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その他（別言語等）のタイトル	ビデオカメラを用いた画像解析による乳牛の体尺測定法の開発
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journal or publication title	Nihon Chikusan Gakkaiho
volume	67
number	10
page range	878-881
year	1996-10
URL	http://id.nii.ac.jp/1588/00000099/

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日 本 畜 産 学 会 報　第67巻　第10号　別 刷
1996（平8）年10月
Reprinted from
Animal Science and Technology, Vol. 67, No. 10
October 1996

—— Research Note ——

Development of a Body Dimension Measurement Method for Dairy Cattle by Computer Image Analysis with Video Camera

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(Received April 1, 1996)

Abstract The body conformation of dairy cattle is closely related to their life-time production. Because of this fact, the development of an accurate and simple method of body dimension measurement using computer image analysis is the objective of this study. A rectangular pipe frame was used as a dimension measurement standard for obtaining photographs. It was placed vertically on flat ground and parallel to the planes which were made by the median line and the points of the pin bone. Two images were photographed : the side view and the dorsal view of an object. The measurements were taken on a wooden cattle model of 1/10 scale and three heads of Holstein cattle. Errors of the ten sites of body dimension measurement points, compared with direct measurements, were the range of −1.9∼2.4% with an average absolute error of 0.8% in the wood model and −3.5∼3.5% with an average absolute error of 1.2% in the live animals. This method was more accurate and simpler than the conventional method of direct measurement of live animals.

Anim. Sci. Technol. (Jpn.) 67 (10) : 878-881, 1996

Key words : Image analysis, Body dimension measurement, Rectangular pipe frame

The body conformation of dairy cattle is known to be closely related to their life-time production[3] and to have a large influence on their ability to give birth to offspring[2].

Ali *et al.*[1] reported that heifers that had specific characteristics in rear part of wide pin bones, roof-shaped rumps, and a small slope from the thurl to the pin bone appeared to give birth to calves more easily. However, the body conformation of animals is often assessed by type scores, a kind of record of categorical traits that is often unsatisfactory for genetic evaluation. A continuous body measurement is an effective alternative means in predicting the calving performance of heifers and in deciding selection replacements. Moreover, the conventional method of direct measurement on animals requires time and labor, so it is difficult for farmers to measure animals routinely.

In recent years, three dimensional measurement for cattle body conformation has been examined[4]. Moreover, there has been some research on the application of computer image

ビデオカメラを用いた画像解析による乳牛の体尺測定法の開発：口田圭吾・蛤谷志乃・斎藤祐介・鈴木三義・三好俊三（帯広畜産大学，帯広市 080）

analysis in the stockbreeding field[5,6]. Kuchida *et al.*[7,8] reported that it is possible to estimate the body volume and the numeration of curvilinear form in beef cattle by using computer image analysis. However, no report has been presented regarding the simplification of the body measurement utilizing this technology. Therefore, the purpose of this study was to develop an accurate and simple method for body measurement using computer image analysis.

Materials and methods

Ten body measurement points were established : the height at the withers, the height at the hipcross, chest depth, hip length, hip bone width, thurl width, pin bone width, the height at the hip bone, the height at the thurl and the height at the point of the hipbone. The equipment used was a digital video camera DCR-VX 1000 (SONY) with a wide-angle lens (SONY VCL-0752 H), a Power Macintosh 8100 AV (Apple) computer for image input and an APTIVA 745 (IBM) computer for image analysis. A computer image analysis program to be run on the Windows 95 operating system was written in Visual C++ (Microsoft).

For image analyses, a measurement standard which is the base for calculation of indirect measurements is necessary. In this study, a rectangular pipe frame (steel with plastic coating, diam. : 2.5 cm) with a perpendicular axis of 150 cm and a ratio between perpendicular axis, the horizontal axis and the depth axis of 3 : 1 : 1 was defined as the measurement standard. The side view and dorsal view of each animal at free angles were photographed. The rectangular pipe frame was placed vertically on flat ground and parallel to the planes which were made by median line for the side view and by the points of the pin bone for the dorsal view (Fig. 1). The calculation of the measurement values was obtained by extending the principle of the clairvoyant drawing method[9] which allows one to calculate the relative coordinate of the optional point in the rectangular angle in a photograph with a diagonal frame.

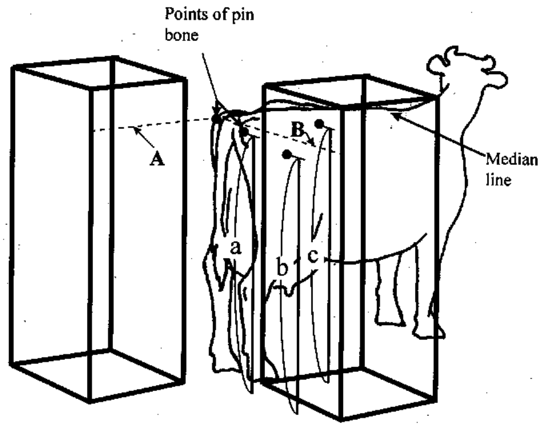

Fig. 1. Body measuring method using rectanglar pipe frame
A : parallel to median line for side view photographing, B : parallel to points of pin bone for dorsal view photographing, a, b, c : height at pin bone, thurl and hip bone, respectively.

A wood cattle model of 1/10 scale on which the measurements could be calculated accurately, and three Holstein cattle fed at the Obihiro University Farm were used to archive the direct measurement values and indirect measurement values utilizing computer image analyses.

Results and Discussion

Because the error of aberration distortion of the video camera lens was sufficiently small compared with that of direct body measurement, the aberration error was ignored in this study. The accuracy of the method was assessed by percentage error between the directly measured values (conventional method) and the indirectly measured values which were obtained using computer image analysis with the video camera. The equation for the percentage error follows :

$$PE = \frac{IV - DV}{DV} \times 100$$

where PE : percentage error,

IV : indirectly measured value obtained

from computer image analysis,
DV : direct measurements on a live animal.

The average percentage error was calculated as the average of the absolute value of percentage error. Measurement values and percentage error for three trials on the wood model are shown in Table 1, and those for three cattle are in Table 2.

It is possible for this system to take a 640× 480 pixel image into video memory. When the whole body image of a live animal is photographed, one pixel is equivalent to about 0.3 cm. For example, the direct measurement value of the height at the withers is between 149.85-150.15 cm for the estimated value of 150 cm for indirect measurement. Therefore, the theoretical minimum scale and percentage error converting the height at the withers are 0.3 cm and 0.2%, respectively. Errors of the

Table 1. Direct and indirect measurement values with percentage error measured on 1/10 scale wood model

	Height at withers	Height at hipcross	Chest depth	Hip length	Hip bone width	Thurl width	Pin bone width	Height at hip bone	Height at thurl	Height at pin bone
Direct measurement (cm)										
	17.4	17.8	10.4	6.5	6.6	8.2	3.6	16.9	14.8	16.8
Indirect measurement										
Trial 1 (cm)	17.6	17.9	10.2	6.5	6.8	8.3	3.6	16.8	14.9	17.0
Error (%)	1.1	0.6	−1.9	0.0	0.0	1.2	0.0	−0.6	0.7	1.2
Trial 2 (cm)	17.7	17.9	10.4	6.4	6.8	8.4	3.6	17.0	14.9	17.0
Error (%)	1.7	0.6	0.0	−1.5	0.0	2.4	0.0	0.6	0.7	1.2
Trial 3 (cm)	17.2	17.7	10.4	6.6	6.7	8.1	3.6	17.1	15.0	16.9
Error (%)	−1.1	−0.6	0.0	1.5	−1.5	−1.2	0.0	1.2	1.4	0.6
Average (cm)	17.5	17.8	10.3	6.5	6.8	8.3	3.6	17.0	14.9	17.0
Error (%)	1.3	0.6	0.6	1.0	0.5	1.6	0.0	0.8	0.9	1.0

Average percentage error was calculated as the average of the absolute percentage error.

Table 2. Direct and indirect measurement values (DV and IV, respectively) with error percentage measured on three live Holstein cattle

		Height at withers	Height at hipcross	Chest depth	Hip length	Hip bone width	Thurl width	Pin bone width	Height at hip bone	Height at thurl	Height at pin bone
Animal 1	DV (cm)	141.5	141.5	73.5	50.0	49.0	50.0	20.0	133.0	121.0	137.0
	IV (cm)	138.4	140.9	76.1	49.3	50.7	49.9	19.3	132.3	120.7	137.8
	Error (%)	−2.2	−0.4	3.5	−1.4	3.5	−0.2	−3.5	−0.5	−0.2	0.6
Animal 2	DV (cm)	146.0	146.0	81.0	52.0	58.0	52.0	23.0	141.0	126.5	134.0
	IV (cm)	144.8	147.0	81.2	53.5	57.3	52.1	23.0	140.6	126.5	135.4
	Error (%)	−0.8	0.7	0.2	2.9	−1.2	0.2	0.0	−0.3	0.0	1.0
Animal 3	DV (cm)	154.0	151.0	84.5	57.0	65.0	57.0	27.0	142.5	129.5	139.5
	IV (cm)	149.6	149.5	82.3	56.6	64.2	57.5	27.0	140.6	127.0	139.1
	Error (%)	−2.9	−1.0	−2.6	−0.7	−1.2	0.9	0.0	−1.3	−1.9	−0.3
Average	Error (%)	2.0	0.7	2.1	1.7	2.0	0.4	1.2	0.7	0.7	0.6

Average percentage error was calculated as the average of the absolute percentage error.

ten sites of body dimension measurement points, compared with direct measurements, were the range of $-1.9\sim2.4\%$ with an average absolute error of 0.8% in the wood model and $-3.5\sim3.5\%$ with an average absolute error of 1.2% in the live animals. The average percentage errors were larger than the expected value. The rather large error for live animals in comparison with wood models might be caused by animal movement during the lag time between measuring and photographing. The percentage errors for chest depth, hip bone width and pin bone width in some animal were higher than other measurement points. This might be caused by the measurement which should be conducted at two points for these width traits, while only one point was required for the height traits such as height at hip bone. Larger percentage error for height at withers than those for height traits at rear part which might be caused by this measurement point was the furthest from the measurement standard which was set up on cow's rear space.

The photographic angle is optional with this method, and the placement of the measurement standard and the operation of computer image analysis software are relatively easy. Moreover, the rectangular pipe frame can be replaced by an automatic weight meter, automatic feeding machine or cattle passageway. This new method provides a simpler method to record the body measurements of live animals.

Acknowledgments

This study was supported by a grant from the Hokkaido Foundation for the Promotion of Scientific and Industrial Technology. The authors gratefully acknowledge Mr. Kieu Minh Luc, Obihiro University of Agriculture and Veterinary Medicine for his helpful suggestion. We also would like to thank the Obihiro University Farm for offering cattle and the Tokachi Federation of Agricultural cooperation.

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