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# Caged mice mating behavior detection in surveillance videos

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ABSTRACT

The purpose of this study is to develop a computer vision-based method to automatically detect the mating behavior of caged mice in surveillance videos. Previously we took advantage of our developed algorithm and analyzed the objects of mating mice in the consecutive frames, we unprecedentedly showed that, to the best of our knowledge, the mice mating behavior can be automatically detected based on video processing (Lo et al., 2009 [13]). In this paper, we proposed an improved method which monitors the distance between two mating objects and more effectively detects the mating behavior. In addition, a more detailed portrayal of the mating behavior can be further elaborated as a function of the distance patterns in the tails of two caged mice. Experimental results show that the current system can effectively detect the mice mating behavior with the highest precision rate of 96.1%, far better than that of our previously proposed method.



## 1. Introduction

Objective measurement of physical activities and behaviors of experimental animals and the wildlife is an important task in biological research. It would inevitably consume a great deal of time and manpower if it has been done through constant visual observation. With the help of video surveillance techniques, unusual animal activities or behaviors can be easily monitored [1–3]. Among the most studied model animals worldwide, murines have been intensively used to display behavioral and physiological disorders in various medical researches [14–19]. Ishii et al. [14–16] monitored mice activities using high-speed cameras and focused their studies on scratching behaviors under the influence of medication using the frame-to-frame differences of leg movements. To evaluate an objective motion, they developed algorithms to perform automatic quantification of leg movements, enabling them to assess the seriousness of dermatitis and the efficacy of new antipruritic drugs in laboratory animals. They also developed an autonomous experimental setup to measure rats' position, number of grooming and rearing in the open-field [17]. In another study [18], Jhuang et al. built a computer vision system to analyze complex behaviors in mice. They tracked and analyzed the mouse behaviors by using the CCD camera with a normal lens and image processing software. Thus human errors and subjectivity due to heavy tasks from experiments can be largely reduced.

The above literatures involve analyzing activities for a single mouse. However, there is no work on detecting the mice mating behavior, which can happen between a pair (one male and one female) of mice. The term mating behavior can be defined as the overall status of intromission episodes during breeding. When breeders are housed as pairs of one male and one female, the male mouse tends to chase the female around in the cage. The male sometimes exhibits typical social interactions with the female, as indicated by licking or grooming of the female, but no signs of intromission. At times they remain sedate and the male mounts to mate. Frequency and duration of intromission episodes determine the pregnancy rate of a female mouse. At the same time, the number of mounts through frequent occurrences of intromission episodes symbolizes the mating capability of a male mouse. Video-monitored mating behavior helps researcher get an idea of the mice mating conditions in relation to a drug treatment or not.

In our previous study, we proposed, to the best of our knowledge, the first detection model of mice mating behaviors based on the analyses of video frames [13]. Briefly, the mouse movement in a cage was detected by the background subtraction method. When two mice had a mutual contact, the corresponding contour can be extracted by the edge detection method, by which the distances between the centroid and the edge pixels of contour were determined as a waveform signal. After further sub-sampling and smoothing the waveform, two decision criteria emerged: (1) the total number of peaks and troughs, and (2) the angle between the two lines connecting the adjacent peak-edges and the centroid

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of the contour. By using these two criteria, we successfully detected mice mating actions in the recorded video [13].

In this paper, a more superior method is proposed to further improve the detection accuracy of the mice mating behavior than that shown in our previous study [13]. The basic preprocessing, object extraction, and contour detection stages in the previous and the current methods are fundamentally similar. Instead of purely utilizing the shape feature of two contacted mice, the tail distance between two mice is determined and used as the first criterion in detecting the mating action. If the tail distance is within a reasonable range, the aspect ratio (AR) of a rectangle that just covers the extracted single object is measured. The mating behavior is confirmed when the AR has been within a given range for a given time duration.

This paper is organized as follows: Section 2 describes backgrounds and preliminaries of the proposed method. Section 3 deals with the detection scheme of mice mating behavior. Finally, experimental results and conclusions are presented in Sections 4 and 5, respectively.

## 2. Backgrounds

Many efficient methods used to detect a moving object and analyze its behavior have been proposed. Each part of the whole framework has also been investigated extensively. Practical applications in this regard include traffic flow monitoring, pedestrian movement analysis, animal behavior detection, and so on. Methods for moving object detection basically can be divided into two main categories: (1) temporally differencing [4]: the current image is subtracted by the previous image in the time domain. Despite the fact that it's difficult to obtain the complete contour and features of the moving object, this method is not easily influenced by light variations. (2) Static background subtraction [5]: this method uses the background image constructed from the previous images. The current image is subtracted by the background image. The net difference is used to consider its movement. Due to the low computation load, this method is easy to perform; however, its outcome can sometimes be falsely influenced by noise.

In certain circumstances, a surveillance system is better off with the static background subtraction method than with the temporal difference method. Several types of background construction methods have been proposed up to now. For example, Hsu et al. utilized the block-based background extraction (BBE) method to construct the background image [6]. On the other hand, Pan's group used the statistics method to construct the background image and applied double-background to update and reconstruct the background image [7]. A background registration technique was used to construct a reliable background image from the accumulated frame differences [8].

Tracking techniques, for example, the model-based tracking of experimental animals, have been an important and hot research topic [9]. Tracking laboratory animals can be achieved based on the optical flow and active contours [10]. The algorithm applied to detect lion faces was based on Haar-like features and AdaBoost classifiers, and the Kanade–Lucas–Tomasi method was further implemented into the tracking strategies [11].

In this paper, the BBE method is used for background image reconstruction. The detailed procedures can be found in Ref. [6]. The background and foreground images have to be processed into their binary versions in the proposed method before they can be used for the object extraction. Fig. 1 shows the block diagram in the pre-processing flow. The description for each block can be found in our previous work [13]. Consider that the mouse size is very different from the normal one when the mice are all rolling themselves up or stand up during the foreground object extraction.

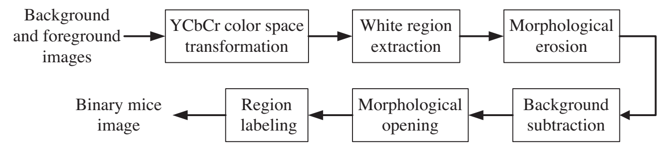


**Fig. 1.** Block diagram of pre-processing for mouse object extraction.

The mouse size was measured under manual supervision before the mating behavior detection. Therefore, the normal mouse size can be obtained and used in the proposed method. In the next section, the mouse tails are also extracted because they can provide useful information. The distance between two tails will be measured and used as an important feature for mating behavior analysis.

## 3. Mating behavior detection

According to the number of detected moving objects, further processing was utilized. If the number of objects was measured as two, the two mice were separated and not in a mating status. If the object number was measured as one, the two mice were considered joining together and could be possibly in a mating status [13]. Fig. 2 shows the system flowchart of the proposed method for mice mating detection. There are six criteria used in the proposed method. The sequential order of these criteria depends on how effectively it can filter out the impossible cases in the proposed method. For example, the object number and tail distance are obvious and useful criteria and thus are used as the first and second criteria, which can significantly reduce the computation amount in the following steps. The detailed steps followed by the object detection are described in the following subsections.

### 3.1. Tail detection and object area determination

As suggested in our previous study [13], the mice in mating will have their two tails close to each other. Two mice in close contact are considered impossible in a mating status if their tails are located in opposite directions or are separated by some distance. However, this significant postulation was not taken into

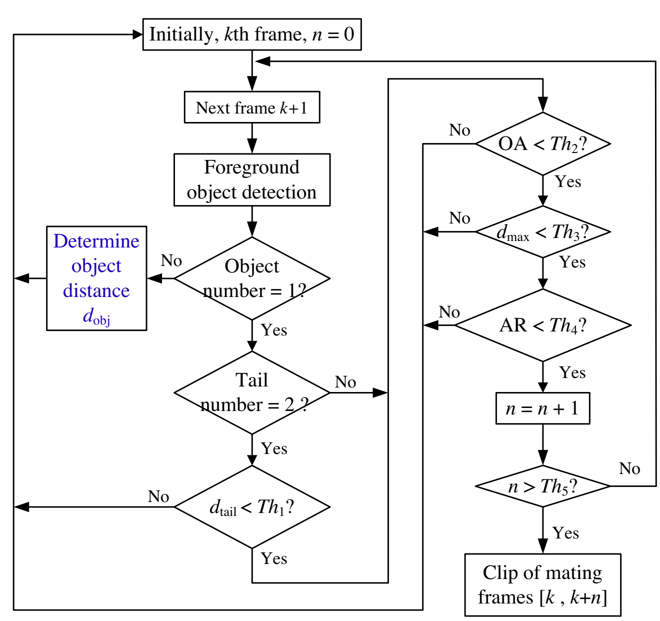


**Fig. 2.** The system flowchart of the proposed method.