Automatic Assessing Body Condition Score from Digital Images by Active Shape Model and Multiple Regression Technique

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Abstract

Body Condition Score (BCS) of a dairy cow is a magnificent indicator for determining energy reserves of cows. The purpose of this study is to assess BCS of dairy cattle by analyzing cows' rear-view images. In order to do so, we first model shape of cow's tailhead area by using active shape model. Then, angle features are modelled as multiple regression model for estimating scores. The experimental results show that proposed system is promising compared to some existing methods.

Keywords: Body Condition Score, Active Shape Model, Multiple Regression Analysis, Angle features.

1. Introduction

Most of the existing methods for measuring Body Condition Scores of dairy cows have been based on a subjective assessment of tissue reserves of lactating dairy cows.[1] BCS is widely considered as an important factor for management of dairy cattle due to its simplicity and repeatability. Moreover, it can evaluate body fat stores and estimate cumulative energy balance through visual or tactile inspection.[2] Svaluation of BCS is important for analyzing health problems, feed intake, and optimal time interval between calving and first insemination. For cattle, sheep and goats, the scoring systems most commonly used for BCS are numerical scales with 5-point, 6-point, 8-point or 10-point scales. For dairy cows, the BCS is normally a number in a scale that spans from 1 to 5 (0.25 increments) or from 1 to 9 (1 increment). Generally, the score range used by dairy management advisors describes thin animals with receiving lower scores and fat animals with receiving higher scores (1 represents emaciated cows, 5 represents obese cows for a 5- point system). For a certain management of farms, the BCS should be assessed. However, this task is time consuming and observed experts need considerable training and experience. Roii et al. stated[3] that automatic and objective BCS will help to ensure that the cow is in the correct condition for each stage of her annual cycle and correct any deficiencies with appropriate dietary changes.

The aim of the proposed research is to develop a system that models the body shape of a cow from the back view images and then assesses the BCS with observed angle features in score estimation. The rest of the paper is organized as follows: section 2 introduces some related works on approximations for automatic body condition scoring system, section 3 describes system overview with theoretical methods that are mainly applied in this research, section 4 explains how the experiments performed with output results, and finally in section 5, the conclusions and future works are described.

2. Some Related Works

Among the many attempts for estimating body condition scores automatically, the first attempt by Coffey et al., tested[4] using line patterns painted with laser light over the tailhead area of the cows. Some attempts apply digital images or some system used videos and an analysis of the cow's contour and shape that commonly involved. Roii et al., have taken[3] 3D images from the above view view of the cow acquisition of data automatically. Halachmi et al., have also taken[5] thermal images and they made decision that fatter cow's shape are rounder. Bewley et al., use[6] top view images, 23 points and 15 angles are

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extracted and show a good correlation with their expected score. Bercovich et al., also used[7] the above view images and they use Fourier descriptors method and regression method for the cow signature showing that body condition score can be automatically extracted from those images. Rafel et al. used[8] twenty-two angle features from the rear view images with the classifiers from Weka tool and they showed that their estimation is possibly comparable with difference of two human experts. Nevertheless, currently most dairy farms don't pay so much attention on automatic estimation of BCS in their dairy management. This is because some systems need to preprocess like laser paint or some systems need to install some kind of high cost camera like 3D camera, 3D Kinect camera, thermal camera despite their usefulness. Some commercial application like DeLaval- 2015 has appeared, but its accuracy was not published in a scientific publication in the statement[3]. So, this study will build the BCS estimation system of using simple 2D images by expressing observed accuracy.

3. System Overview

The proposed system for assessing BCS from digital images contains three main components. The preprocessing of the images, the segmentation of the shape and the estimation of the BCS as depicted in fig 1.

3.1. Preprocessing

The images for this study were collected from the web. We choose the back shape view of cow images because

Fig.1. Main components of the proposed system.

Ferguson et al., agreed[2] that the score of a cow can be assessed by a human observer with only the rear-end view of the cow.

Out of one hundred and thirty images of different cows, only seventy images are selected because of some background noise and position of the cow (e.g cluttered noise mixing with cow's color, very low resolution, too much variation of pose, etc.). Scores are assessed according to Ferguson et al., evaluation chart that one can see Ref. 3 for details. It is the common system used within the United Kingdom (UKBCS system) using a 0
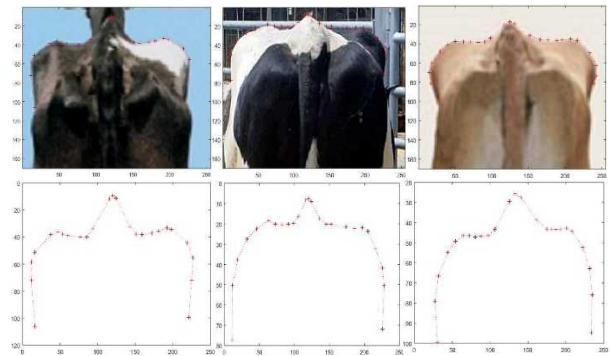

Fig. 2. Cow Images with shape (the upper) and extracted shapes from cow images.

to 5 scale with 0.25 intervals. But in this study, it is observed that scores are ranging from 1.5 to 4.5 with 0.5 increment. Moreover, most frequent scales here are 2, 2.5, 3 or 3.5. These scores are identified and collected with their corresponding cows' images for subsequent analysis. The images are then cropped to resize with the resolution of 255*170 pixels because Rafel et al., recommended[8] that most features or the rear of the cow are distinguishable with this resolution.

Table 1. Anatomical Points Description.

Point	Description
1-3	left hook start points
4	left hook midpoint
5	left hook angle point 1
6	left hook angle point 2
7	left hook angle point 3
8	left hook end point
9	left tailhead depress angle point1
10	left tailhead depress angle point 2
11	left tailhead depress angle point 3
12	tailhead peak angle point 1
13	tailhead peak angle point 2
14	tailhead peak angle point 3
15	right tailhead depress angle point1
16	right tailhead depress angle point 2
17	right tailhead depress angle point 3
18	right hook end point
19	right hook angle point 1
20	right hook angle point 2
21	right hook angle point 3
22	right hook midpoint
23-25	right hook start points

3.2. *Segmentation of the back shape of the cow*

Once we have the preprocessed cows' back view images, we need to extract the computationally manageable representation of the anatomy of the back shape of cows. A computer program written with Matlab 2015a was used in annotating of cow images from the dataset. Twenty-five anatomical points are identified. Those anatomical points according to recognizable features can influence the important information for representation of the shape. Those anatomical points with their description are depicted in the figure 1. The shapes are then aligned to endure the pose (scaling, rotation and resizing). Angles are measured according to law of cosine method using three points. There are five angles totally computed, two angles around the left and right hooks and two angles around the tailhead depression area and one angle at the peak of the tailhead as shown in figure 2.

3.3. *Analysis by Regression Method*

By using those angle features, we compute the regression coefficients in estimation of BCS. The multiple regression method is computed with the equation as follows:

$$BCS_i = b_0 + b_1 Ang_1 + b_2 Ang_2 + b_3 Ang_3 + b_4 Ang_4 + b_5 Ang_5 \quad (1)$$

where BCS_i is the BCS of the ith cow, Ang_1 and Ang_5 are the left and right hook angles, Ang_2 and Ang_4 are the left and right tailhead depression angles, and Ang_3 is the tailhead peak angle respectively. And b_0 is the constant or intercept and b_1, b_2, b_3, b_4 and b_5 are the slope (coefficients) of the three angles respectively. We computed the angles in radian rather than degrees to reduce the variation among values.

4. Experiments and Results

After analyzing those angle features using regression method, the computed regression coefficient and the predicted BCS values are shown in Table 1. In the experiment, we take threshold to those angle values by rounding the point value and then observed that the predicted BCS values are close and some even identical to the estimated BCS as in shown in figure 3. The residual values (which is the difference between predicted values and already estimated values) are 0, 0.5 and 1.
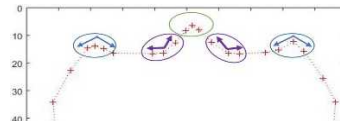

Table 2. (a) Regression coefficients (b) Some angle features with respective BCS from 10 random images out of 70, where Y= BCS and Y' = predicted BCS (c) Correlation of each angle with BCS

b_0	b_1	b_2	b_3	b_4	b_5
-9.2863	2.2450	1.0451	-0.1265	-0.3583	1.3034

(a)

Ang_1	Ang_2	Ang_3	Ang_4	Ang_5	Y	Y'
2.5491	1.4157	2.3629	2.3629	0.1212	2	2.5
2.8389	1.2727	1.8776	1.8776	0.1333	2.5	3
2.5605	1.4049	2.3836	2.3836	0.1695	2.5	2
2.4930	1.2870	2.3031	2.3031	0.1301	1.5	1.5
2.7783	1.5187	2.3119	2.3119	0.1536	3	3
2.9189	1.4515	2.5580	2.5580	0.1085	3.5	3.5
2.7980	1.5669	2.4416	2.4416	0.2446	3	3
2.7762	1.3964	2.4901	2.4901	0.0865	2.5	3
2.7088	1.2597	2.4962	2.4962	0.0948	2	2.5
2.8441	1.3426	2.2667	2.2667	0.1068	3	3

(b)

	Correlation with BCS
Ang_1	0.6090
Ang_2	0.4161
Ang_3	0.1001
Ang_4	0.2229
Ang_5	0.5446

(c)

Out of seventy images, twenty-four images have zero difference, thirty-four images have 0.5 difference and eleven images have 1 difference. We assumed the 0.5 difference is feasible because even the difference between the trained experts can have 0.5 difference in estimating the BCS. Thus, the accuracy for this experiment is 83% which is acceptable to estimate. We also computed the correlation between each angle feature with their respective BCS value as shown in Table 2(c) and we find that all these angle features have the positive correlation with the BCS. This means that if those angle have the higher value (wider angle) the BCS value is the higher value. This assumption agrees with the wider
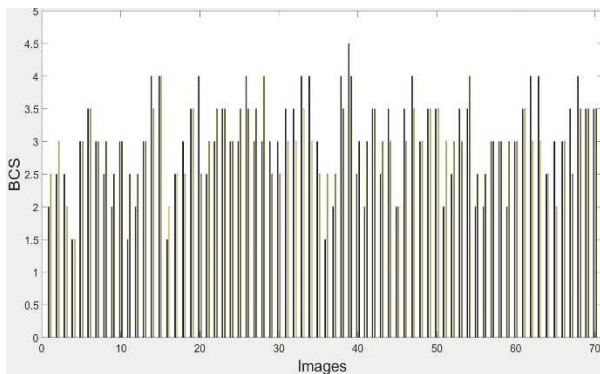
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Fig. 3. Cow Images with shape (the upper) and extracted shapes from cow images.

angles indicate a rounder cow in the statement stated[5] by Halachmi et al., in their study.

5. Conclusion

In this paper, we used the back view images of cows in estimation of BCS. The BCS of the cows are estimated using the 5 point scale. Experimental results showed that this method is effective in assessing the BCS of the cow as the predicted scores are closed to the actual scores. Moreover, our experiment also hold the same impression with the assumption of the rounder shape have the higher scores. In the future, a more robust method for extraction of shape and a dataset of back view cow images useful for cattle management will be addressed.

Acknowledgement

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