A Study for Identification and Behavioral Tracking of Honeybees in the Observation Hive Using Vector Quantization Method

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Introduction

It has been taken an interest in colony and social behavior of animals in behavioral biology. Social insects, such as ant, bee and so on, have been studied as model systems for revealing functions and mechanisms of a crop of animals. It is widely known in the world that the honeybee has a kind of sociality since von Frisch et al. discovered the waggle dance [1].

In order to study the sociality of social insect, the researchers principally have to work hand-to-hand tracking individual behaviors in the experiments that Seeley et al. has done [2]. However, we can record honeybee behaviors in the observation hive by using COTS video as massive contents recently. As alternated, it is needed to take thousands of man-hours for analyzing vast amounts of records [3]. For an example, tracking of animal behavior is one of important but painful work for researcher. It must be very effective to provide a behavioral tracking support system not only individual but also social animals.

In this study, we proposed a new method for identification of individual honeybees and tracking their behaviors simultaneously for analyzing interactions among them. It has been developed a prototype system which is configured with four processes; 1) Separation of object and background by vector quantization, 2) Classification of candidate region of honeybee bodies, 3) Identification to honeybees and 4) Tracking honeybee behaviors. It was applied to the vide image data for a frame of observation hive. It was shown that 73% of individual (more than 500) in each video image are detected and tracked by our system.

Methods

There are several important and difficult points for automatically detection and tracking animal behavior from movie data. In our proposed method, process of behavioral tracking is consists of these four parts;

Separation of object and background by vector quantization

Classification to candidate regions of honeybee bodies

Identification to honeybees

Tracking of honeybee behaviors

Vector quantization method has been applied for various fields, image compression, signal processing, machine learning and so on [4]. It can be approximated each training vector by predetermined code vectors. We applied it for classification of objects, honeybee, nest and other things. In our preliminary analysis, it is shown that objects in the original image were classified into eight categories, and one of these is corresponded with the candidate of honeybee bodies. Therefore, it is possible to extract honeybee body regions by quantized the vector.

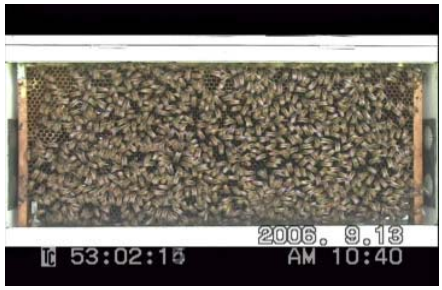

Figure 1a. Original Image

Figure 1b. Original Image

Figure 2a. Individual bee regions

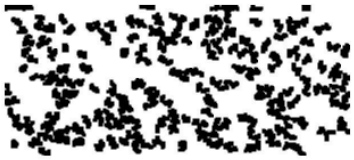

Figure 2b. Regions include plural honeybees

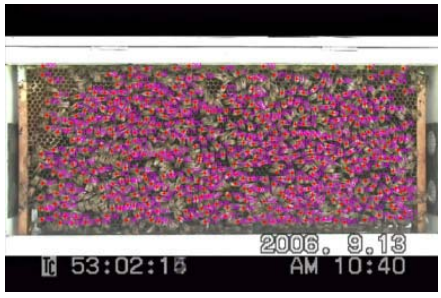

Figure 3. Identified honeybee

Behaviors of honeybees in the observation hive are recorded by handy camcorder as shown in Fig. 1 (a). As the result of first process, the candidates of honeybee bodies are detected as shown in Fig. 1(b). In the next step, each region is categorized by number of honeybee consist in it. After the twice application of image shrinking, object images are classifies into two kinds of region, based on their size. Fig. 2(a) and (b) show the results of classification in the single or plural honeybee body images.

Individual honeybee was identified and labeled based on decomposition of complex honeybee region images in the next step. In order to detect individual honeybee, an ID number is assigned on each honeybee extracted by the sequence of image processing. Video image is a time series data, so we indentified same honeybee in consideration of consistency of position. As the result of numbering, position of each honeybee on the frame of hive is calculated. In Fig.3, it is shown the result of numbered honeybee. In the last step, the frame by frame behavioral tracking is done by converting position of honeybee which has same ID number into time series data.

Results

We developed a prototype system using our proposed method (Fig. 4). As the result of application of our system to 387 images (30 frames per second), which are separated from the 10 minutes' video movie, it was extracted more than 73 % of individual honeybees (510 of 704, 522 of 718, 516 of 700). However, it was seen several failures in detection and identification.The major failures are mistakes of detection of honeybee images. The lost of object tend to lower the tracking precision. In our system, movie data separated into units consist of 50 images, then, trajectories of individual are tracked in each unit. By this treatment, behavioral traces of more than 400 honeybees obtained from movie.

Remarks

In this paper, we proposed a method to extract individual honeybees and track their movements. The system can extract

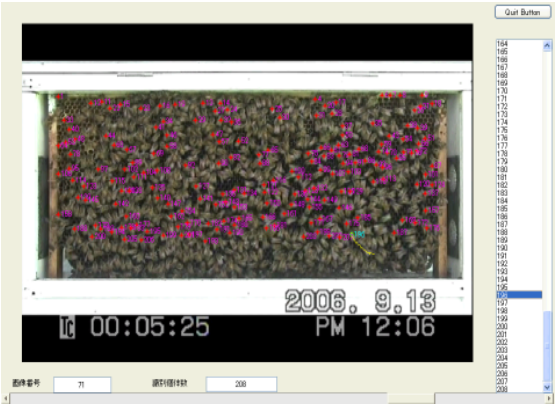

Figure 4. Prototype system

more than 73% of worker honeybees in the hive. The prototype also show that it is possible to track the movement about a part of extracted bees, about 400 bees (about half of entire hive) in every 50 images. As a future work, we will develop a system that can track overlapped honeybees by analyzing behavioral causality. It could be are useful tools for behavioral analysis in order to revealing biological mechanisms of super-organized animals.

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