Institute of Animal Breeding & Husbandry
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Faculty of Agricultural and Nutritional Science
Institute of Animal Breeding and Husbandry

A multi-Kinect system for monitoring & measuring functional traits in dairy cows

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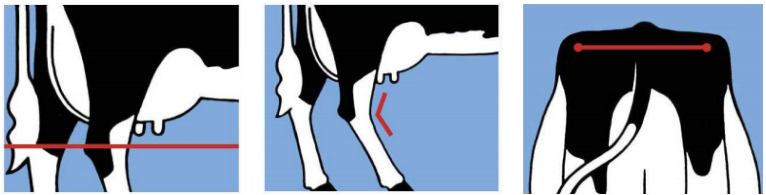
Session 57, Abstract number 22608, jsalau@tierzucht.uni-kiel.de

Introduction & motivation

- Cornerstones of modern dairy cow breeding and husbandry
  - Animal health
  - Productivity
  - Fertility
- Manual or visual evaluation is time consuming and prone to subjectivity
  $\Rightarrow$ Use of sensor technology, i.a. cameras
- High numbers of successful studies in the last years, mainly on health monitoring (lameness, body condition scoring)

Introduction & motivation

- Linear traits: Lengths and angles on the cow's surface



www.holstein-dhv.de/seiteninhalte/exterieur.html

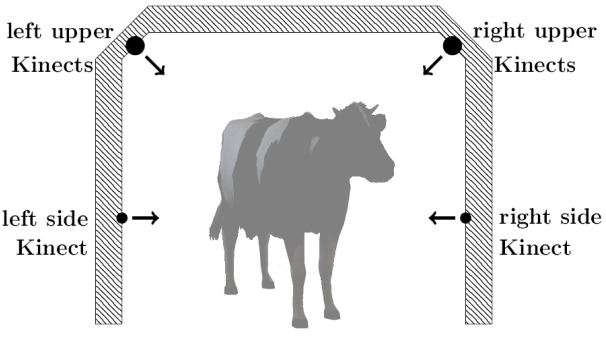
- Basis of breeding success: Selecting the best animals for breeding via conformation recording

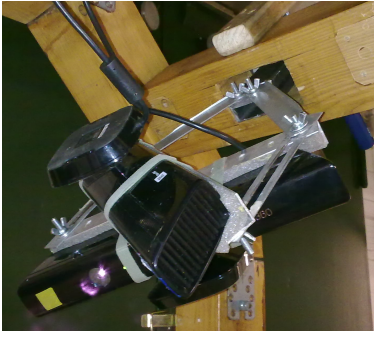
AIM

Measuring linear traits from 3D recordings complementary to visual conformation recording

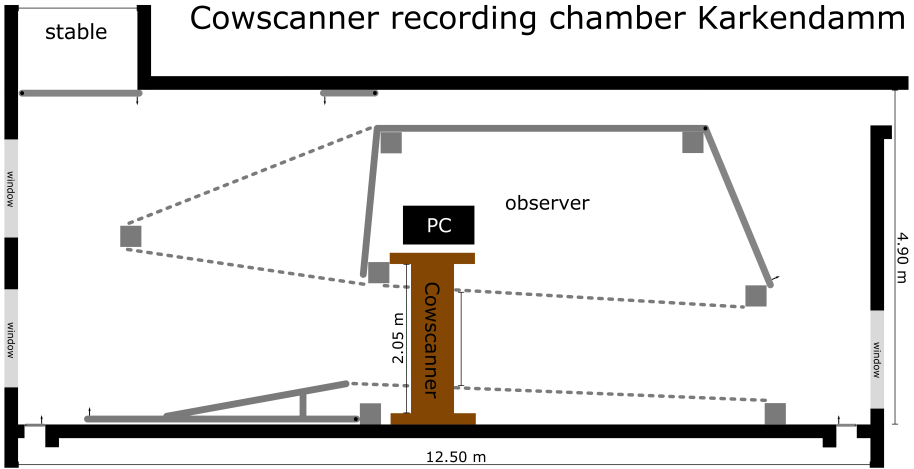
Recording unit

- Wooden framework – passage width: 2.05 m, height: 2.08 m
- Equipped with 6 Kinect cameras





Installation of the recording unit



Areas of development

Hardware and software work items

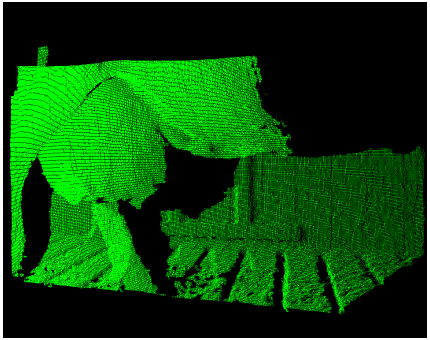
- Hardware specification for recording and storing data
- Regular recordings once a month (November 2015 to April 2016)
  - 17 cows, lactation numbers: 1 to 5
  - Runs through the framework per cow: 3 to 11
- Software development
  - Synchronization
  - Calibration & registration
  - 3D Object recognition (cow's body parts)

3D Object recognition

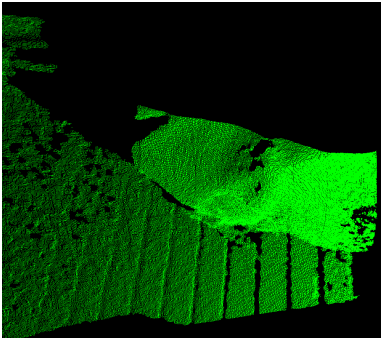
Determination of cow's body parts

Example scenes

recorded from **sideview**



recorded from **topview**

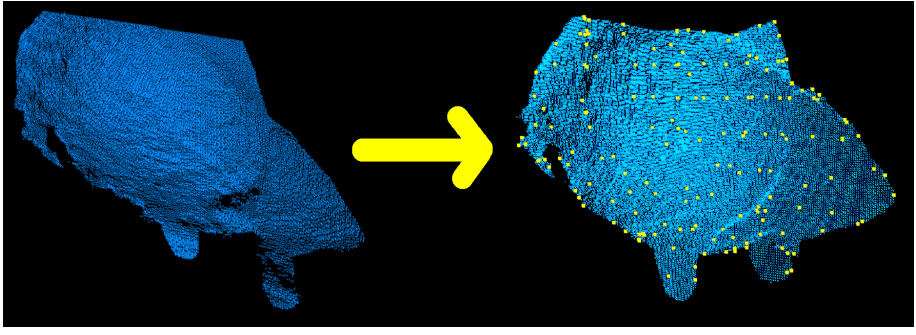


3D Object recognition

Determination of cow's body parts

Body part model "udder" & keypoint extraction

- Manually extracted from a sideview recording
- Reduction to keypoints: Numerically significant properties of surrounding surface



3D Object recognition

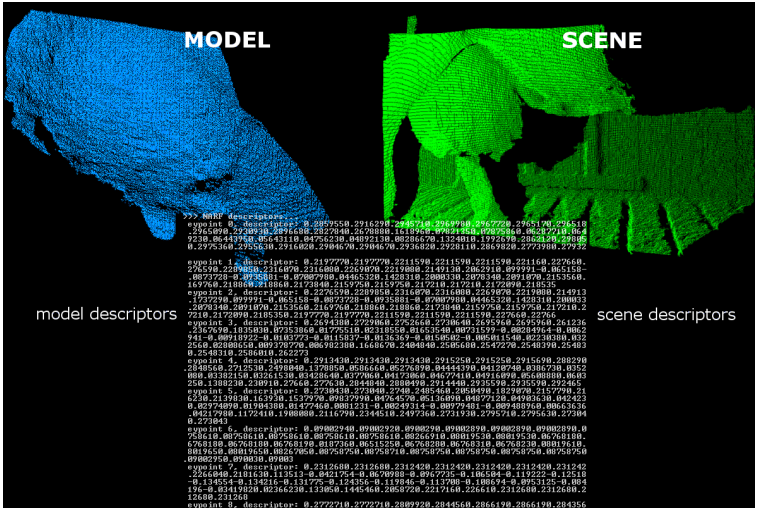
Determination of cow's body parts

Calculation of descriptors

- Holding numerical values of surrounding surface's properties
- Information can easily be stored in data bases

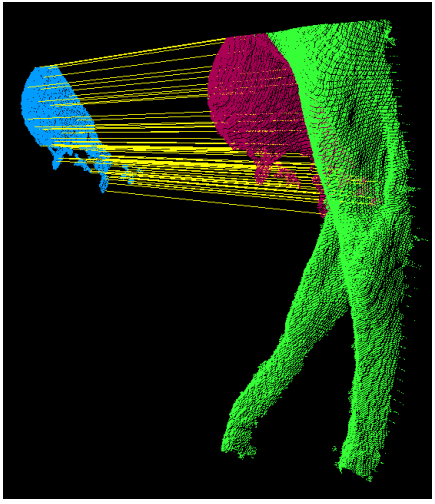
3D Object recognition

Determination of cow's body parts



3D Object recognition

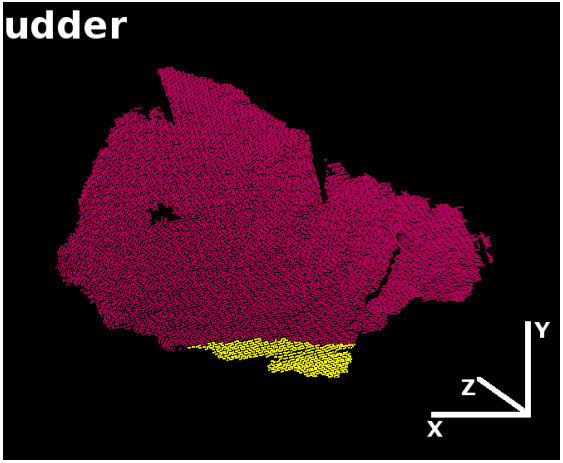
Determination of cow's body parts

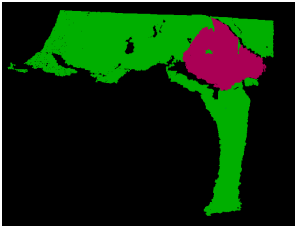


- Descriptor comparison decides which points on the model (blue) match which points on the scene (red)
- Found correspondences (yellow lines) allow an estimation of the object's position in the scene

Calculating linear traits

Udder depth (above ground)

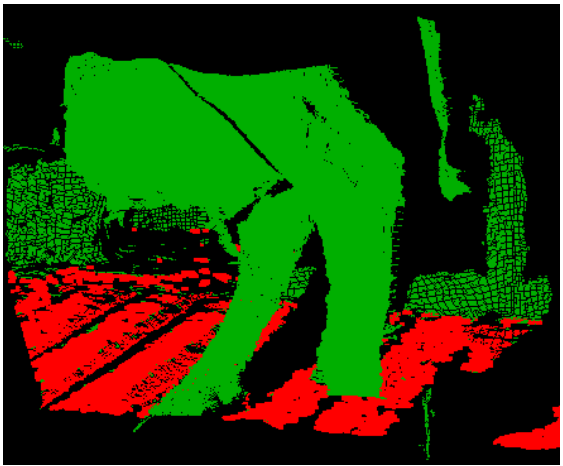




- Isolated udder point cloud can be examined
- Specify the area closest to the ground: $\mathrm{Y} \leq 10\%\,\mathrm{quantile}$

Calculating linear traits

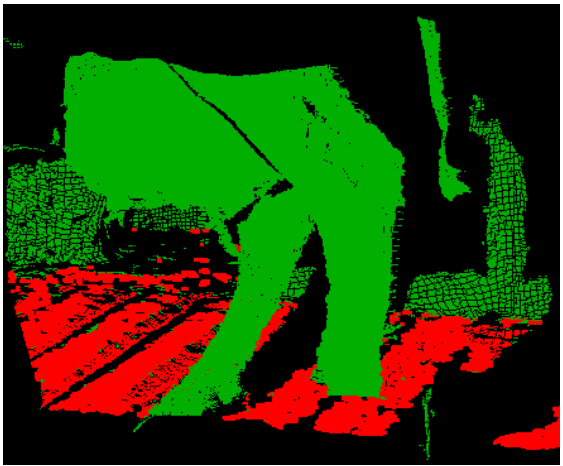
Udder depth (above ground)



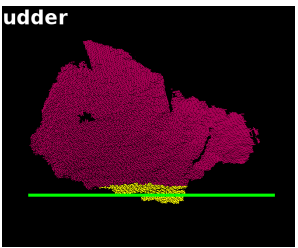
- Use RANSAC algorithm to find the scenery's floor (red)

Calculating linear traits

Udder depth (above ground)



- Use RANSAC algorithm to find the scenery's floor (red)
- Calculate difference between the green line and the floor
  $\rightarrow$ Udder depth above ground



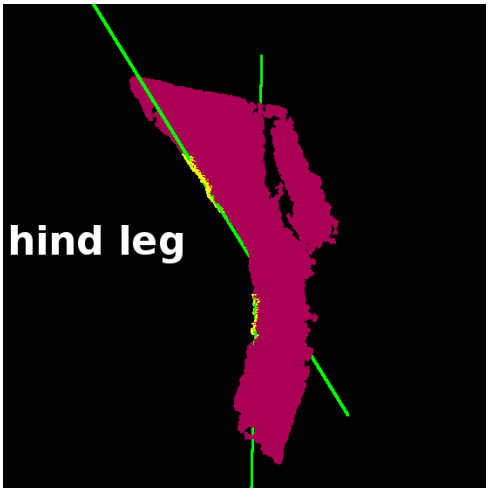
Calculating linear traits

Rear leg angle

- Isolate the rear leg
- Determine the leg's front
- Divide the front in areas above and beneath the joint (yellow)

Calculating linear traits

Rear leg angle



- Approximate both yellow areas by 3D lines:

$$l_1 = \overrightarrow{u_1} + t * \overrightarrow{v_1}$$

$$l_2 = \overrightarrow{u_2} + t * \overrightarrow{v_2}$$

- Calculate angle φ between l_1 and l_2 (in degree):

$$\varphi = \frac{180}{\pi} \operatorname{acos}\left(\frac{\overrightarrow{v_1} \cdot \overrightarrow{v_2}}{|\overrightarrow{v_1}||\overrightarrow{v_2}|}\right)$$

Results

Udder depth (above ground) & rear leg angle

Descriptive statistics

- Values based on raw data
- The traits were for each cow averaged using images from all runs

Information on cows				Udder depth (cm)			Rear leg angle (deg)		
ID	lac	cm	runs	N	mean	std.err	N	mean	std.err
6129	1	144	10	161	61.2	0.5	35	144.6	1.8
6147	1	-	5	306	55.2	0.3	215	149.9	1.2
6169	1	-	10	231	54.7	0.6	161	149.2	1.5
5820	2	148	11	67	47.7	0.6	18	136.9	2.9
5870	2	146	3	42	46.3	0.9	11	144.0	4.5
5967	2	146	10	420	53.8	0.4	164	141.0	1.6
6009	2	146	10	231	49.0	0.6	125	145.7	2.0
6037	2	148	11	16	59.7	1.3	18	144.6	2.8
4843	3	148	10	121	48.1	0.6	27	150.1	2.0
4847	3	148	10	549	49.2	0.3	73	147.2	2.5
4930	3	143	3	178	47.3	0.4	12	154.8	1.8
4939	3	149	10	427	46.2	0.2	294	151.0	1.1
5790	3	146	11	214	48.2	0.4	102	144.5	2.4
5017	4	-	9	546	47.9	0.1	24	148.9	2.3
4771	4	149	10	16	42.4	1.6	2	138.5	6.5
5048	4	147	10	63	44.1	0.5	12	146.4	2.6
4508	5	144	10	45	45.0	0.8	15	143.9	2.4

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Udder depth (above ground) & rear leg angle

- Raw data condensed to one value per cow and run
- Kruskal Wallis tests (cows with only 3 runs excluded) $\longrightarrow$ significant cow effects
  - Udder depth: $p < 0.0001$
  - Rear leg angle: $p = 0.002$
- Mixed linear models to describe UD (udder depth) and RL (rear leg angle)

$$\mathrm{UD}_{i,j} = \mu^{\mathrm{UD}} + cow_i + \mathrm{RUN}_j + \varepsilon^{\mathrm{UD}}_{i,j}, \quad \mathrm{RL}_{i,j} = \mu^{\mathrm{RL}} + cow_i + \mathrm{RUN}_j + \varepsilon^{\mathrm{RL}}_{i,j}$$

$\mu^{\mathrm{UD/RL}}$ overall means; cow_i random eff. i^{th} cow; RUN_j fixed eff. j^{th} run; $\varepsilon^{\mathrm{UD/RL}}_{i,j}$ random residual effects

- Coefficients of determination $R^2 = 1 - \frac{Residual\ sum\ of\ squares}{Total\ sum\ of\ squares}$
  - $R^2_{\mathrm{UD}} = 76.9\%$
  - $R^2_{\mathrm{RL}} = 47.4\%$

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Summary

- Cows were recorded in free walking
- Algorithms to find cows' body parts automatically have been developed and implemented
- Udder depth and rear leg angle have been measured in cm and degree
- Calculated traits showed desired behaviour
  - Lowering of the udder with increasing lactation number
  - Sufficient measurement precision
  - Significant cow effect
  - Moderate to high coefficients of determination

Thank you for your attention!

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Zuchtqualität mit Zukunft!
RSH
Rinderzucht Schleswig-Holstein eG