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COLOR SPACE CONVERSION TECHNIQUE FOR CATTLE REGION EXTRACTION WITH APPLICATION TO ESTRUS DETECTION

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Abstract. *In modern dairy and beef farming with no exception in Japanese livestock industry, an accurate and timely estrus (heat) detection is an important and key factor in efficient and profitable reproductive management performance of cattle herd. Failure in heat detection is costly to the producer and it is considered the critical component of reproductive management. Among many estrus behaviors, visual postures of an individual cow can be successfully recognized and utilized for heat detection. In this aspect, to achieve precise identification and to obtain individual cattle information, extracting cattle region from its background is the fundamental and important step. In general, the inter-frame difference and the background subtraction are widely known as methods to detect moving objects in video images. However, these conventional methods do not work well in Japanese black cattle environments, due to their slow movements. At the same time, since the skin is similar to soil in color, region extraction is not so easy, even if background subtraction is used. Therefore, in this paper, we propose a new method for extracting cattle regions using color space conversion. The proposed method is able to automatically extract cattle regions and tracked cattle from change of the gravity center of the extracted cattle regions. Experimental results show that our approach is effective and promising with high accuracy.*

Keywords: Japanese black cattle, Cattle region, Monitoring system, 2D color space, ***GC*** (Gravity Center), ***VGP*** (Virtual Grounding Point)

1. **Introduction.** In modern dairy and beef farming with no exception in Japanese livestock industry, there are a lot of challenging problems to deal with due to the increasing number of animals being raised and the aging of farmers. Examples of these problems are the high human workload in the livestock industry and the decline in productivity due to the low breeding rate. Therefore, the development of a cattle monitoring system using ICT (Information and Communication Technology) is progressing in order to improve livestock productivity and reduce the labor required for livestock management. In particular, in terms of productivity, there is a need to improve the reproductive rate [1]. When livestock farmers misidentify estrus in cattle and the calving interval is extended, the economic loss is significant, and if estrus can be detected quickly and accurately, production efficiency can be greatly improved [2]. There have been reports of research

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on estrus detection using various sensors. There are methods for estrus detection using accelerometers and temperature sensors, etc. [3,4], but these methods are not non-contact and non-invasive and cause stress to the cattle [5]. Although some estrus detection systems use video cameras, which are less stressful to cattle, most previous research has used the most obvious behavior during estrus, which is mounting [6-9]. Although the focus here is on region extraction for cattle, the ultimate goal of this study is to construct an entire system that reduces the burden on farmers without causing stress to cattle. For this purpose, it is necessary to comprehensively determine multiple signs of estrus as well as riding behavior.

In this study, we adopt a method using a video camera as a non-contact, non-invasive detection method that does not stress cattle. In addition to not stressing the cattle, the use of video cameras, which are widely available, allows us to construct a cost-effective system. In a cattle monitoring system, cattle region extraction is one of essential tasks. There are two main traditional methods, that is, inter-frame difference and background subtraction. However, these two do not work well in our case, because Japanese black cattle move slowly in general and the skin is similar to soil in color. Here we propose a new method to automatically extract cattle regions and tracking using color space conversion. Previously, we published a paper on cattle tracking using SP [10] and LGC [11-15]. The effectiveness of the new method, which updates Region of Interest (ROI) and Scribbles according to the cattle movement estimated from the center of gravity of the extracted cattle region, was demonstrated by experiments [16]. Although it was necessary to draw ROI and Scribbles manually and specify the cattle region first, new method uses color space transformation, so it can be tracked completely automatically from the region extraction. Experimental results show that our method is more effective than the previously published method.

The rest of this paper is structured as follows. Section 2 presents XY color space concepts and Section 3 introduces the proposed method. Section 4 presents the experimental results and evaluation. Finally, Section 5 concludes the paper and explains the future work.

2. XY Color Space.

The XY space is defined as follows by [17].

$$r = \frac{R}{R+G+B}, \quad g = \frac{G}{R+G+B}, \quad b = \frac{B}{R+G+B} \tag{1}$$

$$\vec{E}_x = \left(\frac{\sqrt{2}}{2}, -\frac{\sqrt{2}}{2}, 0\right) \tag{2}$$

$$\vec{E}_y = \left(-\frac{\sqrt{6}}{6}, -\frac{\sqrt{6}}{6}, \frac{\sqrt{6}}{3}\right) \tag{3}$$

where $\vec{E}_x$ and $\vec{E}_y$ are perpendicular to each other and unit vectors.

$$\vec{E}_x \perp \vec{E}_y, \quad \left|\vec{E}_x\right| = \left|\vec{E}_y\right| = 1 \ (\textit{unit vector}) \tag{4}$$

Each pixel value of an input image is transformed from the RGB space to the point (X, Y) on the XY space as follows.

$$\vec{a} = (r, g, b) - \left(\frac{1}{3}, \frac{1}{3}, \frac{1}{3}\right) \tag{5}$$

$$X = \vec{a} \cdot \vec{E}_x, \quad Y = \vec{a} \cdot \vec{E}_y \tag{6}$$

3. **Proposed Method.** In this section, we describe a method for automatically extracting cattle regions using color space transformation and estimating the 3D position of the cattle in a pasture. Figure 1 shows the overall processing flow diagram of this method. Since processing the actual images as they are taking time, each input image is reduced to an experimentally determined size (512×384) in order to speed up the processing. In this method, the input RGB image is converted to XY color space using color space conversion. After the conversion, the value of each pixel is represented in XY two-dimensional space. Figure 2 shows the result of plotting an actual color image in XY space. Next, the input image is classified into the cattle region and other regions. In the XY color space, the combination of X and Y can be used to roughly dichotomize the color of the cattle and the rest of the image. In this section, we use an empirically determined separation line to classify candidate cattle regions and other regions (Figure 2). Figures 3(a) and 3(b) show the results of the binarization process after extracting the original image and cattle area candidates. Morphology is applied for noise removal. There are two types of morphology processing: dilation and contraction. By using a combination of dilation and contraction processes, noise can be removed. The expansion process and then the contraction process can be used to remove small holes and grooves. This is called closing. On the other hand, if the expansion process is followed by the contraction process, isolated points and protrusions can be removed. This is called opening. Figure 3(c) shows the result of combining the expansion and contraction processes to remove the noise. It can be seen that only the cattle area is extracted. The center of gravity is obtained from the extracted cattle area, and ***VGP*** is estimated. ***VGP*** is the position of the cattle

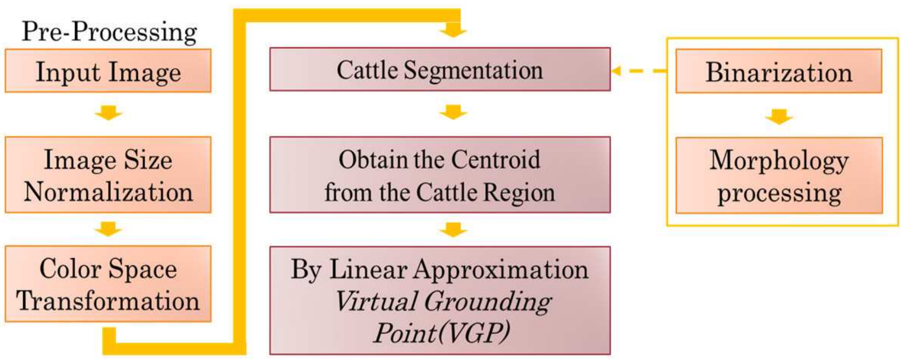

FIGURE 1. Overview of the proposed system

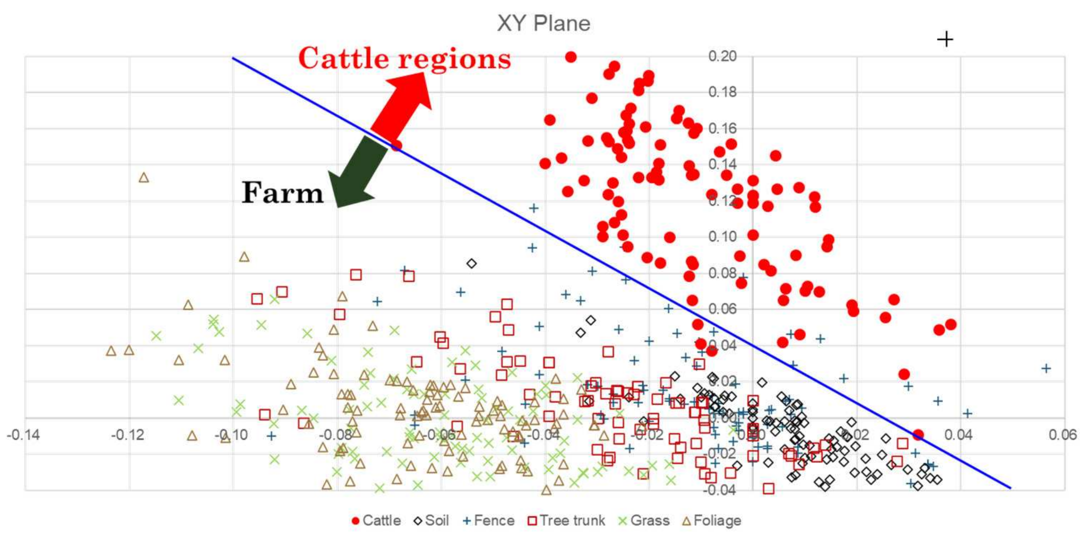

FIGURE 2. XY color space and separation line

(a) Input image (b) Cattle area segmentation using color space conversion (c) Result of morphology processing

Figure 3. Steps of the segmentation of the cattle

on the three-dimensional pasture ground, which is estimated from the centroid by linear approximation, and is one of the essential information for the estrus detection system. By converting the two-dimensional movements on the video image into movements on a three-dimensional plane assuming a pasture, the walking speed and trajectory of the cattle will be closer to the actual movements, and the cattle behavior can be recognized.

4. **Experimental Results.** To verify the effectiveness of the new method, we conducted an experiment using a video taken in the Sumiyoshi Field, University of Miyazaki, Japan. Using the video of cattle running almost linearly, we extracted the cattle area and estimated the $\boldsymbol{VGP}$. Figure 4(a) shows a comparison between the results of extracting the cattle area using color space transformation and estimating $\boldsymbol{VGP}$ and the results of manually extracting the cattle area and estimating $\boldsymbol{VGP}$. Figure 4(b) also shows a comparison of the results of extracting the cattle area using the conventional method [16] and estimating $\boldsymbol{VGP}$ and the results of manually extracting the cattle area and estimating $\boldsymbol{VGP}$. Table 1 summarizes the errors in the coordinates of the $\boldsymbol{VGP}$. Then, the standard deviation of the error margin of $\boldsymbol{VGP}$ has been improved from 9 to 4.3 for the X coordinate and from 5.7 to 3.5 for the Y coordinate.

(a) (b)

Figure 4. Trajectory of $\boldsymbol{VGP}$: (a) Comparison of using the proposed methods and manual; (b) comparison of using the previous methods and manual

Table 1. The error margin using the proposed method and previous method

Error		Max	Min	Average	SD
Proposed method	X	10	−7	−1	**4.3**
	Y	5	−10	−1	**3.5**
Previous method	X	11	−30	0	9
	Y	7	−12	−2	5.7

(pixel)

5. **Conclusions.** In this paper, we proposed a method for extracting cattle regions from ranch images. By using color space transformation, the cattle region can be extracted automatically. We have confirmed the effectiveness of the proposed method in the video of an actual farm. This paper is the development of acquisition method of cattle region, which is one of the essential tasks in a cattle monitoring system. One of the future tasks is to verify the robustness of our method in more scenes and under more difficult conditions.

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