The Cow Gait Recognition Using CHLAC

Shu Mimura† Keichi Itoh† Takumi Kobayashi‡ Tomohiro Takigawa§
Atsushi Tajima§ Atsushi Sawamura∗
Nobuyuki Otsu‡
†United Technologies Institute, 1-1-1 Umezono, Tsukuba, Japan
‡National Institute of Advanced Industrial Science and Technology, 1-1-1 Umezono, Tsukuba, Japan
§University of Tsukuba, Agricultural and Forestry Research Center, 1-1-1 Tennodai, Tsukuba, Japan
∗National Institute of Livestock and Grassland Science, 2 Ikenodai, Tsukuba, Japan

Abstract

This paper reports the preliminary experiments on the cow identification via gait recognition of motion images. The eight cows walking under two different situations have been precisely identified by Cubic Higher-order Local Auto-Correlation (CHLAC). The cow gait recognition using CHLAC is expected to be a landmark achievement for realizing cost-effective dairy cattle breeding management systems which do not use any sensors and hormone in order to determine the timing of artificial insemination in dairy cattle.

1. Introduction

The detection of estrus behavior is essential to determining the timing of artificial insemination in dairy cattle. This is because dairy cattle produce milk only after parturition. If the estrus behavior fails to be detected, the cost of fodders would be wasted until next fertilization. Therefore, various measures such as wireless pedometers and fertilization timing control with hormone are taken to discover estrus behavior. However, these efforts are debatable in the viewpoints of cost and food safety.

We plan to realize a cost-effective and safe breeding management system using Cubic Higher-order Auto-Correlations (CHLAC) [1, 2]. The system uses only video images in order to detect the estrus behaviors, without using any sensors and hormone. To realize CHLAC-based breeding management systems, two technical achievements are necessary. The first is the identification of cows using the CHLAC-based gait recognition. The second is the detection of estrus behaviors by CHLAC.

By integrating these two achievements, the breeding system could precisely identify the cows in estrus status. This paper describes the preliminary experiments of identifying cows by CHLAC-based gait recognition. The experiments using video images of eight dairy cattle show the promising results.

2. Background

Here we briefly review practical efforts for detecting and controlling estrus.

Cows which will be estral in the near future tend to walk around more than usual. Wireless pedometer systems are commonly used to detect this feature. The values of a pedometer attached to a cow are transmitted to a central receiver where estrus cows are analyzed according to the values of pedometers. However, the cost of the wireless systems is expensive, for example, a few thousand dollars per year for 20 cows. In addition, it is troublesome for dairy farmers to detach a pedometer from a cow and attach it to another cow to be estral soon.

On the other hand, estrus timing can be controlled artificially by hormone injection. However, it might arise discussions about dairy products safety and animal welfare.

Figure 1. Example of walking cows on paved road and muddy road

Table 1. Results of cow gait recognition

Motion Image No.	Ground Truth (Cow's ID)	Recognition Result	Voting Result
No.1	**A**	**A**	62.7 %
No.2	**B**	**B**	65.2 %
No.3	**C**	**C**	100.0%
No.4	**D**	**D**	66.0 %
No.5	**E**	**E**	100.0%
No.6	**F**	**F**	100.0%
No.7	**G**	**G**	100.0%
No.8	**H**	**H**	100.0%
No.9	**A**	**A**	76.9%
No.10	**B**	**B**	89.3%
No.11	**C**	**C**	78.5%
No.12	**D**	**D**	74.2%
No.13	**E**	**E**	86.6%
No.14	**F**	**F**	87.8%
No.15	**G**	**G**	83.3%
No.16	**H**	**H**	83.3%

3. Experimental Results of Gait Recognition by CHLAC

We conducted experiments on gait recognition for eight cows. Video images were prepared for each cow walking alone in two situations: on a paved road and on a muddy road. Figure. 1 is a photograph of a cow walking on a paved road (left) and muddy road (right). In total, 16 motion images were prepared for the experiments. The length of each motion images was about 15 seconds. The former half of a motion image is used for learning phase and the latter half used for the gait recognition phase.

CHLAC is a statistical method of motion feature extraction, proposed in [1]. In addition, this method has been successfully applied to human gait recognition [2]. We apply it to cow gait recognition in a manner similar to [2]. First, the methods of frame differencing and binarization are applied to successive frames in the motion images. Next, the CHLAC features (251-dimensional feature vectors) are calculated within a time window running along the time axis of the motion images. The length of the time window, called sample period, is set to 50 frames in this experiment.

In the learning phase, Fisher discriminant analysis is applied to the CHLAC features. The feature vectors associated with each class (cow's ID) tend to form a cluster in the discriminant space. In the recognition phase, the CHLAC features of test motion image are calculated and then the feature within the sample period is classified according to minimum distance to the centers of classes (MDD-rule).

Note that this classification (decision) is performed successively along time axis. For classifying the whole motion image, the decision result at each frame is voted to classes and the test motion image is identified to be the class (cow's ID) obtaining the majority vote. For example, in the recognition of the motion image No.1, the cow **A** and the cow **G** were candidates with 62.7% and 37.3% voting rates, respectively. Because the cow **A** obtained the majority vote, the cow in the motion image No.1 is identified to be the cow **A**. The overall results are shown in Table 1.

Figure 2. Example of estrus behavior: The yellow circle indicates the estrus cow mounting on the other cow.

Table 1 shows the recognition results of 16 motion images. The eight cows have been identified with a 100% accuracy by CHLAC gait recognition.

4. Conclusion

We have introduced the concept of a new cow breeding management system based on CHLAC. The system comprises mainly two components: the gait recognition part and the detection part of estrus behaviors. As to the recognition, the CHLAC-based recognition system has been proposed and the results of the preliminary experiments demonstrated a 100% identification accuracy. The next work is to identify the multiple cows showing up simultaneously. Also, we start the development of the detection part for estrus behaviors (Figure. 2).

References

[1] T. Kobayashi and N. Otsu. Action and simultaneous multiple-person identification using cubic higher-order local auto-correlation. In *International Conference on Pattern Recognition*, pp. 741-744, 2004.

[2] T. Kobayashi and N. Otsu. A three-way auto-correlation based approach to human identification by gait. In *IEEE Workshop on Visual Surveillance*, pp. 185-192, 2006.