Automatic Object Segmentation for Understanding Animal Behavior

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Abstract

The analysis of animal behavior in a group-housed environment is important for minimizing the damage caused by infectious disease. In this study, we propose an automatic segmentation method for group-housed pigs to facilitate the analysis of pig behavior. In particular, we interpret the touching pig segmentation problem in a crowded environment as an alignment problem of the individually identified pigs in the previous frame into the touching pig group in the current frame. According to experimental results with the video data obtained from a Korean pig farm, we believe that our method can be applied to separate touching pigs effectively, and thereby analyzing pig behavior automatically.

Keywords- Livestock Management, Behavior Analysis, Object Segmentation

I. Introduction

Early detection of anomalies is an important issue in the management of group-housed livestock. In particular, the damage caused by the recent outbreak of livestock diseases in Korea such as foot-and-mouth disease was serious. In order to minimize the damage incurred from such diseases, it is necessary to develop the technology for analyzing livestock behavior data automatically. Although some progress in monitoring livestock has been made recently [1], practical issues in implementing an automated behavior monitoring system with a video sensor have not yet been reported. Especially, for monitoring behavior of an individual animal within a group, we need to segment each individual animal automatically.

In this paper, we propose an automatic segmentation method for group-housed pigs in a crowded room. Manual monitoring of individual pigs by farm workers in a large-scale pig farm is almost impossible. For example, a pig farm where we obtained the video monitoring data has more than 20,000 pigs and 1,000 pig rooms. Caring these pigs with 10 farm workers is almost impossible, and an automated analysis of the behavior of an individual pig is required. However, pigs tend to flock together, and it is very difficult in separating individual pigs in a crowded pig room.

We assume the monitored pigs stay in a closed room for a prolonged period of time. Since the separated pigs can be segmented accurately by known techniques, we focus on the touching pigs only. In fact, identifying individual pigs in a crowded room is a difficult task even for a human observer because many rapid movements of pigs may be occurred simultaneously. To solve the pig segmentation problem, we exploit the fact that pigs can move in close proximity but they move away from each other soon by carefully checking the video recorded. Thus, we can assume each pig in a previous video frame is identified individually, and we use this information in separating the touching pigs in a current video frame.

To the best of our knowledge, this is the first report of interpreting the touching pig segmentation problem in a closed room as an alignment problem of the individually identified pigs in the previous frame into the touching pig group in the current frame. Especially, we align each pig in the previous frame independently since pigs are known to be complex, individually different and time-variant [1]. Based on the experimental results, the proposed method can separate touching pigs more accurately than the widely used watershed method [2-3] by a factor of two for some video frames.

II. Alignment of Touching Pigs

The scene in a pig room may contain a complex background and various levels of illumination. In order to extract the pig-related information in a robust manner, we first convert the input RGB values into HSV values and perform binarization to exclude shadows from possible objects. Then, the proposed method determines moving pigs using GMM. If the area of a detected moving pig is larger than a single pig area, we should separate touching pigs from the group.

The main idea of the proposed method is to align the individually identified pigs in a previous frame into the touching pig group in a current frame, thereby facilitating the final goal of segmenting and tracking individual pigs in a seamless manner. By carefully checking the video recorded, we exploit the fact that pigs can move in close proximity but they move away from each other soon. Since we monitor a closed room for a prolonged time, each separated pig can be identified with known segmentation techniques. That is, we can assume each pig in a previous video frame is identified individually, and we use this information in separating the touching pigs in a current video frame.

As shown in Fig. 1, we align the individually identified pigs in the previous frame into the touching pig group in the current frame. For most of the video sequences having touching pigs,
the proposed alignment method can provide accurate segmentation performance. When the pig motions in a group are rapid and have different directions (as shown in Fig. 1), however, we need to consider the local motion of each pig in the group.

As shown in Fig. 2(a), we align each pig in the group sequentially based on the maximum overlap between each pig in the previous frame and the touching pig group in the current frame. Compared to the alignment without local motion consideration (See Fig. 2(b)), the individual alignment with local motion consideration can provide a superior performance. Note that, in both alignments, the remaining white area can be filled with a suitable color by applying a heuristic region growing technique.

III. Experimental Results

In our experiments, we set the resolution size to 640 × 480 pixels and the frame rate to 8 frames/second. The camera was located 4 m above the floor to monitor a pig room that measured 4 × 3 m, and there were 22 weaning pigs in the room. For comparison, we used a typical segmentation method based on the watershed method implemented with the open-source software OpenCV [4] in addition to the proposed method. The watershed-based segmentation method is widely used in separating objects that are touching such as [2].

In general, the typical watershed method was effective, but it was not always accurate in separating touching pigs. It is well known that the watershed-based segmentation method has the problem of over-segmentation [3] as shown in Fig. 3(a). The over-segmentation problem can be mitigated by applying various “complicated” region-merging techniques. With any region-merging technique, however, some case cannot be separated into two pigs properly. This is because the final segmentation after region-merging can be correct (i.e., there will be one boundary per actual pig) if and only if the initial segmentation from the watershed-based segmentation method includes the correct boundary.

On the contrary, we align the “individually identified” pigs in a previous frame into the touching pig group in a current frame, thereby separating the touching pigs successfully. When the pig motions in a group are rapid and have different directions, considering the local motion of each pig in the group individually can provide a superior performance than the alignment without local motion consideration. Compared to the alignment without local motion consideration (See Fig. 1), the quality of the alignment with local motion consideration (See Fig. 3(b)) is sufficient to track individual pigs seamlessly.

In order to evaluate the proposed method quantitatively, we compared the segmentation results obtained by the proposed method for the touching pigs with the ground truth. It should be noted that the pixel-level segmentation accuracy was a quantitative accuracy, so the results could not be perfect, but the qualitative accuracy of the proposed method was sufficiently high to track touching pigs in a seamless manner. Table 1 compares the segmentation accuracy of the typical segmentation method implemented in the open-source software OpenCV [4] with that obtained by the proposed method for the complicated touching pattern.

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<th>Table I</th>
<th>Segmentation accuracy with various methods</th>
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<td>Watershed</td>
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<td>Without Local Motion Consideration</td>
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<td>3-frame</td>
<td>42.80%</td>
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IV. Conclusion

Automated detection of abnormal behaviors in livestock is an important issue in livestock management. We proposed an automated segmentation method for identifying the movements of each pig accurately using visual information acquired from a camera installed in the pig’s house. Especially, this research focused on the touching pig segmentation and interpreted it as an alignment problem of the individually identified pigs in a previous frame into the touching pig group in a current frame, after carefully analyzing the video recorded. From the experiments, the proposed method could provide a segmentation accuracy of 94.53% whereas the widely used watershed method provided a segmentation accuracy of 42.80%.
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References


