Camera technology to bring large scale data from commercial herds

Presented by:

Jørn Rind Thomasen
Senior Project Manager, VikingGenetics

Jan Lassen and Søren Borchersen,
VikingGenetics

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The vision and challenge

- No doubt that camera technology can produce large scale data from commercial herds
- The challenge is to transform the information content in the pictures or videos to valuable phenotypic information

Improving management and genetic decisions

Building strong genomic reference populations for genetic improvement
Many applications in animal and plant production

- High throughput phenotyping in plants
- Drone technology
- Tracking in pigs and poultry
- Milking Robots
  - 3D camera for cow movements and teat detection
- CattleEye – lameness – BCS – Mobility
How can camera technology add value?

• Hard to measure (expensive) traits

• **Lower phenotyping costs**  →  increasing amount of registrations (high throughput phenotyping)

• Round the clock - **24/7 registrations**

• **Objective** and **precise** compared to subjective phenotyping

• **Sequence of pictures or video-snapshots** compared to point-registration

• **Surveillance**
How can camera technology add value?

- **Document production systems (ESG and climate)**
- **Powerful tool combined with AI-Technology and robot development**
- **The intelligent “eye on the cow”**
EXAMPLES FROM APPLICATIONS IN DAIRY CATTLE
CFIT – Cattle Feed InTake
Registrations of individual cow’s feed intake and weight
CFIT – Aim and purpose

• To develop a 3D camera system that can measure feed intake at individual cow level at each visit

• The system may not:
  • Disturb daily routines on farm
  • Disturb cow behavior

• Should be same system as for identification

• Data to be used for breeding and management
The CFIT system – registration 24/7

Registrations are based on 3D images and the use of artificial intelligence.
Cow identification and weight measure

Measure of individual feed - Identification

3D Camera – time of flight

4.5 m 4.2 m
Cow Identification from Contour to MASK-CNN

- ID accuracy with contour model 95-98% in Jersey
- Change of algorithm from contour to MASK-CNN
- Including colour, patterns, contours in model
- **ID accuracy +99%** in all three breeds
Installations and Agreements with test herds

<table>
<thead>
<tr>
<th># cows</th>
<th># herds</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,000</td>
<td>7</td>
</tr>
<tr>
<td>4,300</td>
<td>9</td>
</tr>
<tr>
<td>5,300</td>
<td>11</td>
</tr>
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</table>

Goal: 10,000 registrations per breed in early 2025
Data flow and amount 2023

1,900+ cameras

700,000+ feed visits per day

90,000,000+ images per day

100,000+ meals per day
Cattle Feed Intake (CFIT)

Integrated system
- Algorithms
- Hardware
- Fit into the barn
- Automized system surveillance
- Event detection
- Data integration
Validation study
Validation study at Aarhus University

Challenge the camera system with **different feed densities** – especially with different silage types

- Measure of feed from **scales** and **cameras**
- **4 diets:**
  1. grass silage & barley
  2. grass silage & dry beetroot
  3. maize & barley
  4. maize & dry beetroot
- **48 HOL cows** in trial

Giagnoni et al., 2022
High correlation between kg and volume

1. Grass silage & barley
   \[ R = 0.9, p < 2.2e-16 \]

2. Grass silage & dry beetroot
   \[ R = 0.9, p = 2.8e-15 \]

3. Maize & barley
   \[ R = 0.91, p < 2.2e-16 \]

4. Maize & dry beetroot
   \[ R = 0.93, p < 2.2e-16 \]

Giagnoni et al., 2022
Weight Predicted versus Scale

1,329 Measurements from 102 Jersey cows

460 kg Average weight (350-650 kg)

400 contour points per picture

PLS model

$R^2 = 0.9632$
Preliminary genetic analysis
### Data

<table>
<thead>
<tr>
<th>Breed</th>
<th>Trait</th>
<th>Number of records</th>
<th>Mean</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holstein</td>
<td>DMI</td>
<td>65,393</td>
<td>27.7</td>
<td>12.7</td>
<td>40.9</td>
</tr>
<tr>
<td></td>
<td>BW</td>
<td>65,293</td>
<td>675.8</td>
<td>448.4</td>
<td>905.0</td>
</tr>
</tbody>
</table>

Cows with phenotypes: **2,668**

Cows with genotypes: **1,824**

Manzanilla-Pech et al., 2023
Heritabilities

<table>
<thead>
<tr>
<th>Trait</th>
<th>Pedigree</th>
<th>Genomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI</td>
<td>0.23 (0.02)</td>
<td>0.25 (0.02)</td>
</tr>
<tr>
<td>BW</td>
<td>0.47 (0.05)</td>
<td>0.51 (0.04)</td>
</tr>
</tbody>
</table>

Manzanilla-Pech et al., 2023
CFIT registrations in the Saved Feed index

The goal is to achieve reliability **50%** for the three breeds in early 2025.
CFIT and management
Development of Management software used in the CFIT test herds

Feeding table

Herd level

Cow level
Better claw health with use of Artificial Intelligence

Project period: 2023-2026

Peter Raundal, SEGES Innovation
Motivation

• In Denmark yearly more than 700,000 registrations of hoof treatments
• Approximately 50% of all hoof treatments have at least one claw diagnosis
• Today registrations are done manually

• Automated registrations will initiate more registrations of higher quality giving the farmer a better tool to increase claw health in own herd
• More accurate breeding values for claw health
Installations on the hoof trimmer box

Box with pc AI algorithm

Monitor showing cameras recording

Cameras for recording

Two antenna for recording electronic eartag
How does it work?

• Cameras record during hoof trimming
• **AI-model trained to recognize:**
  • A hoof (extract all other noise)
  • **Hoof trimming** – the cow registrated as trimmed
  • Model is trained to recognize **24 different claw diagnoses**
  • **Treatment** – claw bandage and/or shoe
• Registrations **uploaded to the central cattle database** (DMS)
Improved animal welfare and production with use of new technologies (WelCowTech)

Project in pipeline (2024 -2027)

Lars Arne Hjort Nielsen, SEGES Innovation
Welfare

- Cattle Database
- Activity measures
- Milk volume
- AMS etc.

Algorithms
- Resilience, Disease
- Detection
- Welfare Scores

New indicators based on vision technology

- Annotated data
- AI algorithms
- Movements,
- Welfare,
- Tracking,
- Other Indicators

Prototype

New Prototype

Prototype
**Economic value**

- Actions which increase the cows laying time and milk production (feeding and grouping)
- Early detection of sick and lame cows

**Saving of workload**

- Surveillance of cows through AI
- Detection of cows for hoof trimming and observation

**Assurance of production quality**

- Document animal welfare in an objective manner
- Document variation in behaviour
- Reduced climate impact through increased longevity
To sum up

**Camera Technology** can produce large scale data from commercial herds and provide **new phenotypes** valuable for both management and breeding.

Camera technology combined with **AI technology** is an area **under huge development**.

Important future tool to **improve management** and **genetics** in dairy production.
Thank you!