Development of a System for Determining the Infestation Rate of Bees by Mites

Objectives

To create an automated system capable of real-time determination of the infestation rate of bees by mites through the analysis of images from cameras installed on bee hives, utilizing **computer vision** and **deep learning** algorithms.

"If I have seen further, it is by standing on the shoulders of giants." Sir Isaac Newton

Types of mites parasitizing bees and methods of their detection

Why are bees important?

Bees are important for the ecosystem they provide a range of ecosystem services that contribute to the wellbeing of people whilst maintaining the planet's life support systems. Ecosystem services inherently contribute to achieving global sustainable development. Patel, V. *et al.* (2020)

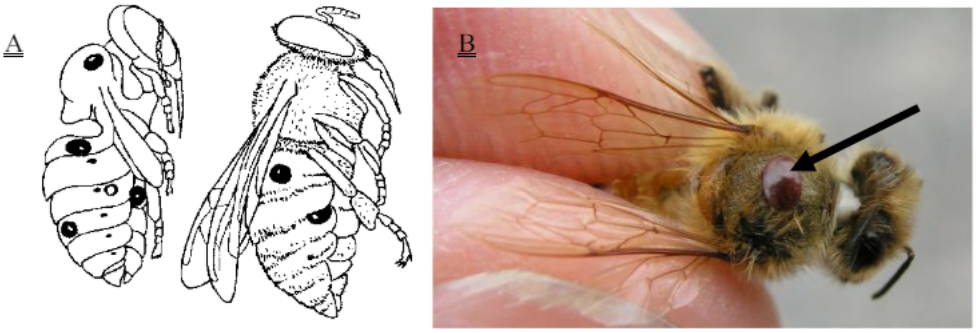
"The importance of bee pollination for food crops has been widely acknowledged, with growing concern of a global crisis as demand for pollination services continues to outstrip supply, with an associated increase in less diverse, pollinator-dependant agriculture systems (Aizen and Harder 2009; Aizen et al. 2019). In addition to improving the yield of some crops (target 2.3) (Klein et al. 2007, 2018; Stein et al. 2017), bee pollination contributes to enhanced nutritional value (target 2.2) and improved quality and longer shelf life of many fruits and vegetables (Klatt et al. 2014), which could potentially help in reducing food waste (target 12.3) resulting from aesthetic imperfections (Gunders and Bloom 2017)." Patel, V. *et al.* (2020)

Types of mites

"There are 2 species of varroa mite: *Varroa destructor* and *Varroa jacobsoni".* Fisheries, A. and (2024)

From the last reference, it is known that the *Varroa Destructor* is a suspected responsible for the collapse and death of European Honey Bee colonies. For sake of this work, will focus in Varroa Destructor

Varroa Destructor



Terrestre, M. (2021)

What does the Varroa Destructor do?

Varroa feeds on the haemolymph and fatty body tissue of the honeybee. Its reproduction is based on laying eggs inside the pupa, so when the bee hatches, it hatches with parasites, which means that, given its exponential growth, the hive collapses due to the number of varroas it has. Sanchez, V. (2023)

How to inhibit Varroa Destructor?

To inhibit the constant reproduction of varroa, there are two ways: by using chemicals or by selecting bees to kill it. In the first case, the use of chemicals, the most used way worldwide, will generate not only an increase in beekeeping production costs, but also the creation of resistance to the product, as well as residuality, which will mean that, when any chemical is applied in the hive, it will remain in contact with the bees, the wax, the honey, and will generate toxicity for the person who consumes it. Sanchez, V. (2023).

Also, there are some paper that use CNN (Convoultional Neural Networks) and DL (Deep Learning) models that by Object Detection there is possible to identify the mite in the bee

Components from video capture and data delivery.

The following information was obtained in the following link: https://www.mdpi.com/2076-3417/11/22/11078, they mention a solution for the same IoT problem using:

- RaspberryPi 4 model B mini-computer with Broadcom BCM2711 quad-core 64-bit ARM-8 Cortex-A72 1,5 GHz processor and 4 GB of RAM
- ArduCam OV5647 5Mpx camera with an LS-2718 CS lens
- GSM modem
- Power Supply

Where the GSM modem and power supply are concerned, we can replace them with Wifi routers and high gain antennas to guarantee the required distance, and for the power supply, an option could be to use solar panels.

Video cameras with suitable specifications for installation on hives

Different papers, use differente cameras, most of them tend to be common web cameras, and what they do is build an isolation to make it resistant to different weather scenarios. Some examples are

- 5MP camera with a fisheye lens of 160° (Voudiotis et al. 2022)
- SVM/CCD camera (Chen et al)
- ArduCam OV5647 5Mpx camera with an LS-2718 CS lens (Mrozek et al. 2019)
- Raspberry Pi v2 8-megapixel (Kulyukin et al. 2019)

Specify requirements for software to process and analyze video data

Due to the lack of elements to proof the concept, the test where developed in a personal PC, here are the specifications

CPU	12th Gen Intel(R) Core(TM) i7-1255U 1.70 GHz
Development Environment	Python 3.12.2 PyTorch 2.2.1 OpenCV 4.9.0 Tensorflow 2.16.1

> 💡 **Note:** For more important packages, see the requirements file in the GitHub project https://github.com/EstebanMedina2021/S-Bee

Data Input

For this project OpenCV library is designed to handle image and video inputs

Video: it supports the avformat container format.

Image: the next files where used to test the project

- JPEG files – *. jpeg, *. jpg.
- Portable Network Graphics – *. png.

Wireless data transmission system for remote access to video streams

Data transmition will by using WiFi and high gain anthenas, possible products would be

- Long-Range Wireless Transmitters/Receivers: Ubiquiti NanoStation AC Loco
- High-Gain Antennas: Alfa 9dBi WiFi Booster SMA OMNI Directional

Dataset of images of bees with and without mites

While several datasets exist that address the issue of bee mite detection, a key challenge lies in the data quality and dataset size. Here are some example of datasets that could be relevant, **VarroaDataset** is one of the most mentioned in papers.

- https://zenodo.org/records/4085044
- https://github.com/schurist/VarroaDataset/tree/master
- https://github.com/BeeAlarmed/BeeDataset
- https://pan.baidu.com/share/init?surl=aEW20Vx1HsjwnTS1JVRkew&pwd=36y2

Inspiration

The project is based on the following paper:

> Detection of Varroa destructor Infestation of Honeybees Based on Segmentation and Object Detection Convolutional Neural Networks
>
> Varroa destructor infestation is a major factor leading to the global decline of honeybee populations. Monitoring the level of Varroa mite infestation in order to take timely control measures is crucial for the protection of bee colonies. Machine vision systems can achieve non-invasive Varroa mite detection on bee colonies, but it is challenged by two factors: the complex dynamic scenes of honeybees and small-scale and limited data on Varroa
>
> https://www.mdpi.com/2624-7402/5/4/102

The original F-YOLOX-b repository (https://github.com/Megvii-BaseDetection/YOLOX) contained deprecated elements that hindered its execution on a personal computer (PC). To address this, the codebase underwent a comprehensive update. This included refactoring the code to a more functional style, improving readability through the addition of comments, and integrating a DeepSort implementation for object tracking capabilities. These modifications successfully enabled the model to be run on a standard computer environment and enhanced its functionality with object tracking.

References

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