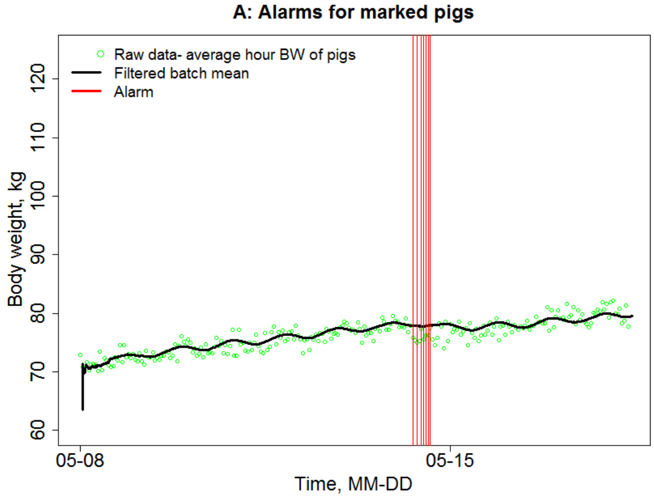
Study 2 - results

DLM with diurnal growth pattern



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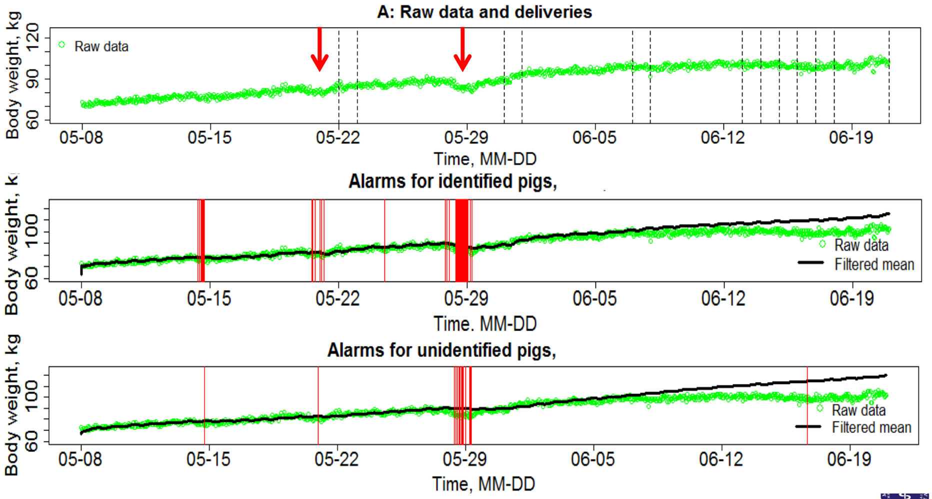
Study 2 - results

Alarms for identified and unidentified pigs



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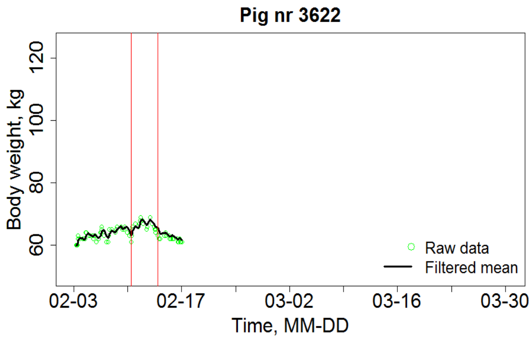
Study 2 - results

Alarms for individual pigs



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Conclusions

- Few new solutions for BW monitoring (3 models):
  - Production control
  - Predicting number of pigs ready to market
  - Frequent monitoring
- Flexible tools – using different level of information
- New view on BW in pigs for frequent monitoring – diurnal pattern
- Batch level alarms on growth are possible with unidentified pigs

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Perspectives for future research and for pig farming

- Economic analyses on value of information
- Combining frequent BW observations with other sensor data
- Testing and calibrating constructed models at a farm level
- Possible application for assessing effect of an intervention (e.g. change in feeding strategy, new vaccinations, modified herd management)

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Study 1

Monitoring growth in finishers by weighing selected groups of pigs – A dynamic approach1 doi: 10.2527/jas.2015-9977

Study 2

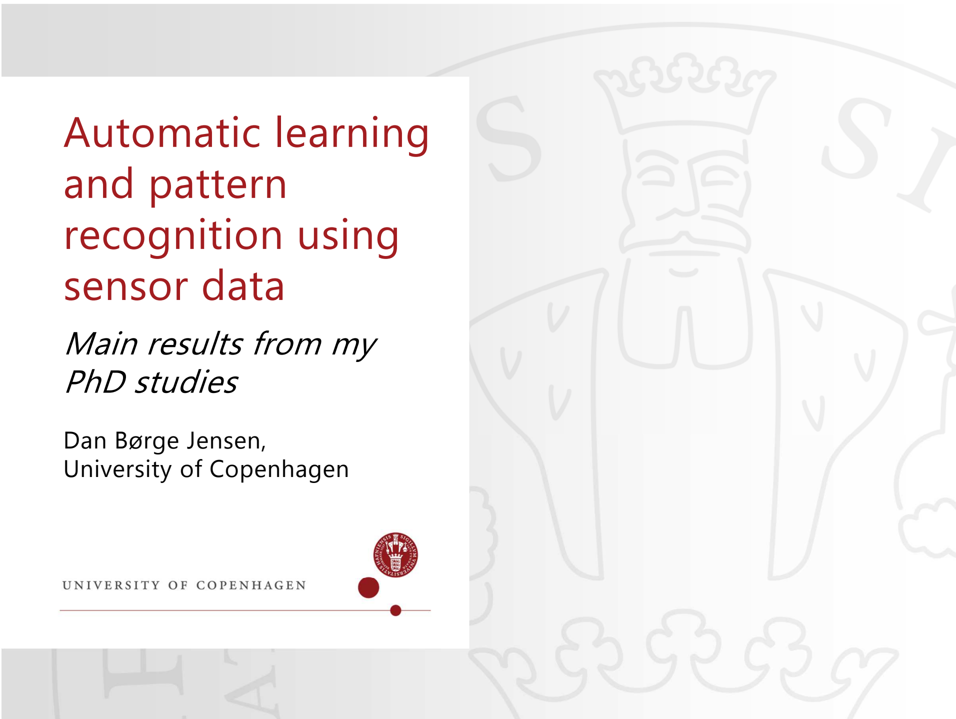
Analyses of body weight patterns in growing pigs: a new view on body weight in pigs for frequent monitoring
doi: 10.1017/S1751731117001690

Detecting abnormalities in pigs' growth – A dynamic linear model with diurnal growth pattern for identified and unidentified pigs
doi: 10.1016/j.compag.2018.10.004

Thanks to:
PigIT
The Danish Council for Strategic Research
Anonymous farmers

2.2.2 Automatic learning and pattern recognition using sensor data

Presentation by Dan Børge Jensen



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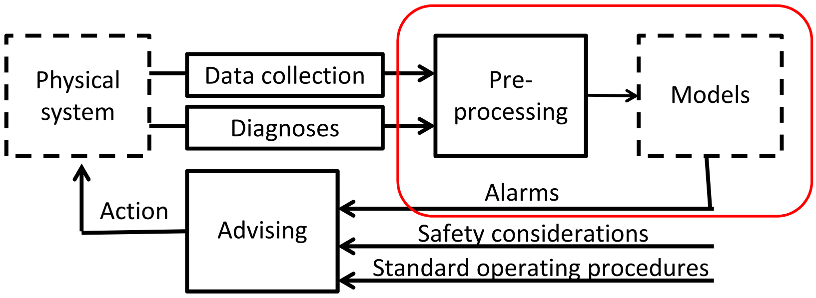
Introduction (1)

- ***The model-based monitoring system***



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Introduction (2)

+ 4 conference papers
+ 2 papers in review
+ some still-unfinished work

FINDINGS

Paper 1

Pen level environment matters!

Published in Livestock Science:

Jensen, D.B., Toft, N. & Cornou, C., 2014.
The effect of wind shielding and pen position on the average daily weight gain and feed conversion rate of grower/finisher pigs.
Livestock Science, (167), pp.1–9.

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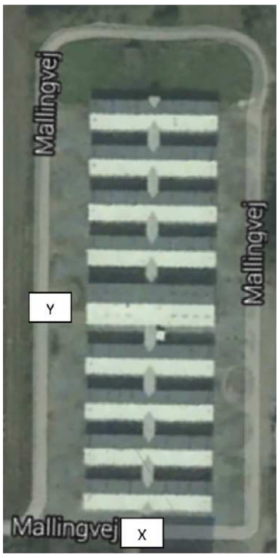
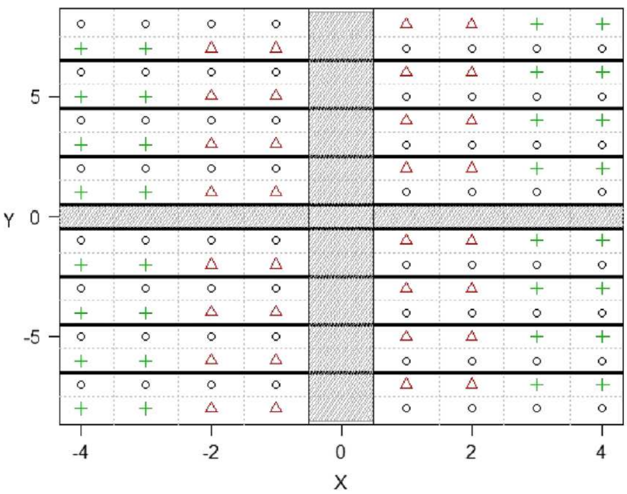
Pen level environment matters! (1)





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Pen level environment matters! (2)

Weekly live weight measurements

Automatic monitoring of feed consumption

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Pen level environment matters! (3)

Results:

- ***Shielding***
  - Unshielded pigs grow more slowly during the winter
  - Larger-than-average pigs grow faster without shielding (except in the winter)
  - The feed conversion rate was not affected

- ***Distance from section entrance***
  - Larger-than-average pigs grow faster when placed away from the section entrance
  - Average daily feed intake was larger for pigs placed away from the entrance
  - The feed conversion rate was not affected

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FINDINGS

Paper 2

Pen-level temperature predicts undesired events (pen fouling or diarrhoea)

Published in Livestock Science:

Jensen, D.B. & Kristensen, A.R., 2016.

Temperature as a predictor of fouling and diarrhea in slaughter pigs.

Livestock Science, 183, pp.1–3.

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Temperature predicts undesired events (1)

- **Assumption:**
- Probability of ***diarrhea and/or pen fouling*** depends on daily ***temperature summary*** variables, such as:

- Min. temperature
- Max. temperature
- Greatest temperature increase
- Greatest temperature decrease

8 variables in total

Variables	Estimate	Std. error	*p*-Value
(Intercept)	−12.78	3.53	0.0003
Maximum temperature, drinking nipple	−0.89	0.35	0.011
Minimum temperature, drinking nipple	1.24	0.43	0.004
Greatest temperature decrease, drinking nipple	−2.13	0.87	0.014
Greatest temperature increase, corridor	2.70	0.90	0.003
Greatest temperature decrease, corridor	1.53	0.89	0.086

Logistic regression model

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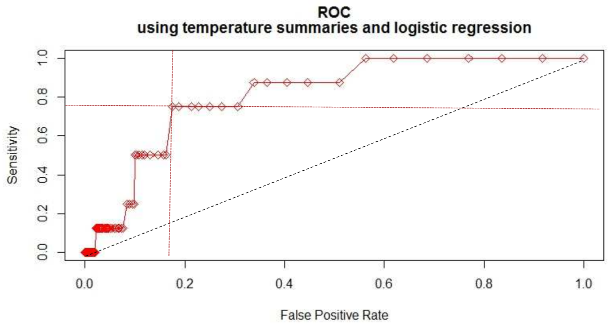
Temperature predicts undesired events (2)

- **Performance:**



AUC:
Diarrhea or pen fouling: 0.80

Pen-level temperature is informative!

FINDINGS

Paper 3

The DLM/Cholesky method can be used for indiscriminant event detection

Jensen, D.B., Toft, N., Kristensen, A.R., 2017. *A multivariate dynamic linear model for early warnings of diarrhea and pen fouling in slaughter pigs.* Computers and Electronics in Agriculture, 135, pp. 51–62.

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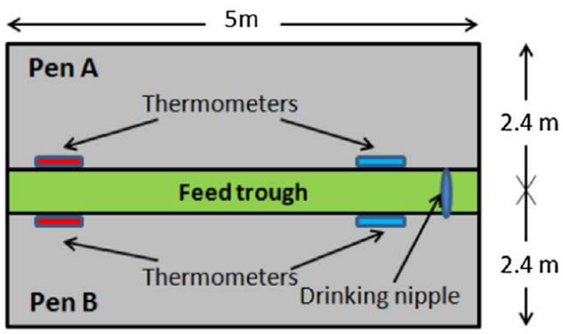
The DLM/Cholesky method (1)

Data source:
Commercial Danish pig farm
12 pens (6 double pens) , 3 grower/finisher periods
Events : Diarrhea (N=11) and pen fouling (N=13)



Data series:
- Temperatures
  - Resting area
  - Excretion area
- Drinking behaviour
  - L/hour/pig
  - Activations/hour/pig
- Feed usage
- Humidity (section level)

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The DLM/Cholesky method (2)
- the Dynamic Linear Model

- **Structure:**
- ***Observation equation***

$$Y_t = F_t' \theta_t + v_t, \qquad v_t \sim N(\underline{0}, V)$$

- ***System equation***

$$\theta_t = G_t \theta_{t-1} + w_t, \qquad w_t \sim N(\underline{0}, W)$$

θ_t	*Parameter vector*
F_t	*Design matrix*
G_t	*System matrix*
V	*Observational variance*
W	*System variance*

- **Usefulness:**
  - Monitoring of (production) systems over time
- **Features:**
  - Provides one-step-ahead forecasts, including estimated forecast variance
  - Dynamic, *i.e.* Adaptive

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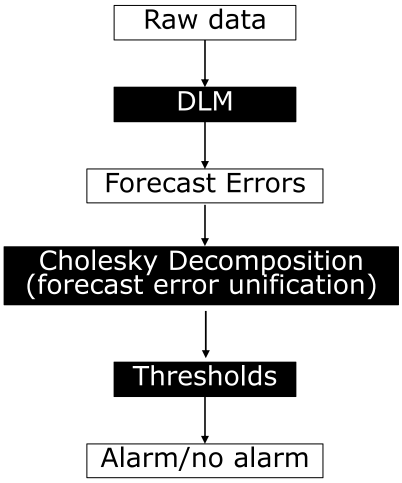
The DLM/Cholesky method (3)



The normality hypothesis:

IF "everything is fine" ***THEN*** "things progress as expected"

Therefore:

IF "things progress UN-expectedly" ***THEN*** "Something is wrong!"

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The DLM/Cholesky method (4)

- **Performance – which variables contribute?**

Omitted variables	AUC
None	0.84
Mean feed usage	0.84
Humidity	0.83
Temperature, excretion area	0.84
Temperature, resting area	0.84
Temperatures, excretion & resting area	0.84
Water flow	0.80
Drinking bouts frequency	0.78
Water flow & drinking bouts frequency	0.76

How many consecutive alarms?
(0-25 hours → ROC curve)

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The DLM/Cholesky method (5)

- **Performance – which variables contribute?**

Included variables	AUC
All	0.84
Feed amount and Humidity	0.52
Temperatures, excretion & resting area	0.75
Drinking behavior	0.84

Unlike Paper 2

How many consecutive alarms?
(0-25 hours → ROC curve)

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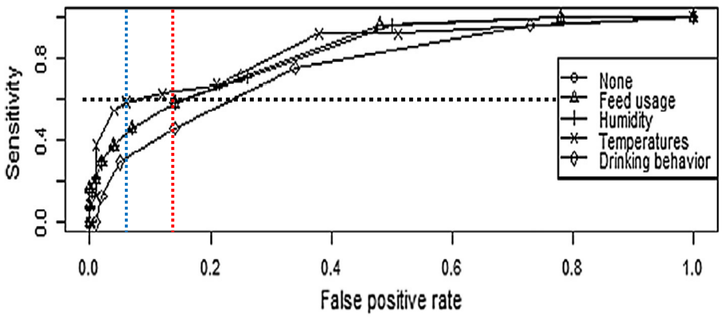
The DLM/Cholesky method (6)



Nothing omitted: AUC = 0.84 Se = 60 → Sp = 0.85

Temperature omitted: AUC = 0.84 Se = 60 → Sp = 0.95

How many consecutive alarms?
(0-25 hours → ROC curve)

Conclusions

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Main conclusions

Precision data are ***useful*** for detecting problems relating to health and welfare in animal production

Dynamic linear models can be used to meaningfully combine ***multiple diverse*** sources of information

- Can determine relative information values!

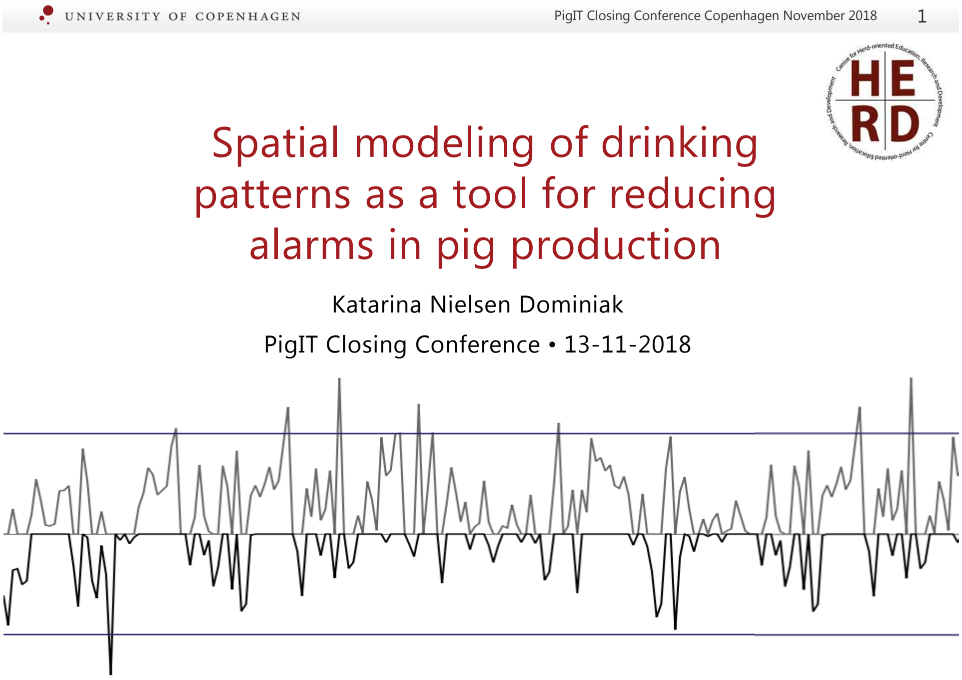
Temperature data and ***drinking behavior*** data are both ***informative***, with respect to undesired events

- However, they may be best utilized in different ways!

There is further ***potential for event-specific*** predictions

2.2.3 Spatial modeling of drinking patterns as a tool for reducing alarms in pig production

Presentation by Katarina Nielsen Dominiak



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Outline

- Background and basic ideas behind my study
- Objective of my study
- Materials and methods
- Main conclusions
- Future perspectives for research and for pig farming

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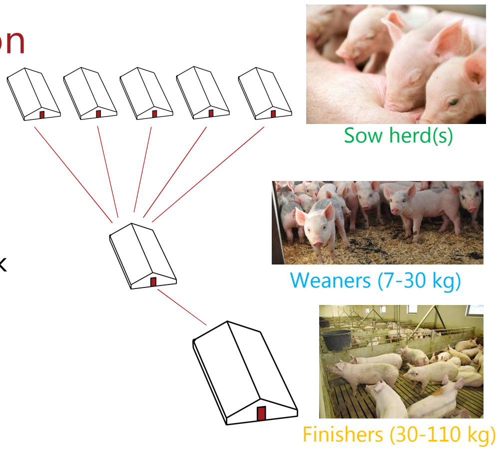
Modern pig production is centralized



More animals per herd → less time per animal during daily check

Early signs of outbreaks might be missed during a busy day

Sensor-based monitoring around the clock →

Real-time notifications of early signs of outbreaks →

Timely interventions may prevent actual outbreaks

A general challenge is:

Too many false alarms

- Costly and time consuming
- Diminish the trust in the detection system
- Devaluate the managerial value

Literature review:
Only three papers focus on methods for reducing false alarms
Dominiak and Kristensen (2018)

Sensor-based detection models - threshold

Low threshold →
- Few sick animals missed
- Many alarms for healthy animals

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One alarm may reflect multiple conditions

General wellbeing(1)

Tail bite?(2)

Stress behaviour?

Respiratory diseases?

Other causes?

Change in feed composition?

(1) Madsen (2005), Dominiak (2017)
(2) Dominiak et al (2018)

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Outline

- Background and basic ideas behind my study
- **Objective of my study**
- Materials and methods
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Objective of my study

To develop and evaluate a decision support system which

- Categorize
- Sort
- Prioritize
- Rank

the generated alarms

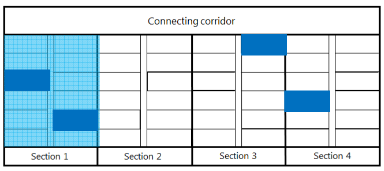
Spatial Decision Support System

- Area-specific alarms system
- Based solely on data from affordable water sensors (flow meters ~ € 45)

Predicts outbreaks of tail biting, diarrhea or pen fouling

Points out specific pens or sections with abnormal drinking patterns leading to outbreaks

The pointed areas are seen as FOCUS AREAS for management



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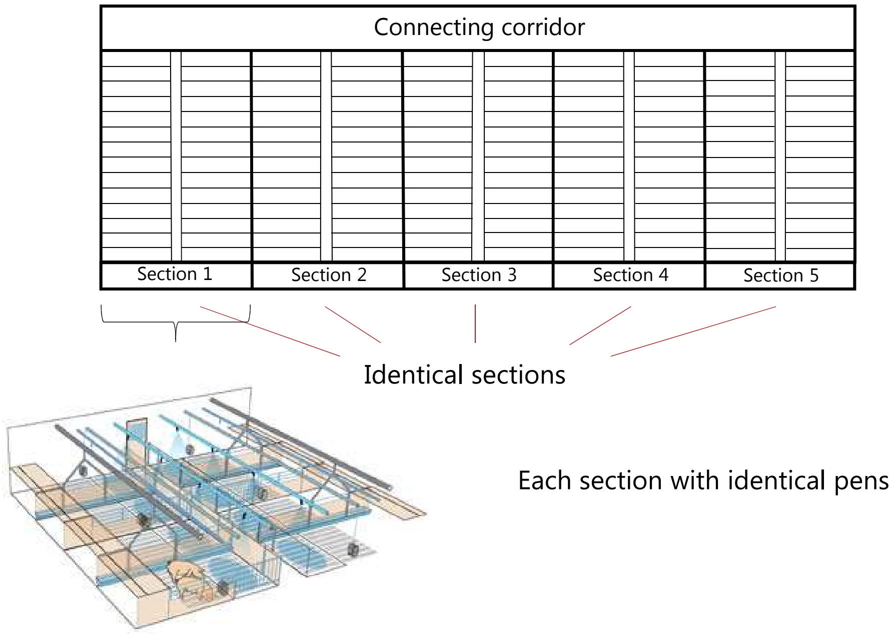

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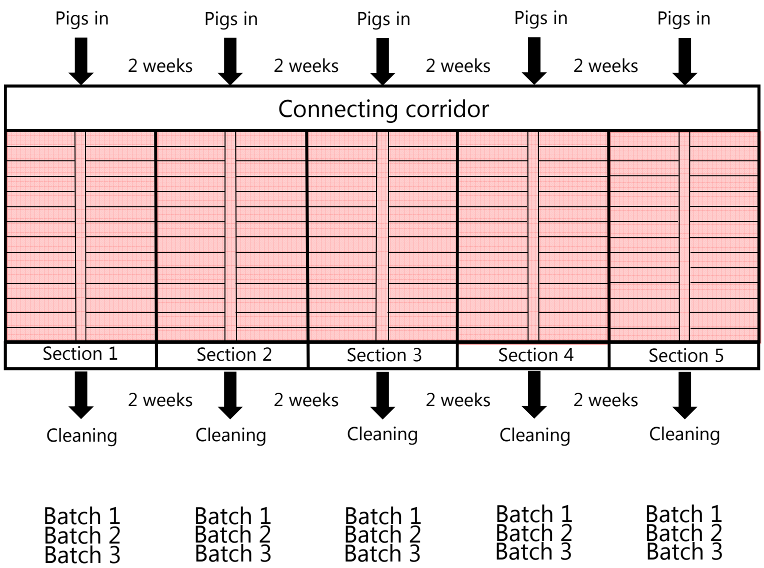
All-In-All-Out bio-security strategy improve animal health



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Outline

- Background and basic ideas behind my study
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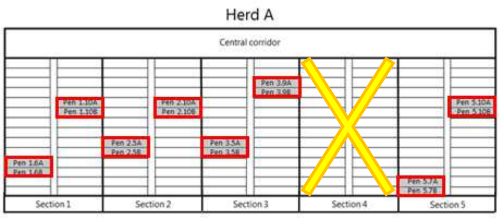
Materials



Herd A

- Finisher herd (30-110 kg)
- 4 sections – randomly chosen
- 8 sensors, each monitoring two pens (36 pigs)
- 7 batches (05/2014 – 03/2016)

Herd B

- Weaner herd (7-30 kg)
- 4 sections
- 16 sensors, each monitoring one pen (15 pigs)
- 13 batches (10/2014 – 12/2016)

Method

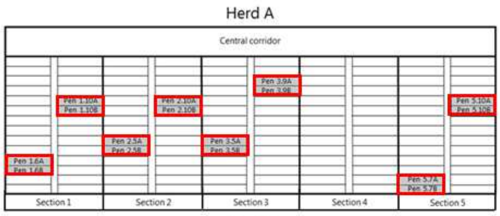
Each sensor in a herd constitutes one variable in a *Dynamic Linear Model* (DLM)

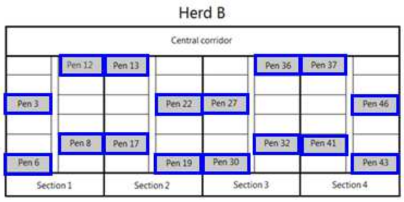
<u>Herd A</u>:
8 sensors → 8 time series of water consumption

<u>Herd B</u>:
16 sensors → 16 time series of water consumption

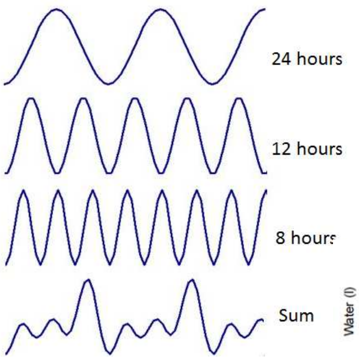
All sensors in a herd monitor simultaneously

Data is aggregated to litres/hour





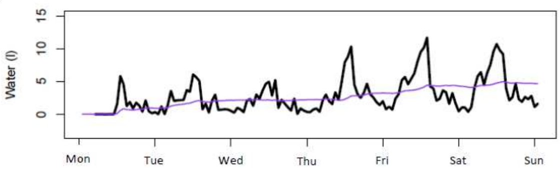
Method



Both finishers and weaners have diurnal drinking patterns

This diurnal pattern can be described by the sum of three harmonic waves

As pigs grow, they drink more water



The full drinking pattern is then described by three harmonic waves and a linear growth trend using a *Dynamic Linear Model*

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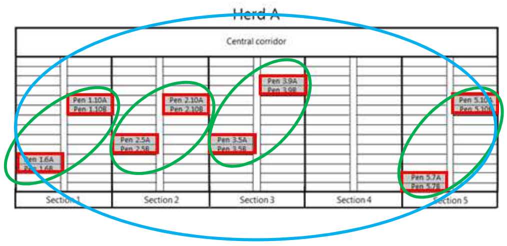
Method

A *Dynamic Linear Model* (DLM) aims to predict the next observation based on all prior observations.

The DLM learns the pattern of data from each sensor and predicts the next observation in each pattern

All new observations are added to the prior knowledge

Model is reset between batches



Interactions between drinking patterns are incorporated through variance components in the DLM:

- Pens within the same section are assumed correlated
- Sections within the same herd are assumed correlated

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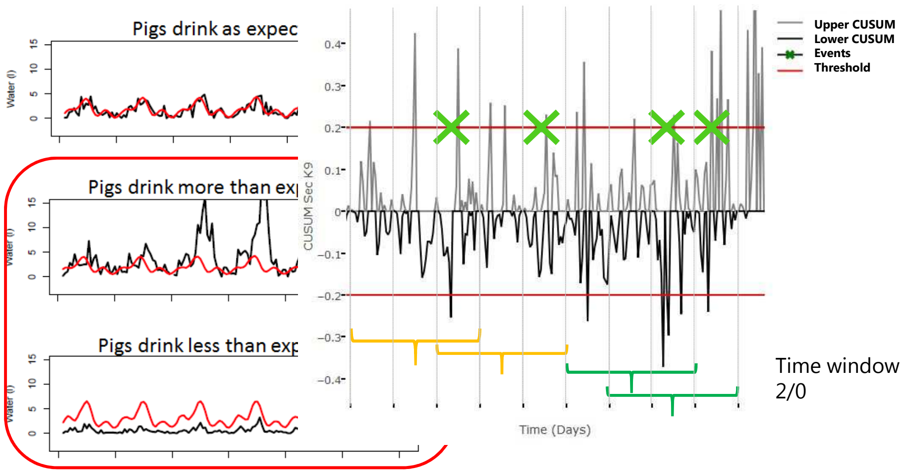
Method

Raw data, actual drinking pattern

Fitted, expected drinking pattern

Cumulated sum of forecast errors in Tabular Cusum

Forecast errors



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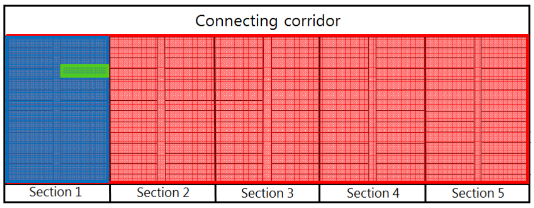
A few results

Unwanted events in any pen within the herd
AUC (48 hours) = 0.92

Unwanted events in a specific section in the herd
AUC (48 hours) = 0.87

Unwanted events in a specific pen in the herd
AUC (48 hours) = 0.87



Herd
Central water supply
Central feeding system
Central electricity

Section
Pigs of same age
Feed mixture
Climate control

Pen
Pigs of same gender/size

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Outline

- Background and basic ideas behind my study
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- Alarms for specific pens and sections point out high-risk areas with high accuracy
- Changes in drinking patterns tends to be related to multiple causes
- Productivity and animal welfare can be improved through automatic monitoring of water data

Outline

- Background and basic ideas behind my study
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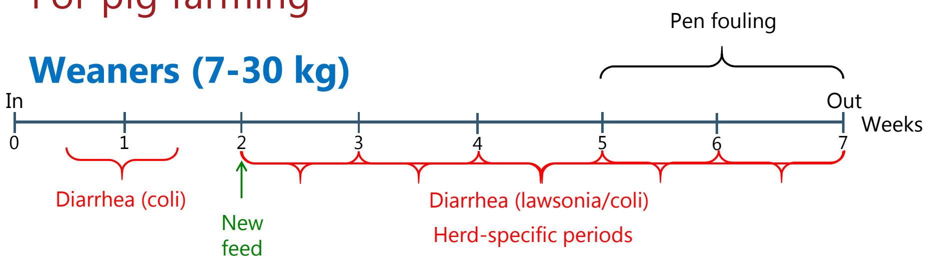
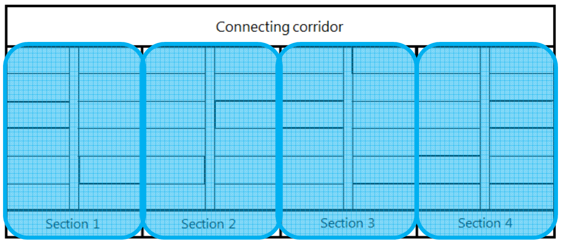
For pig farming



Alarms for specific pens can be added as additional information



Time after insertion: 0-1 week, 2-3 weeks, 4-5 weeks, 6-7 weeks

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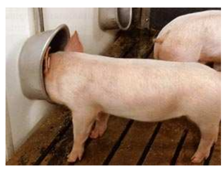
Management

- Climate
  - Ventilation settings/draft
  - Temperature settings
- Feeding system
  - Change in feed composition
- Water system
  - Blocked drinking nipple
  - Leaking drinking nipple
  - Sufficient water supply?



Reflected in Water consumption

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How to respond to area-specific alarms

- Check smart-phone interface
- Go to specific areas where alarms are generated
- If high risk of known condition – choose preventive intervention
- Otherwise check:
  - Climate/ventilation
  - Feeding system
  - Water system

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For research

- Include herd-specific knowledge
  - High-risk periods
  - Age and health status of pigs in a section
- Differentiate between higher and lower water consumption

THANK YOU

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SEGES Danish Pig Research Centre

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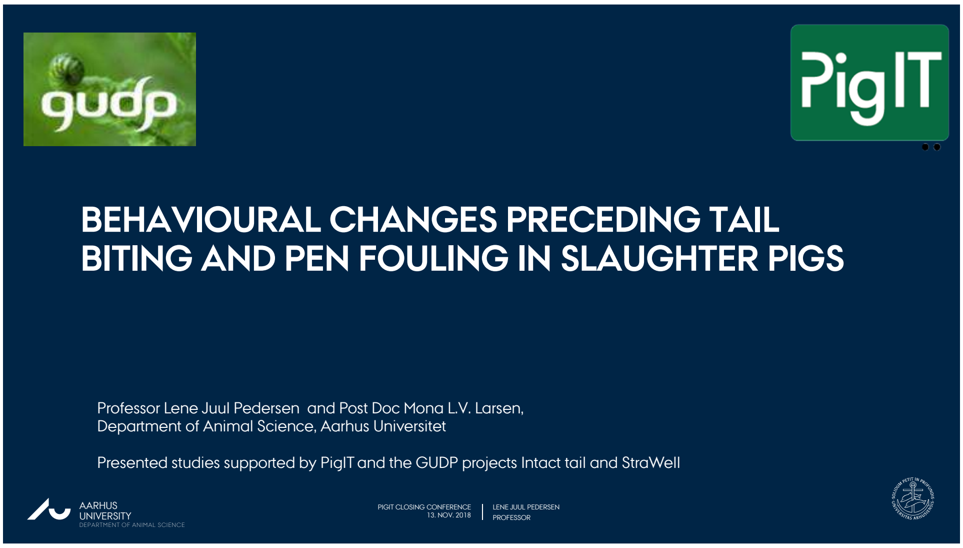
The Danish Council for Strategic Research

This research was funded by the Danish Council for Strategic Research (The PigIT project, Grant number 11-116191)

2.2.4 Behavioral changes preceding tail biting and pen fouling in slaughter pig pens

Presentation by Lene Juul Pedersen



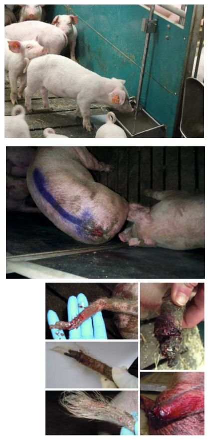
BEHAVIOURAL PROBLEMS IN PIG PENS

Tail Biting:

Redicreted explorative behaviour or sudden foreceful bites

Occurs as a result of increased stress => stress increases the motivation for explorative behaviour

Nothing to explore, behaviour is redirected towards other pigs tails => tail biting and tail damage



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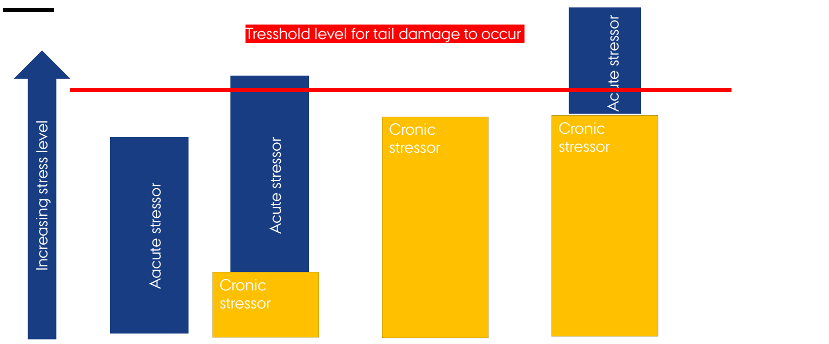
MANY RISK FACTORS ADD UP STRESS (VALROS, 2018)



Tail damage: an "iceberg indicator" for poor welfare

BEHAVIOURAL PROBLEMS IN PIG PENS

Pen fouling:

- When pigs starts dunging in the resting area
- Results in poor hygiejne, increased risk of disease, increased workload
- Risk factors: Inadequate temperatures and high stocking density- indicator of stressfull conditions
- Easily seen in pens with partly solid floor
  - Although pigs in slatted floor pens may be equally affected

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WHY EARLY WARNING ?

- Difficult to eliminate all risk factors – eg. changes in temperature
- Usefull to develop an early warning system
- Our task was to investigate:
  - Behaviours indicative of increased stress prior to tail damage?
  - Behaviours/thermal patterns indicating pen fouling will soon develop ?
  - Warning => intervention => negative events can be avoided

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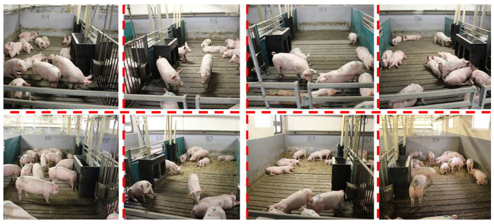
DATA COLLECTED IN EXPERIMENTAL HERD

112 pens with slaughter pigs (4 bcts)

Daily scoring of pen fouling
Pen fouling: >50 % of solid floor wet with faces and/or urine

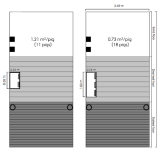
Careful insepction of each pig tail 3 times weekly
Tail damage pen: At least ONE pig with bleeding tail



Tails: docked vs. undocked

Straw: No straw vs. 150 g straw per pig per day

Space/group size: 0.73 m²/pig (18 pigs) vs 1.21 m²/pig (11 pigs)



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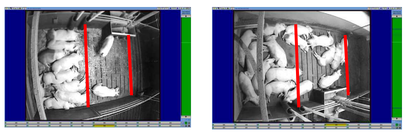
BEHAVIOUR PRIOR TO PEN FOULING

- Pigs lying pattern day -5 to 0 before pen fouling occured observed from video
- Paired control pens and outbreak pens on same days
- Did lying pattern differ between control and pen fouling pens ?



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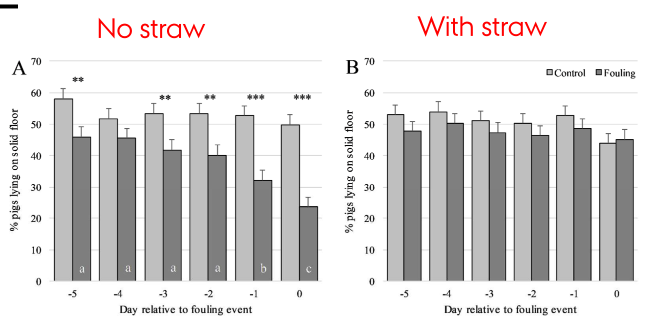
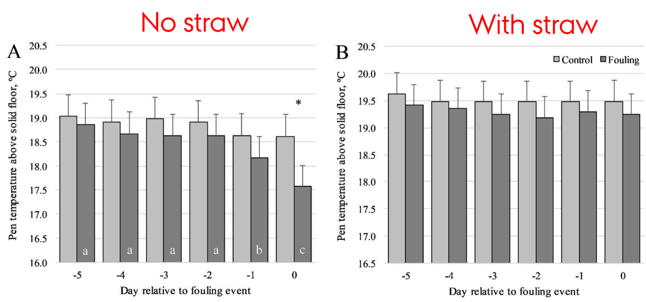
RESULTS- LYING PATTERN



Clear decrease in % pigs lying on solid floor prior to pen fouling
NOT seen in pens with straw

RESULTS- PEN TEMPERATURE SOLID FLOOR



Pen temperature on solid floor reflected lying pattern

PEN FOULING CONCLUSION

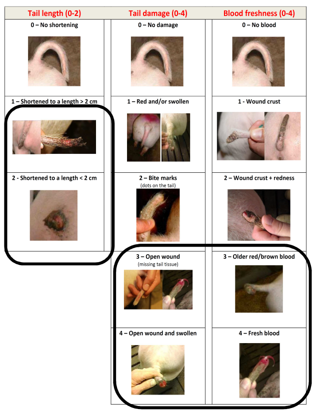
Lying in resting area clearly declined prior to fouling in no-straw pens

Temperature reflected lying pattern – can it be used as early indicator of changed lying pattern ?

Lying in resting area did not decline in straw pens – despite higher temperature - Why ?

BEHAVIOUR PRIOR TO TAIL DAMAGE

- Behavioural changes occur at pen level prior to tail damage ?
- Paired control pens and outbreak pens on same days
- Which behaviours differed between control pens and tail damage pens ?



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FROM LITTERATURE: WHICH CHANGES WERE EXPECTED ? (LARSEN ET AL 2016 REVIEW)

Days preceding outbreak:

Tail posture: less curly tails

Activity: increased

Exploration: increased

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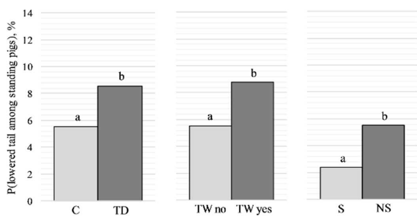
CURLY TAILS

Hanging tails day -3 til -1:

- More in pens developing tail damage day 0
- More in pigs with minor tail wounds
  - Indicates ongoing tail biting behaviour
- More in pens without straw



Larsen et al 2018a

Hanging tails: signal of increased risk of tail damage

ACTIVITY PRECEDING TAIL DAMAGE

Observation of activity day -7 to -1 from video:

Higher activity in pens developing tail damage (TD)

Changes develops PRIOR to day -7

Use of continuous measured activity can increase knowledge

- Automation using eg image analysis needed

Afternoon	P(active), %	
	NON-TD	TD
Day-6 to -7	17.37	21.20
Day-5 to -4	15.06	22.19
Day-3 to -1	14.48	21.49

Larsen et al 2018b

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EXPLORATION TOWARD WOODEN BEAMS

Observation of behaviour directed wooden beams day -7 to -1

Less exploration in pens developing tail damage

Differences only present in pens with undocked pigs

Larsen et al 2018b

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SUMMARY

Behaviour prior to tail damage do differ from that seen in control pens

Changes occur prior to day -3/-7 or are permanently present

Can behavioural changes be refelcted in automated measures using sensors ?

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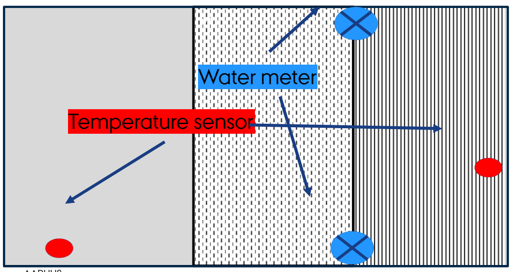
CURRENTLY BEING INVESTIGATED

Water and temperature sensors in each pen
Temperatur and humidity in each section



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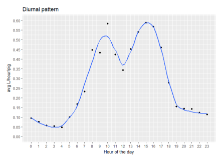
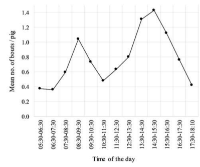
INFORMATION FROM SENSOR DATA

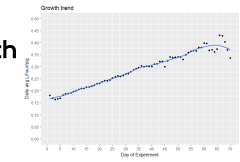
Step1: Modeling of normal pattern:

- **Cyclic diurnal pattern in water consumption:**
  - Two peaks : morning and afternoon
  - Similar to diurnal pattern in explorative behaviour





- **Increased water consumption with growth:**
  - As pigs grow they drink more



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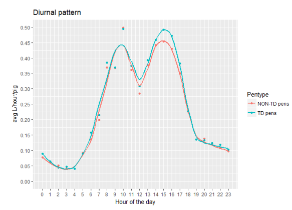
INFORMATION FROM SENSOR DATA

Step 2: Changes prior to tail damage

- Ongoing work
- Extract features of the diurnal pattern and growth trand
- Do these feature differ between control and tail damage pens prior to tail damage ?
- Are the features affected by presense of stressor/risk factors (stocking density and straw allocation) ?



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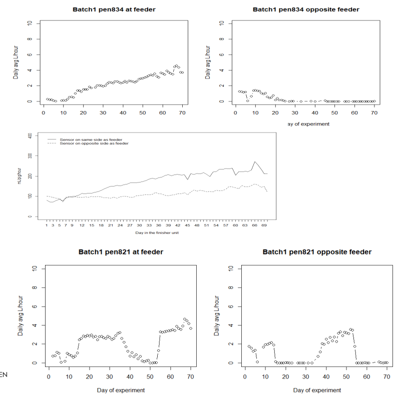
OTHER FEATURES TO EXPLORE

Two water cups:

Not always equally used

Relation to tail damage risk?

Relation to growth?



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DEVELOPMENT OF WARNING ALGORITHM

Step 3: Use data to develop warning

- Use a combination of water and temperature sensors
- Next presentation by Yuvraj Dumon using machine learning
- Input data - same data set
- Specific warning of tail damage events and pen fouling

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Summary and conclusion
• Behavioural changes do occur prior to pen fouling and tail damage:
• Pen fouling:
• lying pattern– may be reflected in pen temperature
• Tail damage:
• tail posture and activity – latter may be reflected in pattern of water consumption
• Demonstrate potentials for developing specific warning algorithms for both pen fouling and tail damage

2.2.5 Using machine learning to predict tail-biting, fouling and diarrhea in pigs

Presentation by Yuvraj Domun

Using machine learning to predict tail-biting, fouling and diarrhea in pigs

Yuvraj Domun

Supervisory team

- Dr. Tom Norton (KU Leuven, HAU)
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- David White (HAU)
- Dr Ian Moorcroft (HAU)

Harper Adams University

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PigIT

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Overview

- The research problem
- The Solutions
- The Results
- Future Directions

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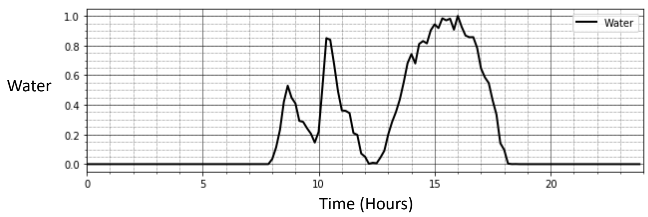
The Problem

Daily Water Consumption



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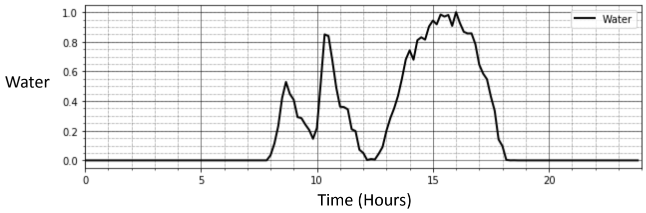
The Problem

Daily Water Consumption



Is this a normal pattern ?

Does it indicate a specific event Y ?

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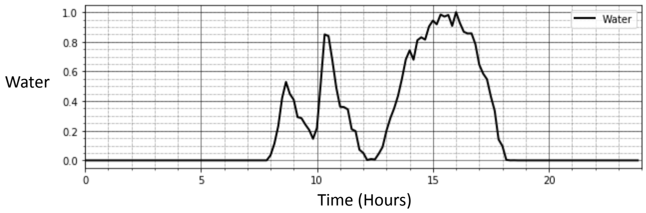
The Problem

Daily Water Consumption



Is this a normal pattern ?

Discriminate Prediction

Does it indicate a specific event Y ?

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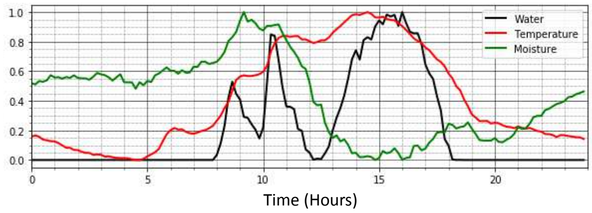
The Problem

Daily Water Consumption

Water

Temperature

Moisture



Is this a normal pattern ?

Discriminate Prediction

Does it indicate a specific event Y ?

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The Problem

Develop systems that can predict specific events.

How?

- What patterns predicts certain events?

Why?

- Targeted treatment.
- Predictive Model.
- More accurate information for farmers.

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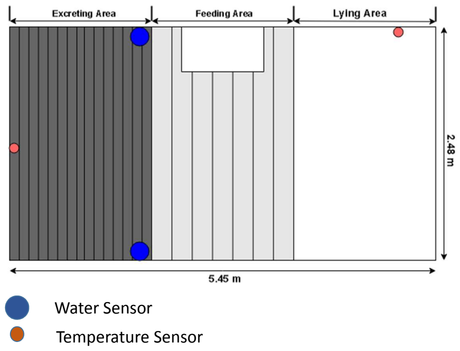
The Problem

Data Overview (Pen layout)

Variable Name	Sampling Frequency	Unit
Temperature (Solid Floor)	1 Minute	Degrees
Temperature (Slatted Floor)	1 Minute	Degrees
Water (Drinker 1)	10 Seconds	Litres
Water (Drinker 2)	10 Seconds	Litres
Relative Humidity (Finisher Unit)	1 Minute	%
Ventilation Output (Finisher Unit)	1 Minute	%
Heating Output (Finisher Unit)	1 Minute	%
Cooling Output (Finisher Unit)	1 Minute	%
Temperature (Finisher Unit)	1 Minute	Sensor



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Solution

Two Proposed Solution:

1. Deep Learning Approach (Automatic Feature Learning)

2. Machine Learning Approach (Manual Feature Extraction)

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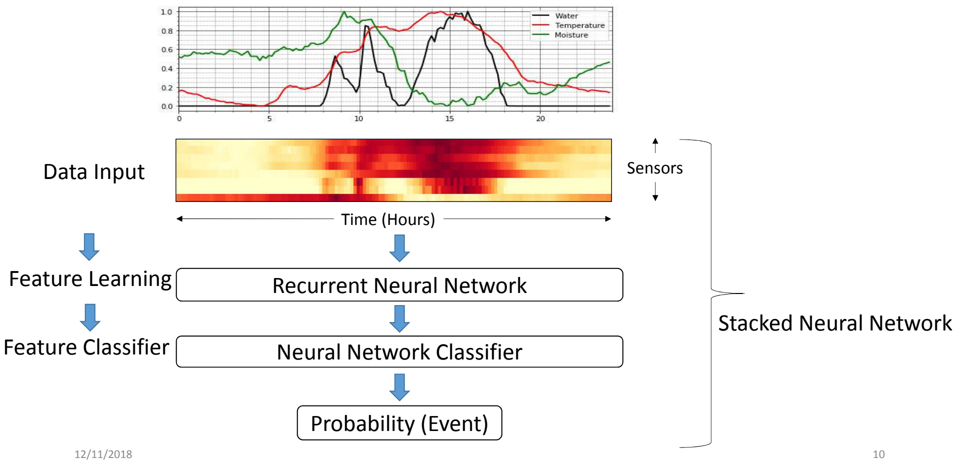
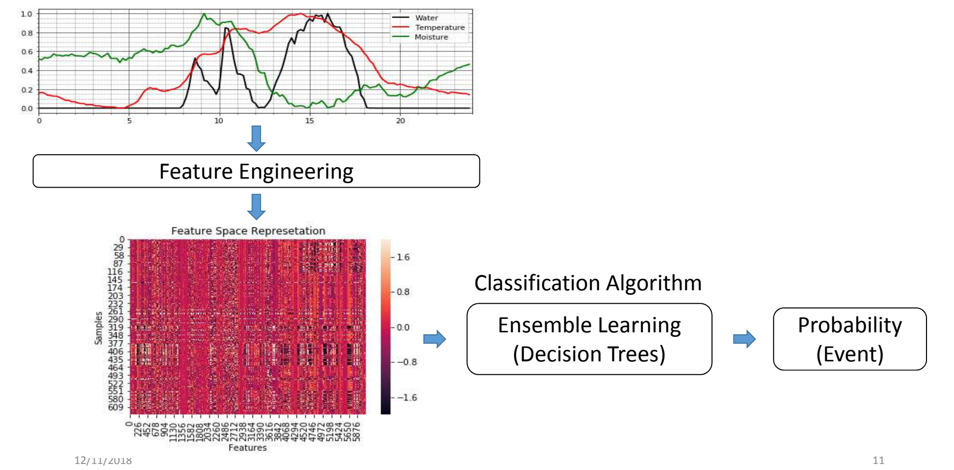
Solution 1 : Deep Learning Approach

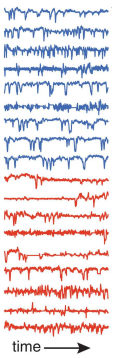


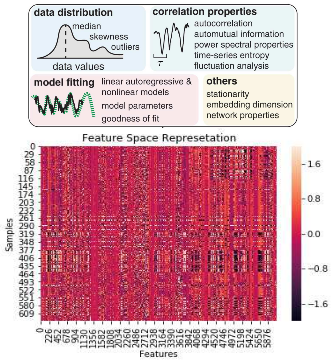
Solution 2 : Machine Learning Approach



Solution 2 : Feature Engineering

Time Series Data → Feature Extraction → Feature List





- Statistical Features
- Spectral Features
- Model Based Features

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Results

1. Model Performance
2. Important Data Type (Sensor)
3. Important Patterns

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Results

Prediction Performance on Unseen Data

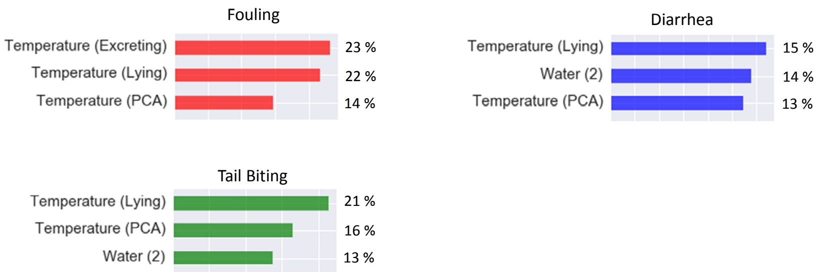
Table 1: Predictive Performance (AUROC) for fouling, tail-biting and diarrhea prediction.

Event	Deep Learning	Machine Learning
Tail Biting	0.709	**0.762**
Fouling	0.812	**0.879**
Diarrhea	0.679	**0.862**

Performance Metric: Area Under the Receiver Operating Characteristic curve (AUROC)

Results

What Sensor Data are important?



Principal Component Analysis (PCA) was applied to highly correlated features to create new features to take into account collinearity. The Feature importance (%) is the total information used by the algorithms to make the final prediction.

Results

What Features are important?

Table 3: Top 3 most important features for predicting Fouling, Diarrhea, and tail-biting.

	Features	Feature Importance
Fouling	Fast Fourier Transform Coefficients	43%
	Quantiles Distribution	10 %
	Entropy	8 %
Diarrhea	Fast Fourier Transform Coefficients	63 %
	Quantiles	7 %
	Continuous Wavelet Transform Coefficients)	7 %
Tail Biting	Fast Fourier Transform Coefficients	54 %
	Linear Trend	11 %
	Entropy	5 %

Principal Component Analysis (PCA) was applied to highly correlated features to create new features to take into account collinearity. The Feature importance (%) is the total information used by the algorithms to make the final prediction.

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Conclusion

- Frequency based Patterns are important.
- Traditional machine learning approach better than Deep Learning.
- Both approaches can learn to predict discriminate events.

Future Studies

- Integrate proposed approach with more advance sensors.
- Can be extended to detect other events beside fouling, diarrhea, or tailbiting.

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Questions?

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