Monitoring behaviour of fattening pigs using low-cost RGB-depth cameras under a practical condition

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Outline

- Introduction
- System and algorithm
- Performance test
- Practical perspective
- Conclusion

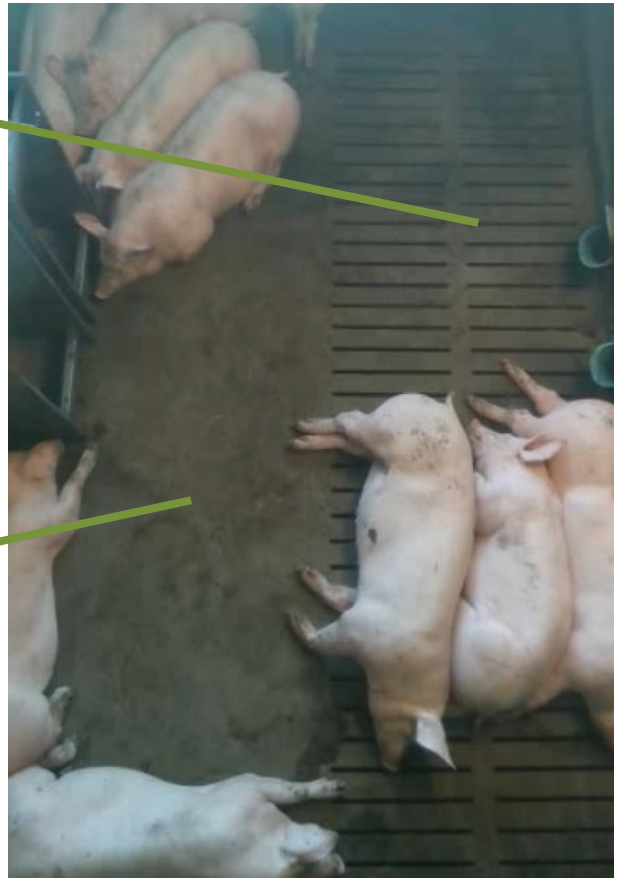
Introduction

Slatted floor

- For excretion

Solid floor

- For resting



Issues

- Increased emissions
- Reduced Hygiene & welfare

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Depth camera

- A promising tool
  - None invasive
  - Do not interact with the pigs
- Low-cost options available
- Active research in pig application

Authors	Year	Objective
Lao et al.	2016	Identifying posture and behaviour
Lee et al.	2016	Detecting aggression
Kim et al.	2017	Identifying standing pigs
Zhang et al.	2018	Continuous tracking
Sa et al.	2019	Detecting pig locations

Depth based monitoring system in pig compartments

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Intel® RealSense™ D415

- Released in 2018
  - Colour, depth
  - Price ~€135
  - Design: accuracy, in/outdoor application

Parameter	Specification
Size	99mm × 20mm × 23mm, 72 gram
Field of view (depth)	65° × 40° × 72°
Resolution (depth)	Up to 720p (16:9)
Range	0.3m ~ 10m
Frame rate (depth)	Up to 90 fps

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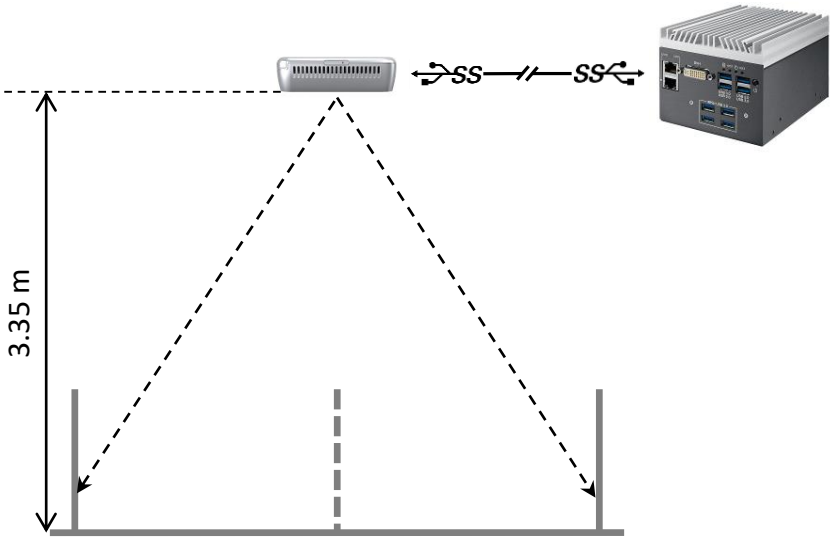
Preparation

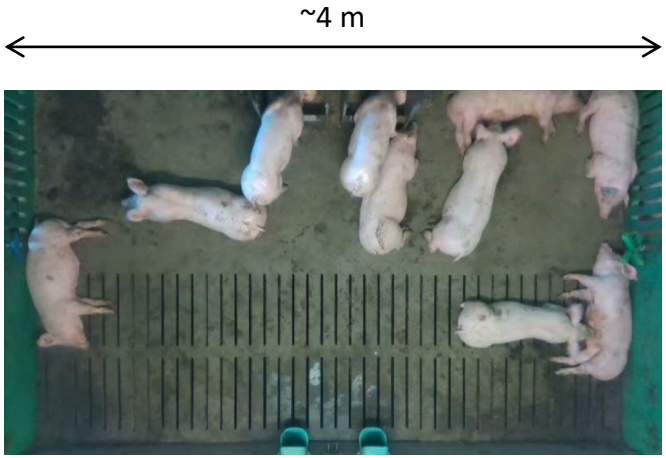
- D415 camera
  - Acrylic enclosure
  - Silicone sealant

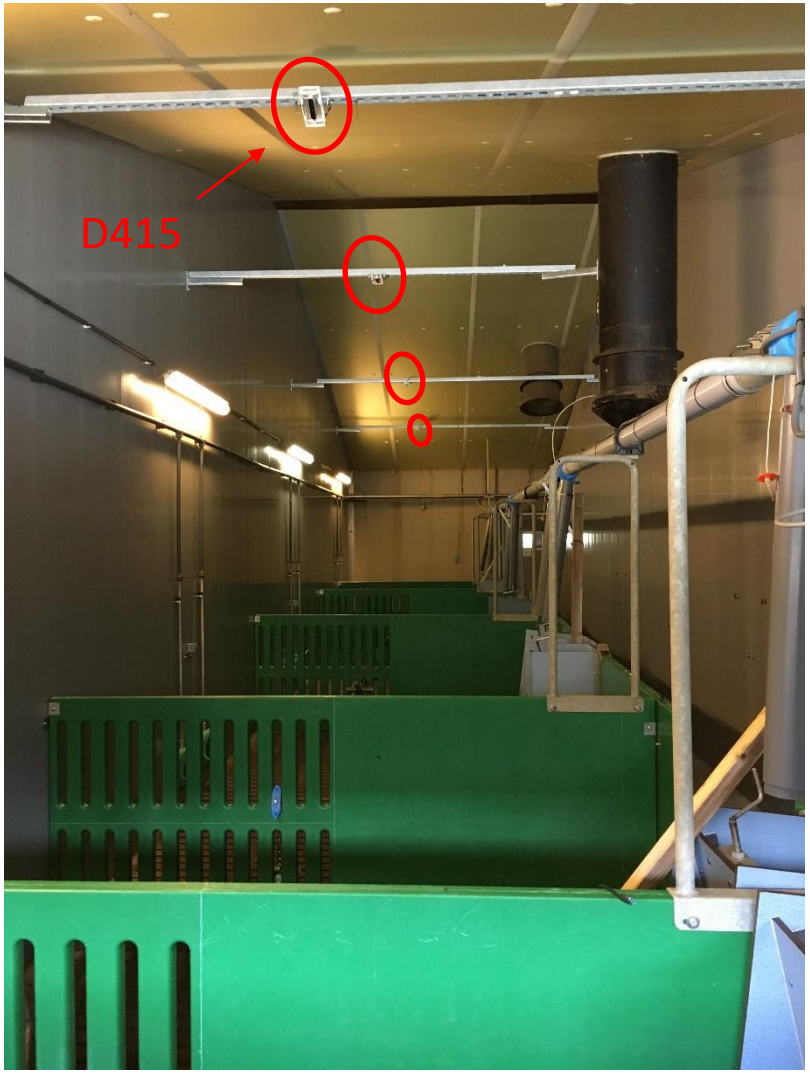
- Logger PC
  - Fanless / passive cooling
  - Adequate CPU (2.0 GHz)

- Active USB 3.0 extension cable

Field setup







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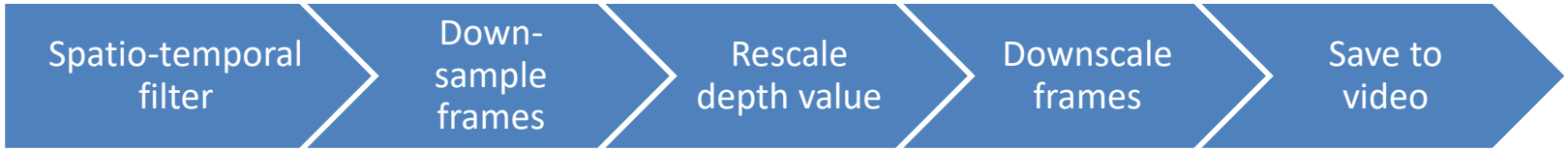
Recording depth videos

- Raw depth value → gray-scale video

Parameter	Camera output	Video
Bit depth (distant res.[1])	16 (~0.1 mm)	
Image resolution	1280 × 720	
Frame rate	6 FPS ⇔ Exposure time	
File size[2]	300 Gigabyte/day	

[1] based on bit depth; not reflecting true accuracy
[2] varies with noise level



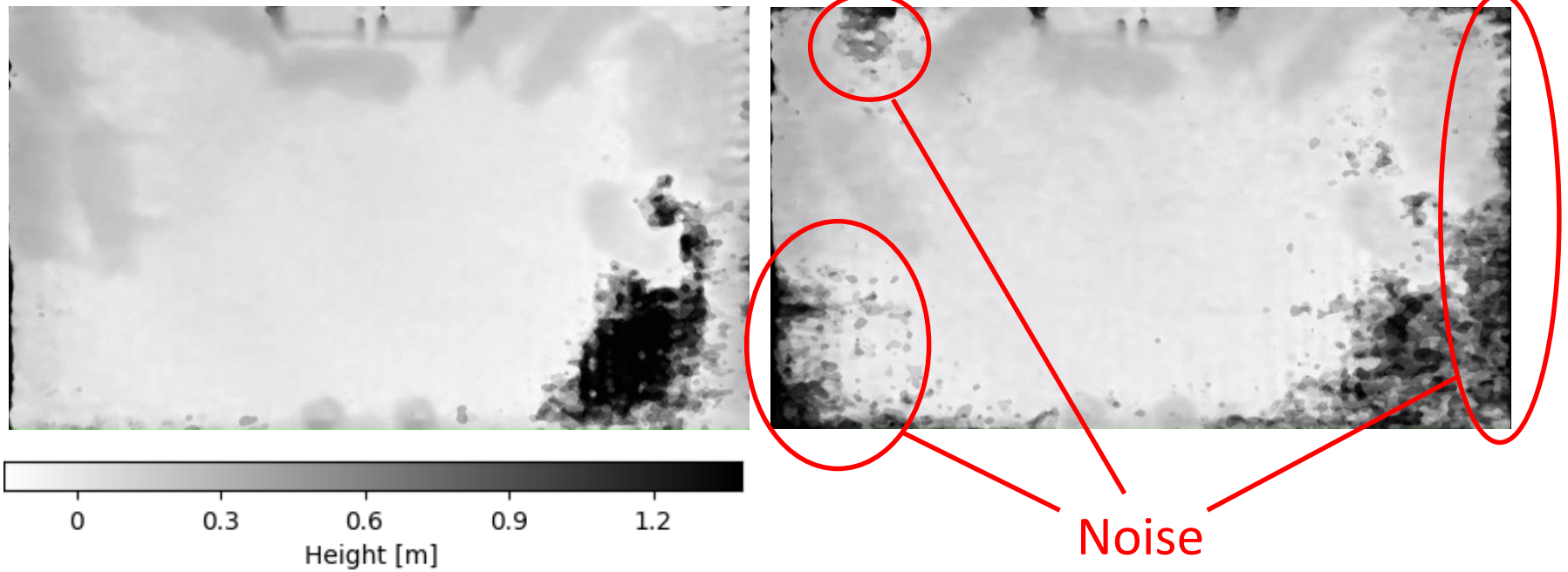
Exposure time

Long

Short

150 ms (max. 6 FPS)

30 ms (max. 33 FPS)



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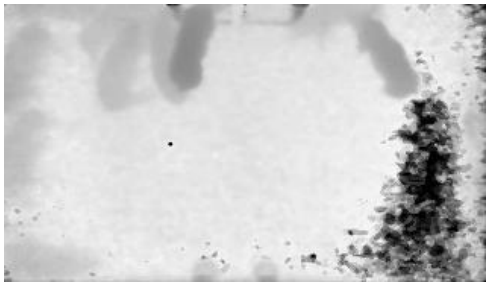
Processing depth videos

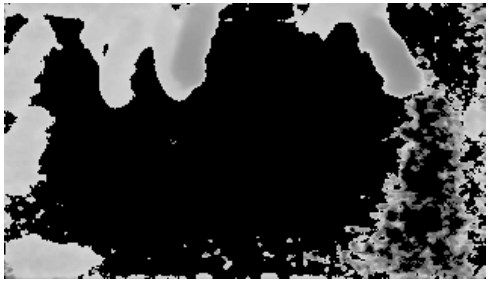
Depth image

Extract fore-ground image

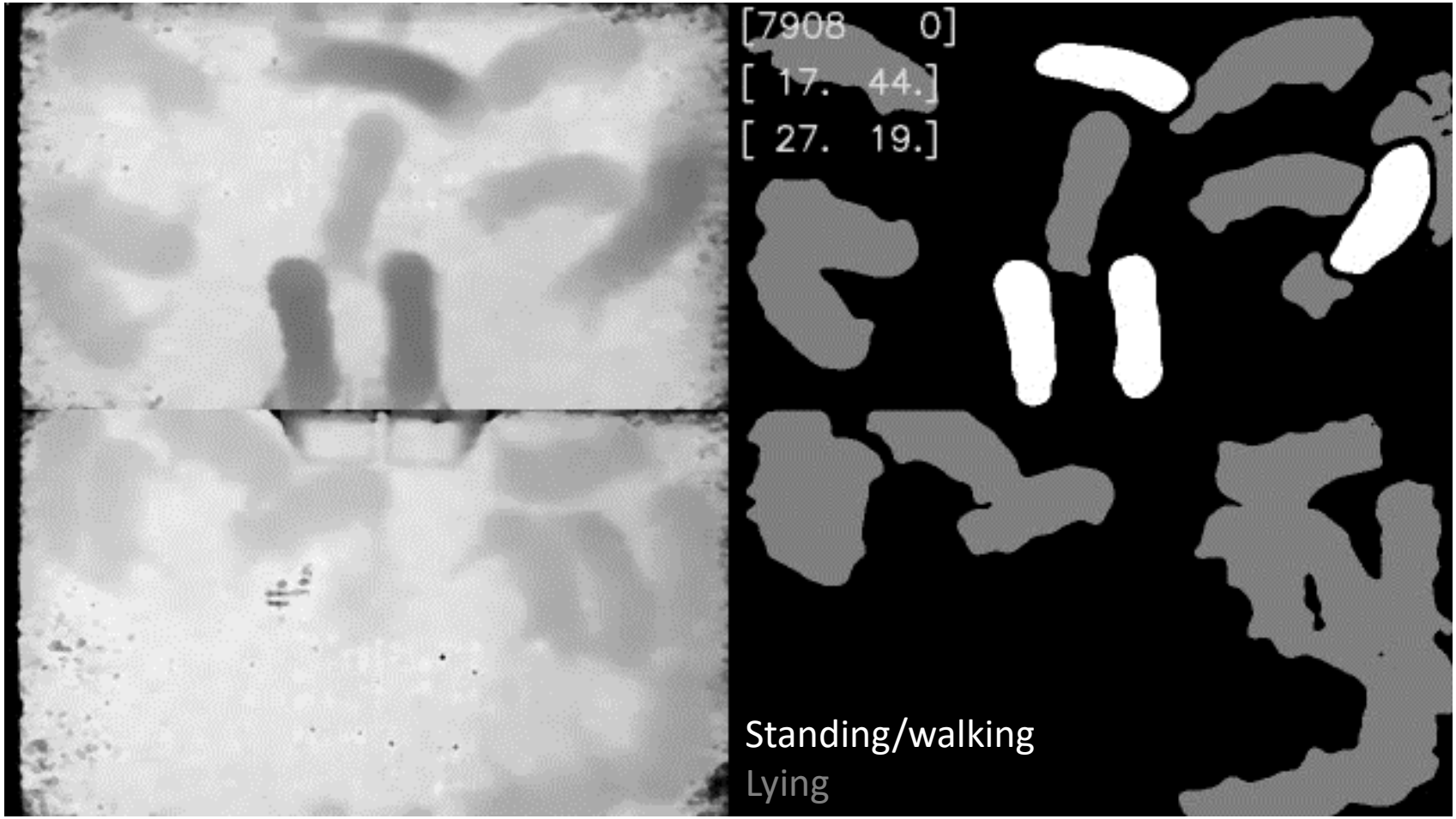
Thresholding & morphological transformation

Extract contours





Processed video



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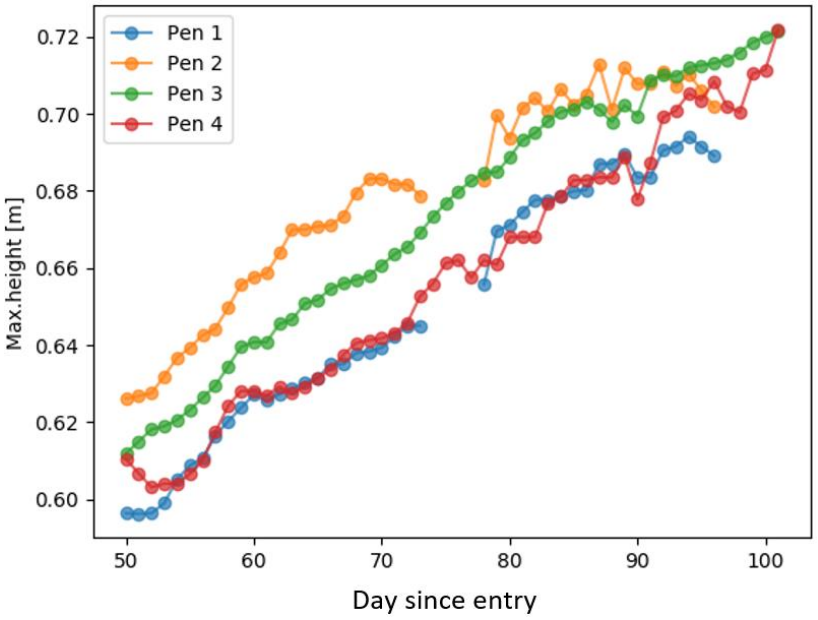
Threshold

- Height:

$$\text{Floor} \underbrace{<}_{\text{Threshold 1}} \text{Lying pigs} \underbrace{<}_{\text{Threshold 2}} \text{Standing pigs} \underbrace{<}_{\text{Threshold 3}} \text{Max.height}$$

- Threshold 1: constant (6 cm)
- Threshold 2: time-varying
  - Pig height ∝ age
  - $Threshold_2 = \beta_0 + \beta_1 \cdot age$
  - Between-group difference
  - Within-group difference
- Threshold 3: constant (87 cm)



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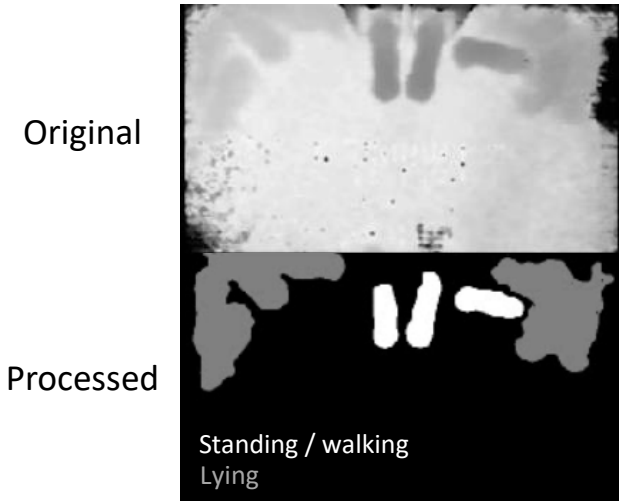
Performance test

Field condition

- Pig compartment
  - Partially slatted floors
  - Natural and artificial illumination

- Frame samples
  - 2 cameras, 70 days recordings (pig age 90~160 days)
  - ~1k random frames / camera
  - Foreground → Standing pig? Lying pig? Noise?
  - Exclude sitting pigs (prevalence 0.4%)



Detection accuracy

Standing pigs

- Sensitivity 92.4%
- Specificity 99.5%

Lying pigs

- Sensitivity 99.7%
- Specificity 91.4%

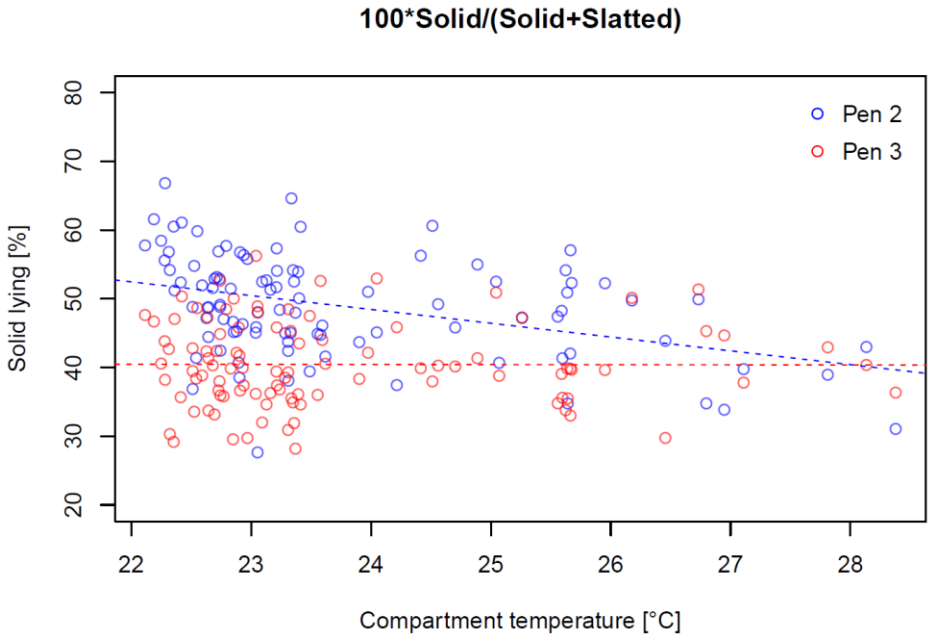
		Predicted		
		Standing	Lying	Noise
Actual	Standing	2282	187	49
	Lying	0	17369	
	Noise	83		
Overall accuracy 98.5%				

What can we do with the output?

Temperature and lying area preference

- Preference measurement
  - Solid vs. slatted
  - 36 days
  - 3-hour average

- Preliminary findings
  - Pen 2: significant temperature effect
  - Pen 3: no temperature dependency



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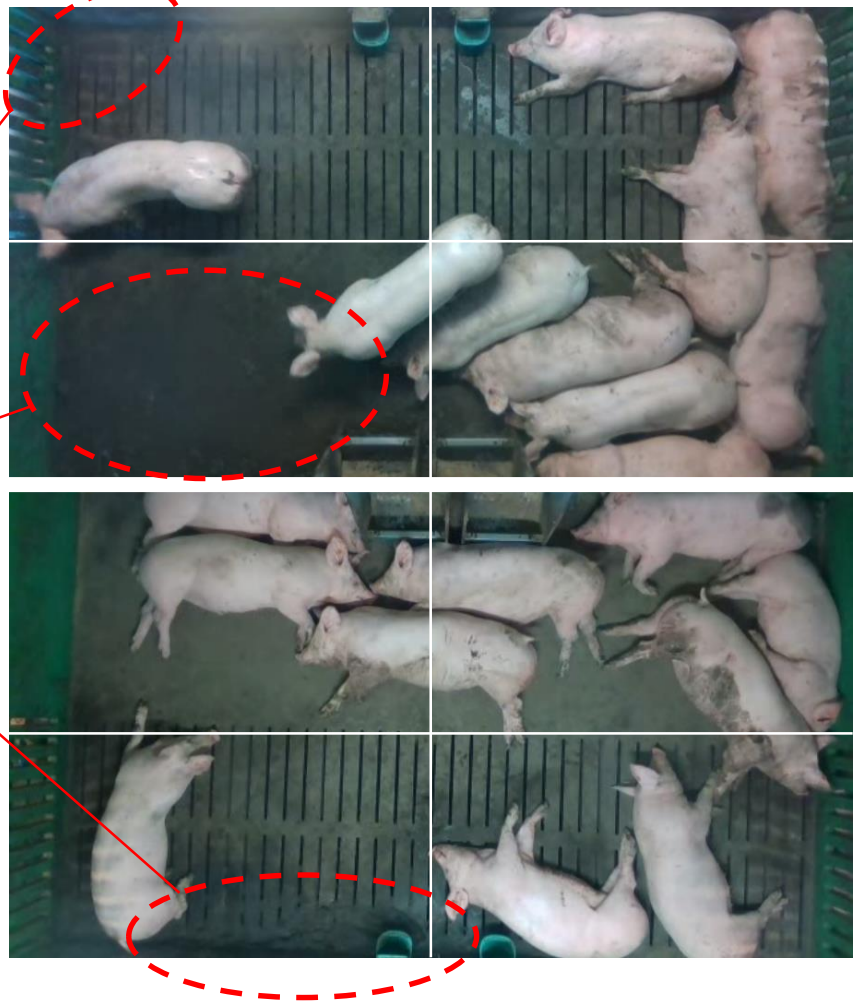
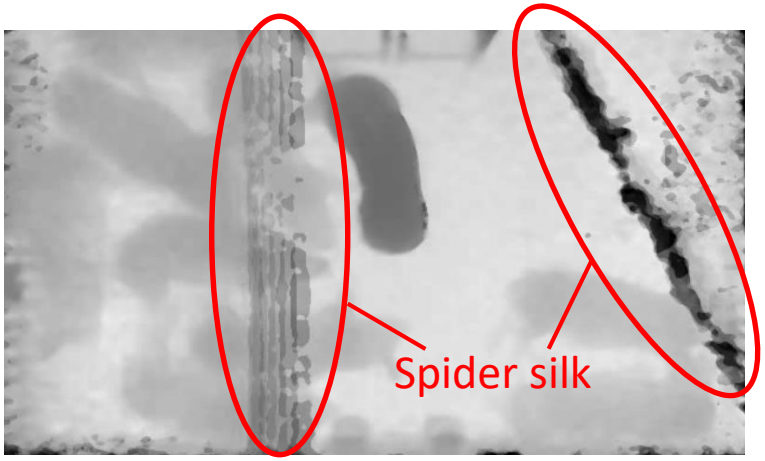
Fouling and time spent lying

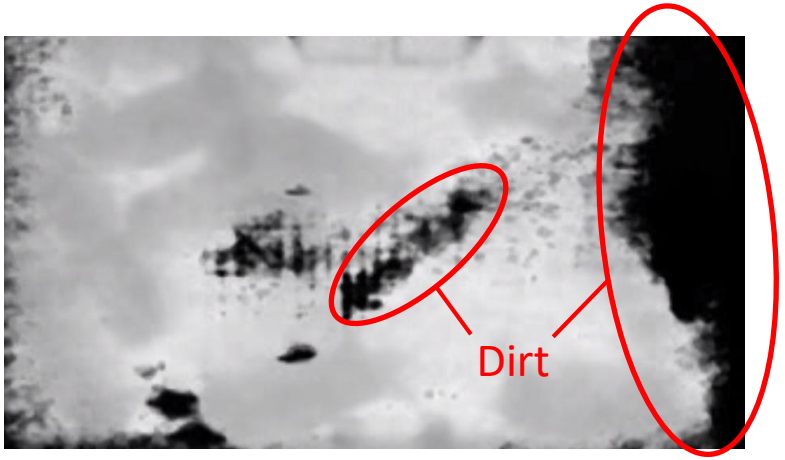


Good enough for practice?

Occlusions

- Temporary
  - Spider silk
  - Insects
- Persistent
  - Dirt (*e.g.* dung of flies)
  - Building structure





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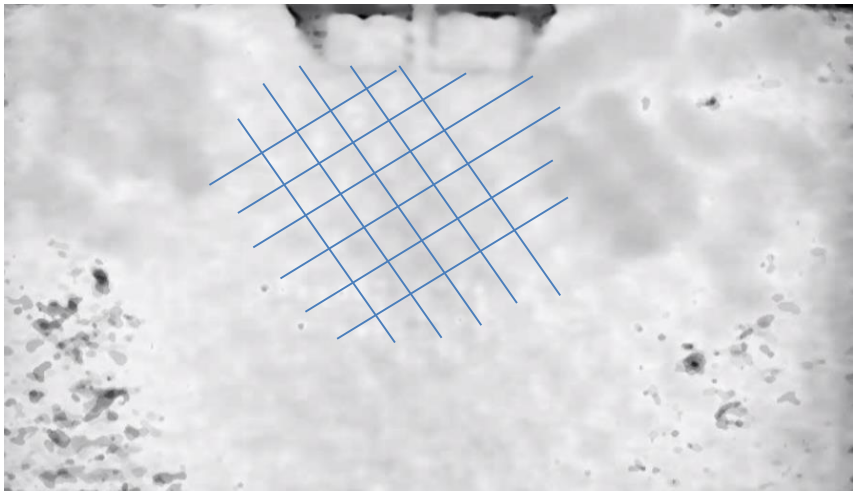
Ghosting

- Cause
  - Temporal filter
  - Long exposure time
  - Movement of object
- Consequence
  - Moving pig → lower height
  - Noise → less distinguishable

Illumination

Low-light



Excessive sunlight

Set-up issues

- USB 3.0/3.1 max. length 15m
  - PC inside the compartments
    - Dust and ammonia
    - Passive cooling ⇔ CPU load
  - RealSense™ over Ethernet (Philip and Anders, 2019)

- Malfunctioning
  - USB extension cable and hub quality
  - Firmware, drivers, software, *etc.*

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Conclusion

- D415 for long-term monitoring pig behaviour is possible
- Standing/lying pigs could be identified/located based on conventional image processing techniques
- Pig compartment is generally challenging for cameras
- D415 still has some performance and stability issues

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Thank you

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