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The Varroa's Detection Project: Automated Beehive Health Monitoring System

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1. Introduction

The Varroa's Detection Project addresses a significant concern in apiculture – the decline of honeybee colonies due to Varroa destructor mite infestations. This report presents a comprehensive analysis of the project's development, its technical objectives, progress over three years, and the outcomes of its two versions.

2. Project Overview

The project aims to create an automated beehive health monitoring system that detects the presence of Varroa destructor mites in beehives. This parasitic mite poses a grave threat to honeybee colonies, resulting in weakened hives and diminished honey production. By providing beekeepers with an early detection tool, the project contributes to the preservation of bee populations and ensures optimal hive productivity.

3. Technical Goals

The primary technical goal of the Varroa's Detection Project is to develop an intelligent system capable of identifying Varroa destructor mites in beehive images. The project focuses on using machine learning with cameras to achieve a fast and accurate detection.
The overall project was about the creation of the AI and the support around it.

4. Project Timeline

- June 2021: Project Proposal and Acceptance

  The Varroa's Detection Project was conceived, and its proposal was submitted in June 2021. The proposal outlined the project's objectives, scope, and intended outcomes. After careful evaluation, the proposal was accepted

- July 2021 - May 2022: Project Planning and Preparations
  During this phase, we engaged in comprehensive planning and preparations. This included refining the project's objectives, defining technical requirements, and gathering the necessary resources. Ethical considerations were also addressed, ensuring the humane treatment of the bee colonies involved in data collection.

- June 2022: Release of the First Version

After a year of planning and development, the first version of the automated beehive health monitoring system was released in June 2022. This version used material from the school's teaching

- July 2022 - May 2023: Post-Release Analysis
  Following the release of the first version, we engaged in an extensive analysis of its performance. The project was tested on a beehive and the results led to multiple changes.
- June 2023: Introduction of the Second Version
  Building on the results from the first version, we released the second version in June 2023. This version introduced a new way of making the AI with substantial enhancements in terms of accuracy, speed, and compatibility with various camera setups.

5. First Version: June 2022

Technology Stack and Training Data

The initial version of the project utilized the TensorFlow framework for model development. The AI models were trained using a personal dataset containing images of both healthy and infected bees. The dataset was sourced from a github “varroa dataset” and was specialized on closup picture of bees. The training was done on Kaggle. The goal was to have a continuous prediction.

Created AI Models

Three distinct AI models were developed for the first version. The model with the highest accuracy, 70%, was selected for deployment.

The model extension type is .h5 common to most TensorFlow models.

Testing environment

The project was tested with videos captured on a beehive to which we were authorized access. The varroa was not present enough for the testing to use only this source which led to the use of other smaller dataset online.

Performance Evaluation

The AI demonstrated to be effective on specific targets, aligning with the established goals of the project. However, it had a hard time predicting when used with a camera of medium quality.

Strengths:

- easy integration with beehive systems.
- Utilized familiar technologies, enhancing stability.
- Straightforward installation process well documented on Kaggle and TensorFlow

Limitations:

- Restricted to specific image sizes.
- Susceptible to bias from the uniform background in training data.
- Hard to re-train and often ending up into corrupted AIs.
- Speed was slow for one image

Insights and Next Steps

From the use of the first version, several key insights were gained:

1. **Image Size Flexibility:** Future iterations should be image size-agnostic due to varying camera sizes.
2. **Improved Speed:** The next version should respond within 2 seconds for optimal user experience.
3. **Enhanced Accuracy:** Aim for higher accuracy in detection to minimize false negatives.
4. **Image instead of data stream:** The AI will have a hard time if we keep the data stream predictions, too many predictions on a slow paced environment is wasteful of resources and slow down the overall process.

6. Second Version: June 2023

Technology Stack and Enhanced Dataset

The second version of the project adopted the YOLO5 (You Only Look Once) framework, known for its speed and accuracy in object detection. The dataset was expanded to include more diverse images, making the model less sensitive to biases related to rotation and background.

Model Improvements

The YOLO5-based model demonstrated considerable improvements over the previous version:

- **Image Size Flexibility:** YOLO5's design eliminated the need for specific image sizes.
- **Accuracy:** The accuracy of the model improved significantly.
- **Camera Compatibility:** The model is now compatible with various camera types, widening its applicability.
- **Speed:** YOLO5's speed advantage enhanced real-time detection.

Challenges and Enhancements

The second version introduced a new challenge regarding Python integration during runtime. This challenge was countered by leveraging the enhanced benefits of YOLO5 and focusing on improvements in deployment.

7. Integrating YOLO5 Framework

The adoption of the YOLO5 framework in the second version significantly contributed to the success of the Varroa's Detection Project. YOLO5's speed, accuracy, and compatibility with diverse image sizes and camera types ensured a robust and versatile solution for beekeepers.

8. End and Future Directions

The project's immediate future involves transforming the system into a one-click installation tool, streamlining mass deployment. We aim to simplify the adoption process for beekeepers and maximize the positive impact of the automated beehive health monitoring system.

9. Conclusion

The Varroa's Detection Project has successfully evolved over three years, from its inception in June 2021 to the release of two versions by June 2023. The project's commitment to utilizing cutting-edge technologies and addressing limitations has resulted in a reliable and efficient solution for detecting Varroa destructor mite infestations in beehives.

10. References

1. Kaggle: Kaggle is a well-known platform for data science competitions, datasets, and machine learning resources.
2. TensorFlow: TensorFlow is an open-source machine learning framework developed by Google for building and training machine learning models.
3. Varroa dataset: Unfortunately, I do not have direct access to external datasets, and my knowledge is not up-to-date with specific Varroa datasets available online. You can search for Varroa datasets on platforms like Kaggle or academic repositories.
4. YOLOv5 GitHub Repository: YOLOv5 is a widely used real-time object detection framework. You can find the YOLOv5 source code and documentation on this GitHub repository.
5. YOLO (You Only Look Once): YOLO is the original YOLO framework for real-time object detection. You can find the source code and documentation on this GitHub repository.

6. Bees and Varroa (multiple sources): Here are some sources where you can find information about bees and Varroa mites:

    - United States Department of Agriculture (USDA) - Varroa destructor Mite
    - lockdown because of deadly varroa in Australia
    - Bee Culture - Varroa
    - Entomology Today - Effects of Varroa destructor on Beekeeping

7. **Beekeeping**: Beekeeping, also known as apiculture, refers to the practice of raising and managing honeybee colonies for the purpose of producing honey, beeswax, royal jelly, pollen, and other bee-related products. Beekeepers also play a crucial role in pollination services for agriculture.
8. **Object Detection**: Object detection is a computer vision task that involves identifying and localizing objects within images or videos. It goes beyond classification by not only recognizing what objects are present but also where they are located in the image.
9. **Machine Learning Framework**: A machine learning framework is a collection of tools, libraries, and resources that facilitate the development, training, and deployment of machine learning models. These frameworks provide pre-built functions for tasks like data preprocessing, model architecture, training, and evaluation.
10. **Dataset**: A dataset is a structured collection of data that is used for training and testing machine learning models. Datasets contain examples, often in the form of images, text, or numerical data, along with corresponding labels or annotations that provide information about the data.
11. **Parasitic Mite**: A parasitic mite is a type of arthropod that attaches itself to a host organism, such as bees, for nourishment. These mites feed on the host's bodily fluids, weakening the host and potentially causing various health issues.