Precision Livestock Farming (PLF)

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Miljø- og Fødevareministeriet
gudp
Svineafgiftsfonden

SEGES
Svineproduktion

PigIT

SPATIAL MODELING OF DRINKING PATTERNS AS A TOOL FOR REDUCING ALARMS IN PIG PRODUCTION

KATARINA NIELSEN DOMINIAK

PHD THESIS · 2017

LANDBRUG FØDEVARER SEGES Svineproduktion

Agenda

- Introduction to Precision Livestock Farming (PLF)
- Work from my PhD and postdoc
- Current PLF projects in SEGES
- Implementation in commercial herds
- Future PLF projects in SEGES
- Trends and research within automatic monitoring and Decision Support Systems

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The vision behind PLF

It is possible to increase

- Animal welfare
- Productivity
- Sustainability

by letting the animals themselves tell us how they are
- and then listen to what they say

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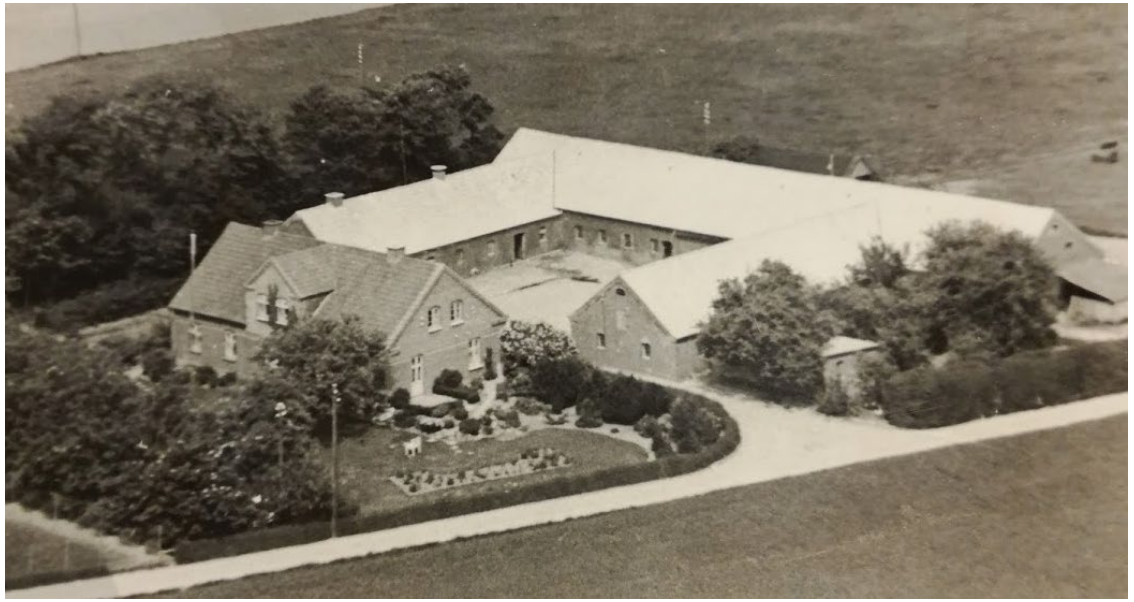
Background



- Modern livestock production is centralized and intensively driven
- Shorter time per animal in everyday routines
- Changing employees with varying degrees of production related knowledge
- Increasing need for centralized overview
- Increasing need for timely interventions and high-level risk management

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General approach

The animals are monitored by sensors

either directly:

- Behaviour (accelerometer, video)
- Locomotion (accelerometer, video)
- Body temperature (thermometer)

or indirectly:

- Water consumption (stress, diseases, growth)
- Feed consumption (stress, diseases, growth)
- Environment (pen fouling, productivity)

Systematic deviations from normal are identificed

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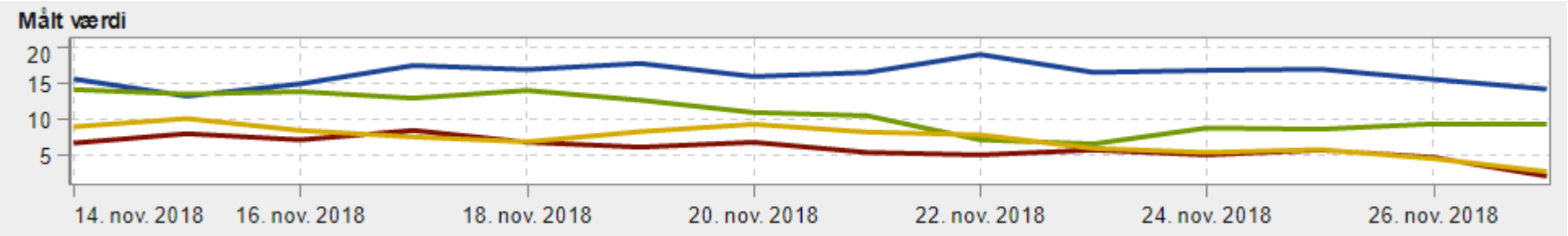
Data – data - data

C	D	E	F	G	H	I	J
Location Description	DayNumbe	HouseStatus	InsideHum	InsideTem	MaxHumidi	MinHumidit	WaterMeter
-Stald 3	9	Startet - dag 9	75	20.4	75	60	3745.0
-Stald 3	9	Startet - dag 9	74	20.5	75	60	3746.0
-Stald 3	9	Startet - dag 9	72	20.7	75	60	3748.0
-Stald 3	9	Startet - dag 9	71	20.8	75	60	3749.0
-Stald 3	9	Startet - dag 9	72	20.9	75	60	3750
-Stald 3	9	Startet - dag 9	73	20.9	75	60	3751.0
-Stald 3	9	Startet - dag 9	72	20.9	75	60	3751.0
-Stald 3	9	Startet - dag 9	72	20.9	75	60	3753.0
-Stald 3	9	Startet - dag 9	72	20.8	75	60	3754.0
-Stald 3	9	Startet - dag 9	71	20.8	75	60	3755.0
-Stald 3	9	Startet - dag 9	74	20.8	75	60	3755.0
-Stald 3	9	Startet - dag 9	75	20.9	75	60	3756.0
-Stald 3	9	Startet - dag 9	74	21.0	75	60	3757.0
-Stald 3	9	Startet - dag 9	73	21.0	75	60	3758.0
-Stald 3	9	Startet - dag 9	74	21.0	75	60	3759.0
-Stald 3	9	Startet - dag 9	74	21.1	75	60	3761.0

	SensorValueReadTimeUTC	Ins	P1_2	P5_6	P7_8	P11_12
1	2015-09-24 06:00:00	2015-09-17	3.330029	3.410323	1.6169586	1.017590
2	2015-09-24 07:00:00	2015-09-17	4.885650	8.846359	3.9152457	3.379308
3	2015-09-24 08:00:00	2015-09-17	9.071743	6.738609	4.6034456	3.196693
4	2015-09-24 09:00:00	2015-09-17	6.008714	10.052194	5.0180491	4.377966
5	2015-09-24 10:00:00	2015-09-17	6.146248	7.554467	5.7899980	4.472397
6	2015-09-24 11:00:00	2015-09-17	6.304965	10.516644	5.3766376	5.562673
7	2015-09-24 12:00:00	2015-09-17	9.700030	12.184348	6.2084638	5.847683
8	2015-09-24 13:00:00	2015-09-17	14.013064	12.408827	9.1226494	6.766499
9	2015-09-24 14:00:00	2015-09-17	12.836916	9.780735	7.5498471	8.685586
10	2015-09-24 15:00:00	2015-09-17	13.182363	11.422172	7.8447242	7.768882
11	2015-09-24 16:00:00	2015-09-17	12.437913	5.076565	3.9282400	5.342906
12	2015-09-24 17:00:00	2015-09-17	8.623640	4.850610	4.7957195	2.809024
13	2015-09-24 18:00:00	2015-09-17	5.757907	4.122432	3.0511184	1.502531
14	2015-09-24 19:00:00	2015-09-17	4.311841	3.333128	2.8333293	3.632200
15	2015-09-24 20:00:00	2015-09-17	3.561559	2.777743	2.7147433	2.750944
16	2015-09-24 21:00:00	2015-09-17	4.484502	4.904933	3.1096207	3.771561
17	2015-09-24 22:00:00	2015-09-17	4.277633	2.789671	1.9994202	1.702655
18	2015-09-24 23:00:00	2015-09-17	3.358966	2.491102	2.1271355	1.768078
19	2015-09-25 00:00:00	2015-09-17	2.956272	2.630463	2.8514657	2.085823
20	2015-09-25 01:00:00	2015-09-17	3.819215	1.893985	0.9532945	1.098944



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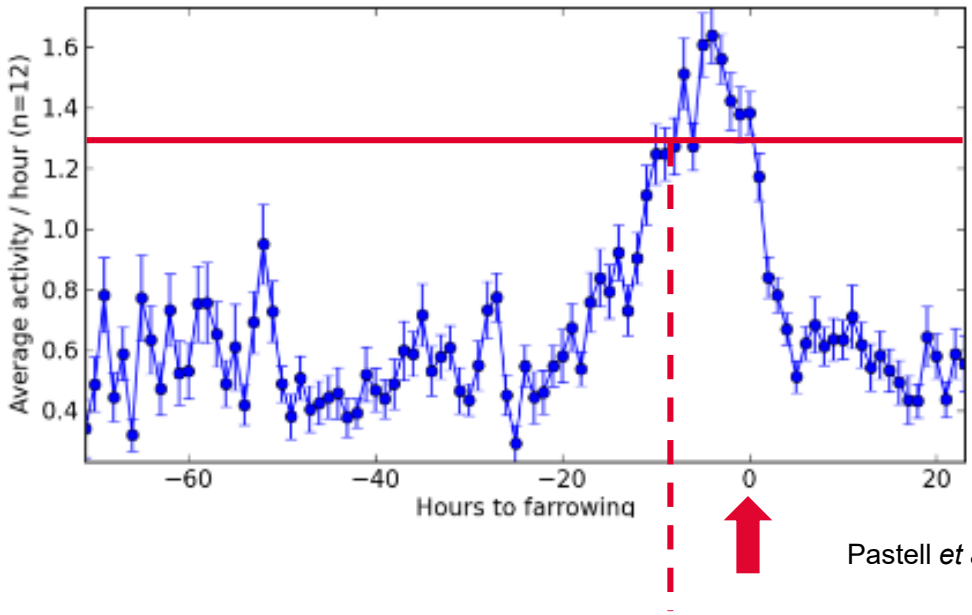
Interpretation of data = value for the producer

Data lay ground for dynamic tools for decision support in the every day management

- ➡ preventive interventions
- ➡ targetet treatments



Pastell *et al* 2013

Better management

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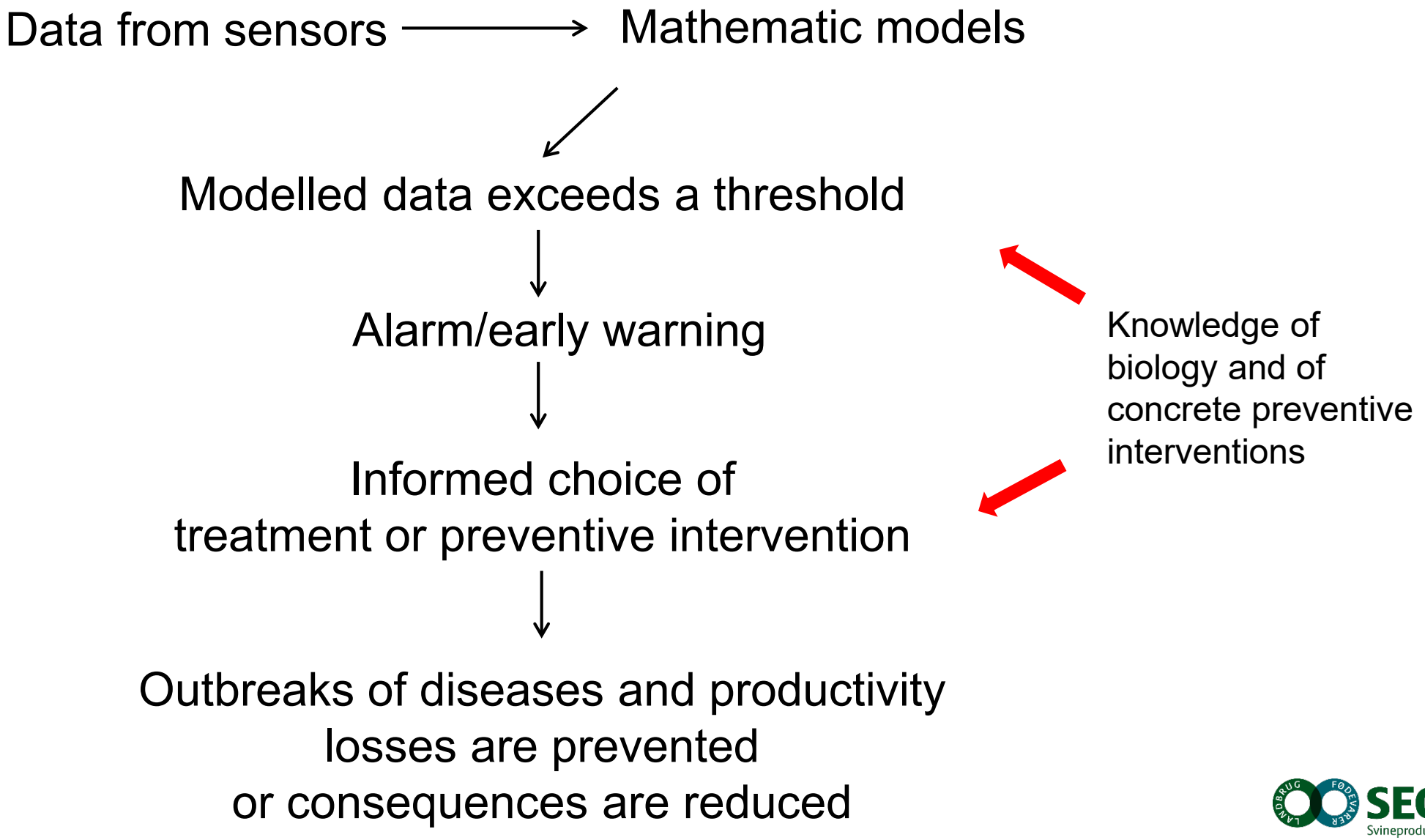
Sensor based decision support system (DSS)



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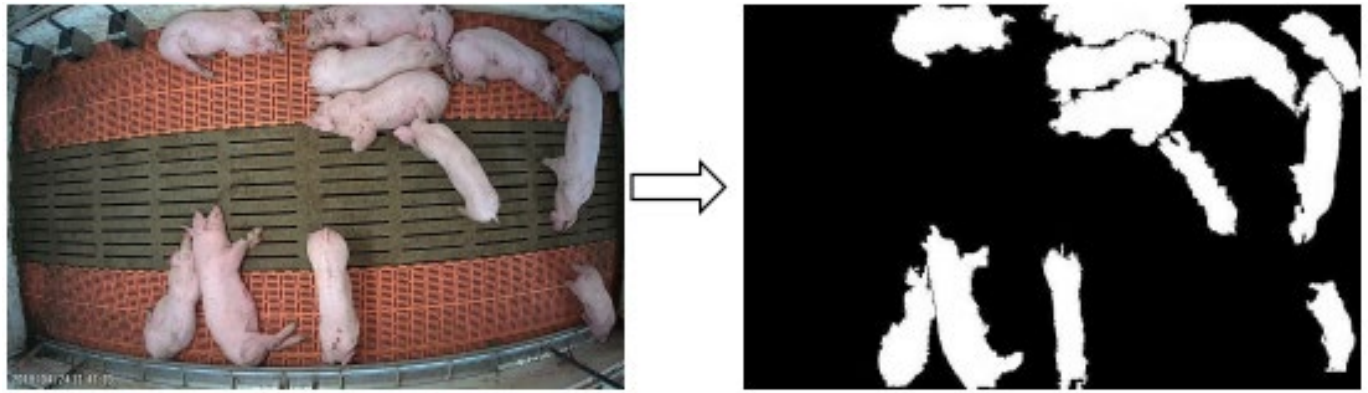
Why PLF is interesting for modern pig producers

- Dynamic information on productivity at pen level and section level
- Early warnings for productivity and health are communicated in real time so the manager can react proactively
- Treatments and preventive actions can be implemented immediately
- Timely interventions lead to reduced use of antibiotics

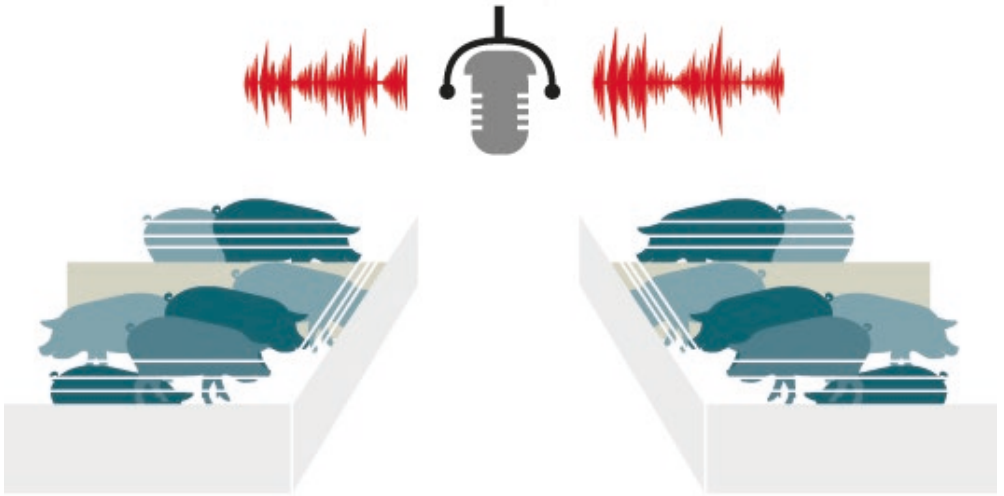
Dynamic ✓

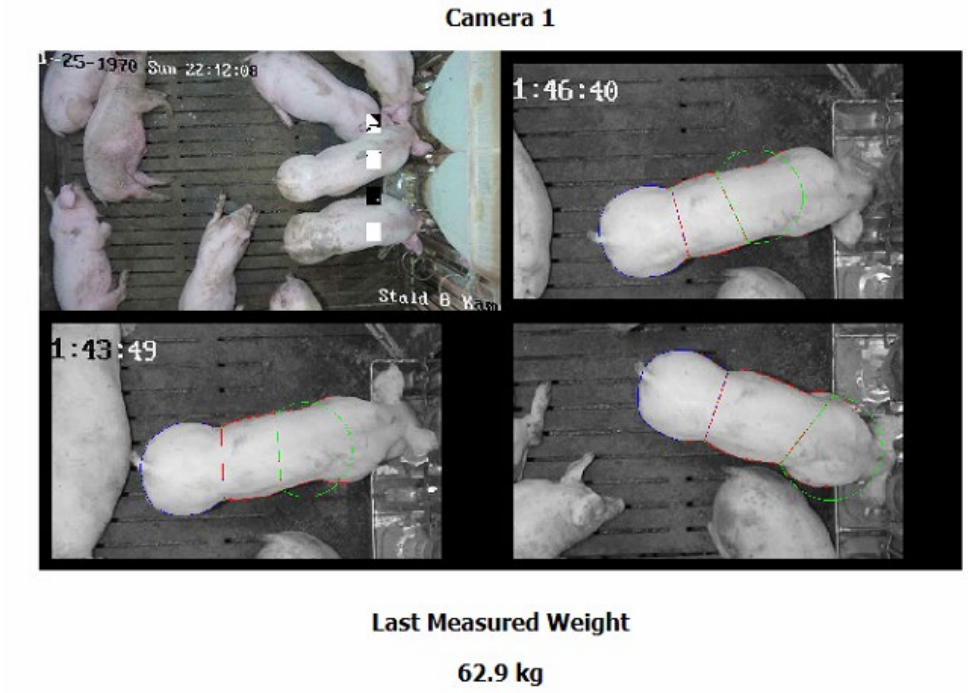
~~Static~~

Examples of PLF



Nasirahmadi *et al* 2018



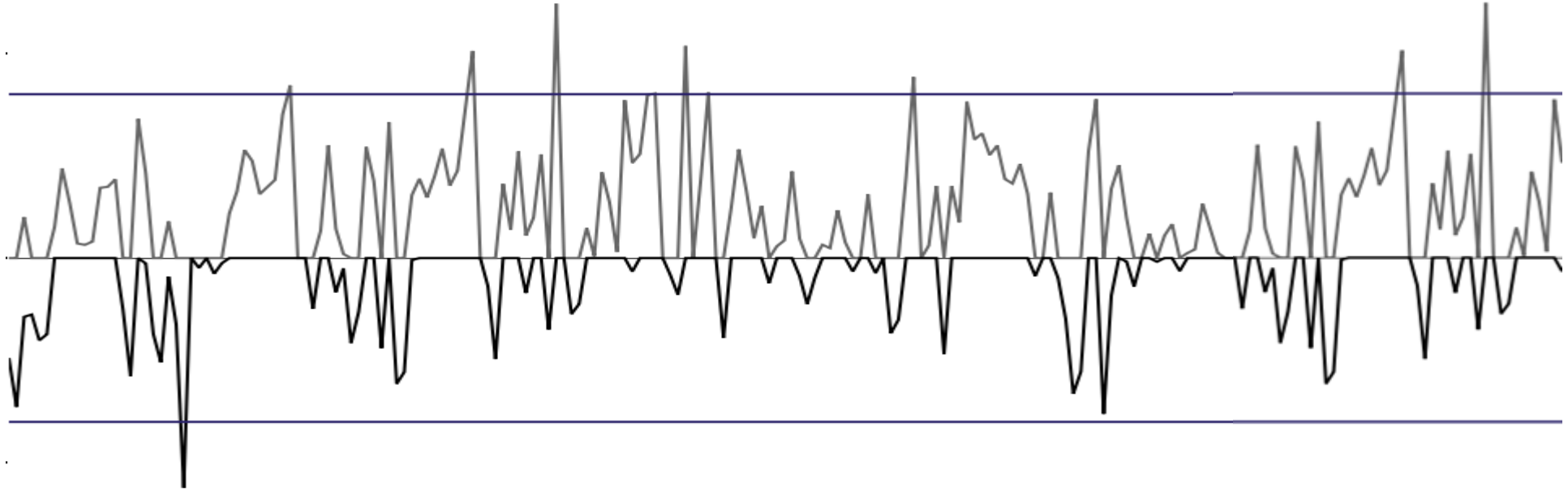



PhD study

Management support through water monitoring

- Pigs' drinking patterns contain high level of information on their health, welbeing and productivity

- Develop a dynamic model which can predict outbreaks of diseases and point out high-risk pens or sections in a herd of growing pigs



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Spatial modeling of water data

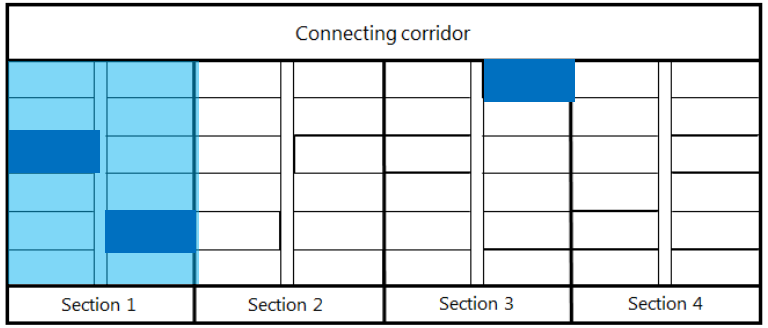
Modeled simultaneously monitored water consumption across multiple pens in multiple sections of a weaner herd and a finisher herd

Correlations between drinking patterns in pens and sections were included

The detection model predicted outbreaks of diarrhea or pen fouling

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

Pointed areas are FOCUS AREAS for management



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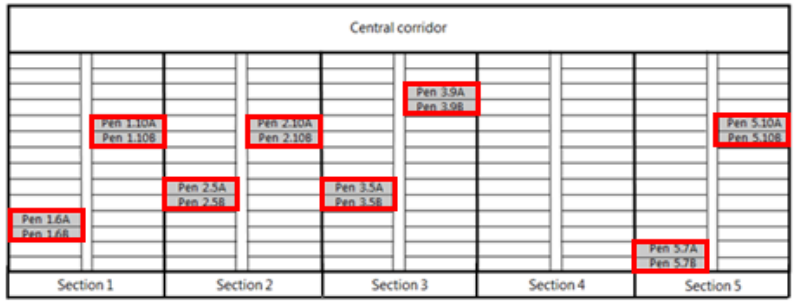
Sensors were installed in both weaner herds and finisher herds

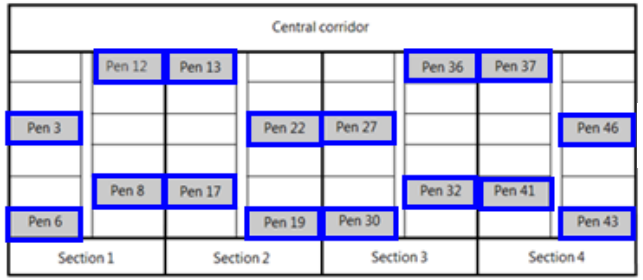
Herd	Variables in DLM
Herd A finishers	8
Herd B weaners	16
Herd C finishers	8
Herd C weaners	4

All sensors monitored water consumption simultaneously

Data was aggregated to liter/hour

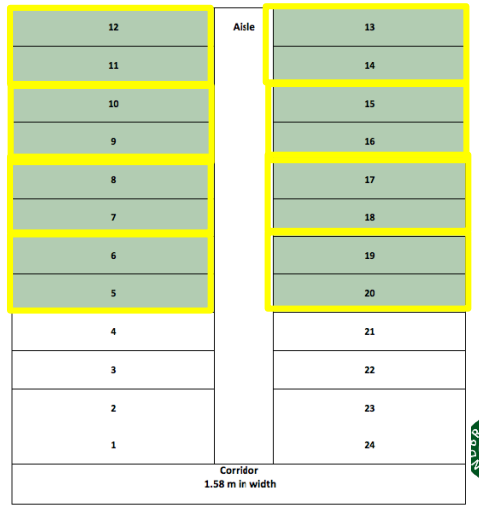


Herd A Finishers

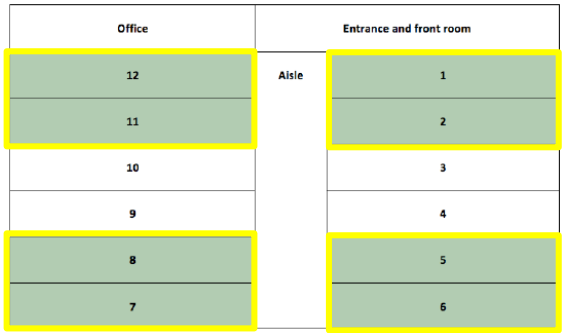


Herd C Weaners

Herd C Finishers



Herd C Weaners



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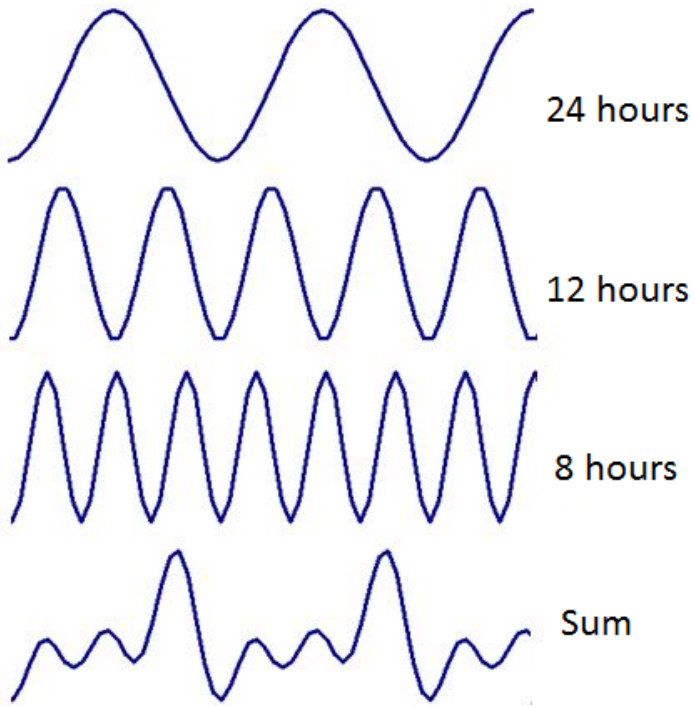
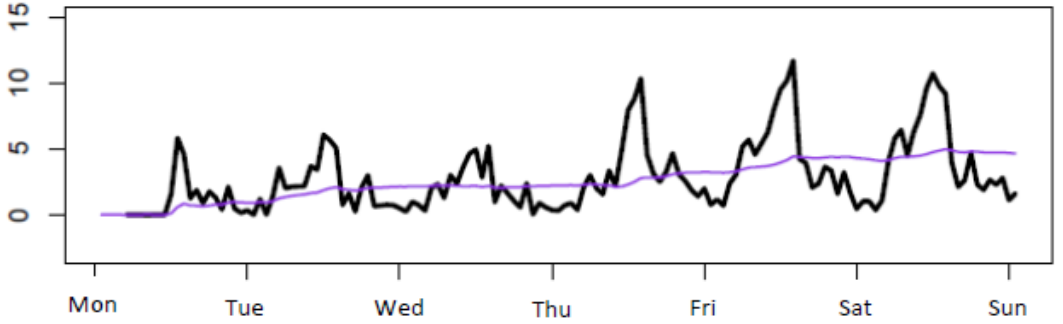


Drinking patterns of both weaners and finishers show clear diurnal pattern

Which can be described by the sum of three harmonic waves

Pigs drink more water as they grow



So the full drinking pattern can be described through three harmonic waves and a linear growth threnden in one Dynamic Linear Model (DLM)

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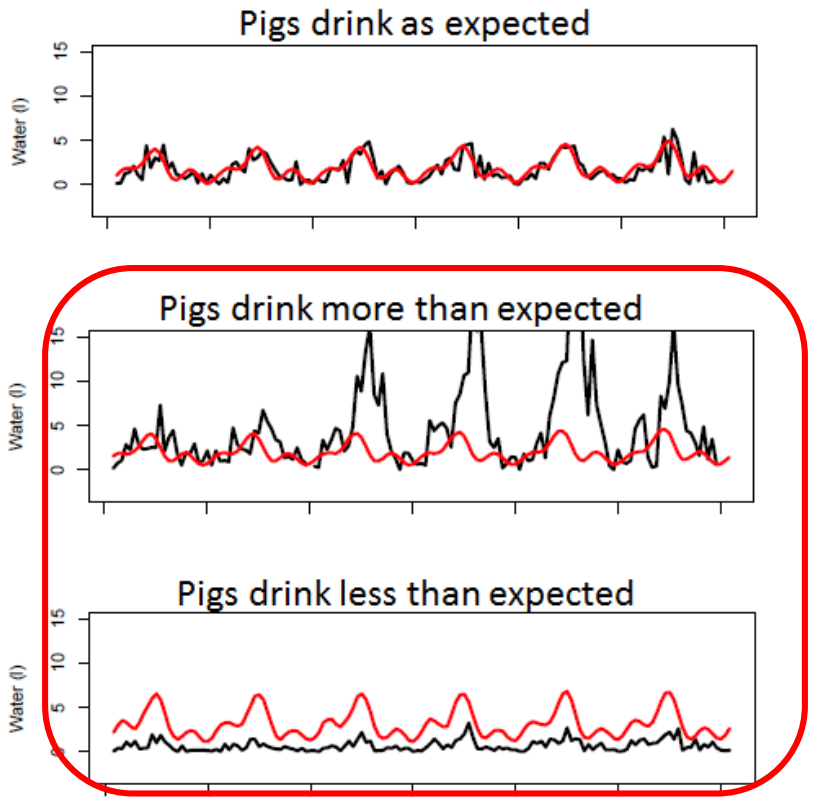
Generating alarms

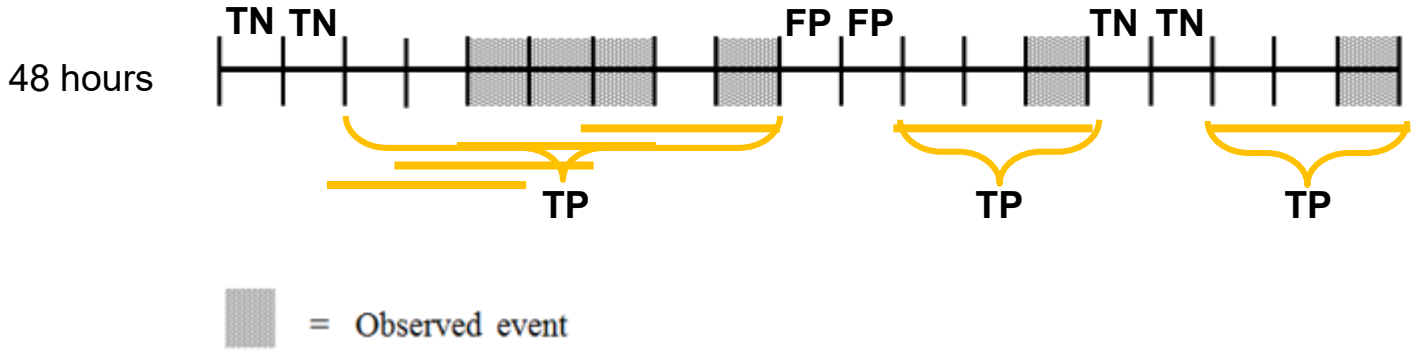
Raw data, actual drinking pattern

Fitted, expected drinking pattern

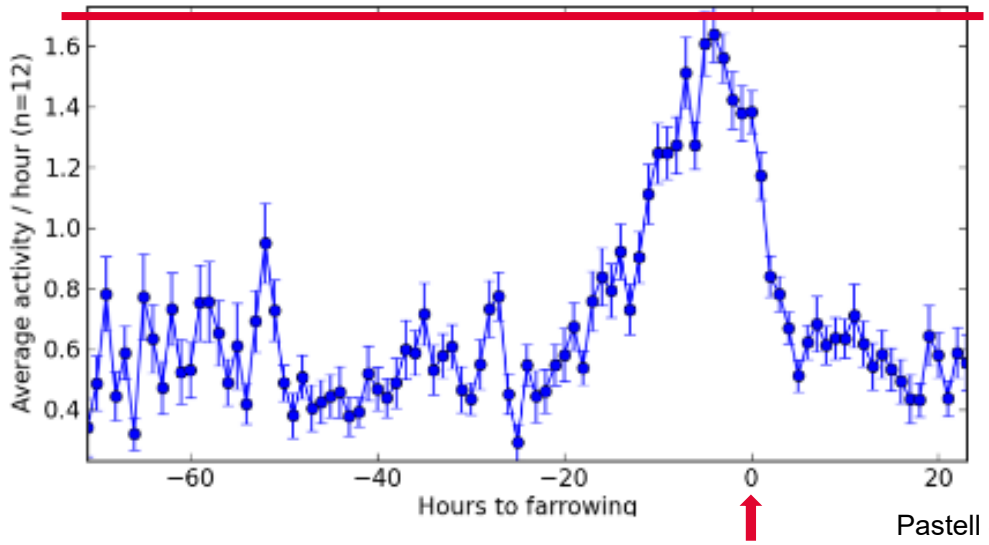


Forecast errors

Time windows are related to an event
All alarms within a time window identify the event correctly (TP)



Performance evaluation – how good is the model?



Too high threshold – no alarms for farrowing

Too low threshold – alarms for farrowing every hour

Pastell *et al* 2013

Based on true and false alarms
Sensitivity and *Specificity* are calculated

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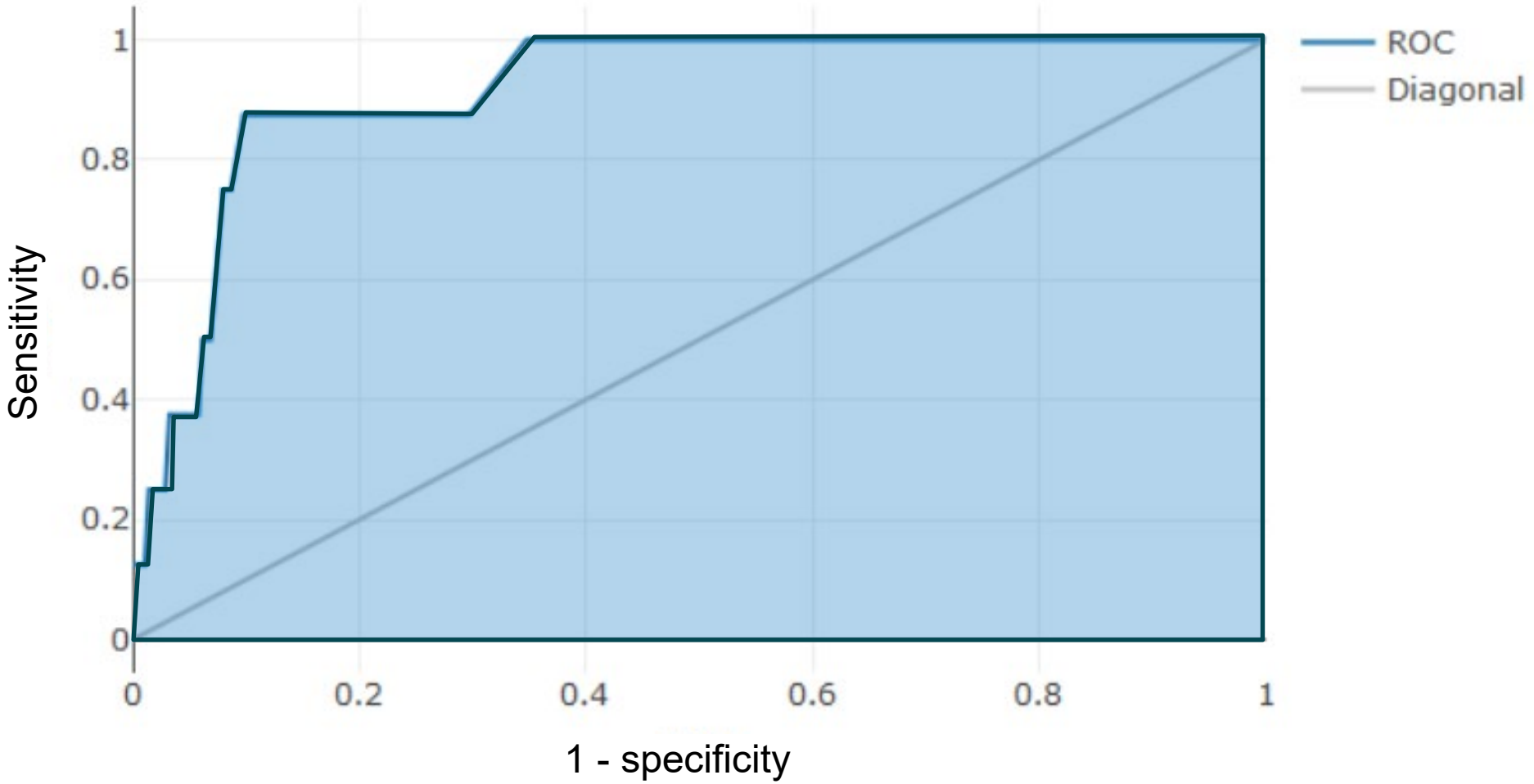
Performance evaluation – how good is the model?



Area Under the (ROC) Curve - AUC

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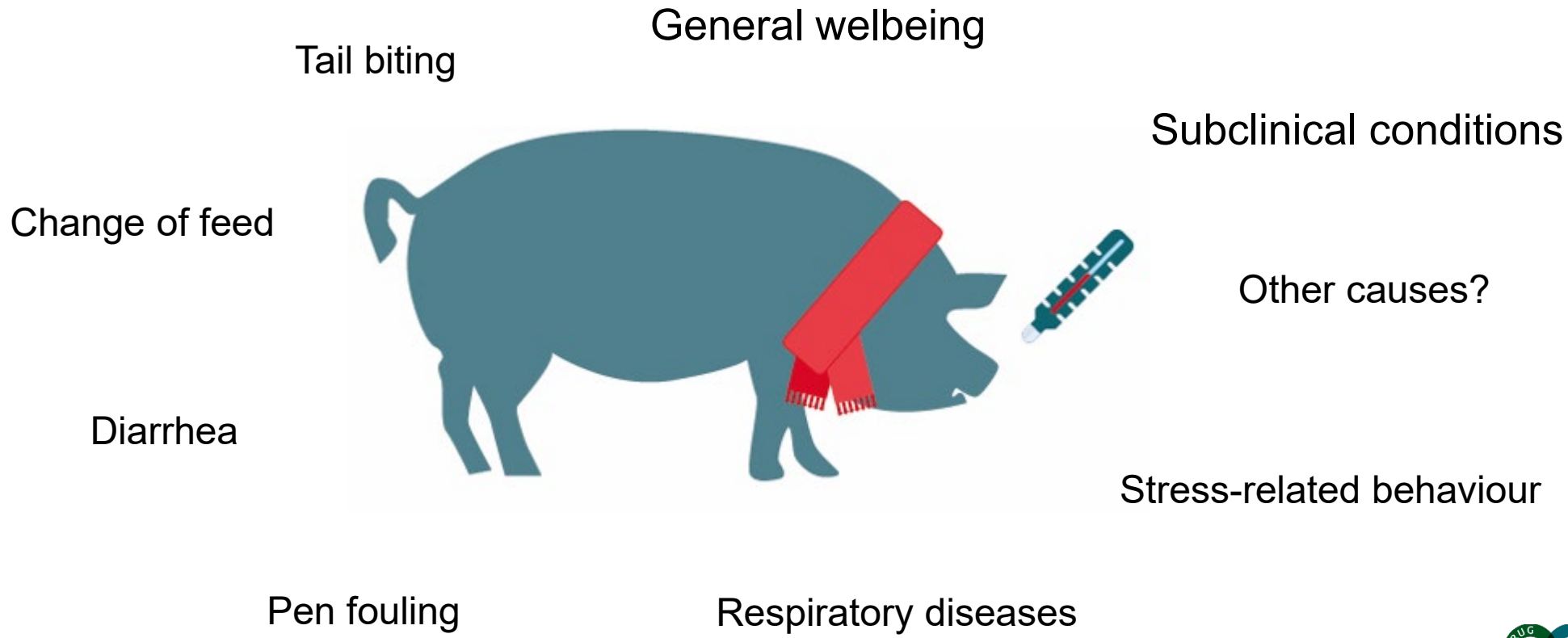
Changes in water consumption are excellent predictors

AUC	Event	Method	Reference
0.80	Diarrhéa or pen fouling	MDLM	Jensen *et al.* 2017
0.87	Diarrhéa or pen fouling	Spatial MDLM	Dominiak *et al.* 2018
0.81	Diarrhéa or tail biting	Spatial MDLM	Dominiak *et al.* 2019
0.77	Tail biting	DLM + ANN	Larsen *et al.* 2019

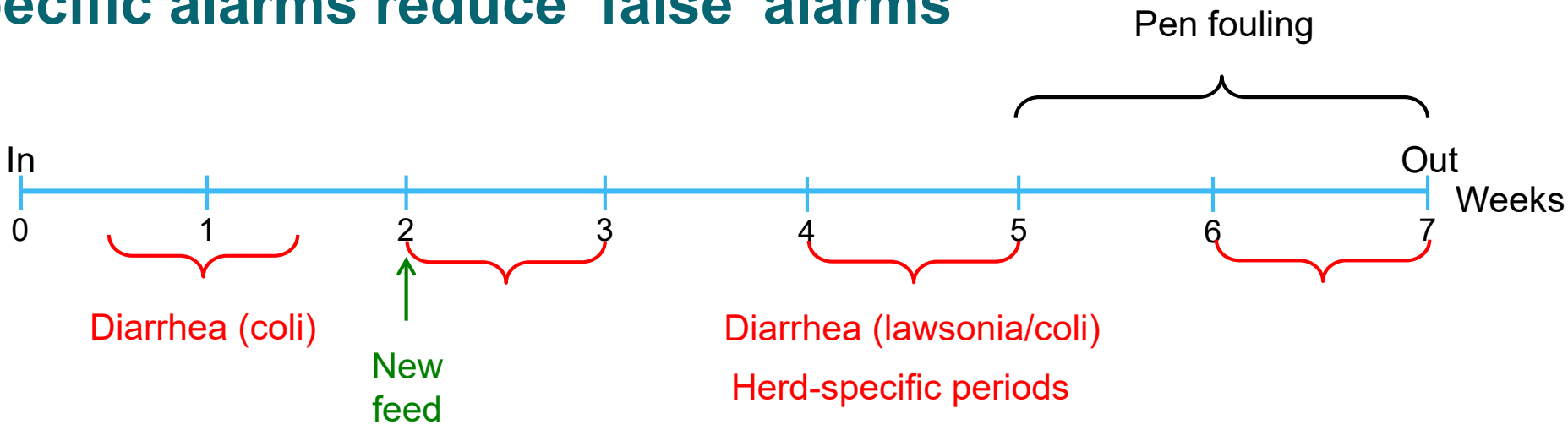
AUC = Area Under the ROC Curve
DLM = Dynamic Linear Model
MDLM = Multivariate Dynamic Linear Model
ANN = Artificial Neural Network

A major challenge – ‘false’ alarms

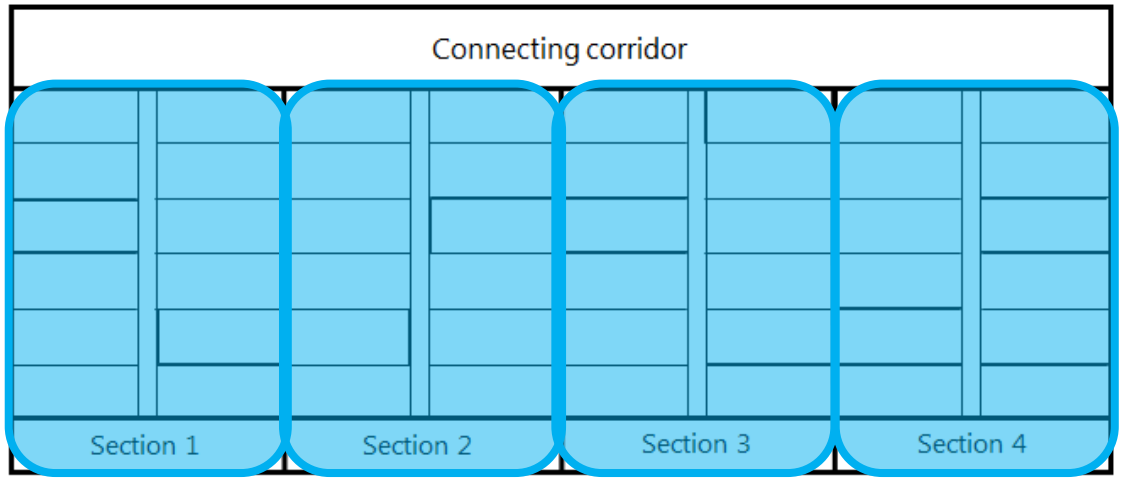
- One alarm can have multiple causes



Area-specific alarms reduce ‘false’ alarms



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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Postdoc

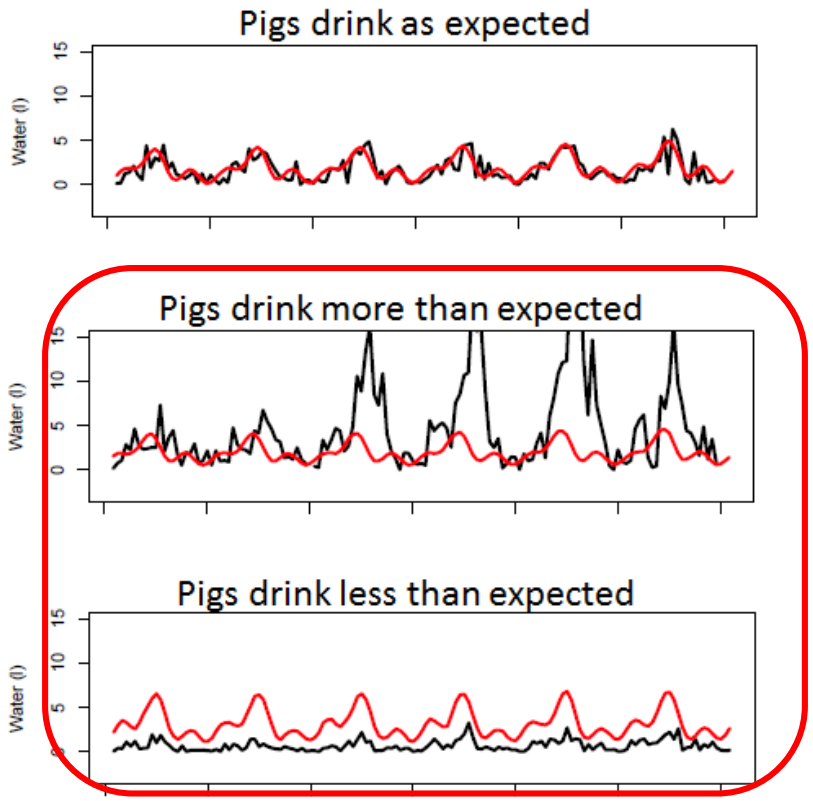
Water consumption liter/hour vs Drinking frequency bouts/hour

when predicting tail biting and diarrhea

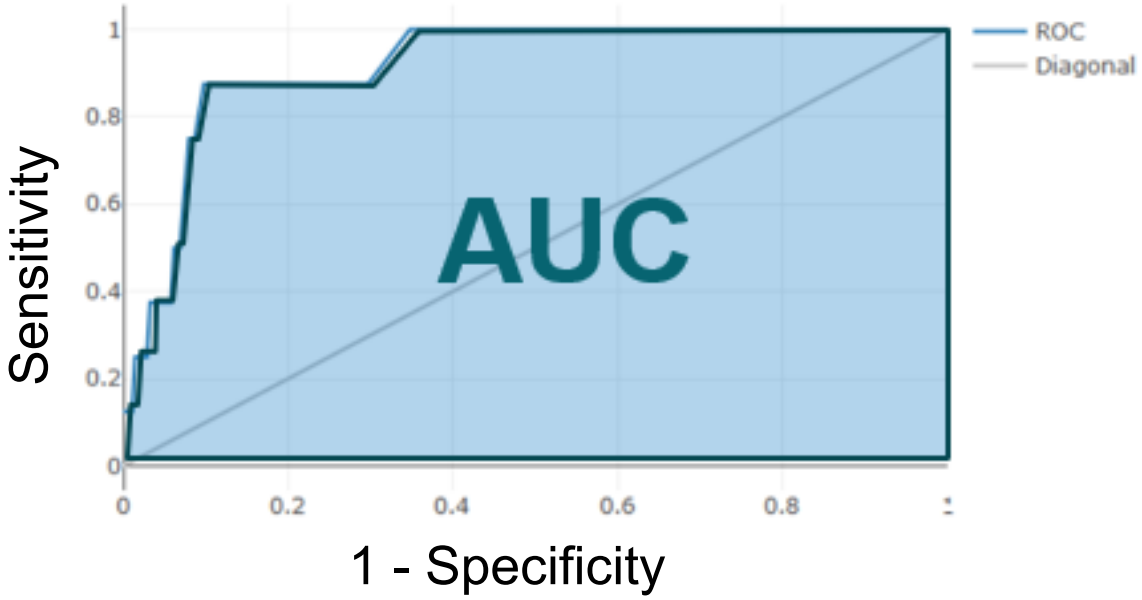
Methods and materials

Raw data, actual drinking pattern

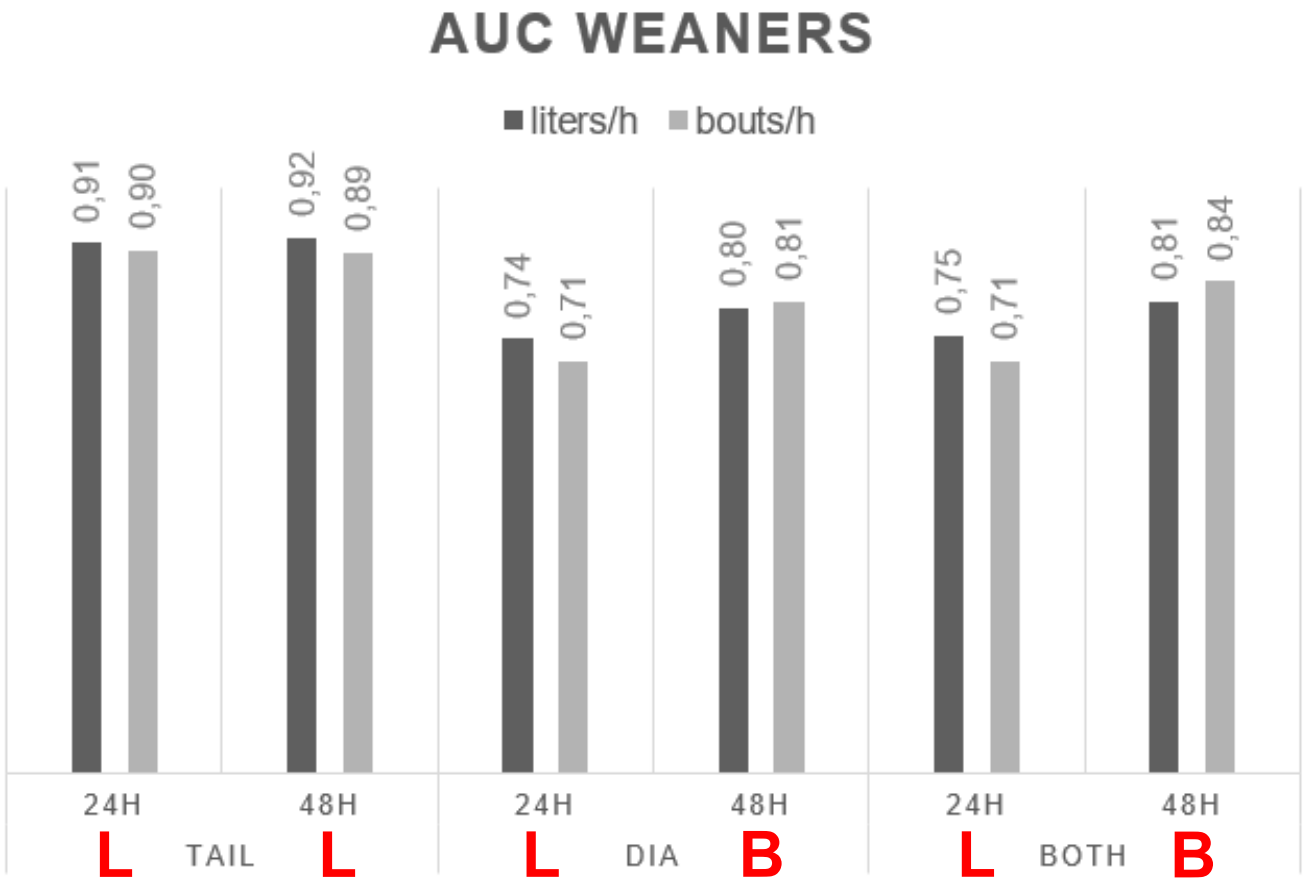
Fitted, expected drinking pattern



Forecast errors

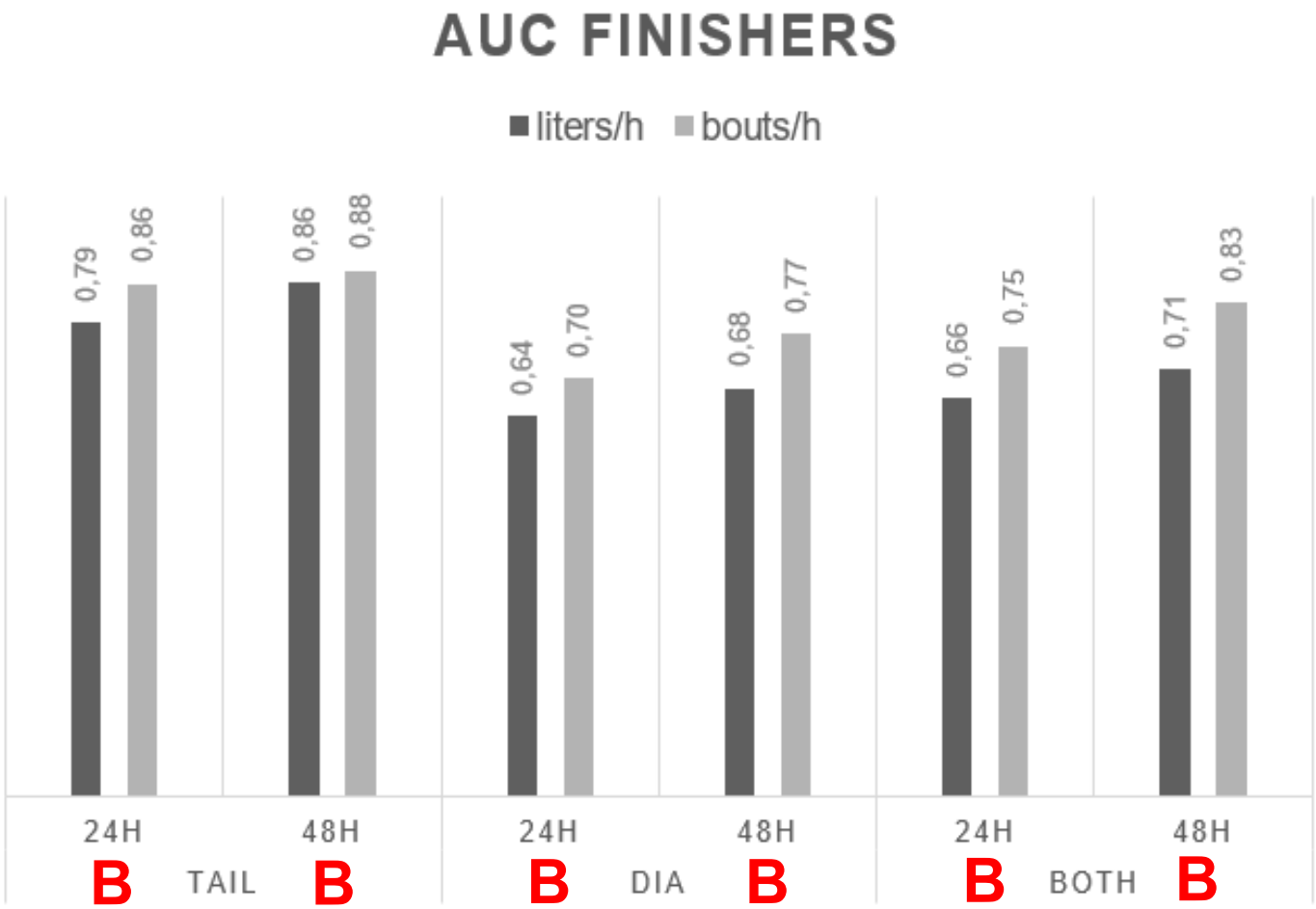


Results - weaners



- **Liters > Bouts**
  for prediction of tail biting
- **Liters > Bouts**
  for short time windows predictions
- **Bouts > Liters**
  for long time windows predictions
  of diarrhéa or either event

Results – finishers



- **Bouts > Liters**
  for all events and both time windows

Conclusion

- Bouts tend to be a better predictor amongst finishers than volume
- Results are less clear amongst weaners, although volume tend to predict better than bouts in the majority of modelled setups

- Differences in predictive performances are numerical and not significant
- Results from **weaners** may reflect naturally high explorative activity
- Results from **finishers** indicate increased activity level in pens with tail biting or diarrhea
- Increased activity level may reflect a stress-related coping mechanism

Current PLF projects SEGES

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PigSys

ERA-NET SusAn project PigSys

IQ IN A BOX

- scientifically based monitoring

Miljø- og Fødevareministeriet

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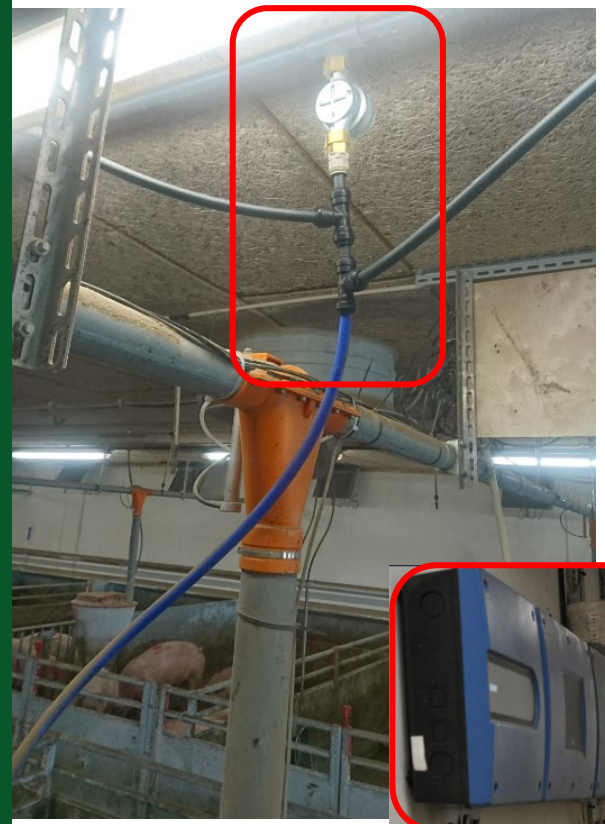
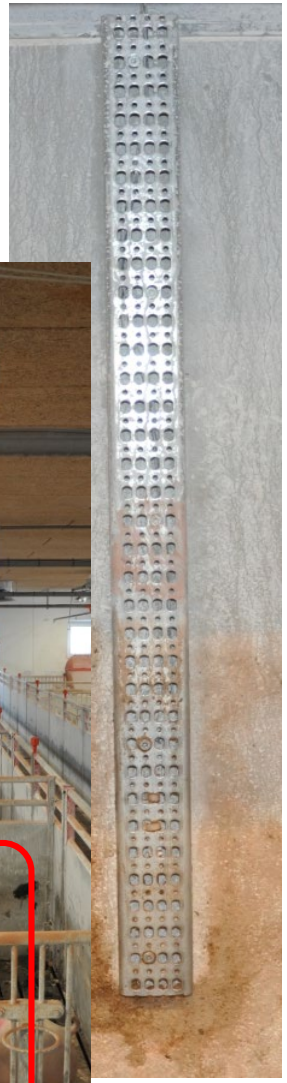
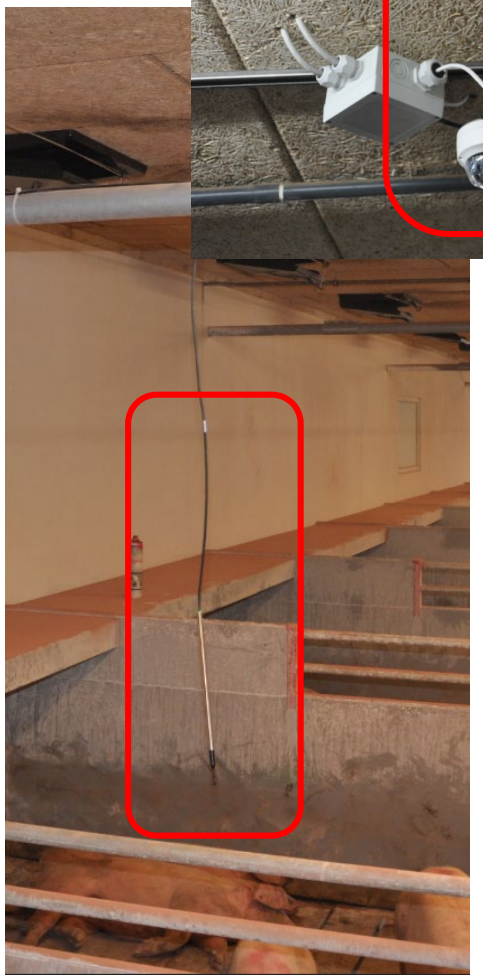
Sensors Fynen Farm







AgriSys
Feed computer

SEGES
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Sensors Sealand farm

Manual registrations in the herds

- Pigs are weighed at insertion
- Dead or removed pigs are weighed
- Events affecting productivity is registered in a logbook

Hold data	
Sektion:	
Batch Nr.:	
Kode:	
Dato:	
Antal:	
Vægt:	
Temperatur:	
Uge ind:	
Vaskes uge:	
Vejning uge:	

Data dag 28	
Kg. Tilvækst dag 28:	
Fe pr. svin dag 28:	
Dato dag 28:	
Vægt start:	

Foder og vand	
Fejl fodring:	
Fejl vand:	

Halebid / stivending / andet			
Dato:	Årsag:	Antal dage	Sti:

Medicinering	
Dato:	
Antal dage	
Årsag:	Diarre
Sektion:	
Antal grise:	
Middel:	Denaguard
Dosis:	1 ml/15 kg dyr

Døde			
Antal:	Dato:	Årsag:	Ventil:

Leveringsdata	
Vejning:	
Uge:	
Antal Rød:	
Antal Blå:	
Leverandørnummer:	

Andre Bemærkninger:	Reparation:

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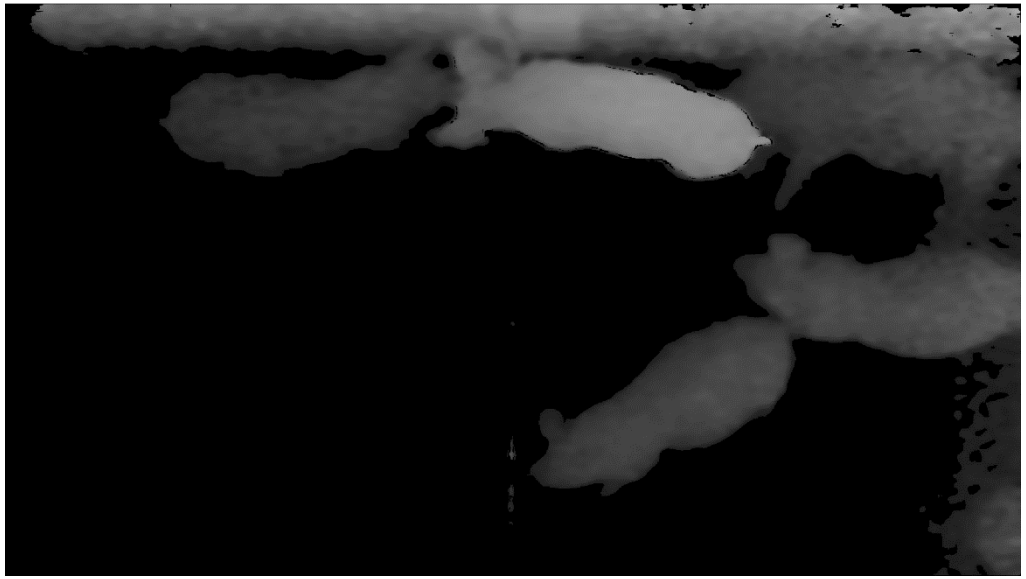
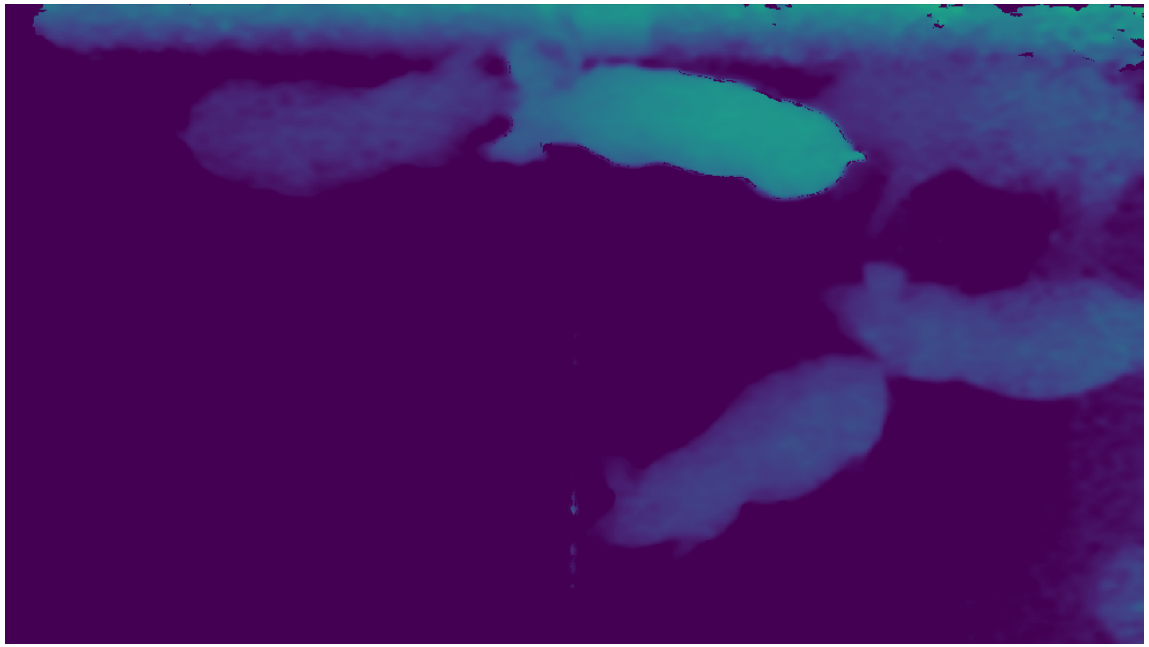
3D weight at animal level and pen level





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Data in PigSys

Data	Animal	Pen	Section
Water consumption		X	X
Feed consumption		X	X
Temperature - Resting area - Manuring area - Room temperature		 X X	 X
Daily gain - Estimates from raw pictures - Pen average/day	 X X	 X X	 X X
Stiview - Behaviour		 X	
Events - Medication - Registration schedule		 X (X)	 (X) X

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Data from PigSys lay ground for another project ‘Produktions monitoring and –optimizing’

Can we predict reduced daily gain at section-, pen- and individual level?

- Multiple daily weight estimates
- Water consumption
- Feed consumption
- Barn environment

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IQinAbox

- IoT boxes installed in five test herds (finishers)
- Farmer register all sections' health status every day
  - Is everything OK?
  - Are any pigs sick or changing behaviour (tail biting/pen fouling)?
- Water consumption (and feed consumption) at section level

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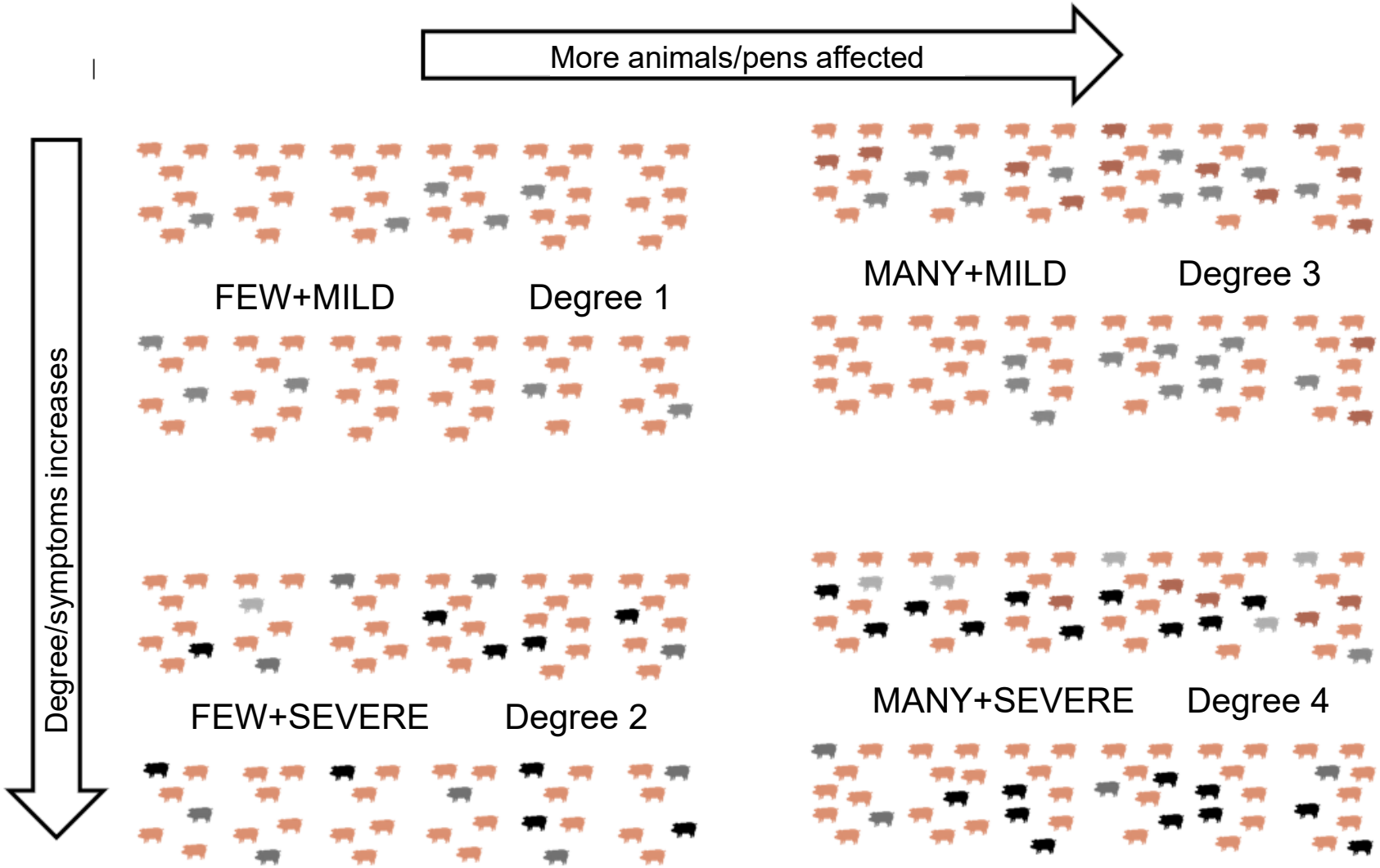
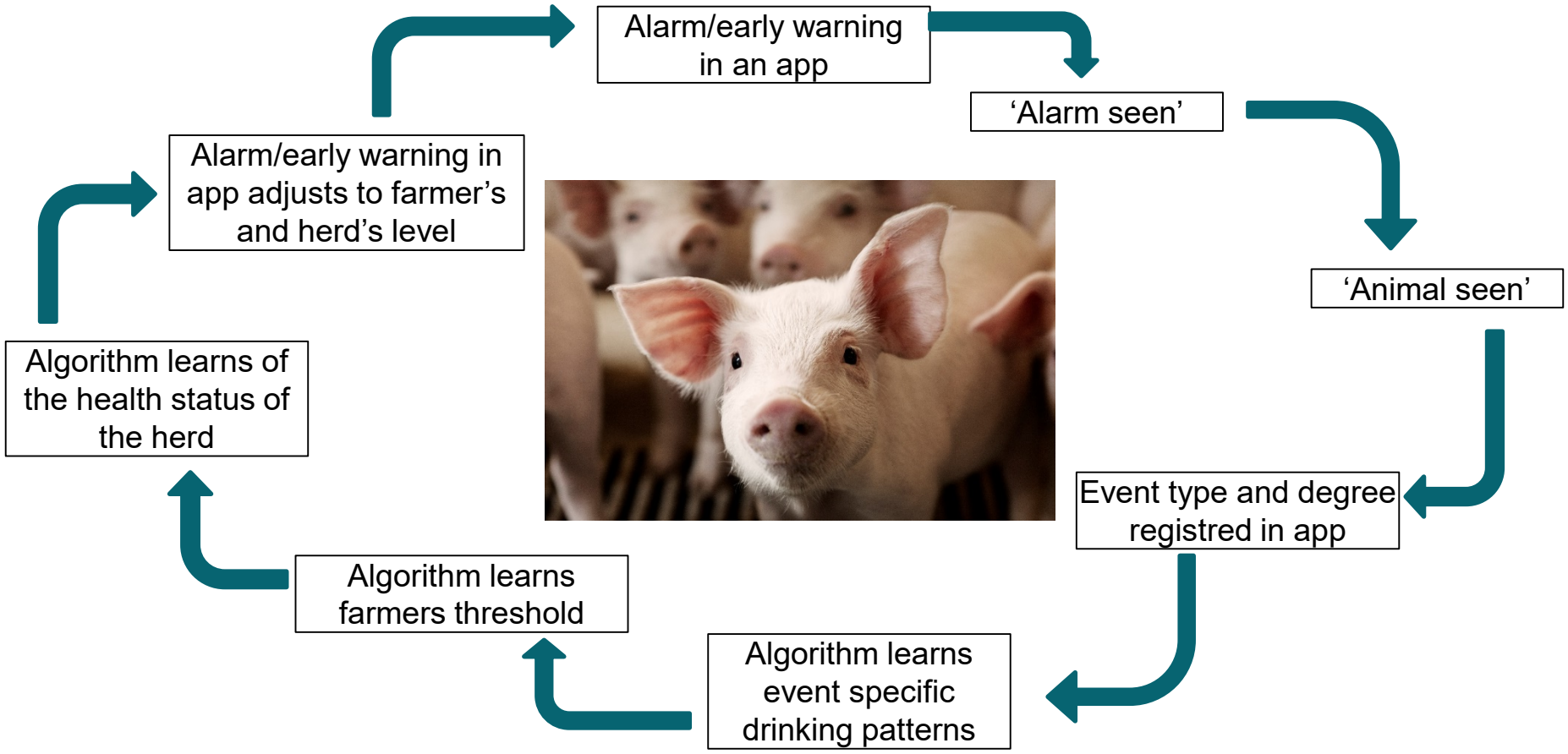
Categories for health status



IQinAbox – feedback loop



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Implementation

Collaboration with commercial companies

- SKOV
- DOL-sensors
- Scio+
- Agrosoft
- Cloud Farms
- IQinAbox

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Future research

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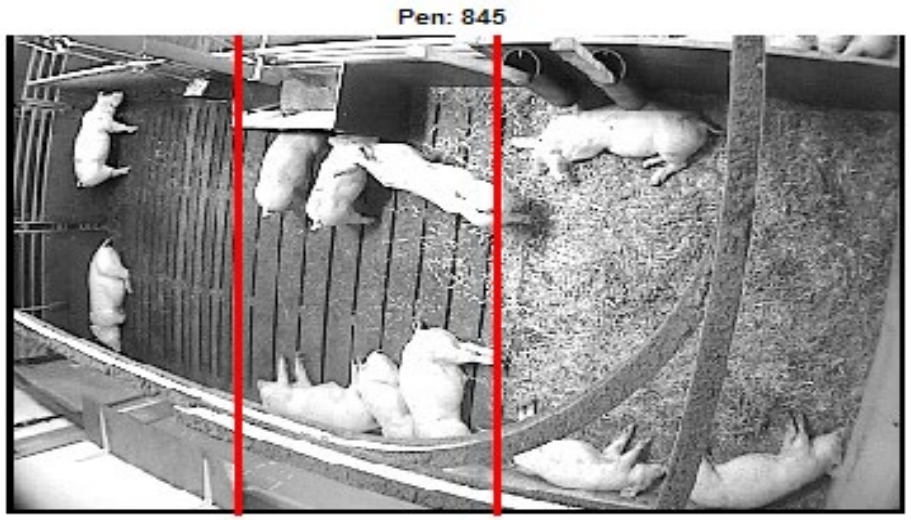
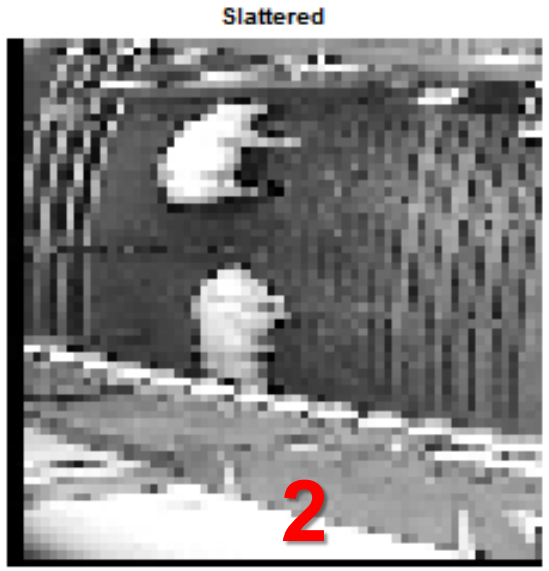
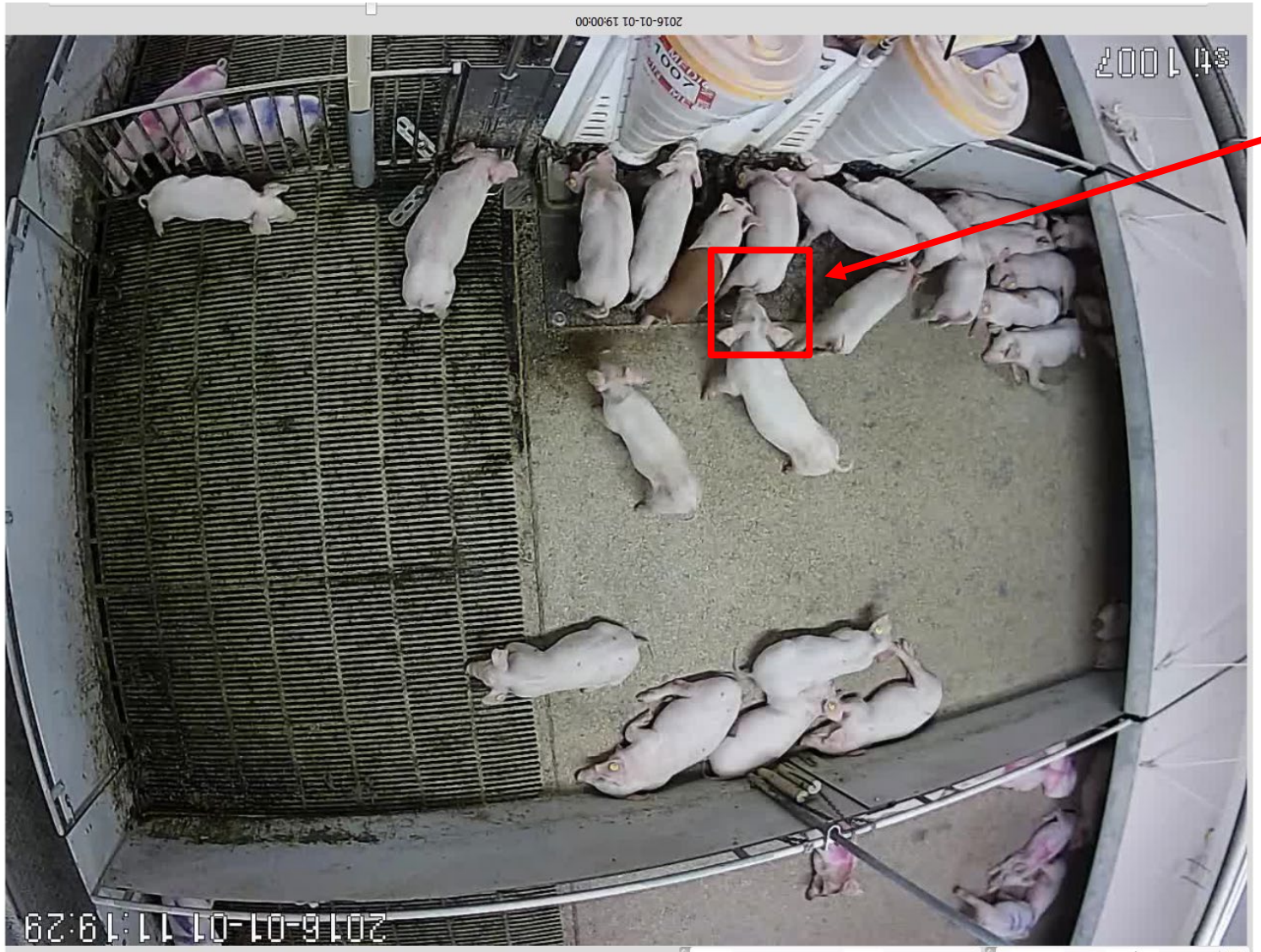
Counting pigs (image regression)

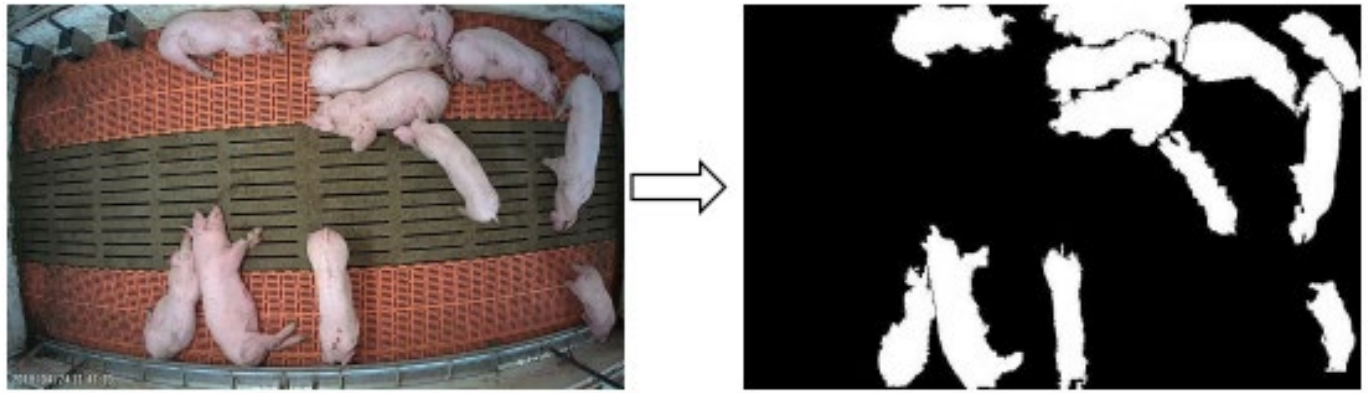




Recognizing tail-oriented behaviour



Object detection



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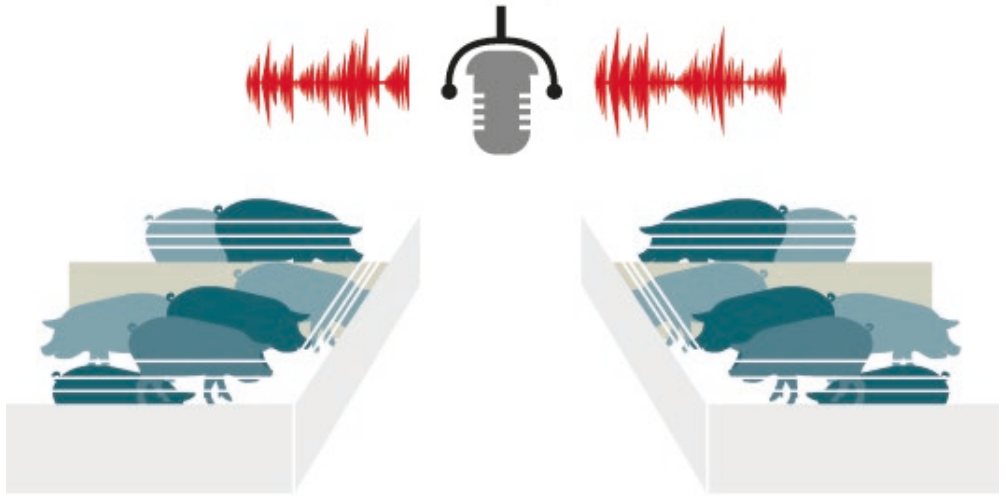

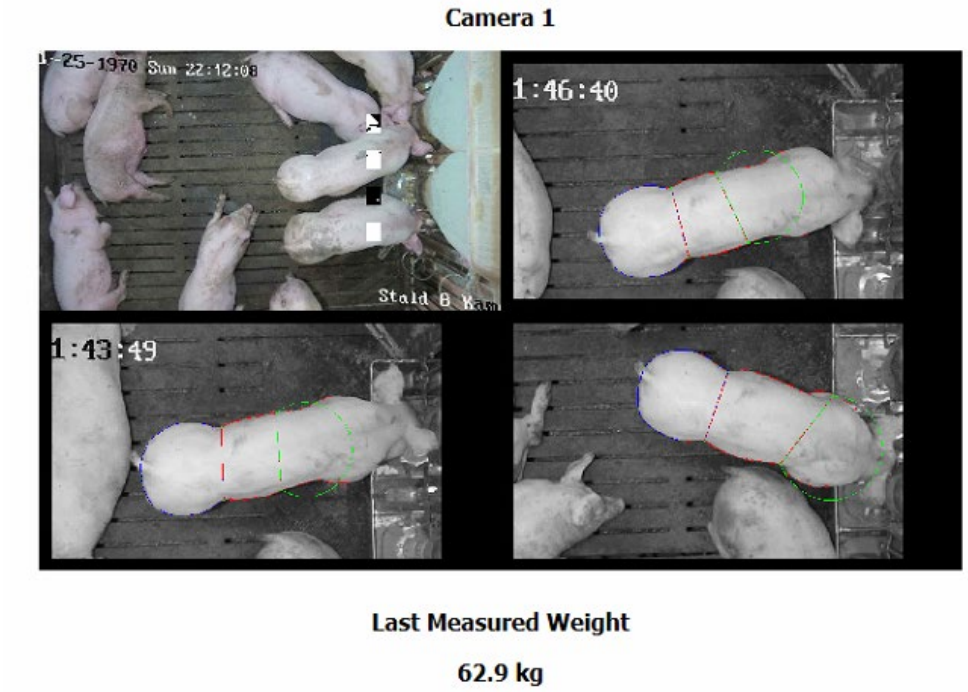

Individual weighing

Biological variation within pen and section

More specific alarms

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Thank you!

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