

Precision Livestock Farming (PLF)

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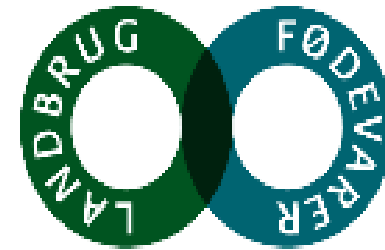
Svineafgiftsfonden





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

KATARINA NIELSEN DOMINIAK
PHD THESIS · 2017



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

The vision behind PLF

It is possible to increase

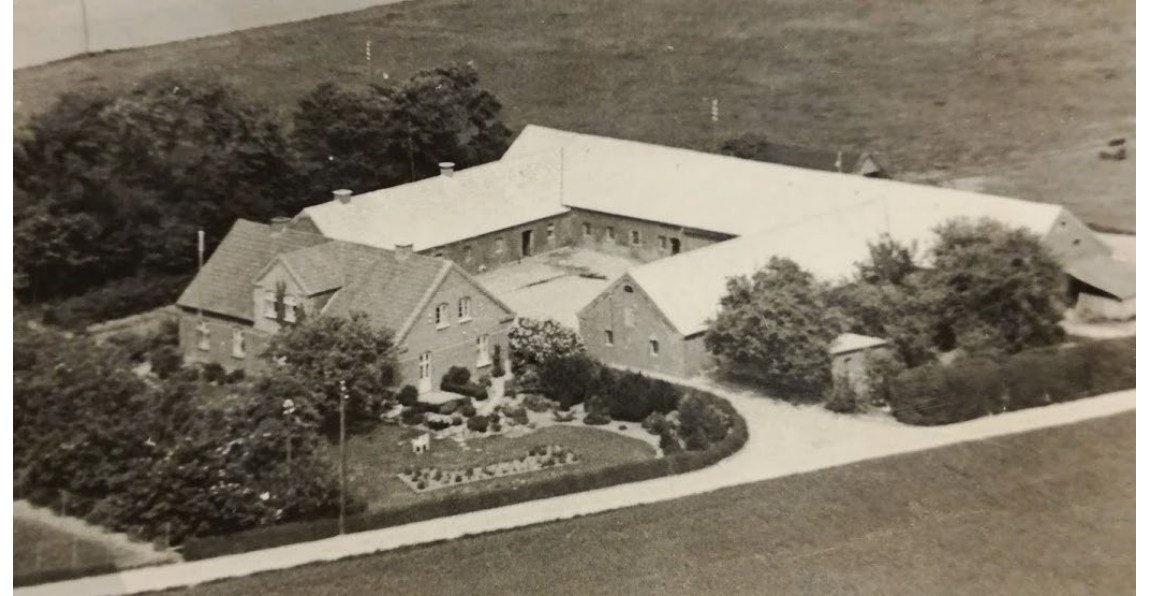
- Animal welfare
- Productivity
- Sustainability

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



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



General approach

The animals are monitored by sensors

either **directly**:

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

or **indirectly**:

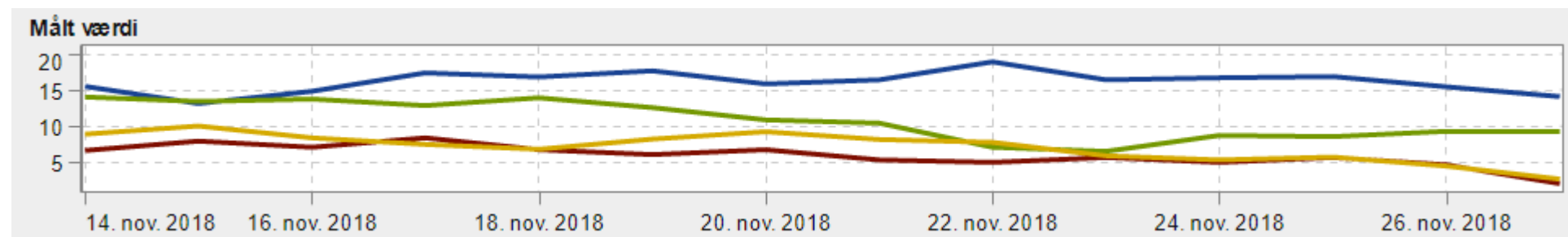
- Water consumption (stress, diseases, growth)
- Feed consumption (stress, diseases, growth)
- Environment (pen fouling, productivity)

Systematic deviations from normal are identified

Data – data - data

C	D	E	F	G	H	I	J
Location Description	DayNumber	HouseStatus	InsideHum	InsideTem	MaxHumid	MinHumid	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

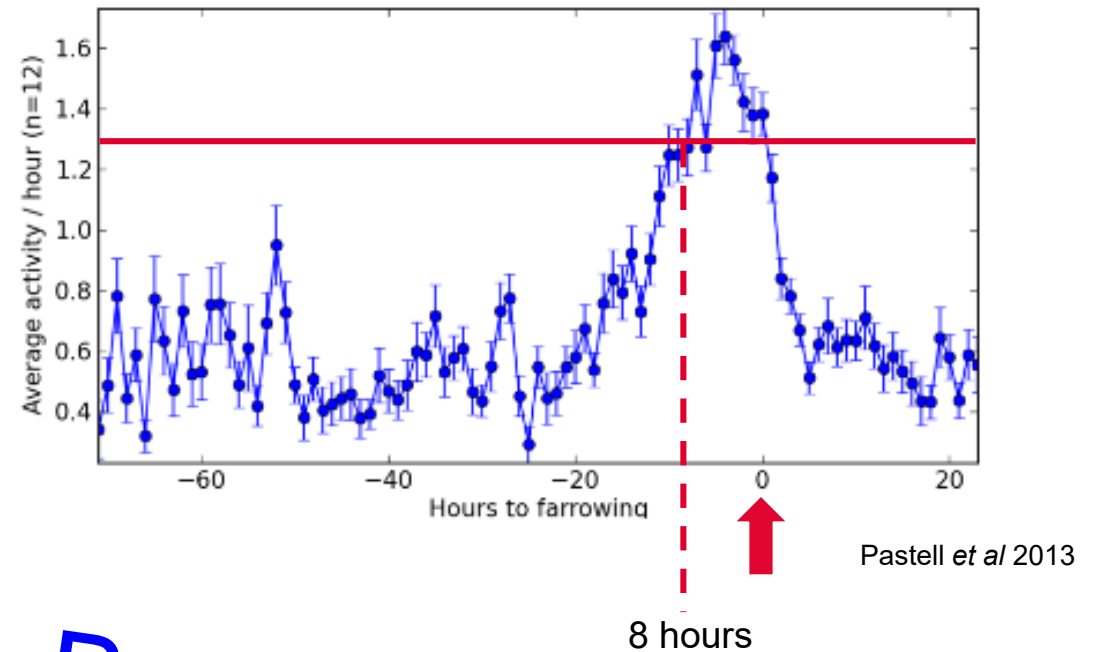
	SensorValueReadTimeUTC	Ins	P1_2	P5_6	P7_8	P11_12
1	2015-09-24 06:00:00	2015-09-17	3.330029	3.410323	1.6169586	1.017590
2	2015-09-24 07:00:00	2015-09-17	4.885650	8.846359	3.9152457	3.379308
3	2015-09-24 08:00:00	2015-09-17	9.071743	6.738609	4.6034456	3.196693
4	2015-09-24 09:00:00	2015-09-17	6.008714	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



Interpretation of data = value for the producer

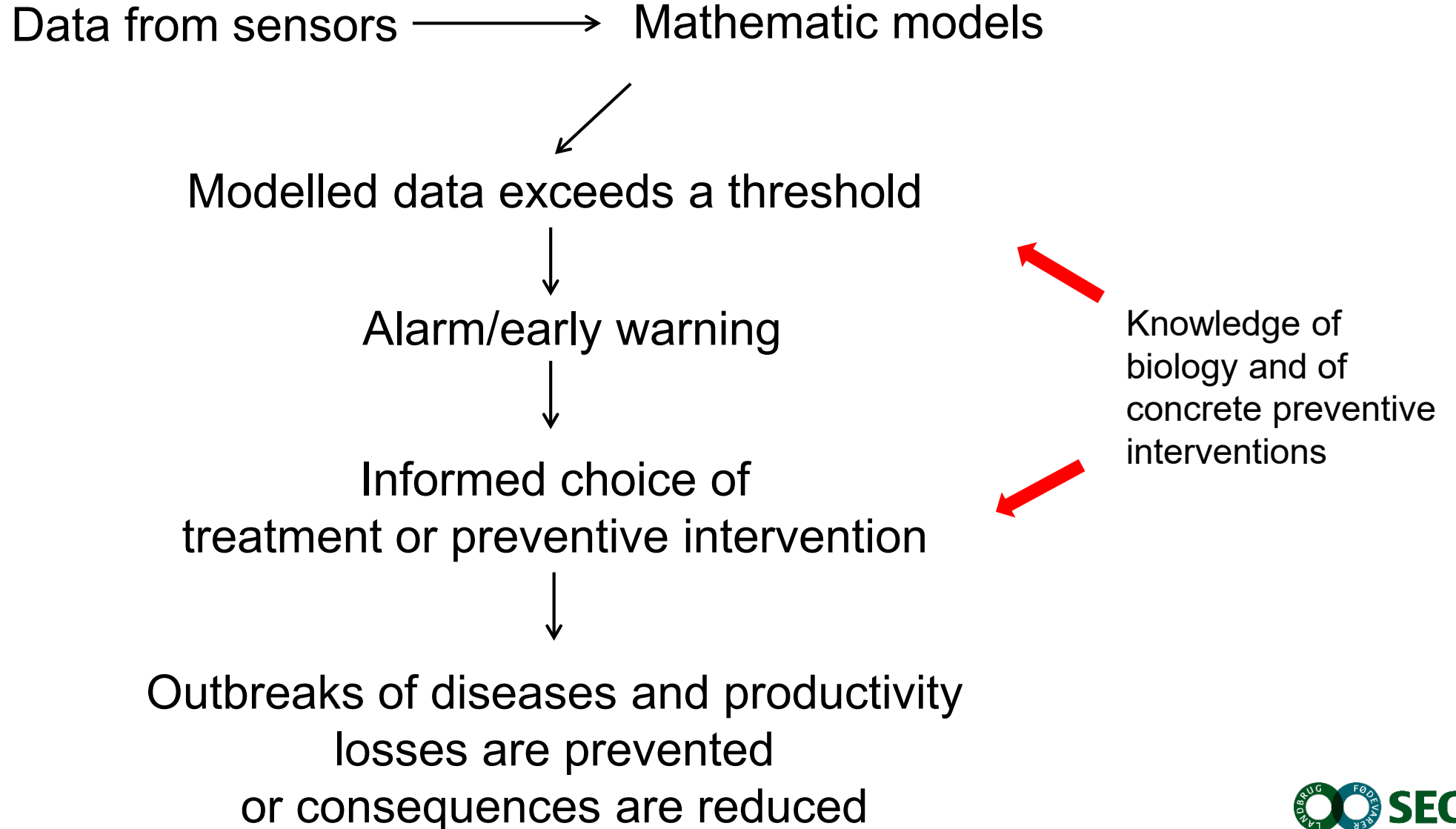
Data lay ground for dynamic tools for decision support in the every day management

- ➡ preventive interventions
- ➡ targetet treatments



Better management

Sensor based decision support system (DSS)



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

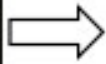
Dynamic



~~Static~~

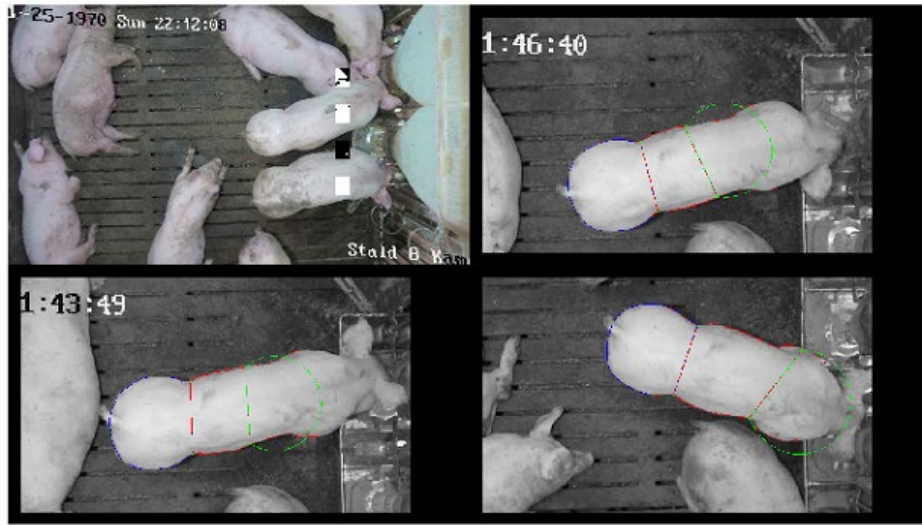


Examples of PLF



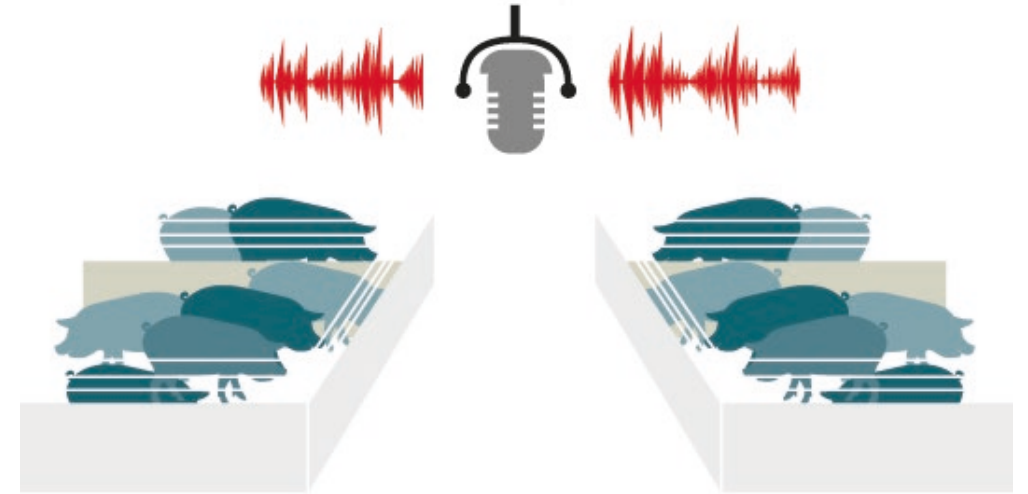
Nasirahmadi *et al* 2018

Camera 1



Last Measured Weight

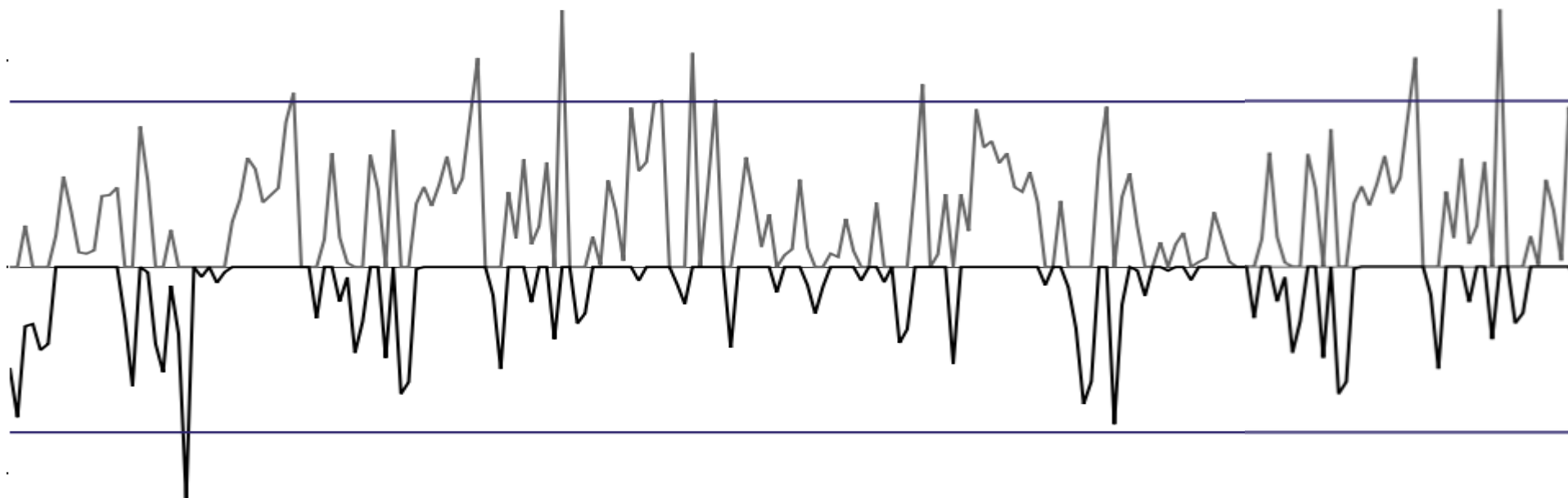
62.9 kg



PhD study

Management support through water monitoring

- Pigs' drinking patterns contain high level of information on their health, wellbeing 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



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

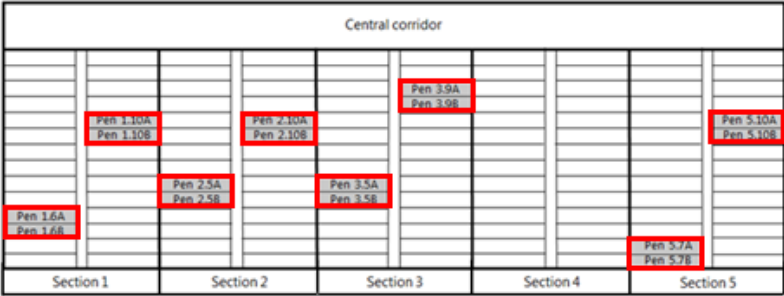
[illegible]

Sensors were installed in both weaner herds and finisher herds

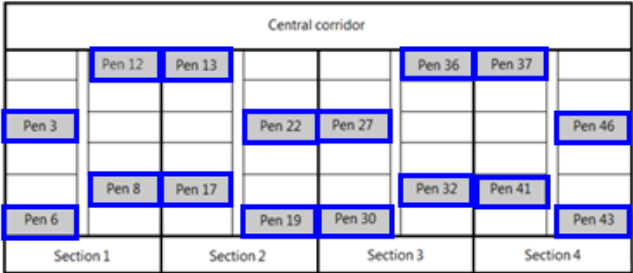
Herd	Variables in DLM
Herd A finishers	8
Herd B weaners	16
Herd C finishers	8
Herd C weaners	4

All sensors monitored water consumption simultaneously

Data was aggregated to liter/hour



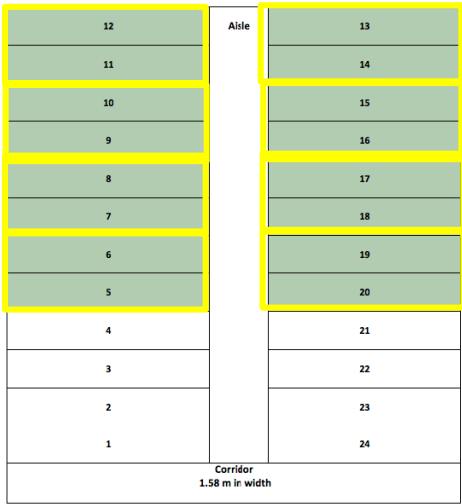
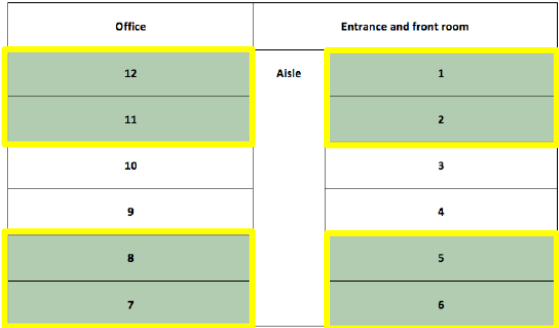
Herd A Finishers

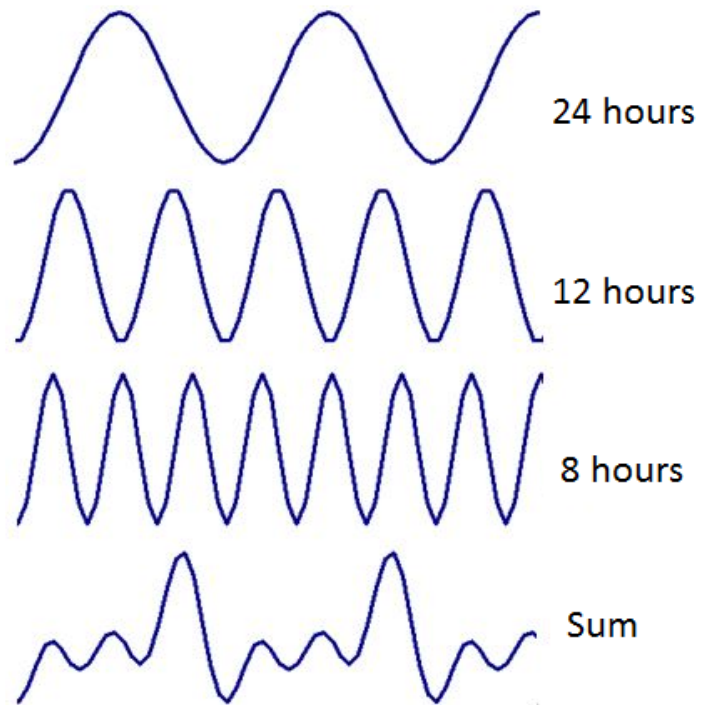


Herd C Weaners

Herd C Finishers

Herd C Weaners

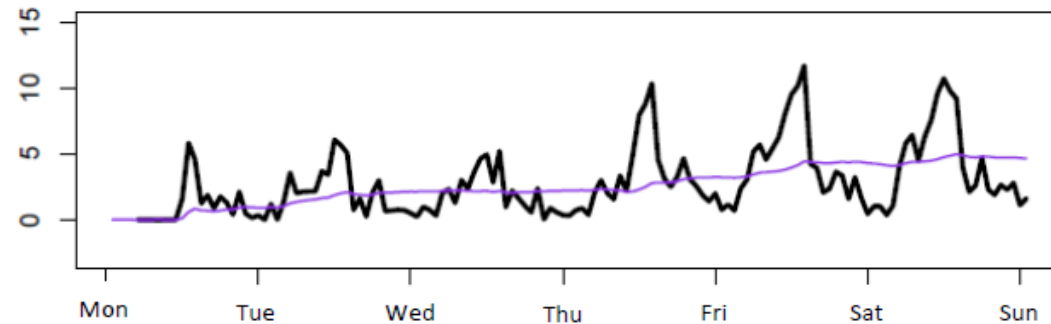




Drinking patterns of both weaners and finishers show clear diurnal pattern

Which can be described by the sum of three harmonic waves

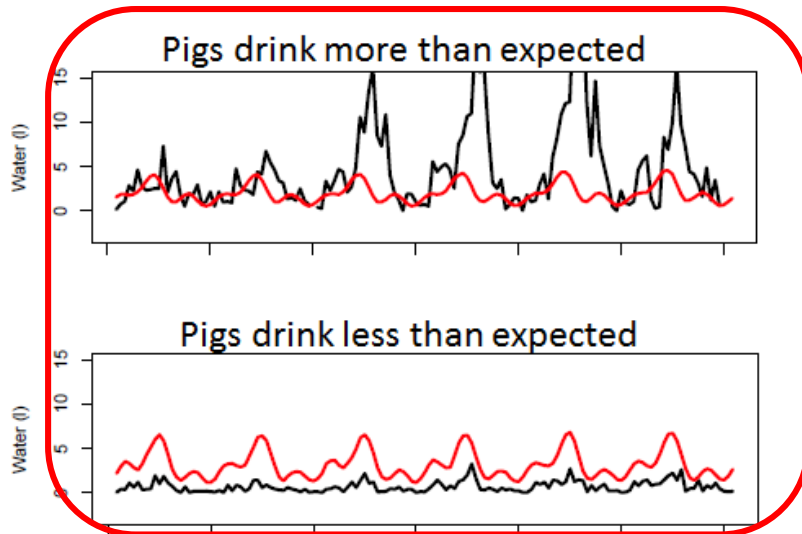
Pigs drink more water as they grow



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

Generating alarms

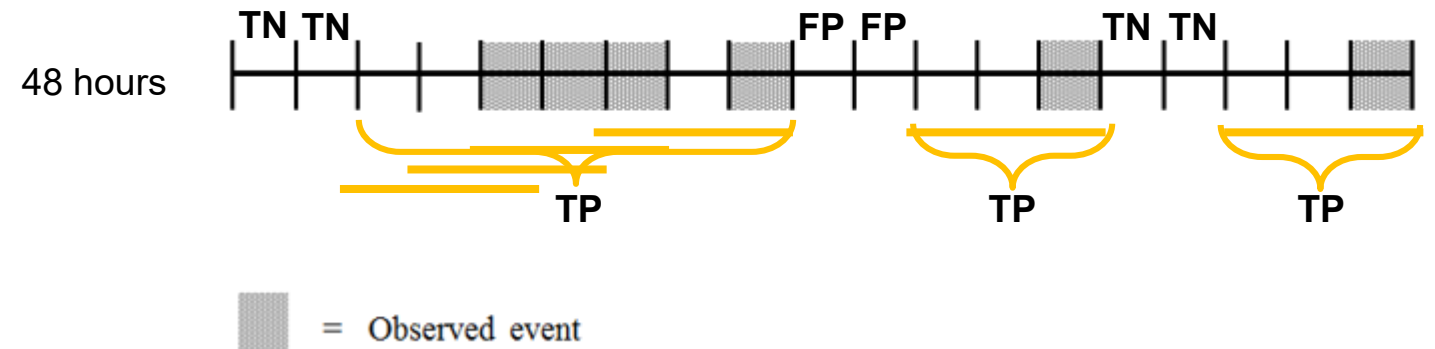
- Raw data, actual drinking pattern
- Fitted, expected drinking pattern



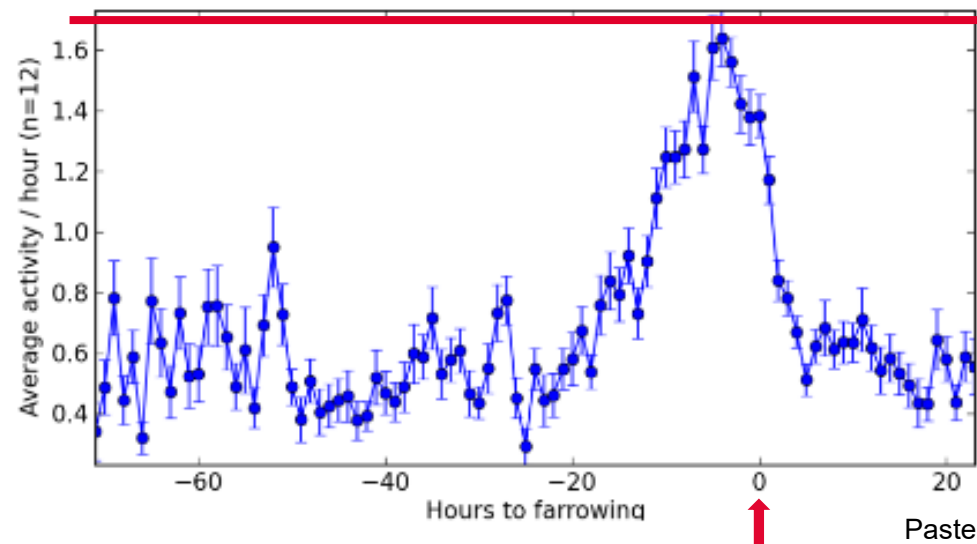
Forecast errors

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?



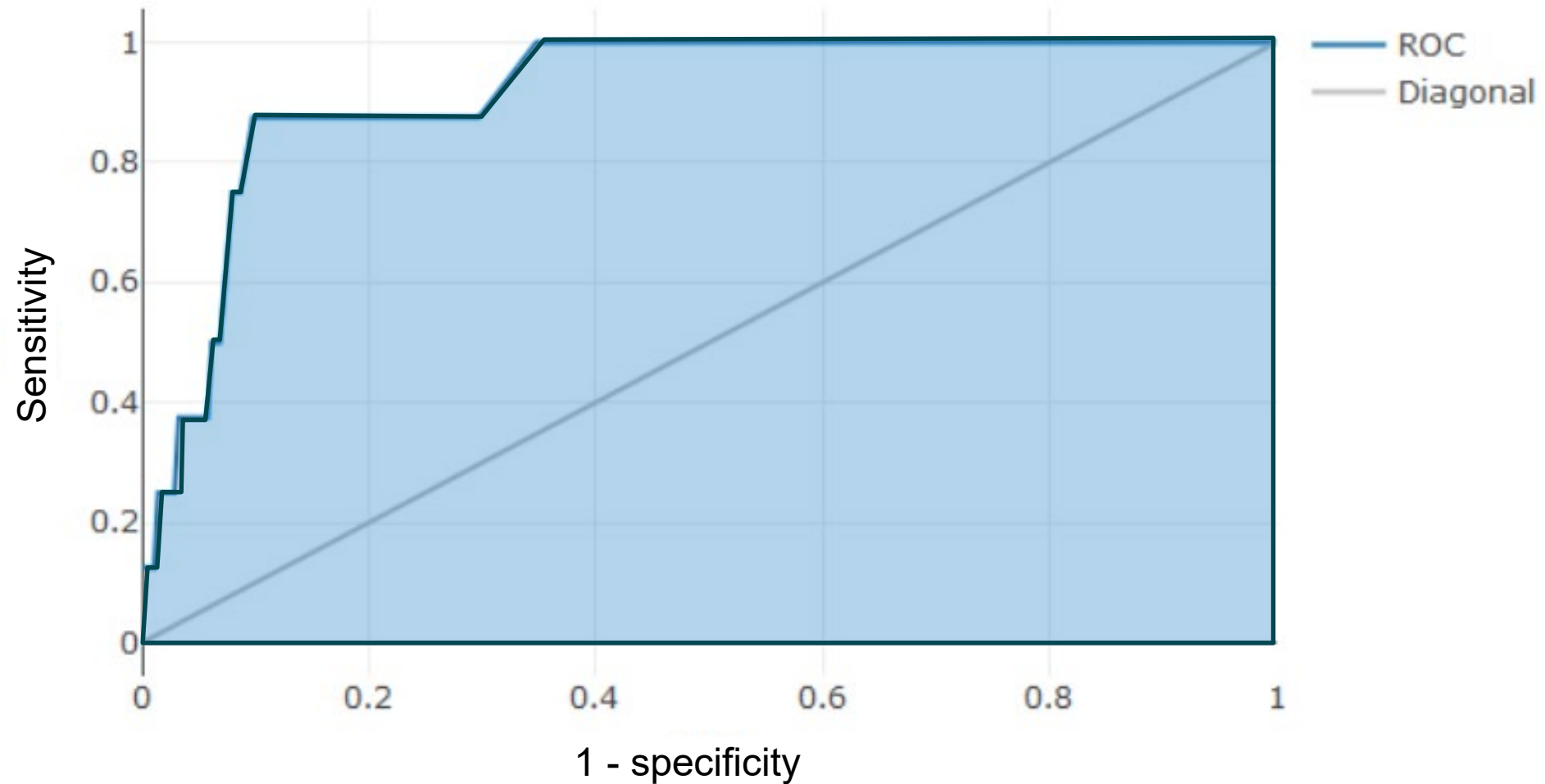
Too high threshold – no alarms for farrowing

Too low threshold – alarms for farrowing every hour

Pastell et al 2013

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

Performance evaluation – how good is the model?



Area Under the (ROC) Curve - AUC

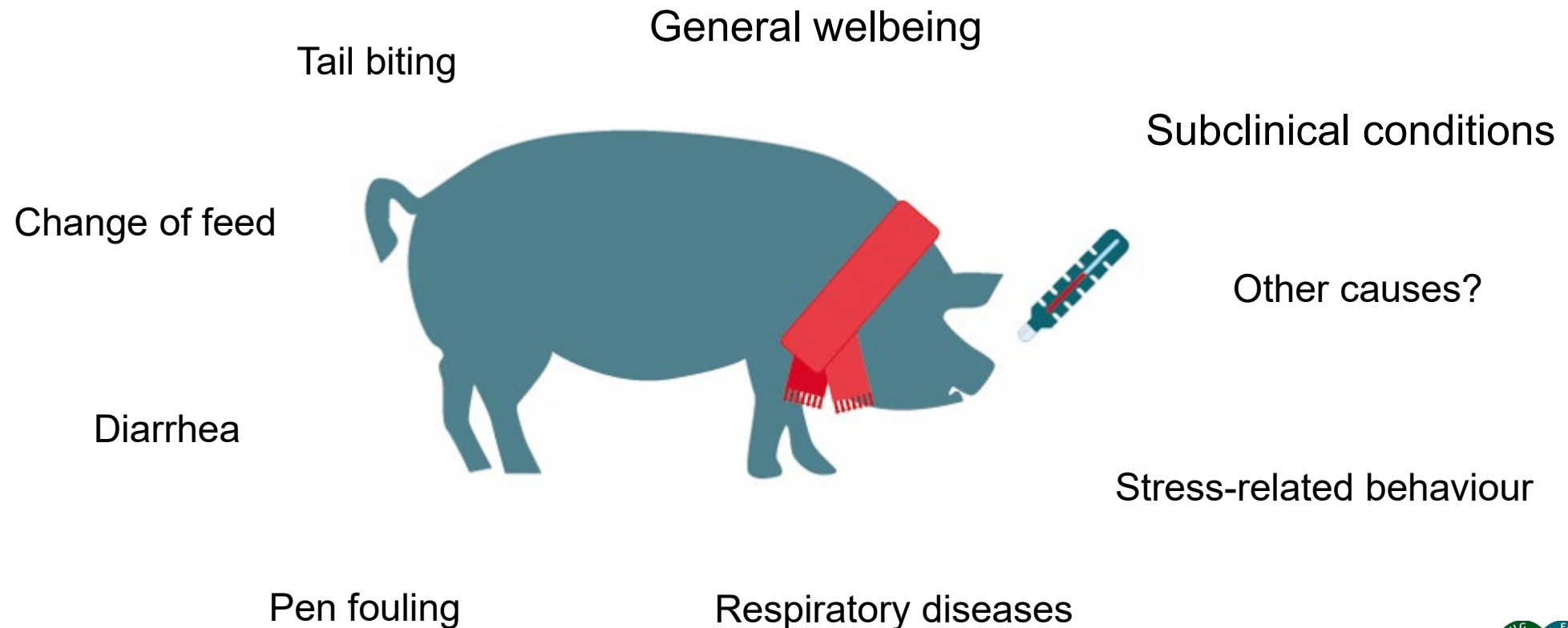
Changes in water consumption are excellent predictors

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

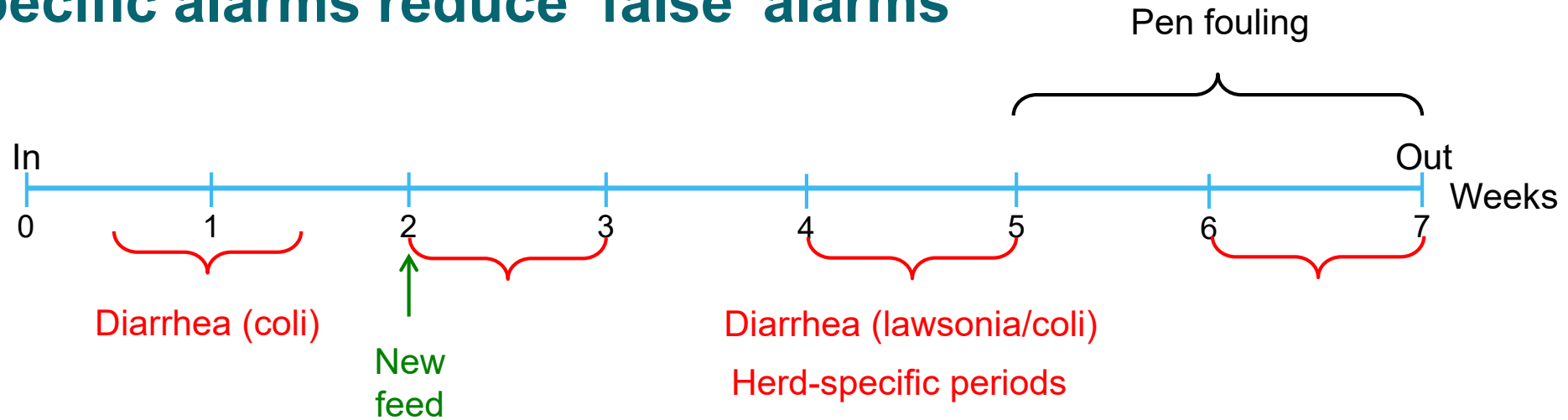
AUC = Area Under the ROC Curve
 DLM = Dynamic Linear Model
 MDLM = Multivariate Dynamic Linear Model
 ANN = Artificial Neural Network

A major challenge – ‘false’ alarms

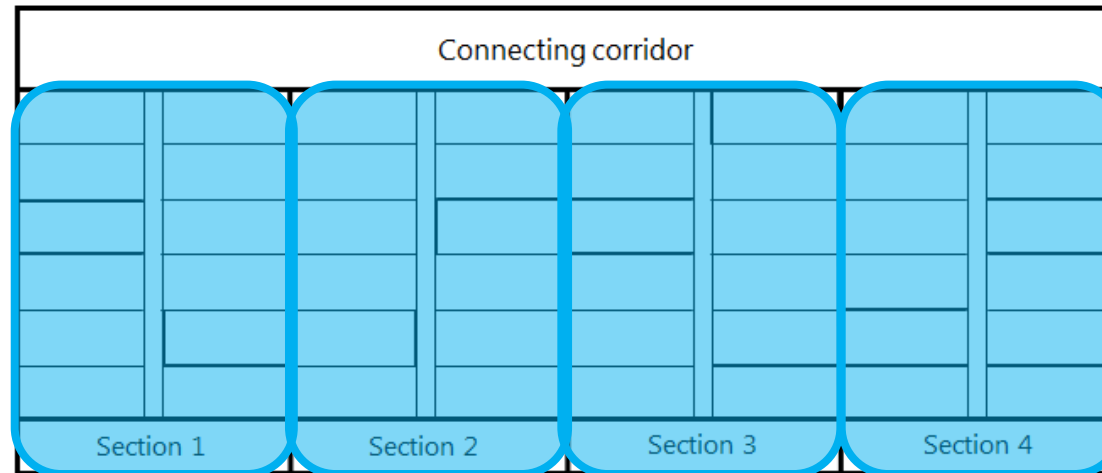
- One alarm can have multiple causes



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



Postdoc



**Water consumption
liter/hour**

vs

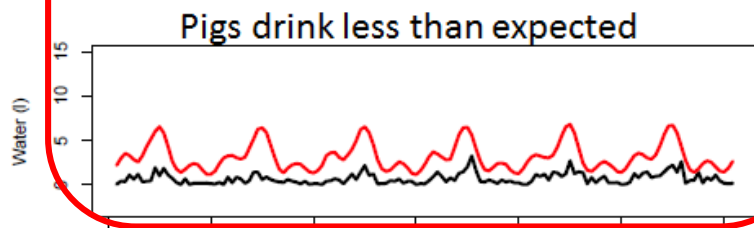
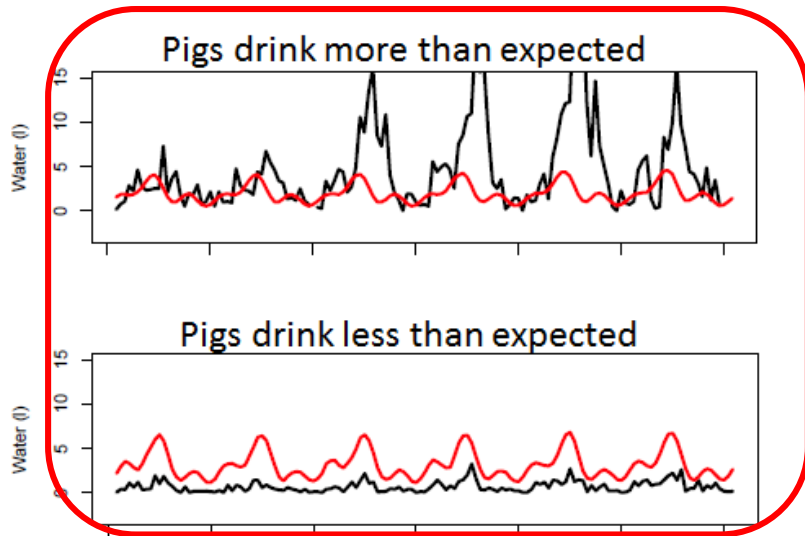
**Drinking frequency
bouts/hour**

when predicting tail biting and diarrhea

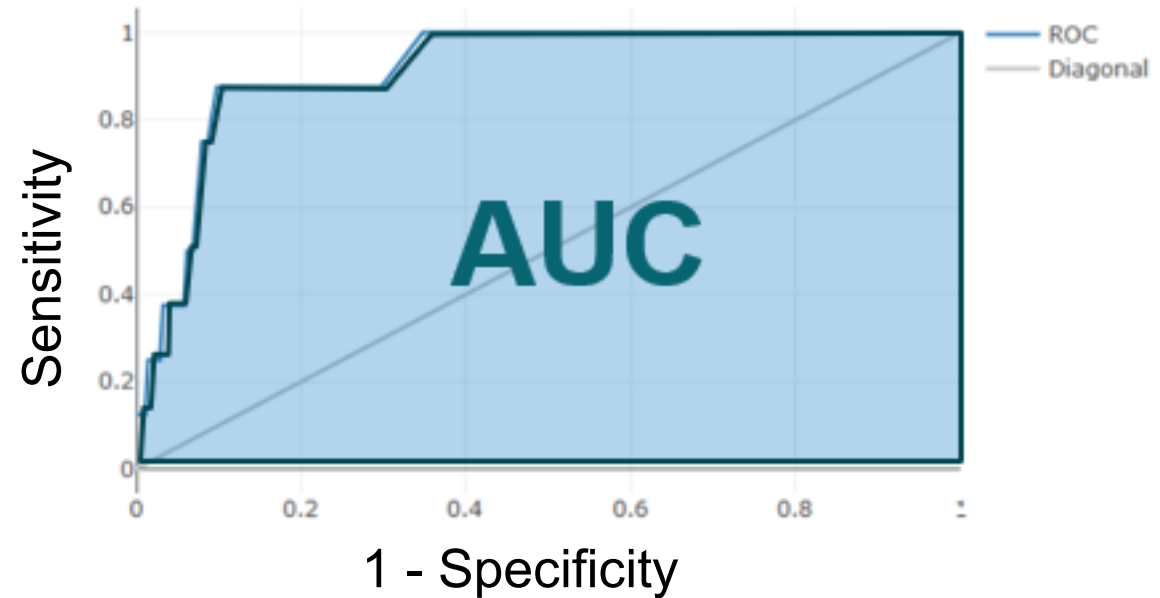


Methods and materials

- Raw data, actual drinking pattern
- Fitted, expected drinking pattern

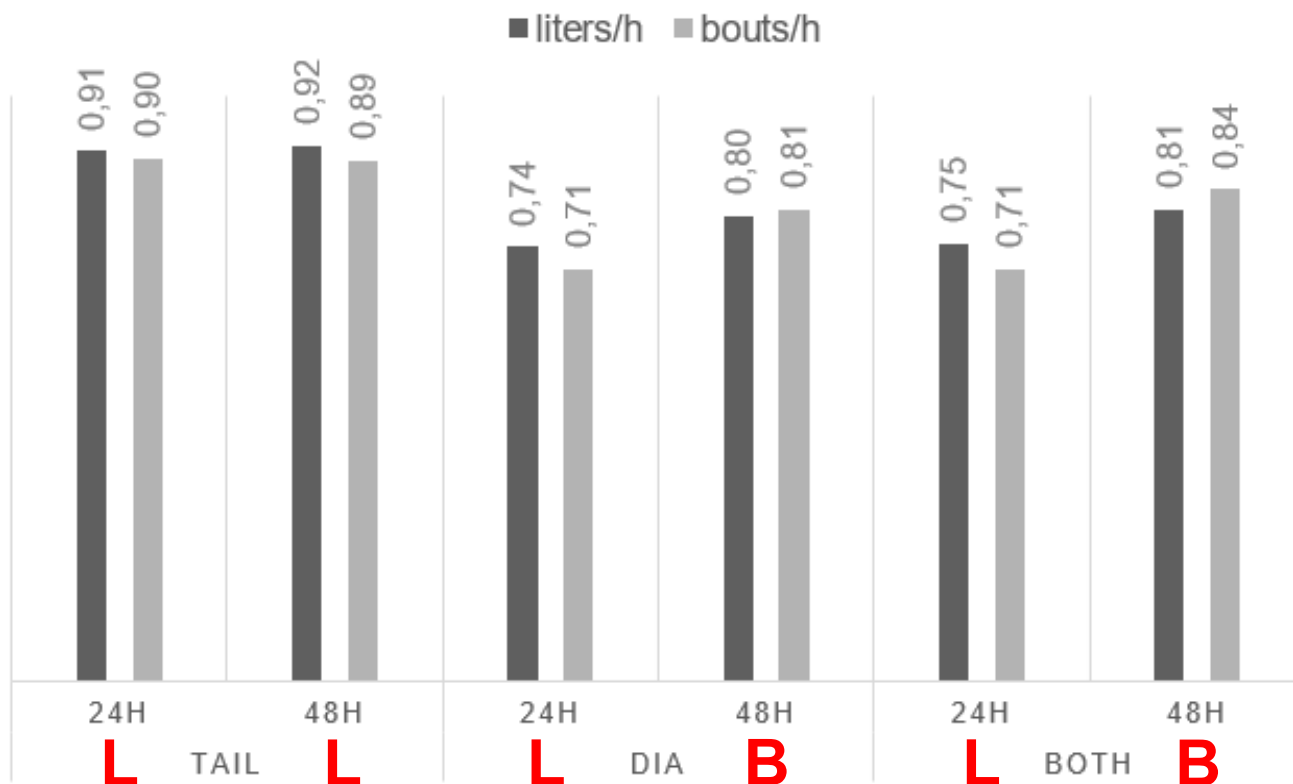


Forecast errors



Results - weaners

AUC WEANERS

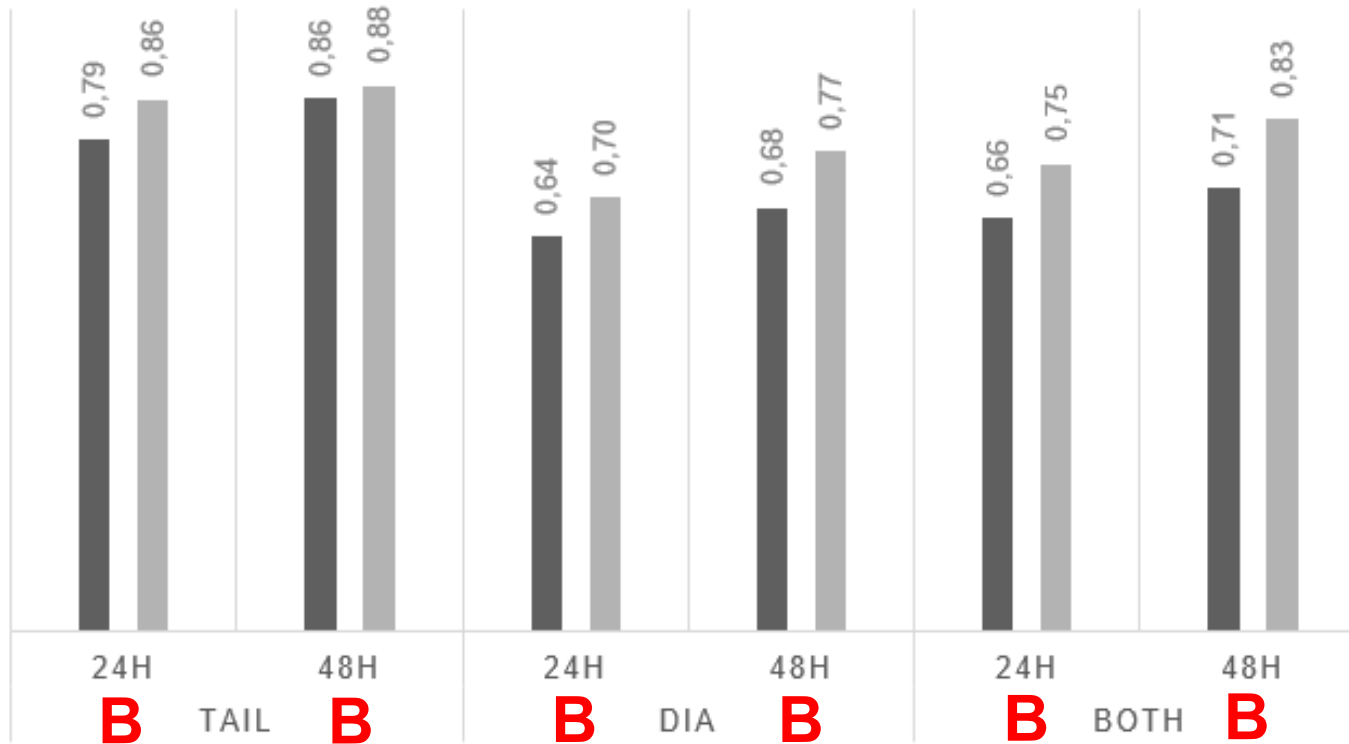


- **Liters > Bouts**
for prediction of tail biting
- **Liters > Bouts**
for short time windows predictions
- **Bouts > Liters**
for long time windows predictions of diarrh a or either event

Results – finishers

AUC FINISHERS

■ liters/h ■ bouts/h



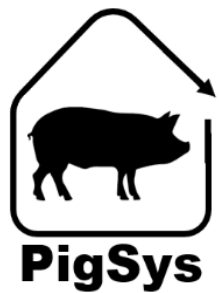
- **Bouts > Liters**
for all events and both time windows

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



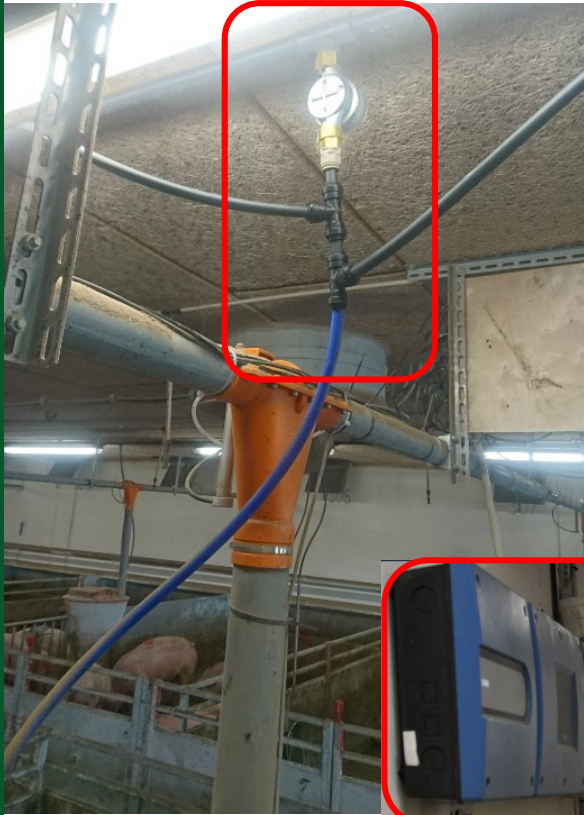
ERA-NET SusAn project PigSys



Svineafgiftsfonden



Sensors Fynen Farm



AgriSys
Feed computer

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:

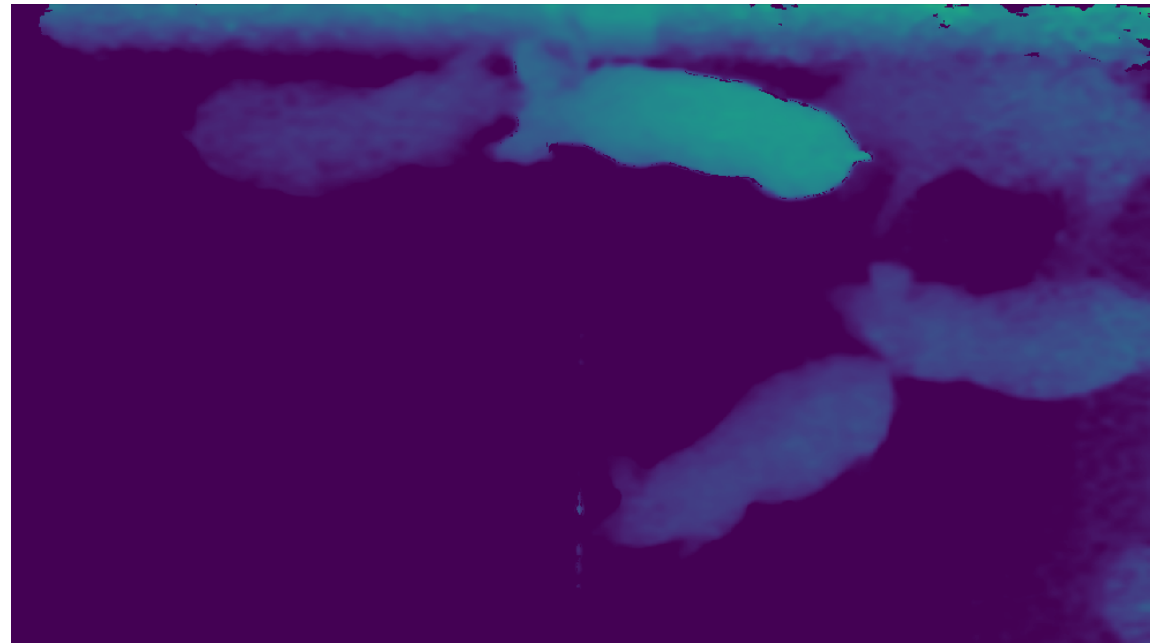
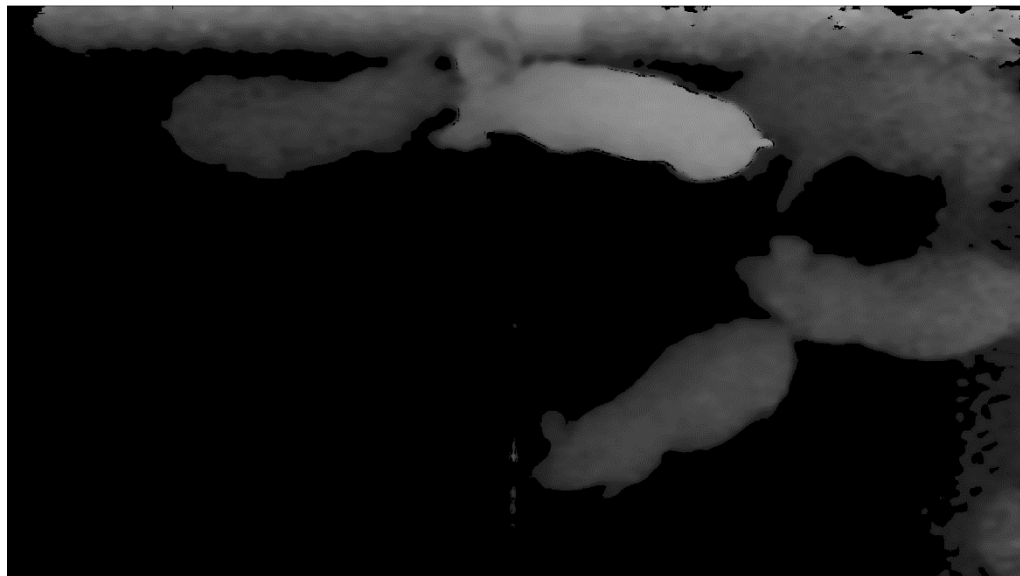
Medicinering	
Dato:	
Antal dage	
Årsag:	Diarre
Sektion:	
Antal grise:	
Middel:	Denaguard
Dosis:	1 ml/15 kg dyr

Døde			
Antal:	Dato:	Årsag:	Ventil:

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

Andre Bemærkninger:	Reparation:

3D weight at animal level and pen level



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

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

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

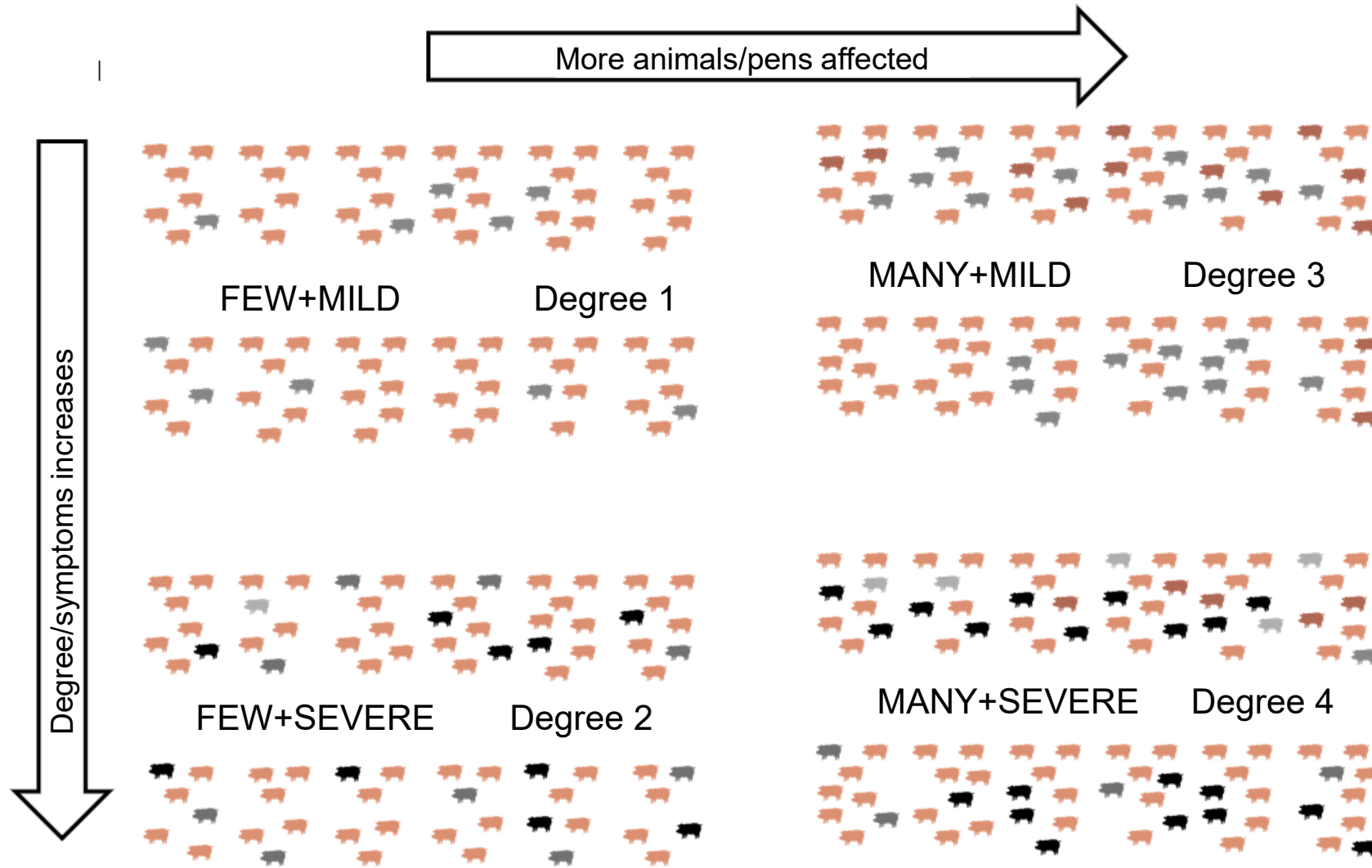
- Multiple daily weight estimates
- Water consumption
- Feed consumption
- Barn environment



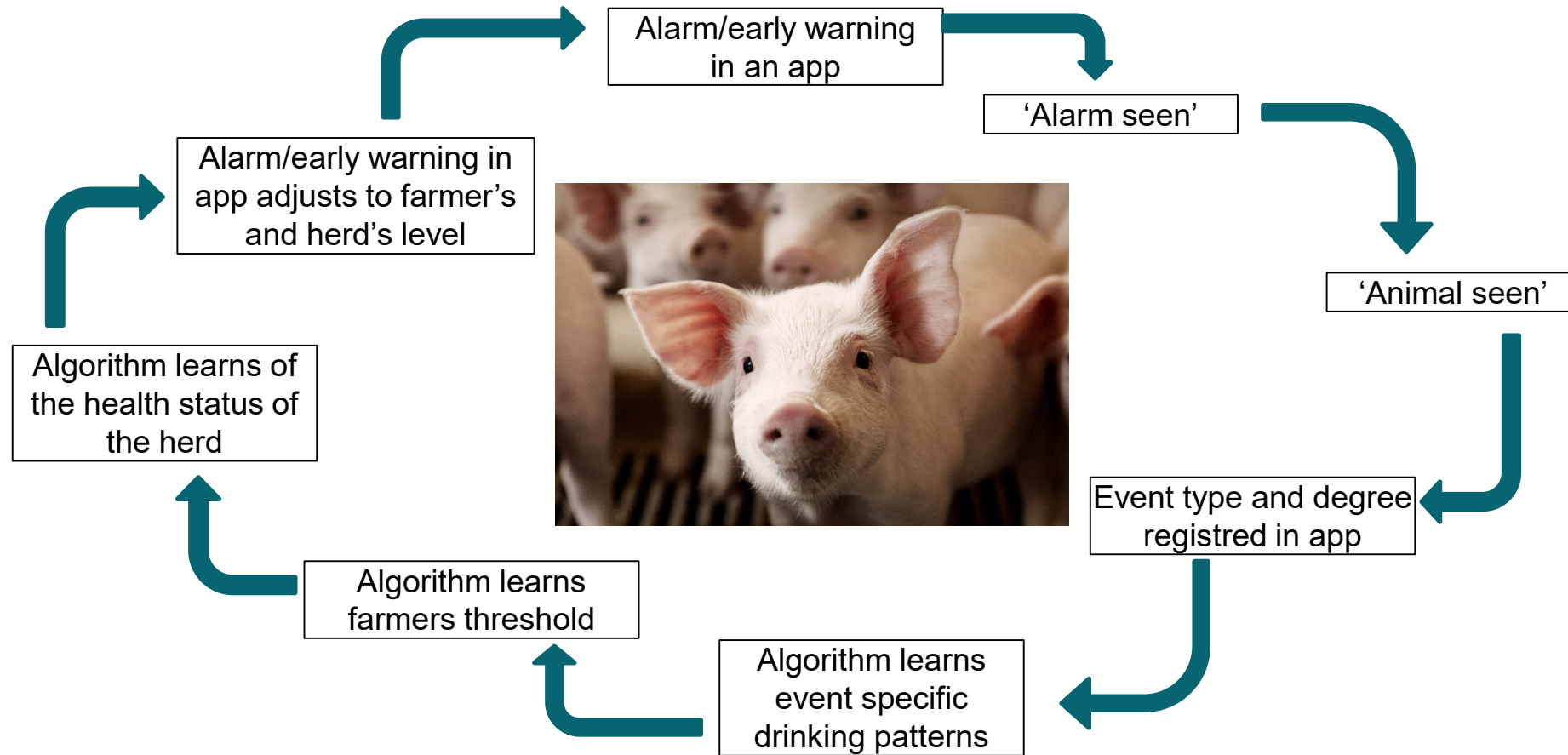
IQinAbox

- 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

Categories for health status



IQinAbox – feedback loop



Implementation



Collaboration with commercial companies

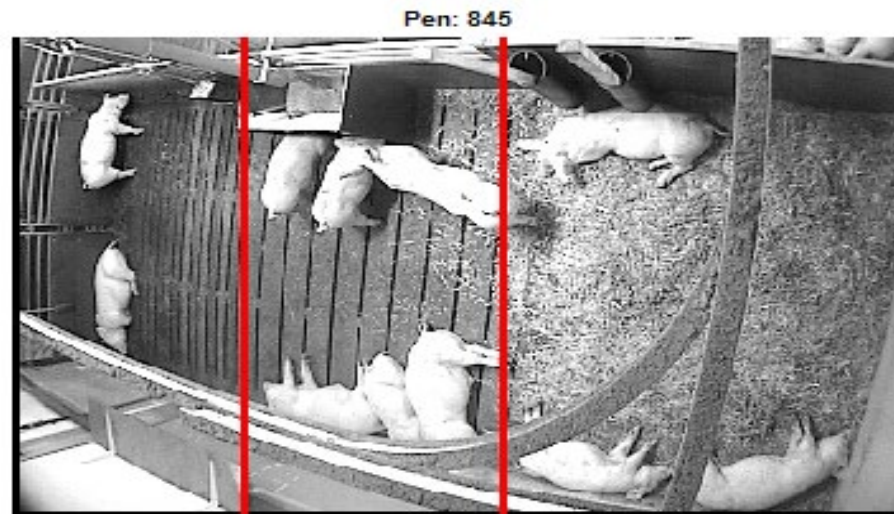
- SKOV
- DOL-sensors
- Scio+
- Agrosoft
- Cloud Farms
- IQinAbox



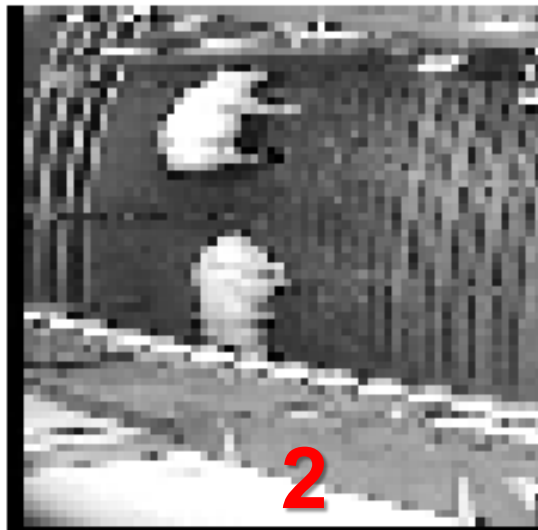
A close-up photograph of two piglets in a farm setting. The piglet on the left is white with pink ears and is sniffing the snout of a piglet on the right. The piglet on the right is pink with a yellowish patch on its head and is looking towards the camera. The background is slightly blurred, showing other pigs and straw on the floor.

Future research

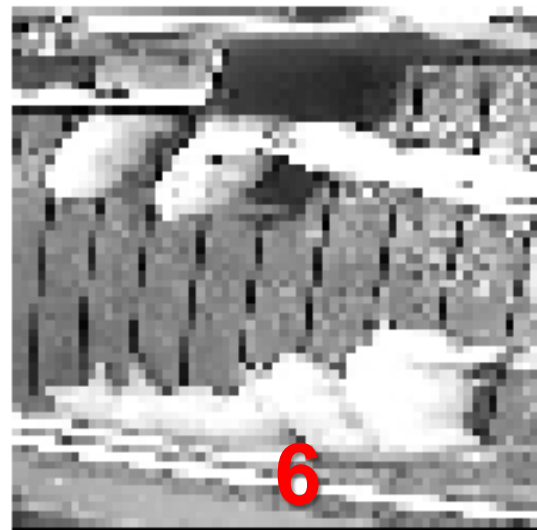
Counting pigs (image regression)



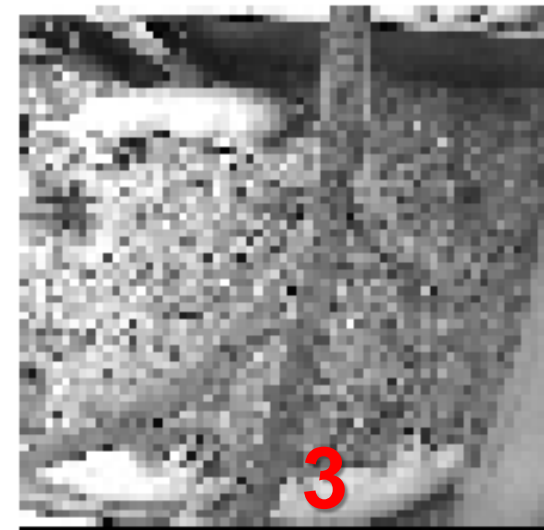
Slattered



Drained



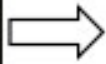
Solid



Recognizing tail-oriented behaviour

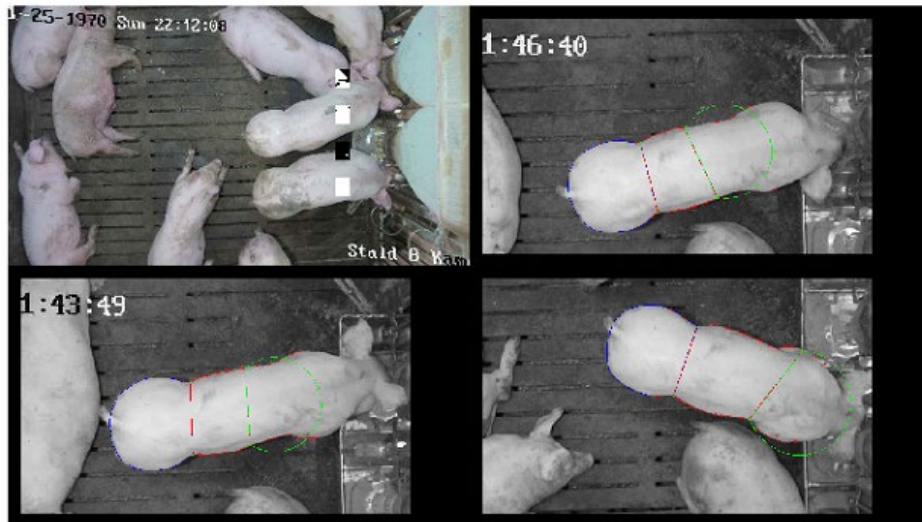


Object
detection



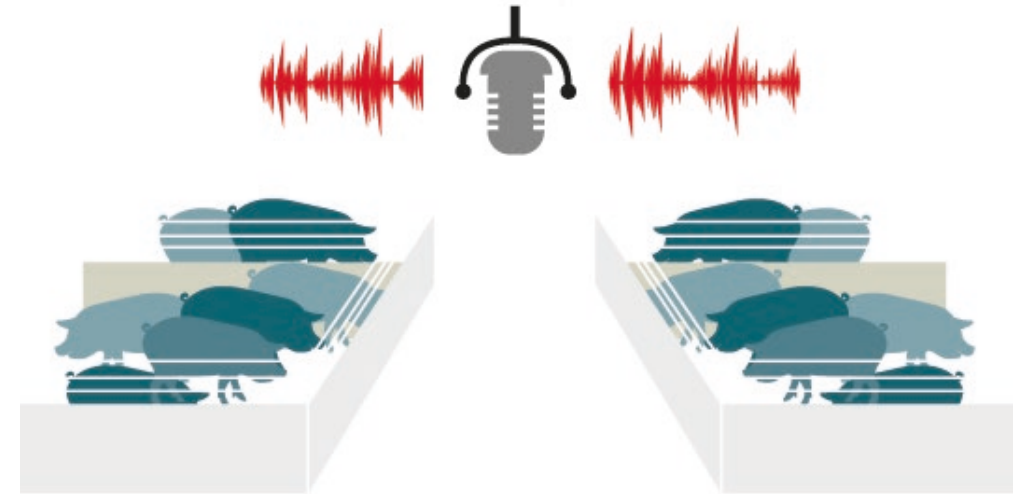
Nasirahmadi *et al* 2018

Camera 1



Last Measured Weight

62.9 kg



Individual weighing

Biological variation within pen and section

More specific alarms

Thank you!

Stay updated on the latest professional
knowledge on pig production

www.svineproduktion.dk

 facebook.com/SegesSvineproduktion

