Honeybee video-tracking for explosive detection

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Abstract:

The utilization of honeybees for automatic explosive detection has been tested during the last few decades. Many biological and technical aspects have been considered, in order to understand all the possibilities for honeybee utilization for explosive detection. The scope of this research is an overview of the honey bees tracking capabilities during the video surveillance of areas potentially contaminated with land mines. The analysis of tracking results may guide to the conclusion of explosive existence which do not include human survey of the examined area. In this paper we present an approach for detection and tracking of honeybees, which enables obtaining a spatio-temporal histogram of honeybees occurrence, and eventually to conclude if there is explosive or not in the area under surveillance.

1. Introduction

Worldwide, countries that have been involved in war confrontations usually have major problem with remaining minefields, even several decades after the war. Demining methods involving humans are time consuming and dangerous, with possible fatal outcomes. Also, the methods of this kind are usually very expensive.

In the past few decades, many research and development projects have been realized in order to determine the possibilities of using honeybees in the detection of explosives, landmines and other unexploded ordnance. Honeybees are known to have excellent sense of smell, which they use to look for food. Training honeybees to smell the explosive, enables us to actively use them to search for landmines. Trained honeybees are expected to hover over landmines and explosives. Therefore, honeybees can be used for inspection of areas potentially contaminated with land mines. Using honeybees for explosive detection is safer and cheaper compared to methods involving humans.

Bee4Exp is project, supported by NATO Science for Peace and Security Programme, which investigates methods for the detection of explosive devices using honeybees trained to smell explosive. One of the goals of Bee4Exp project is to utilize the novel methods for honeybee tracking over the examined area. In this research we try to determine the exact parameters that should be used for video monitoring in order to reliably and accurately track honeybees during the inspection of areas potentially contaminated with land mines.

2. Related work

Possibilities for usage of honeybees for detection of explosives have been widely investi-

gated lately. In several programs of US Defense and Advance Research Projects Agency (DARPA), honeybees were tested for possibilities of chemical signature transport in order to detect explosives and other agents of harm [1, 2, 3].

Important research on honeybees training for explosive detection was done during several research projects. The overall goal of these projects was to determine the methods for bee training and tracing. The method proposed in Tiramisu project included the application of principal component analysis to a sequence of video frames in order to track honeybees [4, 5]. Also, interesting details on possibilities of usage of honeybees in explosive detection is given in [6, 7, 8]. Despite intensive research in previous years, several important questions are left open. How to efficiently capture high quality video during the honeybees' fly over the observed area and how to accurately detect small objects (honeybees) in high resolution videos?

3. Methods for honeybee video-tracking

In this phase of the Bee4Exp project, we implemented a computer vision algorithm for moving object detection and tracking in several video sequences containing flying honeybees. The algorithm includes: video stabilization, optional frame preprocessing, moving object detection and optional postprocessing. In Fig. 1, block diagram of the proposed method is given.

Video stabilization is done by estimating geometric transformation between different video frames, thus it is a crucial step which enables efficient segmentation of moving objects and background. In essence, video stabilization transforms every video frame into the same coordinate system, so moving objects are more likely to be separated from the background.

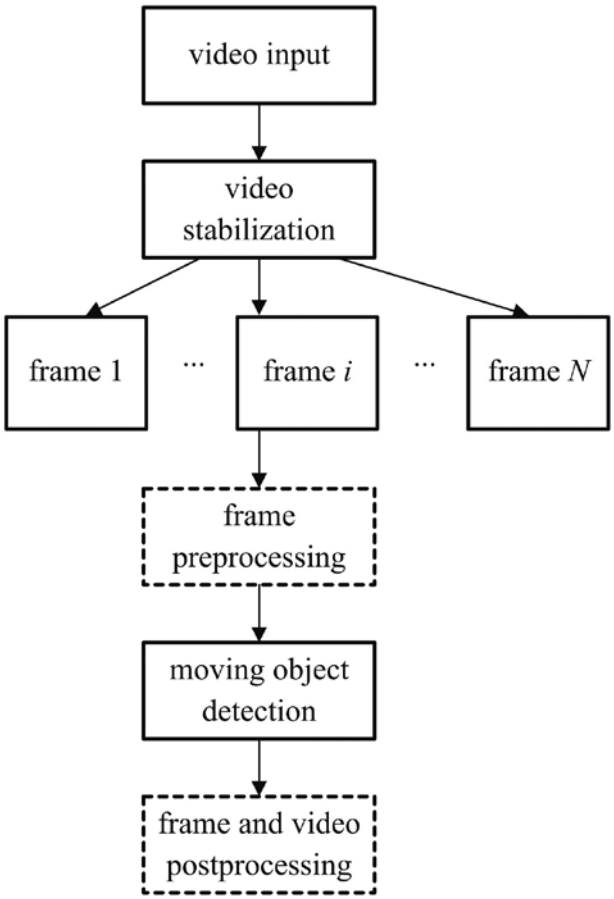

Figure 1. Block diagram of the proposed method for honeybee video-tracking.

Frame preprocessing may include different processing steps in order to enhance moving objects of interest and/or to remove the effect of non-ideal video stabilization. For example, in this research we experimented with calculating difference between the current and previous frame. This difference should emphasize object with large movements between two frames and reduce the background.

Moving object detection includes algorithms for background/foreground separation in the sense that foreground represents moving objects, honeybees in our case. In this research, we used mixture of Gaussians for foreground detection.

Postprocessing may be included to additionally filter the detection results, model honeybee traces, visualize multiple bee traces or to make spatio-temporal histogram of honeybee's activity over inspected area.

4. Used Videos and Results

In order to test the proposed approach, we used videos captured on different locations and with different cameras parameters. For initial experiments we used short videos obtained during the initial phase of Bee4Exp project. Those videos mostly show individual honeybees in full HD video with 30 fps, taken from about one-meter distance. Next, we experimented with various videos with lower resolution and framerate, captured with mobile devices and few meter distance.

After visual analysis of videos, we could notice the following: (1) Individual bees are hard to detect in a single frame, multiple frames should be used for motion detection; (2) Good contrast of honeybees and background is important for accurate detection and can be obtained during the sunny day; (3) capturing from large distances makes honeybees appear to small and nearly impossible to detect.

The result of honeybee tracking, using the method described in previous section, is the following. For the illustration, a short video with resolution 1080x1920 pixels and framerate of 30 fps is analyzed. An example of a frame from the video, after stabilization, is given in Fig 2. Since the position of a honeybee is hard to determine in a single frame, it is highlighted. In the Fig. 3, the result of frame preprocessing is given. Concretely, this step includes converting frame in grayscale and subtraction of corresponding pixel values of previous grayscale frame. Although the processed frame from Fig. 3 gives a good estimation of honeybee position, it still may contain a significant amount of noise that could lead to false positive detection. Fig. 4 gives the result of foreground detection using method based on mixture of Gaussians. As we can notice, honeybee in the current frame is successfully detected.

Figure 2. One frame from video, showing the honeybee. Position of the honeybee is highlighted.

Figure 3. The result of frame preprocessing.

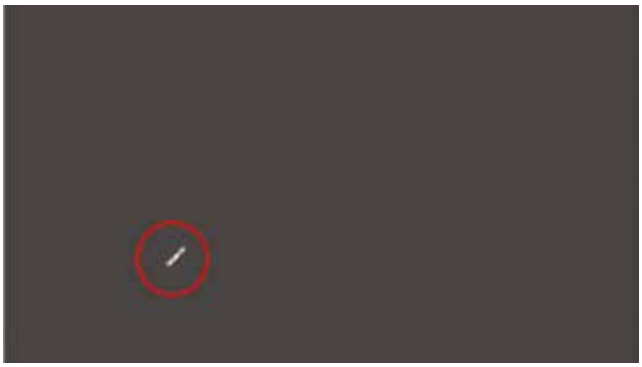

Figure 4. Result of honeybee detection on the current frame, after the preprocessing and foreground detection (background is given as gray).

Figure 5. Honeybee trace captured during the whole video. The white trace represents the places where honeybee is detected on each video frame (background is given as gray).

Nevertheless, observation of one single frame usually does not give a sufficient amount of information to make any kind of conclusion on bee activity over investigated area. For the purpose of honeybee tracking for explosive detection, we are interested in estimation of honeybee's trace over the specific spot, in order to make a spatio-temporal histogram of honeybees occurrences and to conclude if the observed area is suspicious to explosive or not. Fig. 5 gives honeybee trace for the example video.

Conclusion

In this paper, we investigated possibilities to utilize computer vision algorithms for honeybee tracking during the investigation of areas potentially contaminated with land mines. Experimental results showed that tracking algorithm can be successfully implemented in the case of still background, good foreground/background contrast and sufficient video resolution.

Acknowledgement

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