

Segmentation of Group-Housed Pigs using Concave Points and Edge Information

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Abstract— Monitoring behaviour of weaning pigs with weak immune systems is important to reduce huge losses in pig farms. Even though various researches have been reported for monitoring environment of pig farms, segmenting each pig from touching-pigs is still entrenched as a difficult problem. In this paper, we propose a segmentation method for touching-pigs by using concave points and edge information in a video surveillance system. Especially, we interpret the segmentation problem as a time-series analysis problem in order to identify the concave points generated by touching-pigs. Based on the experimental results with the videos obtained from a domestic pig farm, we confirmed that the proposed method could accurately segment the touching-pigs.

Keywords— Livestock Monitoring, Video Surveillance System, Objects Segmentation, Time-series Analysis

I. INTRODUCTION

Pigsties in Korea are very vulnerable to epidemics such as foot-and-mouth diseases because caring for individual pigs by a few farm workers in a large-scale pig farm is almost impossible. Especially, caring for weaning pigs (21 or 28 days old) is the most important issue in pig management because of their weak immunity. However, caring for weaning pigs is difficult in Korean pig farms since an administrator has to manage about 2,000 pigs.

One of the solutions for the problem is using a convergence technology such as the computer and electronics in agriculture, which has been recently researched [1,2]. In this paper, we propose a method that segments individual pigs using a video sensor for individual pig caring.

Recently, a research for effectively managing weaning pigs has been reported [3]. However, the research has some limitations as it can only observe the movements of pigs as a group and cannot observe the movement of each individual pig. In this case, adjacent pigs, denoted as “touching-pigs”, are considered as one pig due to their similar color, and it is hard to track for the movement of individual pigs [4,5]. Therefore, we need to separate the touching-pigs to monitor each individual pig.

As a solution to the segment problem, some researches have been reported by marking different colors or drawing different symbols on the back of each pig [6,7]. However, these methods may not be applied to Korean pigsties because marking and managing 2,000 pigs are difficult for an administrator. Furthermore, a study for tracking three pigs

without any marking has been conducted [8]. However, the method had difficulties in separating touching-pigs. Thus, it is very difficult to achieve individual pig separation with conventional methods in Korean pigsties where 20 pigs should be monitored. Fig. 1 shows touching-pigs in a pig farm.

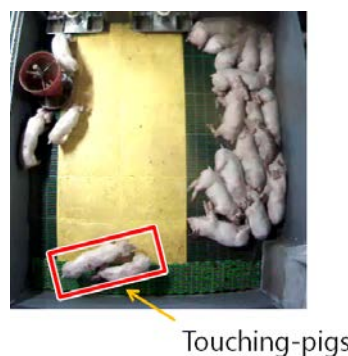


Figure 1. Illustration of “touching-pigs”

Recently, a study [9] of segmentation method using the continuous frame information has been reported in order to solve the touching-pigs problem. Similarly, we could apply the watershed [10,11] which is one of the most widely used tools in image segmentation. However, these methods do not ensure acceptable accuracy for some touching-pigs patterns. Therefore, we propose the following method in this paper. We first convert video data into time-series data, and then find concave points and edge information. Finally, we separate touching-pigs with these two data.

This paper is organized as follows. Section 2 describes the proposed method. Section 3 explains the experimental results. Finally, Section 4 has the conclusion.

II. PROPOSED METHOD

In this paper, we assume that we already obtain touching-pigs image by using method of [9]. It uses Gaussian Mixture Model (GMM) [12,13] to segment between background and foreground in the image for extracting the region of moving pigs. Before applying GMM, we down-sample the image because GMM takes too much time to extract moving regions with the original resolution.

The proposed method extracts the final boundaries of the touching-pigs by using the concave point generated from time-series data and by using edge information.

A. Detection of Concave Points

The foreground image extracted by GMM includes many noises. Thus, the opening operation [14] needs to be applied first to remove the possible noise.

For finding concave points, we generate time-series data from the outline of pigs. When the time-series data are generated, each pixel is checked from the outline with an anti-clockwise search. Then, we extract two near points from the outline sequence. These near points are selected by using the same interval from the checked pixel. Then, we draw a triangle with these three points, and calculate the area of this triangle. That is, the triangle area from each outline pixel is generated as a value of the time-series data.

Fig. 2 shows time-series data representing the area of each triangle. Note that, a boundary sequence value has a positive number if the triangle is located above the foreground (i.e., pig) area. Otherwise (i.e., the triangle is located above the background area, and thus the outline pixel is one of points in a concave region as shown in Fig. 2), the boundary sequence value has a negative number.

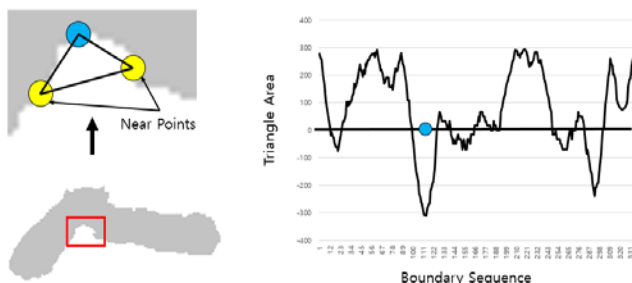


Figure 2. Example of time-series data with concave point and near points

In a concave region, we extract one point that has a minimum value. We denote this point as a “concave point”. Then, we find an opposite point that is apart from the concave point by the half of the outline’s length. By using the concave and opposite points, we can set a search area for edge detection. That is, the search area is set as a minimum rectangle that includes the concave and opposite points. Fig. 3 illustrates a search area, a concave point, and an opposite point.

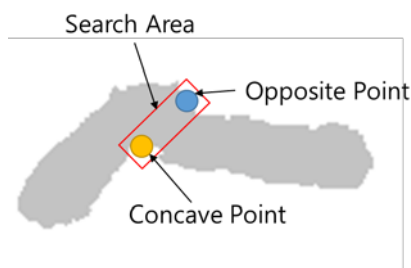


Figure 3. Example of a search area and two points

B. Detection of Edge

By extracting edge information in the search area, we can finally identify individual pigs. In order to extract the edge information, we generate a gray image for foreground. That is, the gray image is generated by merging the original color image and the binary image which is extracted by GMM. We obtain the edge information with Canny operator [14] using the gray image. The Canny operator finds a better edge than other operators such as Laplace or Sobel. Hough transform for the final boundary extracts a straight line in the image information, and the straight line is determined as the final boundaries between the touching-pigs.

III. EXPERIMENTAL RESULTS

A. Experimental Environment

For this experiment, the camera mounted on a height of about 3m in a pig farm located in Sejong City collected the activities of the 20 pigs with 960×540 RGB video resolution and 30 frames per second. The experiments were conducted with Intel i5-4690 processor 3.5GHz and 8GB RAM. In this paper, we assumed that pigs were correctly extracted by GMM. Our goal was to segment the touching-pigs for the images obtained from the camera.

B. Results of Proposed Method

Some noises were removed by performing an opening operation before applying edge detection. After noises were removed from the binary image, we extracted the 2D outline data of the pigs. We traced the outline of pigs with anti-clockwise direction. For all the outline pixels, we found the near points with the same interval which was set to 10% of the total outline pixels. Then, we drew a triangle using these three points and made time-series data of the area. A concave point was detected by using the time-series data. The concave point and the opposite point were extracted to set a search area. In the search area, touching-pigs' boundary was finally determined by applying edge detection and Hough transform. From the experimental results, the accuracy of watershed method [10,11] was 52.43%, while the accuracy of the proposed method was 93.67%. Fig. 4 shows the segmentation results of two methods.

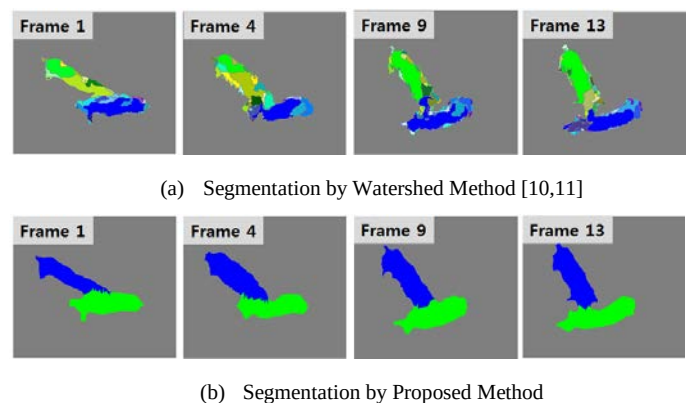


Figure 4. Comparison of watershed and proposed methods

IV. CONCLUSIONS

In this paper, we proposed a method for segmenting touching-pigs in a video surveillance system. Experimental videos with 20 pigs were obtained from a crowded room environment. GMM first extracted the touching-pigs image. Then, the touching-pigs image having two-dimensional "outline" data without additional marker for individual pig was converted into one-dimensional time-series data. Finally, concave points were detected from the time-series data, and the detected concave points and edge information were used to separate touching-pigs. Based on the experimental results, the proposed method can provide better performance than conventional separation methods such as watershed.

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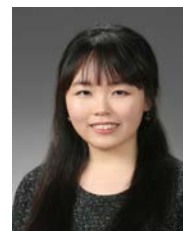
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