Applying parameter of body-shape in the automation of dairy cow **Body Conditioning Scoring**

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OBJECTIVE

The aim of the study was to advance the development of an apparatus and methods for automatic and objective monitoring of cow body fat reserves. **The hypothesis** tested in this study was that "if a cow is fatter, her body shape is more likely to be rounded and therefore a parabola may fit better to the cow's shape". A feasibility study was conducted to investigate the use of body-shape parameter that may lead, in the future, to the development of an apparatus and methods for automatic monitoring of cow body fat reserves on live dairy cows.

INTRODUCTION AND CASE

Body condition scoring (BCS) is a technique to estimate an animal's body energy reserves, i.e. estimating fatness or thinness of cows according to a numerical scale eg the five-point scale (Edmondson *et al.,* 1989). In dairy herds, body condition scoring of dairy cows is used as a management tool. Body condition score is an indicator for how well the feed ration fits with the milk production of the cow. Body condition influences productivity, reproduction, health and longevity (Heinrichs & Ishler, 2004). The current method of measuring BCS is manual and subjective. Manual estimation of BCS is time consuming in large farms and requires trained labour. Therefore the development of a device for automatic, objective monitoring of body condition scoring is of interest. Few attempts to automate the BCS are reported in the literature (Coffey *et al.,* 2003; Ferguson *et al.,* 2006; Bewley *et al.,* 2007).

MATERIAL and METHODS

- Data were collected at the Scottish Agricultural College Crichton Royal Farm in Dumfries, Scotland, UK in September 2007
- The study involved 186 cows
- The thicknesses of the muscles and fat layers was measured by ultrasound device, Sonovet 2000 (Medison, Korea)
- The Sonogram of the longissimus dorsi muscle (LDM) was carried out from the 12th and the 13th vertebrae. The thickness of the fat is the distance between the dorsal fascia of LDM and the ventral layer skin. The converting factor from the thicknesses of the fat and muscle layers (in millimetre, so called Tot_mm) on the 1-5 BCS scale was:

Ultrasound scoring =5*(log(Tot_mm)-3.6) *(Eq. 1)*

where
- Tot_mm was the thickness of the fat and muscle layers (in millimetre)
- 5 and 3.6 normalized the ultrasound units into the 1-5 BCS scale
- the log function depressed the large variation found in our ultrasound measure ments in the large values

- **The manual BCS** was obtained from two different technicians according to a five-point scale (Edmondson *et al.,* 1989).
- BCS was measured in the same week as measuring by ultrasound and by thermal camera.
- **A thermal camera** was linked to the barn ceiling above the cow body weighting scale, at the exit of the milking parlour.
- The cow identification was done electronically (RFID), with the antenna attached to the weighing scale.
- The video from the camera was divided into frames by using 'serif movie plus 4'.
- The frames were manually observed in order to select the best frame from each cow.
- Identified frames were fed into Matlab software for image processing analysis (Anonymous 2005).

Figure 1. **Model inputs: thermal images taken from bird's eye view.**

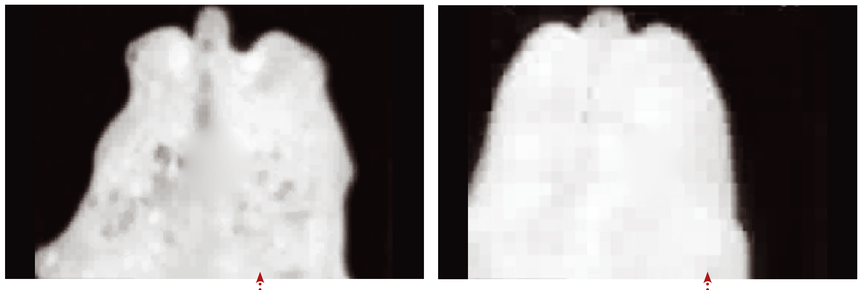


Figure 2. **Cow contour vs. fitted parabola.**

The thin cow (No.1358):
Manual BCS = 1.25
Thermal BCS = 1.30
Ultrasound total thickness = 40 mm
(1.44 in BCS units)

The fat cow (No.1640):
Manual BCS = 3.00
Thermal BCS = 3.50
Ultrasound total thickness = 74 mm
(3.52 in BCS units)

The visiul difference between fat and thin cows is presented in Figure 2. It can be seen (Fig. 2) that in a fatty cow, only the tailhead diverges from the round shape of the fitted parabola, while many deviations can be noticed in a thin cow. The converting factor from 'distance from parabola' to 1-5 BCS scale was

TBCS= 5*9*(1./MAE) *(Eq 2.)*

where
- TBCS stands for thermal BCS
- 9 is the best fit ever reached in our herd (i.e. only the tailhead diverse from the parabola shape)
- 5 normalized the model output into 1-5 BCS scale
- The distance between the fitted parabola and the cow contour was expressed in **MAE** (mean absolute error) units

Therefore, the hypothesis tested in this study was that **"if a cow is fatter, her body shape is more likely to be round and therefore the parabola may fit better to the cow shape and the resulting MAE is smaller". If a cow is thin, her body shape is less round and therefore the MAE is larger.**

RESULTS

The model outputs are the thickness of the body reserve measured by the thermal video camera (so called Thermal Body Condition Scoring, TBCS) compared with (1) the thicknesses of the fat and muscles layers measures by the ultrasound and (2) the manual Body Conditioning Scoring (so called BCS).

Table 1. Model validation; comparison of thermal camera, ultrasound and manual body condition scorings

			Cross Correlation Coef.		
	Average	SD	BCS	TBCS	US
BCS	2.17	0.30	1	0.36	0.40
TBCS	2.14	0.62		1	0.48
US	2.16	0.69			1

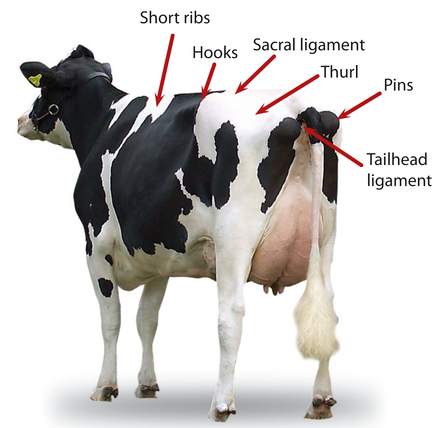
US=Ultrasound
TBCS= Thermal camera
BCS=Manual body condition scoring

Table 2. Model validation; Consistency check; Thermal camera body condition scorings (TBCS) measured in days 1, 2 and 3

			Cross Correlation Coef.		
	Average	SD	Day 1	Day 2	Day 3
Day 1	1.99	0.62	1	0.46	0.67
Day 2	1.99	0.66		1	0.61
Day 3	1.95	0.59			1

Table 3. Consistency check of the reference numbers; Manual BCS measured by technician 1 and 2

			Cross Correlation Coef.	
	Average	SD	Technician 1	Technician 2
Technician 1	1.99	0.41	1	0.78
Technician 2	2.22	0.33		1



Using equipment:

Medison SonoVet 2000

Thermal camera placed above stationary weigh station

CONCLUSIONS

- **A model based on thermal camera and image processing algorithms aiming for evaluation of cow body reserve was designed and implemented on 186 cows.**
- **Results suggest that further study with more cows may open the gate for automating BCS monitoring.**
- **Suggestions were made for further research.**

SUMMARY

A feasibility study on the introduction of body-shape parameter that may lead, in the future, to the development of an apparatus and methods for automatic monitoring of cow body reserves on live animals. The hypothesis tested in this study was that 'if a cow is fatter, her body shape is more likely round and therefore the parabola may fit better to the shape of fat cow rather a thin cow'. About two hundred Holstein-Friesian cows were monitored by means of thermal camera, ultrasound and manual body condition scoring (BCS).
An image-processing model was designed and implemented. The model calculates the parameter of cow body shape. The model outputs were validated against the precise measurements of the thickness of fat and muscle layers using ultrasound and manual BCS. The correlation found in this study between the thermal camera and the fat and muscle thickness was 0.48. The thermal camera overcomes some of the drawbacks of a regular camera. The hooks and the trailhead nadirs of a thin cow diverge from the round shape drawn by the parabola. Further research is needed in order to reach full automatic, accurate, body conditioning scoring.