The Identification of Japanese Black Cattle by Their Faces

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ABSTRACT : Individual management of the animal is the first step towards reaching the goal of precision livestock farming that aids animal welfare. Accurate recognition of each individual animal is important for precise management. Electronic identification of cattle, usually referred to as RFID (Radio Frequency Identification), has many advantages for farm management. In practice, however, RFID implementations can cause several problems. Reading speed and distance must be optimized for specific applications. Image processing is more effective than RFID for the development of precision farming system in livestock. Therefore, the aim of this paper is to attempt the identification of cattle by using image processing. The majority of the research on the identification of cattle by using image processing has been for the black-and-white patterns of the Holstein. But, native Japanese and Korean cattle do not have a consistent pattern on the body, so that identification by pattern is impossible. This research aims to identify to Japanese black cattle, which does not have a black-white pattern on the body, by using image processing and a neural network algorithm. 12 Japanese black cattle were tested. Values of input parameter were calculated by using the face image values of 12 cows. The face was identified by the associate neural memory algorithm, and the algorithm was verified by the transformed face image, for example, of brightness, distortion, noise and angle. As a result, there was difference due to a transformation ratio of the brightness, distortion, noise, and angle. The algorithm could identify 100% in the range from -30 to +30 degrees of brightness, -20 to +40 degrees of distortion, 0 to 60% of noise and -20 to +30 degree of angle transformed images. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 6 : 868-872)***

Key Words : Cow's Face, Image Processing, Identification, Japanese Black Cattle, Associative Memory

INTRODUCTION

Modern livestock producers are concerned with not only increasing production, but also delivering a superior quality of animal production. Up until now, farm environment has been studied for optimization of aerial environment to increase its production, and in the very near future, animal farming will demand optimization of the production environment for animal welfare and health. Cattle farming also demands precision livestock farming in the production and environmental control. Special attention has to be given to the management of feeding, animal health, and fertility.

Human-animal interactions are a common feature of modern wellbeing farming systems, and research in a number of livestock industries has shown that the interactions between stockpersons and their animals can limit the productivity and welfare of the animals (Hemsworth and Coleman, 1998). Individual management of the animal is the first step for precision farming and animal welfare. Accurate recognition of each individual animal is important for precise management. Electronic identification of cattle, usually referred to as RFID (Radio Frequency Identification), has many advantages for farm management.

The identification of the individual cow is one of the problems. Consequently, identification systems of various types have come to fruition recently. Generally, these systems use the RFID. In practice, RFID implementations can cause several problems. Reading speed and distance must be optimized for specific applications. In 1995, International Committee for Animal Recording (ICAR) developed a set of requirements regarding (among others) reading distance and reading speed (Geers et al., 1997). Error-free reading should be possible at a distance of 0.4m while the animal is moving with a speed of 3 m/s. With modern transponders, reading ranges up to 0.8m and reading speed up to 4 m/s proved to be possible (Klindtworth, 1998), thus easily fulfilling these requirements.

Image processing is more effective than RFID for the development of a precision livestock farming system. Recently, the production of the livestock must take into consideration animal welfare and precise environment control. The identification research of dairy cattle by using image processing is being advanced (Morio and Ikeda, 2000; Kim, 2001; Morio et al., 2003). But until now, the researchers' studies focused on the dairy cattle (Holstein) that have a black-and-white pattern on the body. Most cows, including Japanese black cattle, do not have a black-and-white pattern on their body. Therefore, research regarding the identification of cows that do not have a black-and-white pattern on their body is necessary.

The aim of this research is to investigate the

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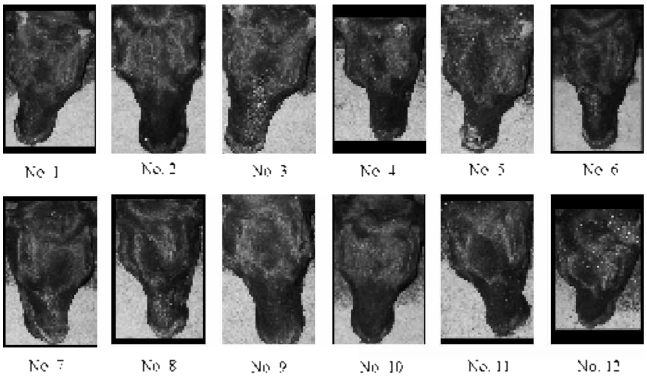

Figure 1. The face pictures of gray level image of Japanese black cattle.

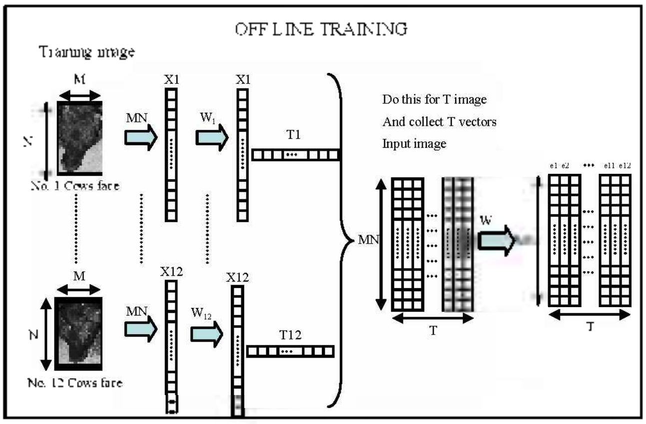

Figure 2. The offline training of the identification algorithm for Japanese black cattle faces.

identification of cattle by using image processing. This research is conducted to identify Japanese black cattle, which does not have a black-and-white pattern on the body, by using image processing of the face via a neural network algorithm. Further research on this topic is warranted because of its important implications for not only the animal wellbeing but also the stockperson health. The identification of the animal must be studied to improve animal welfare and precision livestock farming.

MATERIALS AND METHODS

Materials

The study used the head of 12 Japanese black cattle that were bred on an experimental farm of Kyoto University. The image of the cows' faces was captured by the video camera at feeding time. The face images are trained to a gray level image for the identification. The training images are shown in Figure 1.

Training and recognition

The cows' face images for the identification used gray level image. The image size for the calculation was 172×280 pixels. The algorithm for the identification of the cows' faces used the associative neural memory. Generally, identification using the associative neural memory takes a long time. The real time processing of human facial recognition proposed the Eigenface method that uses the eigen-vector to save processing time (Belhumeur et al., 1997; Turk and Pentland, 1991).

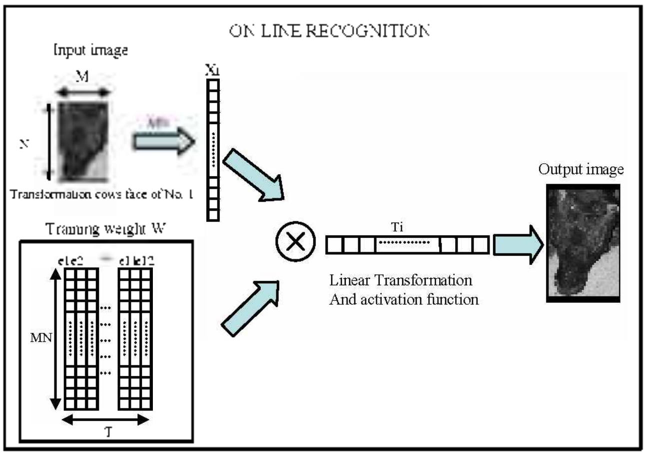

Figure 3. An outline of the identification algorithm for Japanese black cattle faces.

The algorithm of associative neural memory used the weight value (W) which is the same as the linier transform matrix in the method of eigenface. I can make Japanese black cattle face images in the weight value (W) as follows:

$$
\begin{aligned}
W &= W_1 + W_2 + \Lambda + W_m \\
&= \sum_{m=1}^{M} s^T(m)t(m) \\
&= s^T(1)t(1) + s^T(2)t(2) + \Lambda + s^T(m)t(m)
\end{aligned}
$$

Experimental method and verification of the algorithm

The algorithm for this study for the cow's identification is shown in Figure 2. The twelve faces were used for the training using the gray level values in each pixel. The weight value, W, for identification were obtained from the training result of the Japanese black cattle's faces as shown in Figure 3.

The experimental design for the verification of identification algorithm is shown in Table 2. I defined four variables in the gray level image for the verification. The variables are brightness, distortion, noise, and angle in the image. Distortion is given to verify robustness to the aberration of the camera lens. I transformed the variables by 10 degrees and used Paint Shop Pro 6 to transform the image in terms of brightness, distortion, noise and angle.

The general expression was defined for verification such that "+" sign for light site and "-" sign dark site in brightness, "+" sign for from around to center and "-" sign from the center to around in distortion, "+" sign for right hand side and "-" for left-hand side. Noise is represented by

Table 1. The experimental design for verification of the identification algorithm

Variables	Pixels used	Degree of transformation image										
Brightness (grade)	172×280pixels	-50	-40	-30	-20	-10	0	+10	+20	+30	+40	+50
Distortion (grade)	172×280pixels	-50	-40	-30	-20	-10	0	+10	+20	+30	+40	+50
Noise (%)	172×280pixels	0	10	20	30	40	50	60	70	80	90	100
Angle (degree)	172×280pixels	-50	-40	-30	-20	-10	0	+10	+20	+30	+40	+50
	100×100pixels	-50	-40	-30	-20	-10	0	+10	+20	+30	+40	+50

Table 2. The result of identification by changing the brightness of the image

Brightness	Number of the cow											
(grade)	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
-50	○	○	○	×	×	×	○	×	○	○	○	×
-40	○	○	○	○	○	×	○	○	○	○	○	○
-30	○	○	○	○	○	○	○	○	○	○	○	○
-20	○	○	○	○	○	○	○	○	○	○	○	○
-10	○	○	○	○	○	○	○	○	○	○	○	○
0	○	○	○	○	○	○	○	○	○	○	○	○
+10	○	○	○	○	○	○	○	○	○	○	○	○
+20	○	○	○	○	○	○	○	○	○	○	○	○
+30	○	○	○	○	○	○	○	○	○	○	○	○
+40	○	×	○	×	○	×	○	×	○	○	×	×
+50	×	×	×	×	×	×	×	×	○	×	×	×

Table 3. The result of identification by changing the distortion of the image

Distortion	Number of the cow											
(grade)	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
-50	×	×	○	×	○	×	×	×	○	○	×	×
-40	×	×	○	×	×	×	×	×	○	○	×	×
-30	×	×	○	×	○	×	○	×	○	○	○	×
-20	○	○	○	○	○	○	○	○	○	○	○	○
-10	○	○	○	○	○	○	○	○	○	○	○	○
0	○	○	○	○	○	○	○	○	○	○	○	○
+10	○	○	○	○	○	○	○	○	○	○	○	○
+20	○	○	○	○	○	○	○	○	○	○	○	○
+30	○	○	○	○	○	○	○	○	○	○	○	○
+40	○	○	○	○	○	○	○	○	○	○	○	○
+50	○	○	○	○	○	○	×	○	○	○	○	×

%. depending upon the extent of input noise.

The training image size of the cow's face was defined to two sizes, which were 172×280 pixels and 100×100 pixels. The concept does not change for the whole life the brow pattern on the face.

RESULTS AND DISCUSSIONS

The result of brightness transformation

First of all, the identification algorithm was tested by changing the brightness grade from -50 through +40. Table 2 shows the verification result of the identification algorithm.

It recognized all twelve faces from -30 grades to +30 grades. Beyond this range, it recognized 6 faces on +40 grades and 1 face on +50 grades in the positive grade while 11 faces on -40 grades, and 7 faces on -50 grades in the negative grade. The algorithm for identification for the study could not recognize for more than 40 grade.

The result of distortion transformation

The distortion was tested to validate the identification algorithm by changing distorting grade of the cows' faces. Table 3 shows the result of identification with the change of the distortion of the image. Their faces were recognized from -20 grades to +40 grades. While it recognized 6 faces on -30 grades, 3 faces on -40 grades, 4 faces on -50 grades in the negative grade, and 10 faces on +50 grades in the positive grade. Thus, the algorithm for identification could not recognize beyond -30, +50 grades. No distortion by the lens should be ensured for the improvement of the recognition ratio.

The result of noise transformation

The noise was also tested to validate the identification algorithm by changing noise strength of the cows' faces. Table 4 shows the result by changing the input noise strength of the image. Their faces were recognized their faces from 0% to 60% of input noise. Beyond this range, it

Table 4. The result of identification by changing the noise of the image

Noise (%)	Number of the cow											
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
0	○	○	○	○	○	○	○	○	○	○	○	○
10	○	○	○	○	○	○	○	○	○	○	○	○
20	○	○	○	○	○	○	○	○	○	○	○	○
30	○	○	○	○	○	○	○	○	○	○	○	○
40	○	○	○	○	○	○	○	○	○	○	○	○
50	○	○	○	○	○	○	○	○	○	○	○	○
60	○	○	○	○	○	○	○	○	○	○	○	○
70	○	×	○	×	○	×	○	×	○	○	○	×
80	○	×	○	×	○	×	×	×	○	○	×	×
90	×	×	○	×	○	×	×	×	○	×	×	×
100	×	×	○	×	○	×	×	×	○	×	×	×

Table 5. The result of identification by changing the cow's face angle (172×280 pixels)

Angle (degree)	Number of the cow											
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
-50	×	×	×	×	×	×	×	×	×	×	×	×
-40	×	×	×	×	×	×	×	×	×	×	×	×
-30	×	×	○	×	×	○	×	×	×	×	×	×
-20	×	×	○	×	×	○	×	×	×	○	×	○
-10	×	○	○	×	×	○	○	×	○	○	×	○
0	○	○	○	○	○	○	○	○	○	○	○	○
+10	○	○	○	×	×	○	○	×	○	○	○	×
+20	○	○	○	×	○	○	○	×	○	×	○	×
+30	×	○	○	×	×	○	○	×	×	○	×	×
+40	×	×	○	×	×	○	○	×	×	○	×	×
+50	×	×	○	×	×	○	×	×	×	○	×	×

Table 6. The result of identification by changing the angle (100×100 pixels)

Angle (degree)	Number of the cow											
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
-50	○	×	×	○	×	○	○	×	○	×	×	×
-40	○	×	○	○	○	○	○	×	○	×	○	○
-30	○	○	○	○	○	○	○	○	○	○	○	○
-20	○	○	○	○	○	○	○	○	○	○	○	○
-10	○	○	○	○	○	○	○	○	○	○	○	○
0	○	○	○	○	○	○	○	○	○	○	○	○
+10	○	○	○	○	○	○	○	○	○	○	○	○
+20	○	○	○	○	○	○	○	○	○	○	○	○
+30	×	○	○	○	○	○	○	○	○	○	×	×
+40	×	×	○	○	×	○	×	×	○	○	×	×
+50	×	×	○	×	×	○	×	×	○	○	×	×

recognized 7 faces on 70% of input noise. 5 faces on 80% of input noise and 3 faces 90% of input noise. Thus, the algorithm for identification could not recognize for more than 70% input noise.

The result of angle transformation

The noise was tested to validate the identification algorithm by changing angle of the cows' faces using 172×280 pixels image. Table 5 shows the result by changing the angle transformation of the image. No angle was found to recognize all the faces. It recognized only 7 faces at 10 degree. 8 faces at +10 degree and +20 degree and 5 faces at +30 degree.

Thus, the algorithm for identification could not recognize the change of angle using a 172×280 pixels image. This is due to the fact that background is included in the image. The background in the image changes with change of the angle, simultaneously with the face. The training was done to overcome the drawback by using 100×100 pixels of cow's face pattern image. which is between the two eyes of the face. The cow's facial pattern does not change during the cow's life.

Table 6 shows the result of the verification with change angle by using 100×100 pixels image.

It recognize their faces from -30 degree to 20 degree. Beyond this range. it could recognize 9 faces at -40 degree. 5 faces at -50 degree in the negative degree. 9 faces at 30% degree. 5 faces at 40% degree and 4 faces at 50 degree in the positive degree with the change of cow's face angle. This improvement is ascribed to the effect of background by decreasing 172×280 pixels image training to 100×100.

CONCLUSIONS

The goal of this paper is to investigate the possibility of the identification of cattle by using image processing. The majority of the research have been performed for the identification of the black-white patterns of the Holstein. The purpose of this study is to identify Japanese black cattle, which does not have black-white pattern on the body, by using image processing of the face and a neural network algorithm.

The 12 Japanese black cattle were tested for recognition. Values of input parameters were calculated by using the face image values of 12 faces. The cattle face was learned by the associative neural memory algorithm, and the algorithm was verified by the transformed face image of brightness, distortion, noise, and angle.

The results showed that it recognized their faces from -30 grades to +30 grades with the change of brightness, from -20 grades to +40 grades in distortion, and from 0% to 60% in input noise of the gray level image. However it could not recognize all faces at any degree of the change of cow's face angle by using 172×280 pixels image. Whereas it recognized their faces from -30 degree to 20 degree with the change of angle by using a 100×100 pixels image.

As a result, it comes into the conclusion that this algorithm is not suitable for real time processing for moving cows, however, used for real-time identification of stationary cows in the feeding area.

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