

# GAITWISE, an automated detection system for lameness in dairy cattle



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# Dairy lameness situation

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

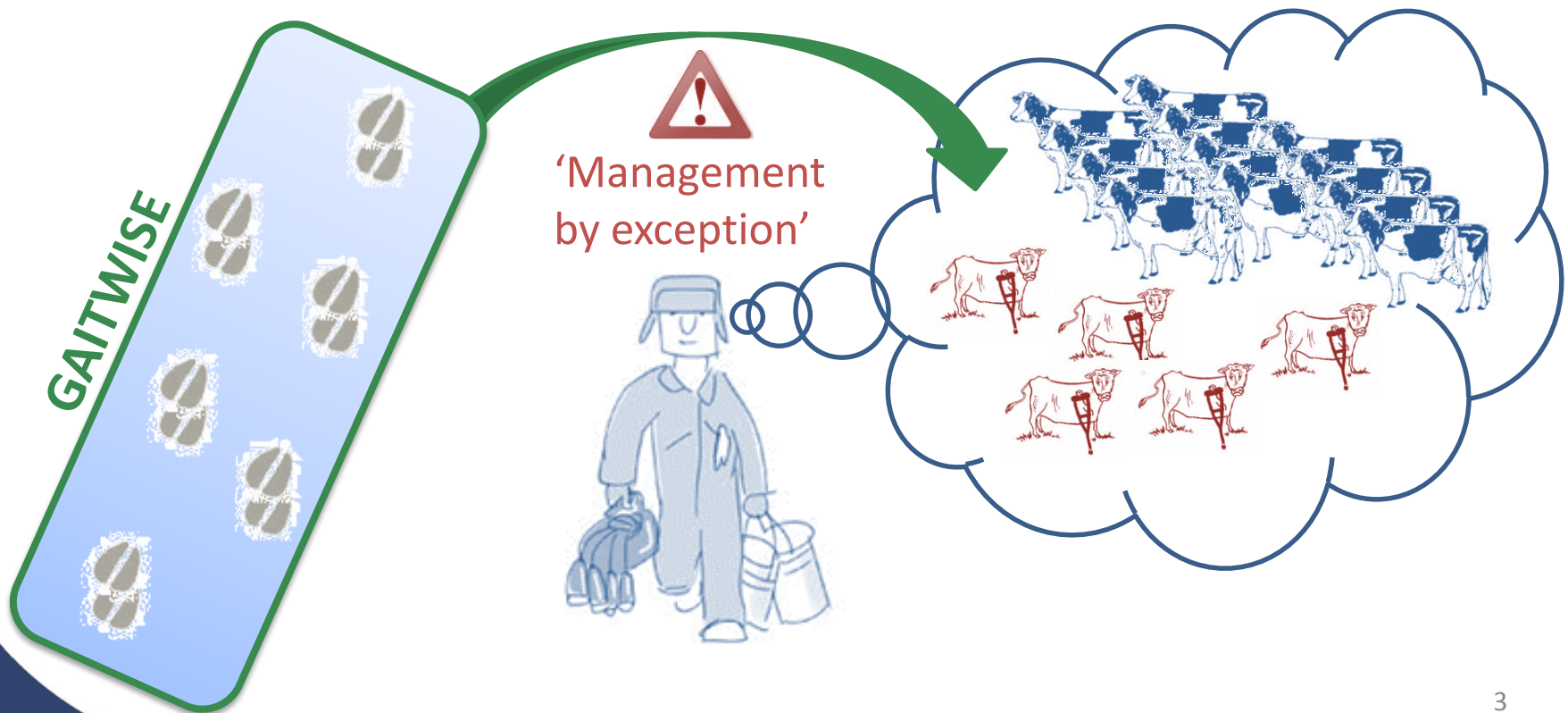
➔ Detect those cows that need extra attention



# Dairy lameness situation

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

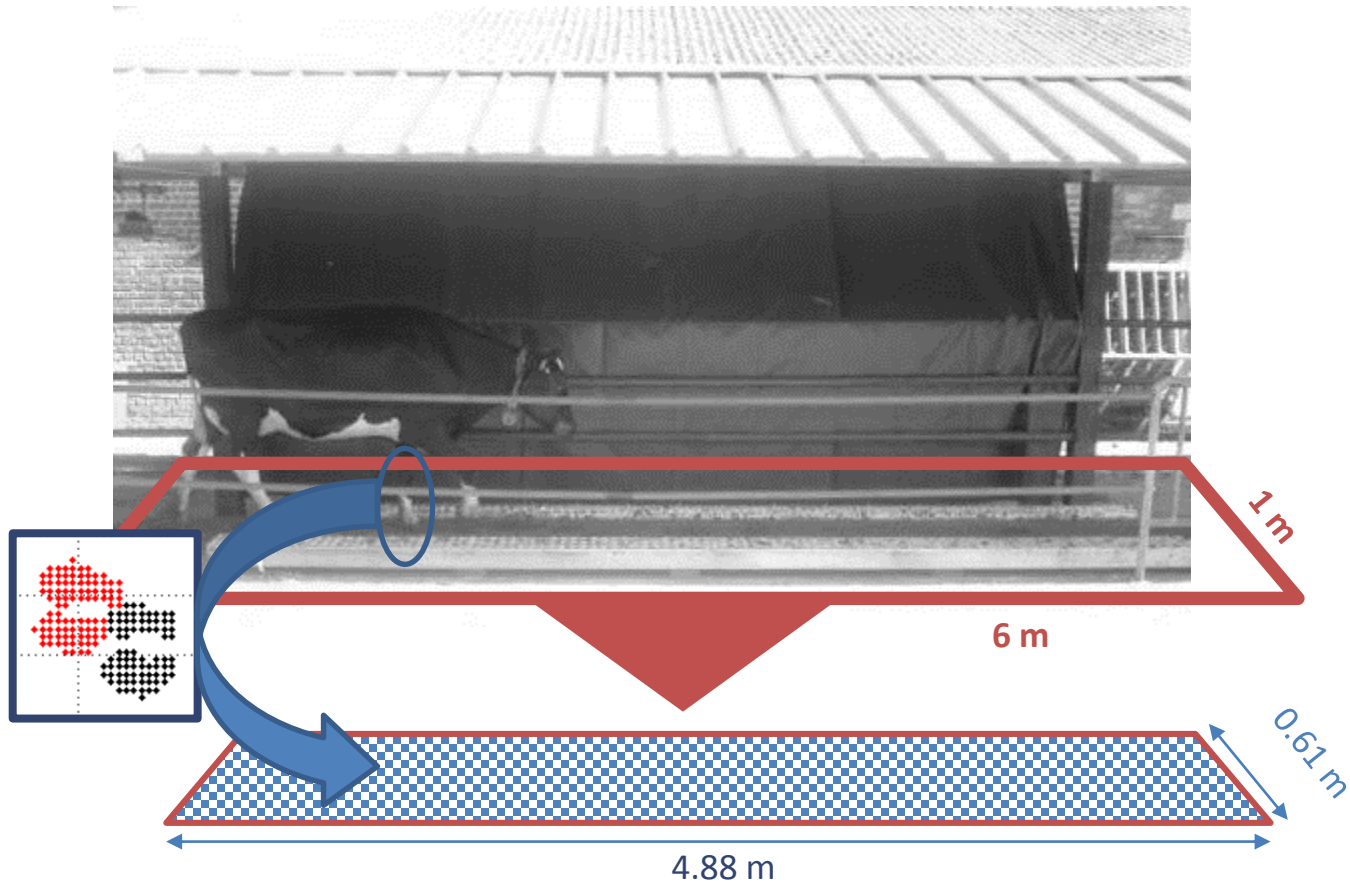
➡ Detect those cows that need extra attention



# Lameness detection

1. Monitoring cow gait
2. Detection algorithm  
to alert for changes  
in gait relevant for  
lameness

# Monitoring cow gait

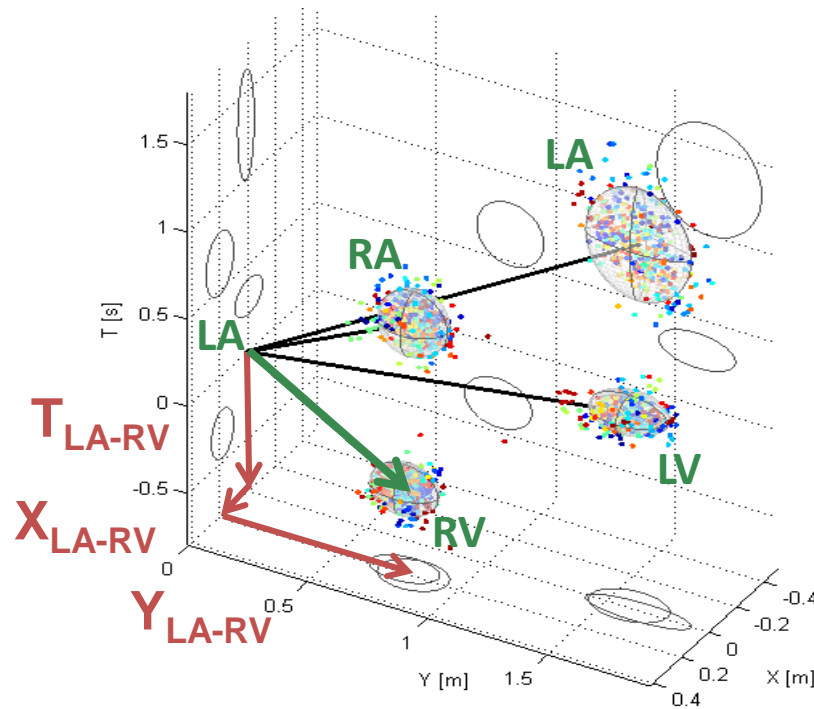


**TIME – LOCATION – FORCE**

# Monitoring cow gait

## 20 Basic variables

→ Between-imprint gait variables (12)



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

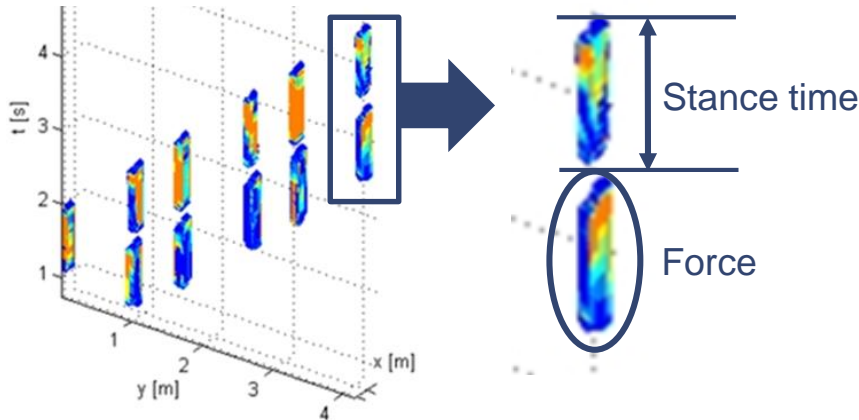
# Monitoring cow gait

## 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)



$Force_{LA}$   
 $Force_{RA}$   
 $Force_{LV}$   
 $Force_{RV}$

$Stance\ time_{LA}$   
 $Stance\ time_{RA}$   
 $Stance\ time_{LV}$   
 $Stance\ time_{RV}$

# 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
Stridelen <sup>th</sup>	<b>Slower</b> <b>Shorter strides</b>			
Stridetime				
Stance time				
Step Overlap	<b>Less step overlap</b> <b>More abduction</b>			
Abduction				
Asym. Stepwidth	<b>More asymmetry</b>			
Asym. Steplength				
Asym. Steptime				
Asym. Stance time				
Asym. Force				

# Detection algorithm

Stridelenlength

~~Stride time~~

Stance time

Step Overlap

Abduction

~~Asymmetry in Stepwidth~~

Asymmetry in Steplength

Asymmetry in Steptime

Asymmetry in Stancetime

~~Asymmetry in Force~~

Cross validation

82 %

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

# Detection algorithm

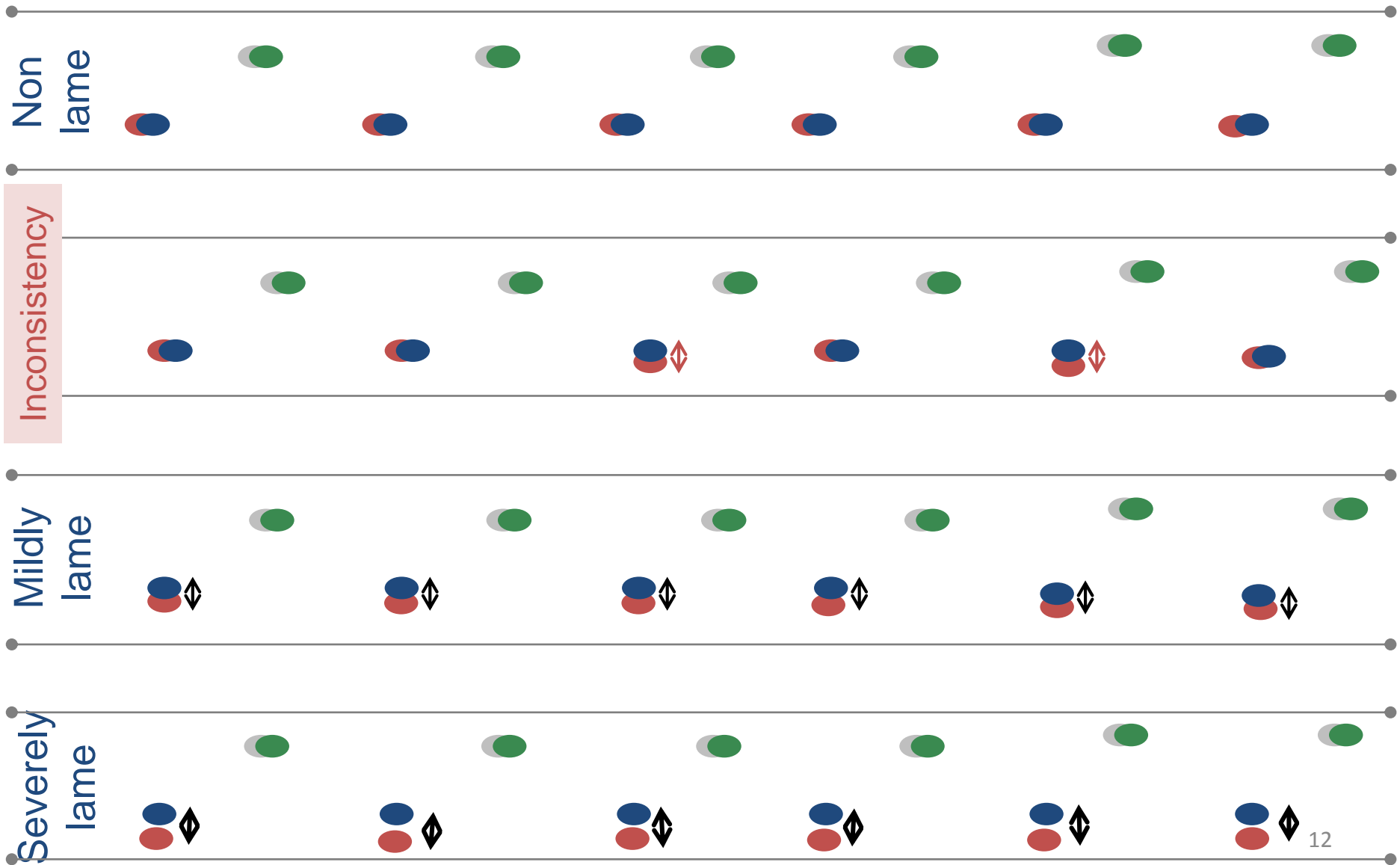
How to improve the misclassification of mildly lame cows?

- *Other 'normal' causes of changes in gait variables*

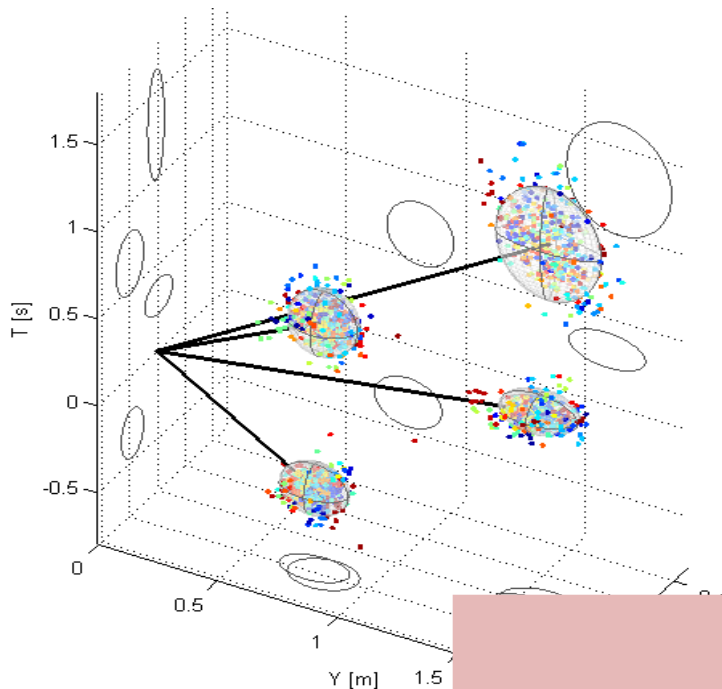
→ *presentation 5.4 in session 5*

- *Look for other variables more suited for detection of mildly lame cows*

→ *Variables of gait inconsistency*



# Variables of gait inconsistency



T<sub>LA-LA</sub>  
T<sub>LA-RA</sub>  
T<sub>LA-LV</sub>  
T<sub>LA-RV</sub>

X<sub>LA-LA</sub>  
X<sub>LA-RA</sub>  
X<sub>LA-LV</sub>  
X<sub>LA-RV</sub>

Y<sub>LA-LA</sub>  
Y<sub>LA-RA</sub>  
Y<sub>LA-LV</sub>  
Y<sub>LA-RV</sub>

Stance time<sub>LA</sub>  
Stance time<sub>RA</sub>  
Stance time<sub>LV</sub>  
Stance time<sub>RV</sub>

Force<sub>LA</sub>  
Force<sub>RA</sub>  
Force<sub>LV</sub>  
Force<sub>RV</sub>

INCONSISTENCY\_...

T<sub>LA-LA</sub>  
T<sub>LA-RA</sub>  
T<sub>LA-LV</sub>  
T<sub>LA-RV</sub>

X<sub>LA-LA</sub>  
X<sub>LA-RA</sub>  
X<sub>LA-LV</sub>  
X<sub>LA-RV</sub>

Y<sub>LA-LA</sub>  
Y<sub>LA-RA</sub>  
Y<sub>LA-LV</sub>  
Y<sub>LA-RV</sub>

Stance time<sub>LA</sub>  
Stance time<sub>RA</sub>  
Stance time<sub>LV</sub>  
Stance time<sub>RV</sub>

Force<sub>LA</sub>  
Force<sub>RA</sub>  
Force<sub>LV</sub>  
Force<sub>RV</sub>

# Detection algorithm

- compare variables between groups of  
non-lame – mildly lame – severely lame cows

Inconsistency in stepwidth

**Inconsistency in steplength** ✓

**Inconsistency in steptime** ✓

**Inconsistency in stance time** ✓

Inconsistency in force



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

# Detection algorithm

Classification-model

20 Basic variables

+ 20 Inconsistency variables

Cross validation

77.4 %

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

# 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 (poster 9.5.23)



# Any questions?

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