Estimating Body Condition Score of Cows from Images with the Newly Developed Approach

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***Abstract* - The Body Condition Score (BCS) is the level of energy reserves in many species, including dairy cattle. For the exact management on dairy farms, the judgment process of BCS is critically important. In this study, the implementation of newly developed approach to estimate body condition score is proposed. Back view images of the cow were used in this system. The area around the tailhead and left and right hooks are segmented automatically and then classified that region for estimating the body condition score. The three main steps conducted are (1) segmentation of cows' images, (2) extraction of region of interest (ROI) by using the convex hull method, and (3) calculation of parameter using moving average method. To confirm this new approach, back view images of various cow types are used and the experimental results confirm its effectiveness with accurate results.**

Index Terms - Body Condition Score (BCS); region of interest (ROI); convex hull method; moving average; segmentation.

I. INTRODUCTION

Estimating body condition score (BCS) is a practical method of evaluating changes in fatness or thinness of cows. Achieving correct body condition at calving is important to avoid calving difficulties and losses [1]. There are two common scoring systems: (1) five point scoring system from score 1 to 5 with the interval of 0.25, and (2) nine point scoring system from score 1 to 9 with the interval of one. No matter of any scoring system, the lowest score denotes an extreme thin cow, while the highest score denotes an excessively fat cow. And the change in score mainly occurs in the calving and breeding process. The usefulness, validity, and precision of BCS for assessing body energy reserves are well documented [2]. Traditionally, the assessment of BCS is considered by farm experts. Despite the general consensus on the benefits of the BCS evaluation in farms, less than 5% of US dairy farms have adopted this practice in the production chain [3]. Furthermore, the measurements must be revised frequently on each cow augmenting hence the costs for the farms. Estimating BCS using visual inspection by farm experts is time consuming and subjective process. Some scoring system of BCS using image processing technology becomes popular recently with the aid of assisting traditional manual approach and to reduce time consuming in farms. However, even single observation of the BCS for a certain cow is not enough sufficient and there may be some deviation even between expert human observers on the same cow. It still needs to learn some kind of method with sufficient knowledge on different types of cows to identify the exact score.

In this research, the previous works that related to the estimation of BCS are shown in the Section 2. In section 3, we describe our proposed system with the experimental results that have been achieved. Finally in section 4, we summarize the conclusion of the current work and the future work.

II. PREVIOUS WORKS

Some related works that attempt in estimating body condition score. One of the very first attempts with addressing this type of estimation using computer technology is by Coffey et al., [1] in 2003. In their attempt, the laser pattern over the tail head region of cows is projected to segment. Roii et al., [2] used 3D Kinect camera and captured images from the above view. Then, they developed the regression model to find the correlation between BCS and features. Bewley et al., [3] manually identified anatomical points to the cow images which are taken from the above of the cow. Then, the angle features from those points are measured and determine the BCS with the regression machine. Battiato et al., [4] also used the above view cow images and modelled the features with regression model. Rafel et al., [5] used 2D images of cows taken at the rear. The angle features are extracted from the shape and analyzed. They assumed that their estimation error is comparable with that of two human observers. Most of the system used the angle features in estimating the body condition score after extracting the cow images. Despite their attempts, our purposed system is to propose a newly developed approach to estimate the BCS effectively by using simple and low cost 2D images.

III. THE PROPOSED SYSTEM

The aim of the proposed system is to implement the newly developed features to decide BCS accurately. Our system has three main steps. Firstly, the segmentation process using edge feature and contour feature is performed. Then, the extraction of the region of interest is computed by using the convex hull method. This so-called region of interest (ROI) is the region of the cow around the hook and pin area which apparent in deciding the changes of BCS is computed. Finally, parameter calculation upon the extracted region

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using the moving average method is processed to predict the score. In our system, three types of cow images which are Crossbred, Friesian and Jersey are tested. The architecture of the proposed system is shown in Fig 1.

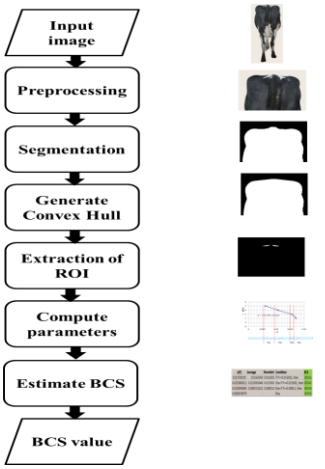

Fig. 1 Architecture of the Proposed System.

A. *Preprocessing*

The variation of different BCS values depends mainly in the regions of hook and tailhead area. The assumption is that the bigger and deeper the area between hook and tailhead area, the smaller BCS value and vice versa. Preprocessing step is done on the cow's back view images before performing any operation.

The cow images to test in this study are collected from the web. There are total one hundred and thirty cow images which are captured from the back view. The groundtruth BCS values are identified according to Ferguson et al. [6] evaluation chart. This Ferguson chart is the standard system which used the United Kingdom (UKBCS system) with a 0 to 5 scale of 0.25 intervals.

In this study, the one hundred images are used for training and thirty images are used for testing. It is observed that BCS scores are ranging from 2 to 5 with 0.5 increments in our study and the frequent scales here are 2, 3, 4 and 5. All cow images are scaled as 255*170 pixels respectively as shown in Fig 2. We applied this resolution to images because Rafel et al., [5] recommended that the important features of backview of cow are distinguishable using this resolution.

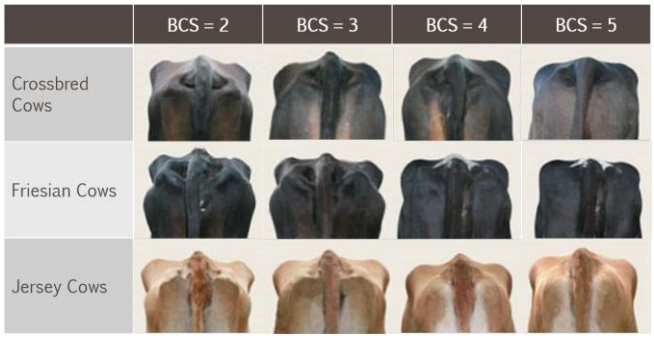

Fig. 2 Some of the Cow Iimages that are taken from Back View with Groundtruth BCS Values.

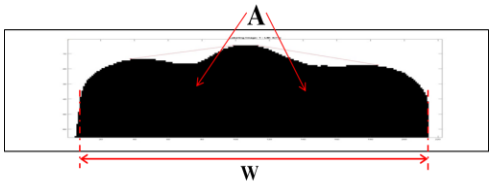

Fig. 3 Parameter Calculation from the Segmented Image

B. *Filtering of Preprocessed Images*

Next, the color transformation process is performed in order to assist in the further processing steps. Although the RGB color spectrum is conducted in the color representation process, it is not always suited in the processing steps. In this study, the gray level transformation is processed. Then, the filtering process is performed to smooth the image when the scaled image of cow is inputted. The Gaussian function is useful for smoothing images or detecting edges after smoothing. In this system, Gaussian filter is used as this filter can smooth noisy regions still keeping the structure of edges.

C. *Segmentation*

After the filtering process, the detection of edges from the smoothed image is processed. In our experiment, various types of edges (canny, prewitt, sobel, etc) are tested in order to find the most representable edge and we choose the canny edge as it can represent effectively. The canny edge first smooths the filtered gray level intensity image. Then, it produces segments by following high gradient magnitudes from one neighborhood to another. At the same time, the extraction of contour is processed by using the active contour method.

After that, the superimposing process is performed. The edge extracted image with contour extracted image is imposed. There are various ways to superimpose images in analyzing images. In this study, the superimposing is achieved by overlapping the two image objects. And then, skeletonization process is performed to represent the general form of an image. Skeletonization is a common processing operation in in pattern recognition computed by means of morphological operation [8].

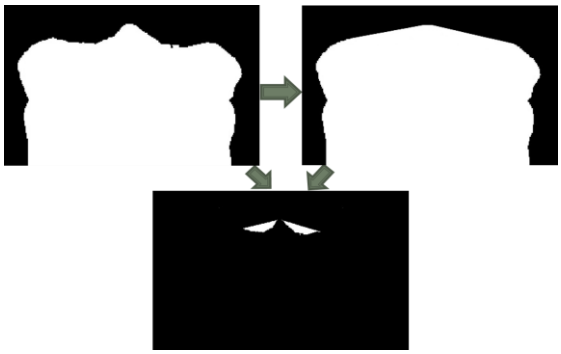

Fig. 4 Construction of Convex Hull to the Segmented Image and Extraction of Region of Interest (ROI).

TABLE I
BCS ESTIMATION USING THE PROPOSED SYSTEM

P	*Moving Average*	*Condition*	*BCS*
Crossbred Cows			
0.017030190	0.016305400	if P>=0.016305, then	2
0.015580611	0130630480	else if P>=0.013063, then	3
0.010545484	0.008310232	else if P>=0.00831, then	4
0.006074979		else	5
Friesian Cows			
0.019989673	0.019118092	if P>=0.019118, then	2
0.018246511	0.014291751	else if P>=0.014292, then	3
0.010336990	0.008684593	else if P>=0.008685, then	4
0.007032195		else	5
Jersey Cows			
0.02670440	0.023931817	if P>=0.023932, then	2
0.02115924	0.019692946	else if P>=0.019693, then	3
0.01822666	0.016736882	else if P>=0.016737, then	4
0.01524711		else	5

D. Constructing Convex Hull

The convex hull of a geometric object (such as a point set or a polygon) is the smallest convex set containing that object. Computing the convex hull means that a non-ambiguous and efficient representation of the required convex shape is constructed [11].

In this study, the region of interest is the region between the tailhead of the cow and two hooks (left and right) because this area is regarded as the prominent area the BCS of the cow. We applied the convex hull method to construct the closed curve around the area between hook and tailhead of cow as shown in the Fig 3.

E. Parameter Calculation from Segmented Image

The calculation of parameter using the count of white pixels area and width between left and right hook is computed using the following equation:

$$P = \frac{A}{w^2} \ . \tag{1}$$

Where, P is the parameter, A is the count of white pixels area, and w = width of pixels. The ROI area is then calculated by differencing the filled convex hull image (closed curve) to the segmented image before performing closed curve as shown in Fig 4.

F. Computing Moving Average

After calculating the parameters, the moving average of two consecutive data values is calculated with the purpose of getting smooth data. A moving average also called a moving mean (MM) or rolling mean is commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles [12]. The first element of the moving average is obtained by taking the average of the initial fixed subset of the data series and repeated over the entire data. Then, we decide the thresholds experimentally to get the BCS value.

IV. Experimental Results

In our experiment, the computed region of interest extracted using the convex hull method is shown in Fig 4. We take that region of interest to calculate the parameter. The resultant parameter is then smoothed by using the moving average method and then performed threshold. The resultant thresholds for each cow type (Crossbred, Friesian, Jersey) are shown in the Fig 5.

Table 1 depicts the estimation of BCS on various cow types (Crossbred, Friesian and Jersey) using the proposed method. The values of P in the first column are the resulted parameter values using the equation 1. Then, we compute the moving average of those two consecutive parameter values. By taking the rounded values on those moving average values, then the BCS values are estimated. In this study, it is assumed that the 0.5 variation between the groundtruth score and estimated score is feasible as even the variation between the trained observers can have 0.5 differences in BCS judgment. In our experiment, we find that these computed thresholds claim the accurate score of cows with the groundtruth score which is estimated by the human expert by using this proposed approach.

V. Conclusions

In our study, we perform the estimation of BCS of dairy cows using the back view images. Our experiment performs using two main steps: the extraction of the region of interest (ROI) that shows the variation of the BCS, and the estimation of BCS value using the parameter calculated from the ROI. We imply the convex hull method in extracting parameter. For the estimation process of BCS, we used the moving average method in analyzing and estimating the BCS value. The experimental results confirm that BCS value for various types of cows can be estimated accurately by using this new approach.

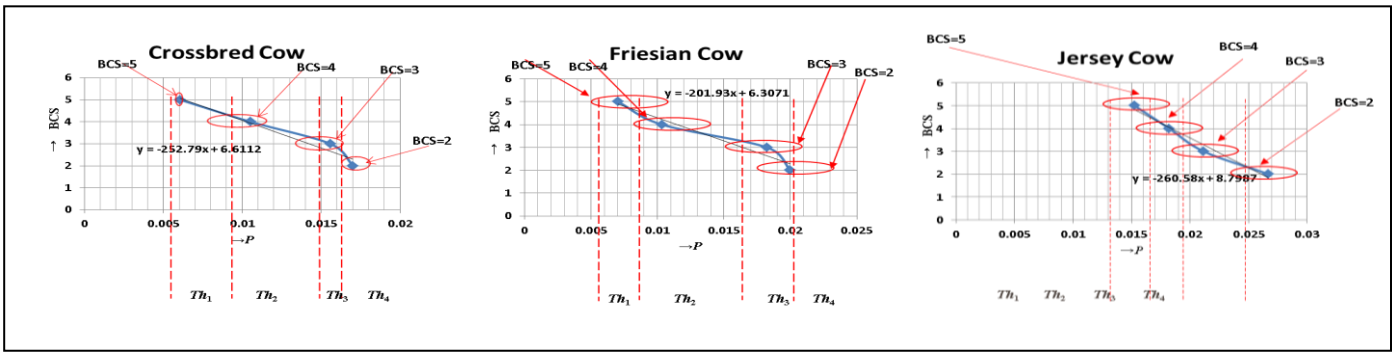

Fig. 5 Parameter Values Resulted from Crossbred, Friesian and Jersey Cows.

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