Detecting and Studying in-field Lotus Flower Visiting Behavior of Honey Bees

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Background

Honey bees have a crucial role in the pollination of various cultures and specifically in human-cultivated crops. The environmental impact of human activities markedly increased, which is a serious threat to honey bees' health, thus to food safety for humankind. In order to help people and organizations set protection plans and raise awareness about the issue, getting knowledge about honey bees visiting behavior in flowers is important a crucial lever. Detecting and counting the bee's flower visitings is time-consuming and is traditionally made by using complex installation in fields that ease image segmentation. An algorithmic workflow combining video preprocessing and a deep convolutional network is proposed to tackle this task.

Methods

The flowering lotus (Nelumbo nucifera) cultivars used in this study were grown at the Institute for Sustainable Agro-ecosystem Services (ISAS), The University of Tokyo (Nishi-Tokyo City, Tokyo, Japan). We use commercial level time-lapse cameras with a waterproof function (TLC200, Brinno Incorporated, Taipei) to collect images of lotus flowers. The camera was set facing lotus flowers and take images at 5-second intervals, and all the images were converted to video with 10 frames/second rate. First, a pixel-by-pixel classification approach using RGB and HSV values is proposed to all the frames to segment flowers from the background; Then, an absolute difference is made between the frame of interest and the mean of 12 frames before it. Before this difference, a gaussian filter is applied to all the frames. Finally, this difference is converted to a grayscale image on which a threshold is applied. This final image was used to extract candidate regions that had the movement on the frame of interest. All the candidate regions will be fed into a pretrained deep learning convolutional neural network to select the ones that correspond to honey bees and discriminate from the background. The deep learning model finally outputs bounding boxes of the regions that contain honey bees.

Results

The lotus flower dataset used for the testing of the workflow contains 2862 labeled honey bees. The proposed method was able to detect and accurately classify 70 % of them. By running this method through a full-day time-series of lotus images (with images taken between 4 AM and 7 PM), we were able to output the total number of visiting honey bees for one day, which led to an understanding of honey bees' visiting behavior, estimating the number of visits and the influence of the daytime on the visiting bees counting. These results show that flower-visiting starts early in the morning around 5 AM when the lotus flower opens. The most crowded period is during the first two hours until 7 PM. Then, a low number of visits can be observed around 8 AM, with an increase in visits after 9M until the beginning of the afternoon at 2 PM. The biggest number of visits is reached between 5:45 AM and 6 AM with 1401 identified honey bees.

Conclusions

As a result, our proposed method proved its ability to provide visiting bees' counting graphs in order to build an analysis of honey bees visiting behavior. As a prolongation, this method may be run on a larger dataset (higher sampling rates) with higher definition input images to tackle the difficulty of detecting honey bees, which are partially covered by lotus flowers' stamens. Moreover, as the workflow is efficient to detect moving objects, a more complex convolutional neural network may allow the detection and classification of more different insect species present on lotus flowers. Finally, it may be interesting to compare pollination headcounts between lotus flower species to determine whether it has an effect on honey bees' attraction.