

Detection of the Flying Bees Using Morphological Image Processing

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ABSTRACT

By scattering pollen to flowers, bees allow plants and trees to bear fruit and disperse their seeds. This important task of bees in life continues the oxygen cycle, which is vital for humans. To put it briefly, a large part of life on earth depends on bees doing their job. In last years, there has been an annual decrease in the number of bee colonies. For this reason, it is of great importance to keep the bee population under control and to prevent its decline. In this study, the coordinates of a bee swarm in the sky were detected using morphological image processing methods. In this research, two main morphological image processing methods, erosion and dilation, were used. Morphological image processing algorithms were developed using the MATLAB program. The program takes a photo of bees in the sky as input and detects the coordinates of the bees by processing this photo. In this way, objects other than bees in the photograph were removed using image processing methods. With the developed algorithm, the coordinates were determined in the photograph where only the bees were visible. The obtained coordinates are written on the command line of the MATLAB program. Thus, the instantaneous location of the bees could be determined properly.

Keywords: Digital image processing, Morphological operations, MATLAB, Honey bees, Computer vision

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I. INTRODUCTION

At least 35 percent of crops and 90 percent of all plants need to cross pollination to spread and thrive [1]. Bees play a very important role in the protection of biodiversity and nature. Bees allow pollination and, as a result, the formation of fruits and vegetables [2]. By carrying pollen from one flower to another, bees ensure the existence of different plant species, which is a very important element for the health of nature [3].

There are more than 20,000 bee species worldwide. However, much of it is disappearing faster than ever due to climate change, pesticide poisoning and habitat destruction [4], [5]. Climate change poses a major threat to many species. If the habitats needed by currently endangered species are not protected, there will be great famines and humanitarian crises in the future [6]. Extreme rainfall could disrupt bees' foraging patterns. Wildfires and floods may destroy bee habitat and food sources [7].

For this reason, it is of great importance to analyze the distribution of bees and to determine the potential threats in the region [8]. Orr et al. defined the global patterns of bee biodiversity. They stated that the findings of the research will contribute to future studies on threats to bees, such as habitat destruction and climate change, and ecosystem analysis [9]. Beaurepaire et al. focused on the worldwide distribution of the Western Honey Bee. They determined that the spread of these viruses causes an important risk for the beekeeping and pollination [10]. The use of image processing methods is of great importance in order to keep the diseases on bees under control and to protect the quality of beekeeping [11]. Thanks to image processing methods, living things in motion can be detected [12], [13]. It is also possible to classify living things detected by machine learning methods [14], [15].

In this study, the coordinates of the bees in the sky will be found by using the MATLAB program and morphological image processing techniques. In this study, morphology image processing algorithms were developed using the MATLAB program. The developed algorithm takes a photograph of a swarm of bees in the sky as input. This photo is processed with erosion and dilation, which are image processing methods. First of all, objects other than the bees in the photograph are destroyed. Thus, an image containing only bees is obtained. Then, using this image, the x and y coordinates of the bees are determined. The x and y coordinates of the bees will be printed on the command line of the MATLAB program.

II. MATERIALS AND METHODS

In this study, image processing algorithms were used to determine the coordinates of bees in the sky. Image processing algorithms were developed using the MATLAB program. While developing the necessary algorithms, the Image Processing Toolbox in the MATLAB program was used. An image with numerous bees was processed using morphological image processing techniques. Objects other than the bees were destroyed in the photograph, and then the coordinates of the bees were determined. In this research, erosion and dilation image processing techniques were mainly used. Erosion and dilation are the two main techniques used in morphological image processing and form the basis of other morphological image processing techniques. These techniques were first developed for binary images and then began to be used for grayscale images. Erosion is used for removal of structures of certain shape and size, given by structural element [16]. In mathematical morphology, an image is seen as a subset of a Euclidian space R^d . E is defined a Euclidian space and A is defined a binary image in E . The erosion of the binary image A by the structuring element B is defined as in equation 1. Erosion operation is represented by \ominus symbol.

$$A \ominus B = \{z \in E \mid B_z \subseteq A\} \quad (1)$$

B_z is the translation of B by the vector z as represented in equation 2.

$$B_z = \{b + z \mid b \in B\}, \forall z \in E \quad (2)$$

Dilation is used for filling of holes of certain shape and size, given by structural element [17]. The dilation of A by B is defined as in equation 3. Dilation operation is represented by \oplus symbol. In equation 3, $b \in B$ and A_b is the translation of A by b .

$$A \oplus B = \bigcup A_b \quad (3)$$

The techniques used in image processing and the photographs obtained at each stage are explained in the Results and Discussion section.

III. MORPHOLOGICAL IMAGE PROCESSING

The coordinates of the bees were determined by the algorithms created using the MATLAB program. The algorithm takes the RGB (Red Green Blue) image as an input directly and produce bees' locations in x - y coordinates. Firstly, the original image is read with MATLAB program from the file. The original photo was taken in Koru District, Ankara, Turkey. Koru District is a region located in the west of the capital Ankara. The coordinates of the place where the photo was taken are (39.889371, 32.671197). The map view of the place where the original photo was taken is shown in Figure 1.

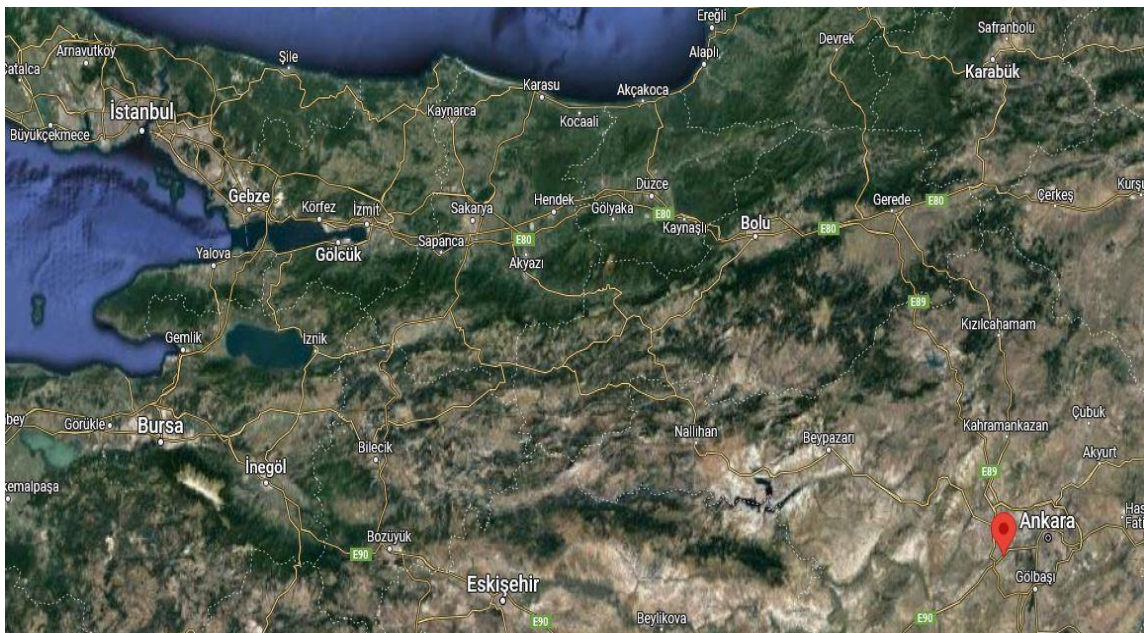


Figure 1: Map view of the place where the original photo was taken

The original image is given in Figure 2. This image is taken as input by the algorithm.



Figure 2: The original input image

Sharpening enhances the definition of edges in an image. The original image has been sharpened to make the bees in the image appear clearer. The sharpened image is shown in Figure 3.

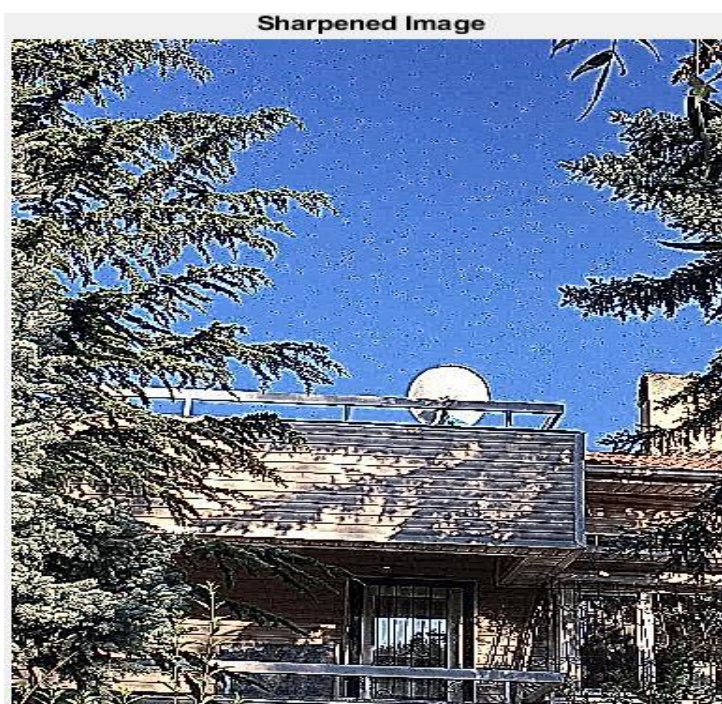


Figure 3: The sharpened image

An image has 3 channels, red, blue and green. In other words, the image is composed of three images (one for each channel). The blue channel was chosen to facilitate image processing in the next step because the sky in the background of the bees is blue.



Figure 4: The blue channel image

Then, the image is converted to a binary image with a 0.5 standard threshold value because the main region of interest are bees. In the black and white image obtained, the bees became more prominent. This image is shown in Figure 5.

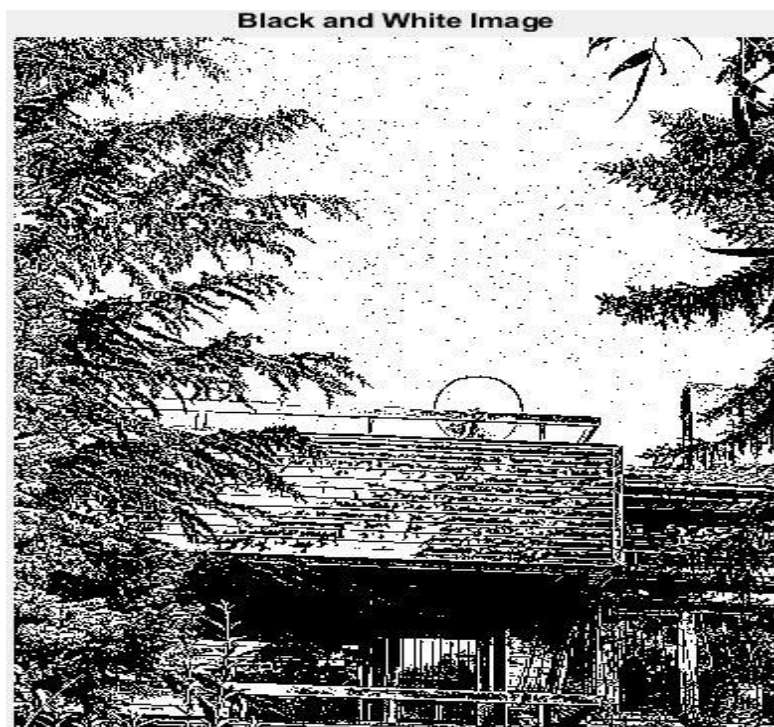


Figure 5: The black and white image

In order to determine the coordinates of the bees more easily, objects other than the bees will be destroyed in the image. For this purpose, firstly, the picture was inverted. The inverted image is given in Figure 6.

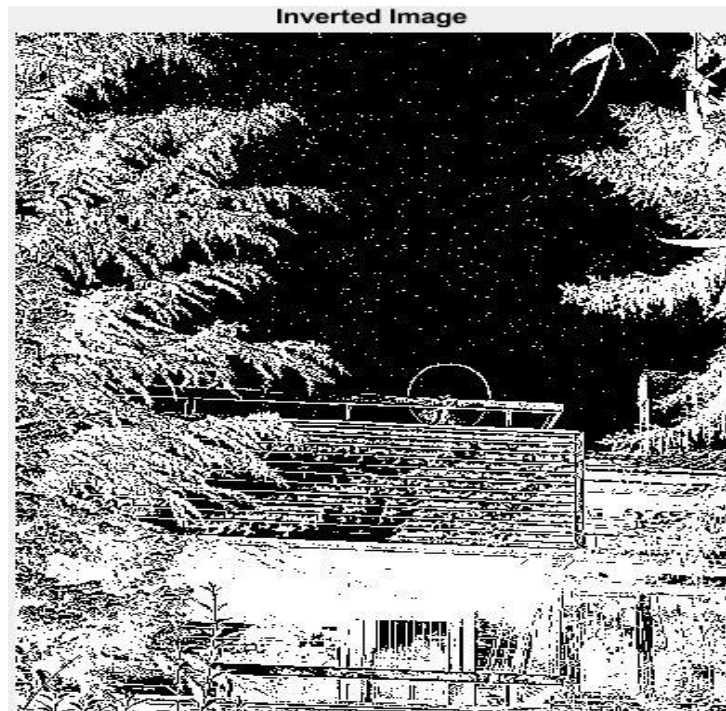


Figure 6: The inverted image

Holes in objects other than bees in the image have been filled. This will make it easier to remove these objects from the image.

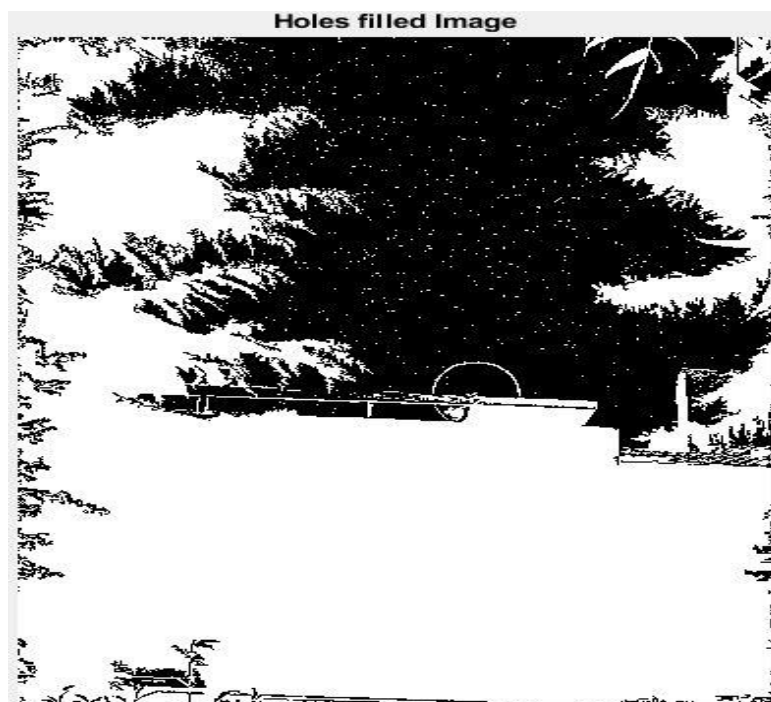


Figure 7: The holes filled image

Then the bees in the current image were removed. Since bees are less than 14 pixel in size, anything less than 14px has been removed. The image with the bees removed is shown in Figure 8.

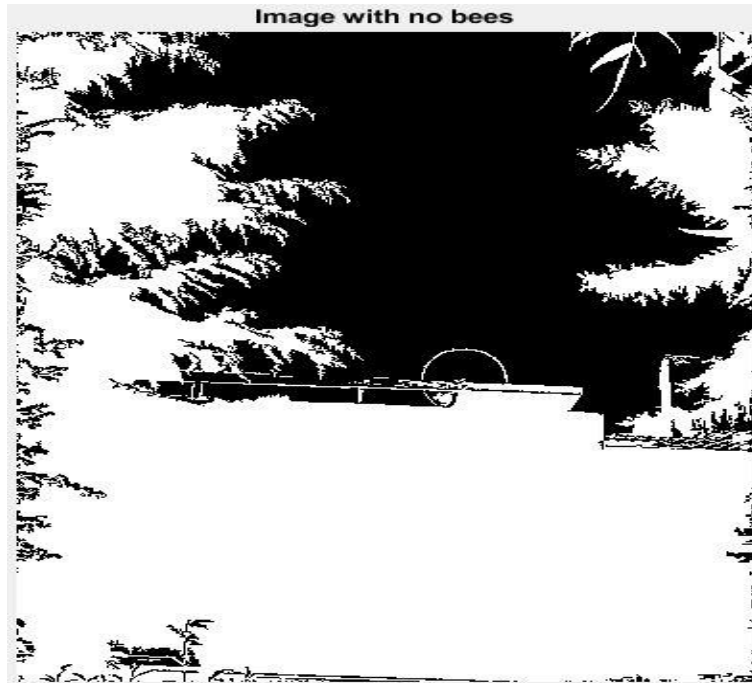


Figure 8: The image with no bees

Then, Figure 8 is subtracted from the Figure 7. In this way, an image with only bees was obtained. Figure 9 shows the image with only bees. The x and y axes are determined with the axis image command in MATLAB.

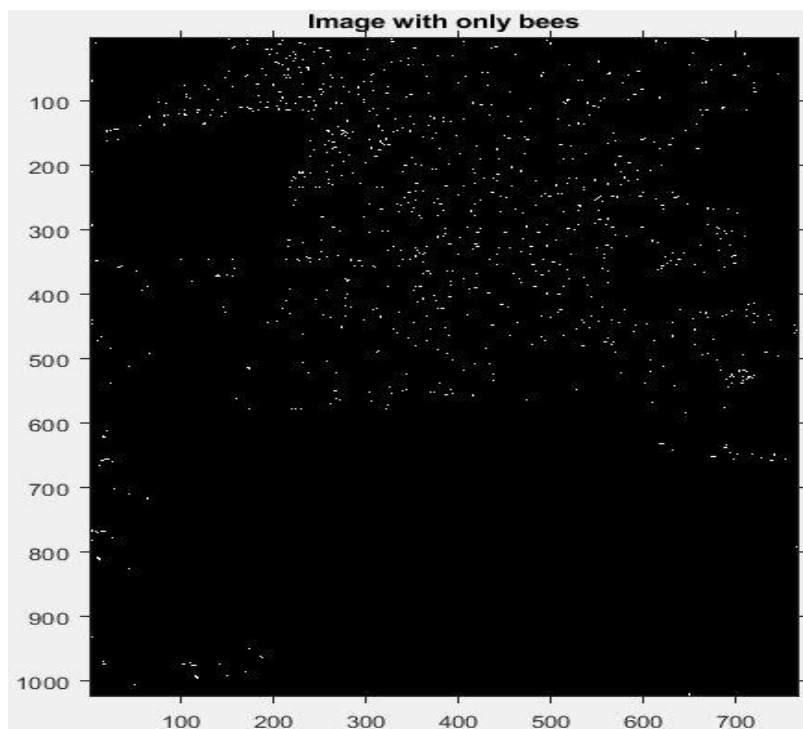


Figure 9: The image with only bees

Then, the location of each bee was determined using the `bwconncomp` and `regionprops` functions in MATLAB. `Bwconncomp` function finds and count connected components in binary image. `Regionprops` function measures properties of image regions. Then, using the for loop, the x and y coordinates of all bees were written to the command line in MATLAB. The algorithm was able to precisely determine the x and y coordinates of the bees,

along with their fractions. An image obtained from the MATLAB command line and showing the x, y coordinates of the bees is given in Figure 10.

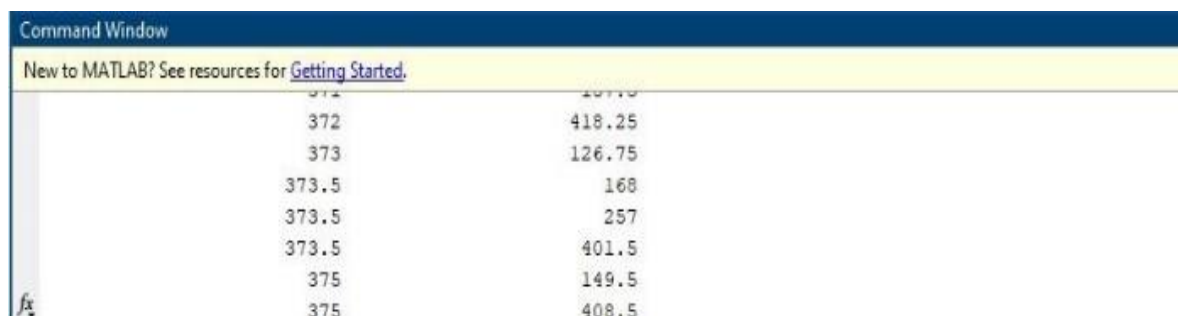


Figure 10: The coordinates in the command window

IV. DISCUSSION AND CONCLUSION

In this research, the coordinates of bees in the sky were determined using morphological image processing methods. MATLAB software was used in the research. The algorithm developed using MATLAB software takes the photo of the bee swarm as input and processes the image. Objects other than the bees in the image were removed by using morphological image processing methods. Then, an image containing only bees is obtained. Thanks to the developed algorithm, the x and y coordinates of the bees are written on the MATLAB command line.

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