Knowing the normal variation in lameness variables in order to build a warning system

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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

‘Management by exception’

False alerts???
Gaitwise

TIME – LOCATION – FORCE
### Gaitwise

#### 10 Specific variables

- Stride length
- Stride time
- Stance time
- Step overlap
- Abduction
- Asymmetry in
  - Stepwidth
  - Steplength
  - Steptime
  - Stance time
  - Force

#### Cross validation
Leave - one cow - out

<table>
<thead>
<tr>
<th>Reference</th>
<th>Model</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NON-lame</td>
<td>MILDLY lame</td>
</tr>
<tr>
<td>NON-lame</td>
<td>34</td>
<td>8</td>
</tr>
<tr>
<td>MILDLY lame</td>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td>SEVERELY lame</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

Specificity

- 88
- 85
- 100

Sensitivity

- 81.7%
Detection algorithm

How to improve the misclassification of mildly lame cows?

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

- Other ‘normal’ causes of changes in gait variables

- Use a detection algorithm based on individual thresholds compared to group thresholds
What causes normal variation?

Environmental and cow-specific factors that influence cow gait

Criteria for cow selection:
- No other health problems (mastitis, ...)
- Non-lame according to expert
- Received no trimming sessions prior and during experimental period

→ 30 cows
→ 5 months
What causes normal variation?

*Environmental and cow-specific factors that influence cow gait*

Selected factors:
- Light/dark environment
- Wet surface (rain)
- Age
- Production level
- Lactation stage
- Gestation stage
## What causes normal variation?

<table>
<thead>
<tr>
<th>Gaitwise variables</th>
<th>P-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymm stepwidth</td>
<td>0,004</td>
<td></td>
</tr>
<tr>
<td>Asymm steplength</td>
<td>0,028</td>
<td>0,004</td>
</tr>
<tr>
<td>Asymm steptime</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asymm stance time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asymm force</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stride length</td>
<td>0,001</td>
<td></td>
</tr>
<tr>
<td>Stride Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stance Time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step Overlap</td>
<td>0,044</td>
<td></td>
</tr>
<tr>
<td>Abduction</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Shorter, more asymmetrical strides with less step overlap
What causes normal variation?

<table>
<thead>
<tr>
<th>Gaitwise variable</th>
<th>P-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymm stepwidth</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Asymm steplength</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asymm steptime</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Asymm stance time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asymm force</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Stride length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stride Time</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Stance Time</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Step Overlap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abduction</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

Slower, more asymmetrical strides with more abduction.
What causes normal variation?

<table>
<thead>
<tr>
<th>Gaitwise variable</th>
<th>P-value (light)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymm stepwidth</td>
<td></td>
</tr>
<tr>
<td>Asymm steplength</td>
<td>0,001</td>
</tr>
<tr>
<td>Asymm steptime</td>
<td></td>
</tr>
<tr>
<td>Asymm stance time</td>
<td></td>
</tr>
<tr>
<td>Asymm force</td>
<td></td>
</tr>
<tr>
<td>Stride length</td>
<td>&lt;0,0001</td>
</tr>
<tr>
<td>Stride Time</td>
<td></td>
</tr>
<tr>
<td>Stance Time</td>
<td></td>
</tr>
<tr>
<td>Step Overlap</td>
<td>0,002</td>
</tr>
<tr>
<td>Abduction</td>
<td></td>
</tr>
</tbody>
</table>

Shorter strides, more asymmetrical with less step overlap.
Detection algorithm

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Synergistic Control (SGC)

Statistical Process Control (SPC):
- Normal variation
- Abnormal variation due to lameness

→ Use of control charts
→ Preprocess data by Engineering Process Control (EPC)

(Mertens et al., 2009)
Synergistic Control (SGC)

Huybrechts et al., 2014

4 milkings before
Synergistic Control (SGC)
Challenges for further development of Gaitwise

- Improve lameness detection
  - Combining Gaitwise data with other data
  - Including information on normal variation
  - Improve the detection by using individual thresholds

→ SILF-project
Smart Integrated Livestock Farming

SILF is an ICT AGRI era-net project (2013-2016) involving:

a,f,h Institute for Agricultural and Fisheries Research (ILVO), Belgium
b Department of Engineering - Operations Management, Aarhus University (AU), Denmark
c Center for Research and Technology (Cereteth), Greece
d Department of Biosystem Engineering, University College of Dublin (UCD), Ireland
e Department of Animal Production Research, MTT, Finland
g Mechatronics, Biostatistics and Sensors Unit (MeBioS) – Catholic University of Leuven, Belgium
Smart Integrated Livestock Farming

- Poster during 1st DairyCARE conference
  - Copenhagen, 22\textsuperscript{nd} - 23\textsuperscript{rd} of August 2014
  - Proceedings on website
    www.dairycareaction.org
Any questions?

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