Research on the Method of Individual Identification of Chickens Based on Depth Image

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Abstract. In order to accurately extract the individual images of chickens from the complex background, the experiment took green shell laying hens which scatter-feed as the segmentation target, and proposed a method of individual identification of chickens based on range image, including image background segmentation and chicken overlapping segmentation. First of all, the depth image after background segmentation is obtained by using fixed threshold segmentation method and morphological processing, and then the image with adhesion is separated by using the method of concave point analysis. Through the recognition of 200 depth images, the results showed that the recognition algorithm can effectively separate the adhesive individuals, thereinto, the correct recognition rate for the image without adhesion is 100%, while the recognition accuracy was 93% for images with adhesion. The comprehensive recognition accuracy was 97%.

Keywords. Background segmentation; thresholding; overlapping segmentation; concavity analysis.

1. Introduction

With the continuous improvement of welfare of livestock and poultry breeding, machine vision technology has been widely used in intelligent livestock and poultry breeding. Due to the diversity of the breeding environment and the uncertainty of the behavior and color of the poultry, the accurate extraction of the images of individual chickens from the complex background has become a key step in the application of machine vision technology to monitor the health status of individual chickens [1-2].

At present, there are a variety of background segmentation algorithms, such as segmentation based on chromatic aberration, watershed algorithm, clustering segmentation, etc. [3-5]. To identify livestock and poultry, Bi Minna et al. [6] proposed a segmentation method of multi-color model chickens based on chromatic aberration information. The segmentation of layers and backgrounds was realized by analyzing the color characteristics of layers and backgrounds under different color models. However, the segmentation effect was not ideal due to the influence of different lighting conditions. Van Hertem [7] compared the processing of cow side view by using different segmentation algorithms, and the results showed that the adopted algorithm was less robust to the side view image with dynamic background. According to the research on the separation method of adhesion individuals, Niu Jie et al. [8] achieved an effective segmentation for the images of grains with different adhesion degrees by using the segmentation method of adhesion grain images based on the position and posture information of the adhesion points of the image skeleton. Li Yongwen et al. [9] proposed a pest image segmentation method...
based on form factors and location of segmentation point in order to solve some problems such as adhesion in pest identification. Baek et al. [10] segmented the group of pigs by using the concave point and edge information. The method was tested in a real breeding environment and worked effectively.

Compared with the traditional color image, the depth image is not affected by the external environmental factors such as illumination, so it has been used widely. Mortensen et al. [11] proposed a depth image-based estimation model for broiler body mass, while Lao Fengdan et al. [12] realized the automatic identification of the group behavior of laying hens and the individual behavior in the group by processing deep images. This paper aiming at the problem of individual identification in a complex background. The depth image was obtained after background segmentation by combining the morphological image processing with the segmentation method of setting threshold, then using concave point analysis to separate the adhesive images. This method provides technical support for the continuous monitoring of the health status of individual chickens.

2. Experimental Material

The experiment was carried out in Huixin breeding co., Ltd., Lingqiu county, Datong city, Shanxi Province. A 1m*1.3m*1.5m chicken coop was built in the idle chicken coop, with a feeding trough and a water trough outside to provide feeding and drinking water for the chickens. Chose the 20-week-old green shell layer hens as subjects for the experiment. A kinect2.0 camera was installed 2m above the ground at the center of the chicken coop for shooting. The color resolution of the camera was 1920 pixels x1080 pixels, with 30 frames per second (fps). The depth resolution is 512 pixels x424 pixels, with 30 frames per second (fps), and the measurement range is 0.5-4.5m. Figure 1 shows the digital image and depth image acquired by the camera.

![Figure 1. Image acquisition: (a) digital image. (b) depth image.](image)

3. Experimental Methods

3.1. Background Segmentation of the Crowd Images

3.1.1. Depth Image. Depth image is also known as distance image. The pixel value in the image refers to the distance between each point in the scene and the image acquisition device. It can directly reflect the geometric shape of objects in the shooting scene. Compared with two-dimensional digital images, depth images can obtain three-dimensional information of objects and provide three-dimensional body size features for the behavior recognition and weight estimation of poultry while simultaneously avoiding the influence of uneven illumination. For the Green-eggshell Chickens, the experiment objects, their feathers are earthen yellow and similar to the color of feed. It is difficult to separate the head of the layer from the two-dimensional digital images when they are eating. But it is possible to extract the complete segmentation images of chickens according to the information of depth images.

3.1.2. Background Segmentation. The ROI region was extracted and the depth image obtained in the experiment was analyzed. The original size of the depth image was 512 pixels*424 pixels. Those chickens which lived in neighboring cages within the camera coverage might have interference in the experiment. The ROI region could be set to avoid the interference of the barbed wire and the adjacent
chicken coop, reduce the computing amount of image operation and save the operation time. The ROI region extraction is shown in figure 2.

![Figure 2. The extraction of ROI region: (a) actual image; (b) ROI region labelling.](image)

The threshold segmentation is carried out by using the pixel difference between the layer region and the background region in the depth image. It has the best segmentation effect when the threshold value is determined to be 0.19, as shown in figure 3b.

Use morphological filtering. The morphological operation of image has the functions of eliminating image noise, segmentation of independent image elements and connection of adjacent elements. As can be seen from figure 3b, the ground manure leakage network and the edge of the feed trough were wrongly divided into chicken bodies after threshold segmentation. The relatively thin wire mesh in the image was filtered through morphological open operation, and the processing results were shown in figure 3c.

Remove the limited area. Figure 3c obviously shows that a small number of false targets still exist in the image, which can be solved by removing small areas. First of all, photoshop was used to determine the minimum area of a single individual. When the area of a connected area in the image is less than the minimum area, the pixel of the connected area is set to 0. It is shown in figure 3d after removing the limited area.

![Figure 3. The processes of background segmentation. (a) ROI region. (b) Threshold segmentation. (c) Morphological filtering. (d) Remove the limited area.](image)

The coordinates with pixel 0 are extracted after the segmented binary image is obtained, and the corresponding coordinate pixels in the depth image are set to 0, so that the depth image with background segmentation can be obtained. The result is shown in figure 4.

![Figure 4. The background segmentation of depth image.](image)
3.2. The Separation of Adherent Individuals of Chickens

The morphology of laying hens is variable, which would probably produce multiple minimum values, thus it is not suitable to use the morphological watershed method in this paper. Through the analysis of the binocular figure of the conglutinating chickens, the bodies of the conglutinating chickens are oval and the contour of the conglutinating chickens is concave. Therefore, the bodies of conglutinating chicken are separated by using the concave point analysis method. The specific steps of overlapping segmentation are as follows.

Step 1. Identify the adhesions. By using photoshop to determine the maximum area of a single individual, we could calculate the area of the connected area in the binary image. If the area was larger than the maximum area of an individual layer, the adhesive chicken bodies were determined in this area.

Step 2. Detect convex hull and convex defect. Convex hull is a convex polygon formed by the outermost point of the connection area in the image. The difference set between the convex hull and the contour of the connection area is convex defect. Based on the analysis of convex defect, the concave point can be determined according to the vertical distance between the pixel point of convex defect contour and the convex hull, that is, the point with the largest distance is the concave point.

Step 3. Match concave point. Connect the two nearest concave points to complete the adhesion separation, and repeat the above steps until there is no conglutinate area in the image. The separation process is shown in figure 5.

Figure 5. The segmentation of conglutinations: (a) binary Image; (b) convex hull; (c) overlapping segmentation.

4. Experimental Result and Discussion

In order to quantify the segmentation effect, the segmentation accuracy is defined as:

\[ S = \frac{A_1}{A_0} \times 100\% \]

\( A_1 \) is the area where it is extracted for individual recognition, and \( A_0 \) is the real area of the target. The target real image area was obtained by using Photoshop.

200 images were randomly selected from the images obtained in the experiment and processed using the individual identification algorithm proposed in this paper. The results are shown in table 1. As for 114 images without adhesion, the recognition accuracy is 100%. As for 86 adhesive images, the correct recognition rate was 93%, among which 6 adhesive images were over-segmented. Because when laying hens pecked feathers or spread wings, they would not be identified as single individuals but as adhesive individuals, resulting in excessive segmentation, as shown in figure 6. The accuracy of the method is 97%.

| The number of images (picture) | The number of images with adhesion | The number of images without adhesion |
|-------------------------------|----------------------------------|-------------------------------------|
| The total number of images     | 200                              | 86                                  |
| Correct identification         | 194                              | 80                                  |
| Correct recognition rate %     | 97                               | 93                                  |

Table 1. The verification of the method of separation of adhesions.
Figure 6. The example of inaccurate segmentation: (a) binary image. (b) over-segmentation image.

5. Conclusion
The identification of individual layers is the key step in the detection of laying hens physiological health. This paper proposes a method to identify individuals from chicken flocks which based on depth image. Combing a fixed threshold segmentation method with morphology processing to extract the target. The conglutination chickens were separated by means of concave point analysis. The experimental results show that the recognition accuracy of non-adhesion is 100%. As for the adhesion, the recognition accuracy was 93%. The comprehensive recognition accuracy was 97%.

In this paper, the method is based on a convex defect corresponding to a concave point when the concave point is detected, so It still needs further study on the situation of individuals of multiple adhesion and a convex defect corresponding to multiple concave points.

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