GAITWISE,
a walk-over system for automated lameness detection in dairy cattle

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Dairy lameness situation

Negative effect on cow health, welfare, longevity and production
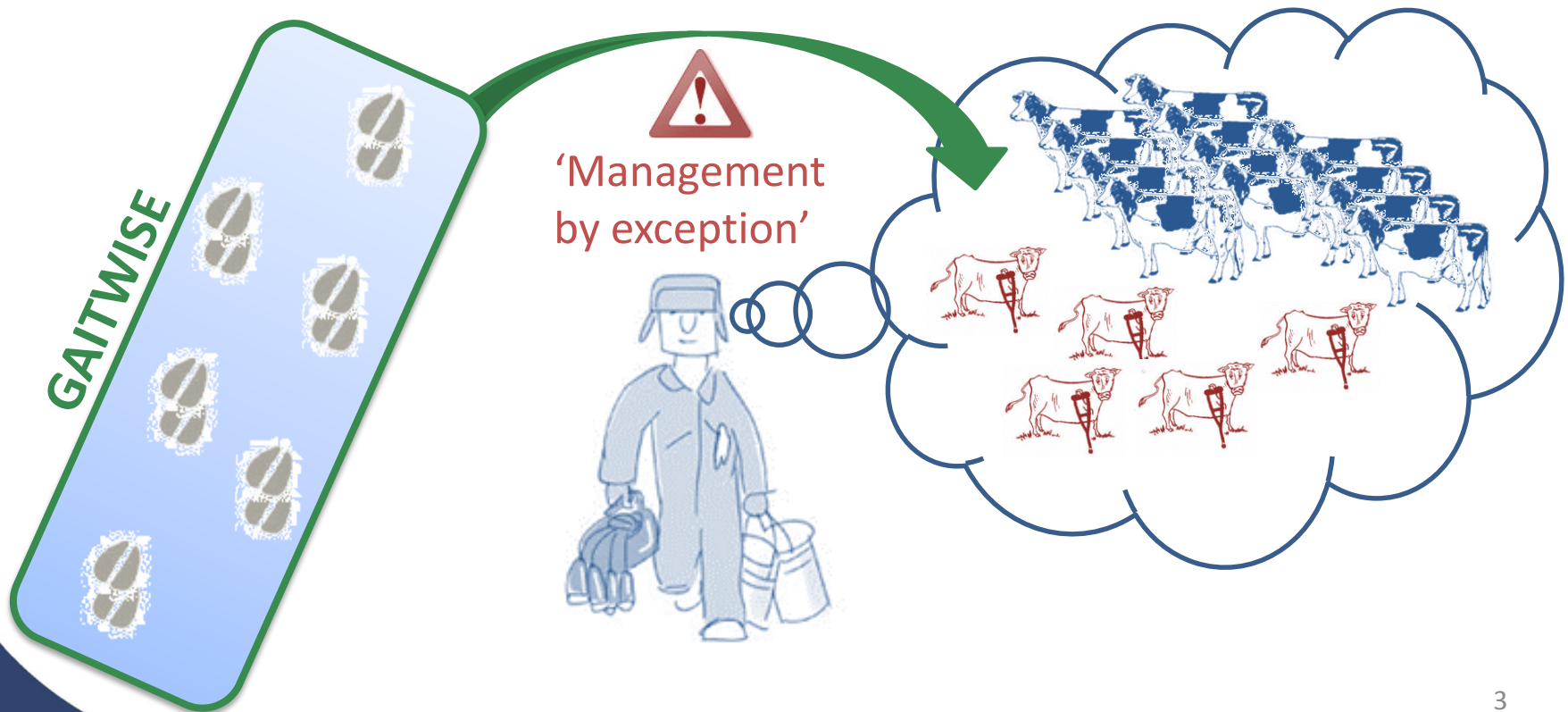High prevalence hugely underestimated

→ Detect those cows that need extra attention

Dairy lameness situation

Negative effect on cow health, welfare, longevity and production
High prevalence hugely underestimated

➡ Detect those cows that need extra attention

GAITWISE

⚠ 'Management by exception'

Lameness detection

1. Monitoring cow gait

2. Detection algorithm to allert for changes in gait relevant for lameness

Lameness detection

1. Monitoring cow gait

- Alternative for LS
  - → Measuring gaitvariables
  - → More than one gait cycle
- Measuring multiple varibles
- Measuring different types of variables
- Fully automatically and real-time
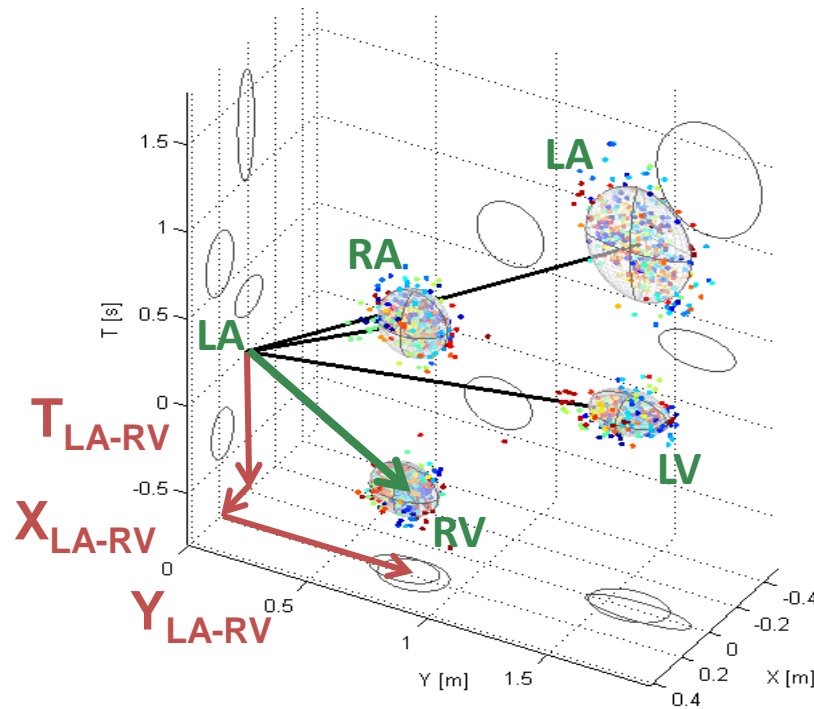
Monitoring cow gait

1 m

6 m

0.61 m

4.88 m
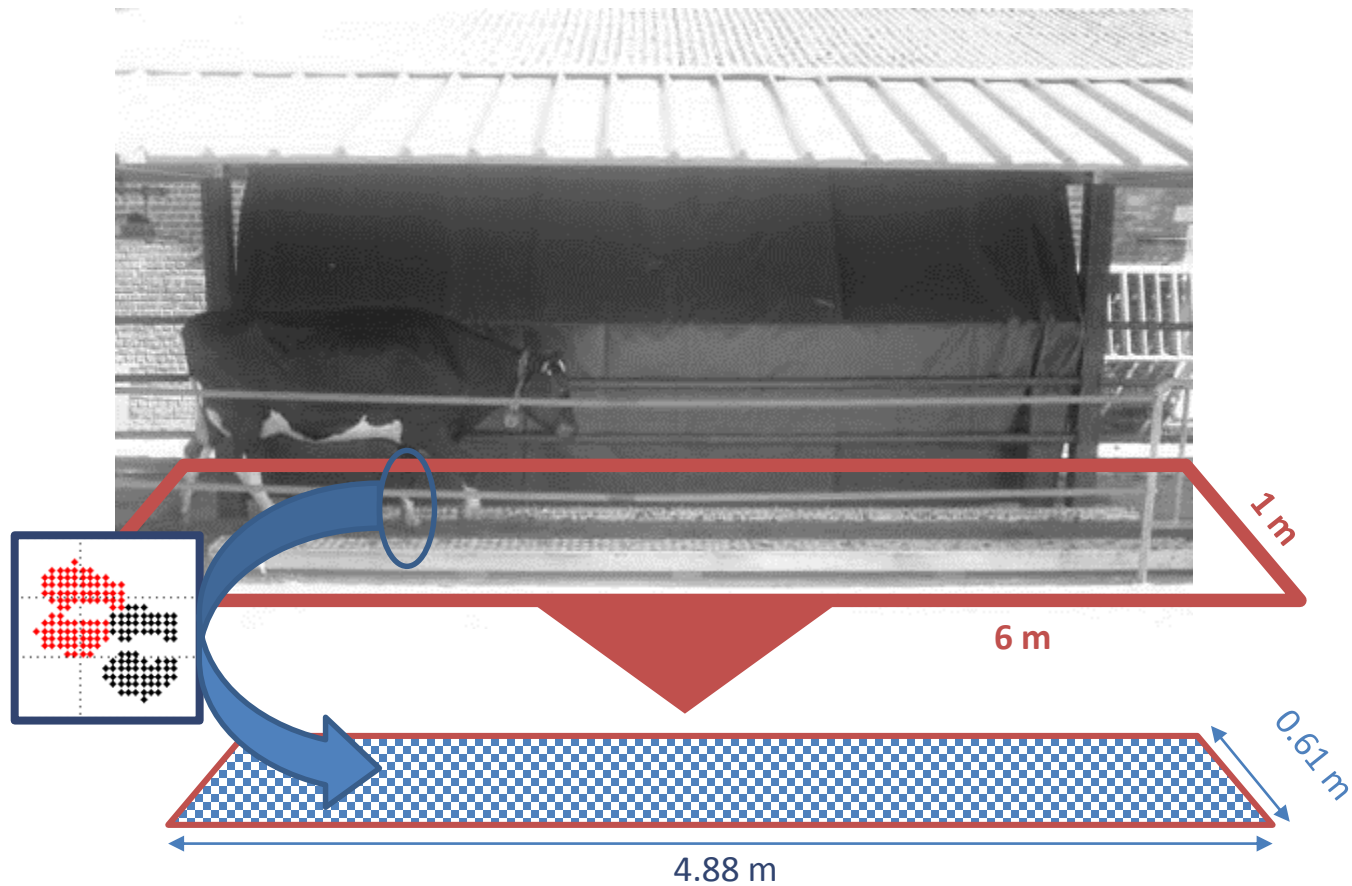
TIME – LOCATION – FORCE

Monitoring cow gait

20 Basic variables

→ Between-imprint gait variables (12)

$$T_{LA-LA} \quad X_{LA-LA} \quad Y_{LA-LA}$$
$$T_{LA-RA} \quad X_{LA-RA} \quad Y_{LA-RA}$$
$$T_{LA-LV} \quad X_{LA-LV} \quad Y_{LA-LV}$$
$$T_{LA-RV} \quad X_{LA-RV} \quad Y_{LA-RV}$$

Monitoring cow gait

20 Basic variables

→ Between-imprint gait variables (12)

T_{LA-LA} X_{LA-LA} Y_{LA-LA}
T_{LA-RA} X_{LA-RA} Y_{LA-RA}
T_{LA-LV} X_{LA-LV} Y_{LA-LV}
T_{LA-RV} X_{LA-RV} Y_{LA-RV}

→ Within-imprint gait variables (8)
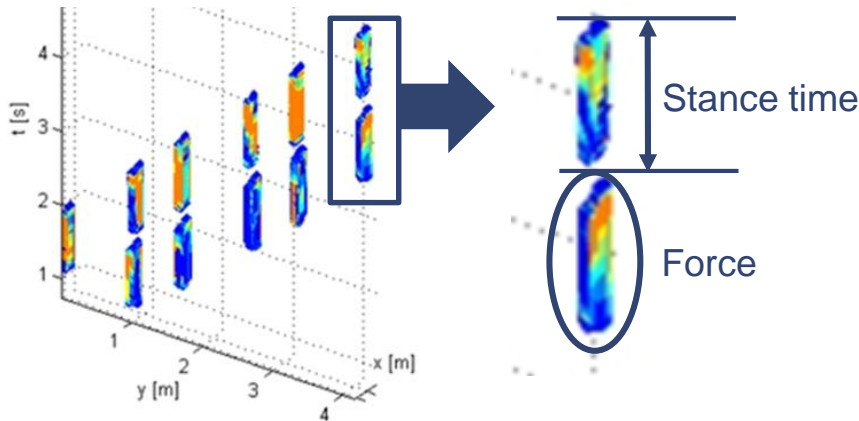
$Force_{LA}$ $Stance\ time_{LA}$
$Force_{RA}$ $Stance\ time_{RA}$
$Force_{LV}$ $Stance\ time_{LV}$
$Force_{RV}$ $Stance\ time_{RV}$

Monitoring cow gait

10 Specific variables

→ Stride length
→ Stride time
→ Stance time
→ Step Overlap
→ Abduction

→ Asymmetry in
  Stepwidth
  Steplength
  Steptime
  Stancetime
  Force
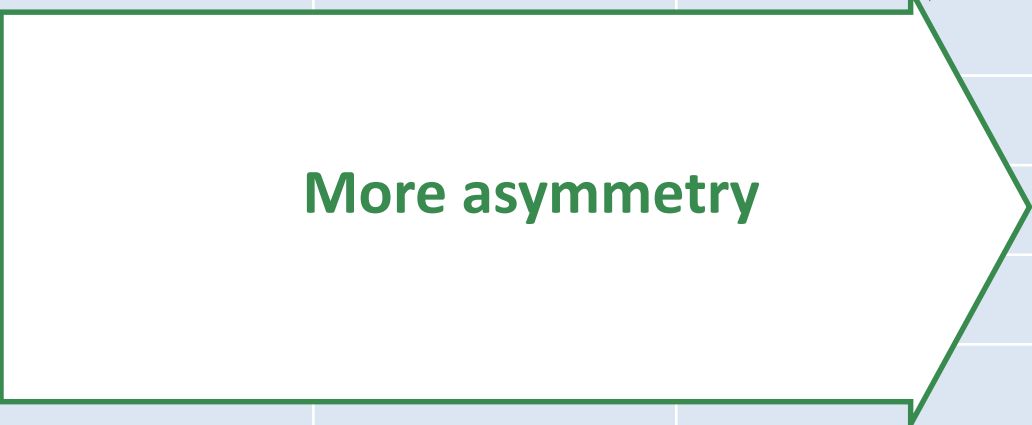
Detection algorithm

Gait differences between groups of

Specific variable	Non-lame (39 cow; n=661)	Mildly lame (36 cow; n=126)	Severely lame (42 cow; n=393)	P-value
Stridelength				
Stridetime				
Stance time	**Slower** **Shorter strides**			
Step Overlap				
Abduction	**Less step overlap** **More abduction**			
Asym. Stepwidth				
Asym. Steplength				
Asym. Steptime	**More asymmetry**			
Asym. Stance time				
Asym. Force				

Detection algorithm

Stridelength

Stride time

Stance time

Step Overlap

Abduction

Asymmetry in Stepwidth

Asymmetry in Steplength

Asymmetry in Steptime

Asymmetry in Stancetime

Asymmetry in Force

82 %

Reference	Model			Sensitivity
	NON-lame	MILDLY lame	SEVERELY lame	
NON-lame				81
MILDLY lame				76
SEVERELY lame				88
Specificity	88	85	100	

Detection algorithm

How to improve the misclassification of mildly lame cows?

- *Other 'normal' causes of changes in gait variables*
    - → *presentation 5.4 in session 56 on Thursdag (nr 455)*

- *Look for other variables more suited for detection of mildly lame cows*
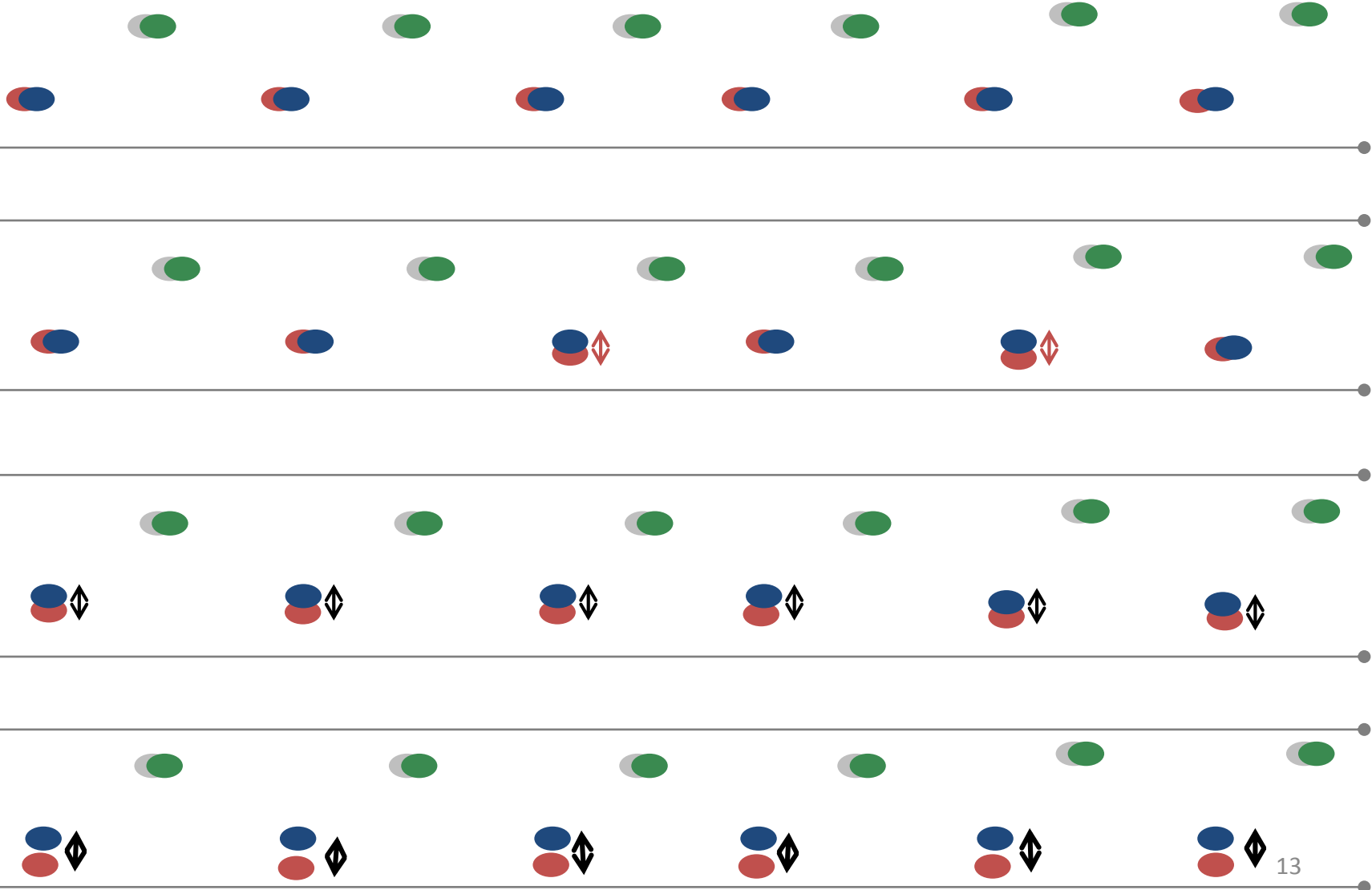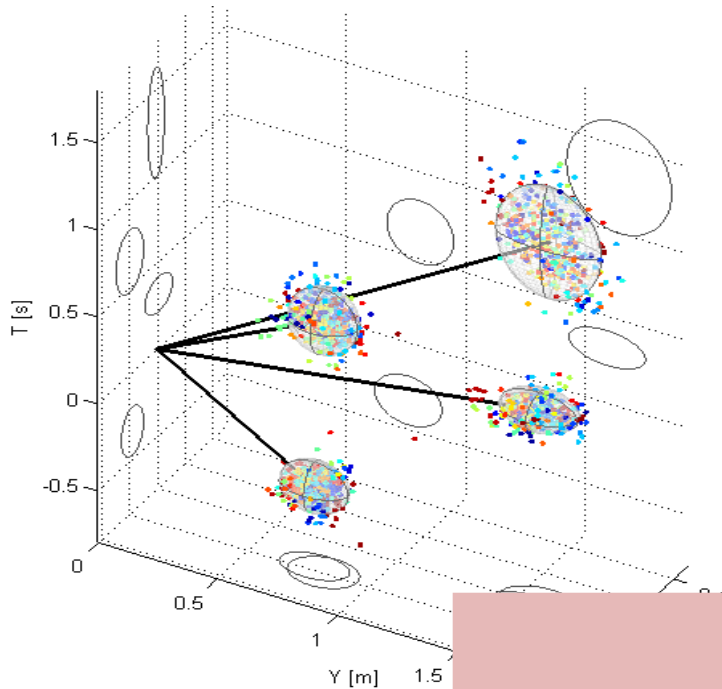
    → *Variables of gait inconsistency*

Non lame

Inconsistency

Mildly lame

Severely lame

Variables of gait inconsistency

T_{LA-LA} X_{LA-LA} Y_{LA-LA}
T_{LA-RA} X_{LA-RA} Y_{LA-RA}
T_{LA-LV} X_{LA-LV} Y_{LA-LV}
T_{LA-RV} X_{LA-RV} Y_{LA-RV}

Stance time $_{LA}$ Force $_{LA}$
Stance time $_{RA}$ Force $_{RA}$
Stance time $_{LV}$ Force $_{LV}$
Stance time $_{RV}$ Force $_{RV}$

INCONSISTENCY_...

T_{LA-LA} X_{LA-LA} Y_{LA-LA}
T_{LA-RA} X_{LA-RA} Y_{LA-RA}
T_{LA-LV} X_{LA-LV} Y_{LA-LV}
T_{LA-RV} X_{LA-RV} Y_{LA-RV}

Stance time $_{LA}$ Force $_{LA}$
Stance time $_{RA}$ Force $_{RA}$
Stance time $_{LV}$ Force $_{LV}$
Stance time $_{RV}$ Force $_{RV}$

14

Detection algorithm

- compare variables between groups of

non-lame − mildly lame − severely lame cows

Inconsistency in stapwidth
Inconsistenty in steplength ✔
Inconsistenty in steptime ✔
Inconsistenty in stance time ✔
Inconsistenty in force

- Two case-control studies (Van Nuffel et al. 2013)

Detection algorithm

Classification-model
20 Basic variables   **+ 20 Inconsistency variables**

77 %

Reference	Model			Sensitivity
	NON-lame	**MILDLY lame**	**SEVERELY lame**	
NON-lame				71
MILDLY lame				88 ← 76
SEVERELY lame				78
Specificity	94	87	86	

Conclusions

&

Suggestions for further development and research

STRENGTHS Gaitwise

- Real-time, automated measurements
- Wide range of variables – relevant for lameness
- Validated detection model

Specific variables
Severely lame → Se 88%
　　　　　　　　Sp 100%

Inconsistency variables
Mildly lame → Se 88%
　　　　　　　Sp 87%

Challenges for further development of Gaitwise

- Reducing cost (downscaling)

- Improve detection of mildly lame cows
  - Testing new or adjusted gait variables
  - Combining Gaitwise data with other data
  - Improve the detection by using individual thresholds
    → SILF-project
       presentation in session 56
       on Thursday

Any questions?

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