Detection of hornets at a beehive entrance

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**Project owner**: Artjom Kurapov / Gratheon

Project owner

Gratheon develops an **open source robotic beehive** as a data service for semi-professional beekeepers.

The aim is to save bees, improve efficiency and increase food security.

One of the many products provided is an **entrance observer** - a set of cameras and hardware devices that analyze a beehive entrance. It records a video stream, runs AI analysis that sends metrics and videos to a web app for preview and alerts.

The problem

- beehives are attacked by hornets
- without action colonies may be destroyed within hours
- early detection is critical
- automated detection at a beehive entrance can help alert beekeepers
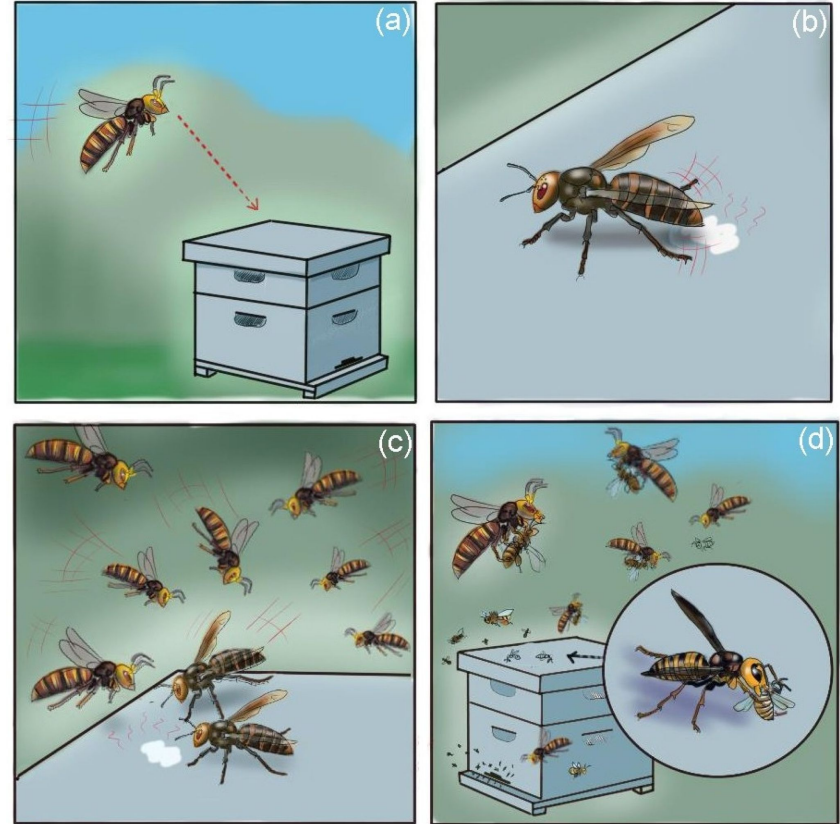
Main methodology

1. Tried and failed to find sufficient data online
2. Manually labelled images
3. Researched applicable models
4. Trained different models and compared the results
5. Dockerized the best model

Team worked as a whole. Otto and Kadi-Liis more specialized in data, Karen and Albert in modelling.

Dataset

- Manually labeled ~1250 images of bees and hornets using Roboflow as a team
- Bees were also added to the training set to reduce the FP rate as it is crucial to keep the users trust and minimize false alarms
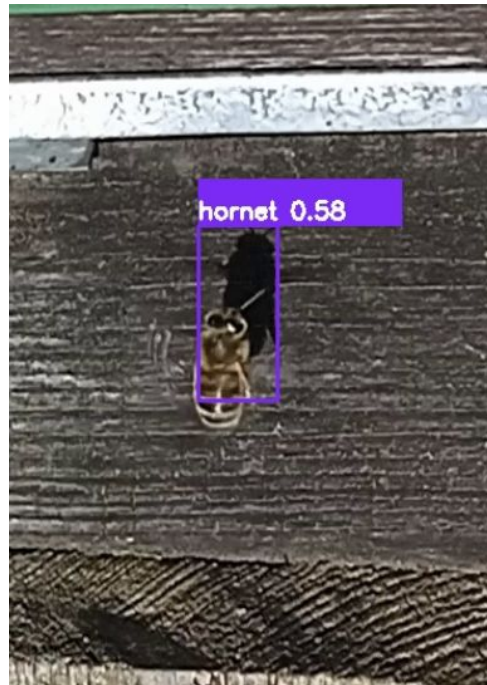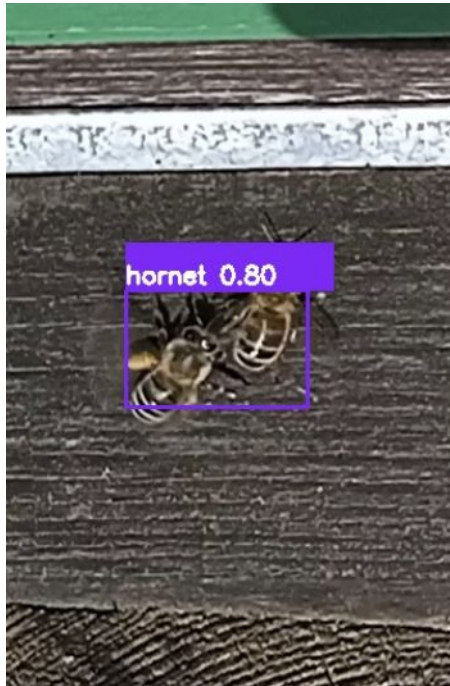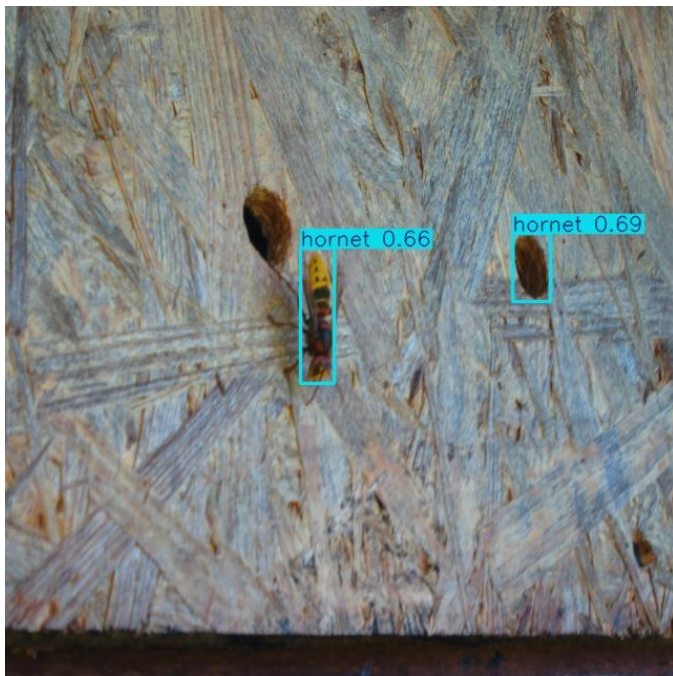- With augmentations the training set increased to ~3000 images

Model	Yolov8-nano	Yolov8-medium	Yolov11-nano	Yolov11-medium	RT-DFTR-lite	RT-DFTR-R50	EfficientDet-D0	EfficientDet-D2
Precisions	0.967	0.943	0.951	0.882	0.924	0.896	0.747	0.800
Recall	0.912	0.869	0.895	0.811	0.895	0.832	0.842	0.758
F1-score	0.939	0.905	0.922	0.845	0.863	0.812	0.792	0.778
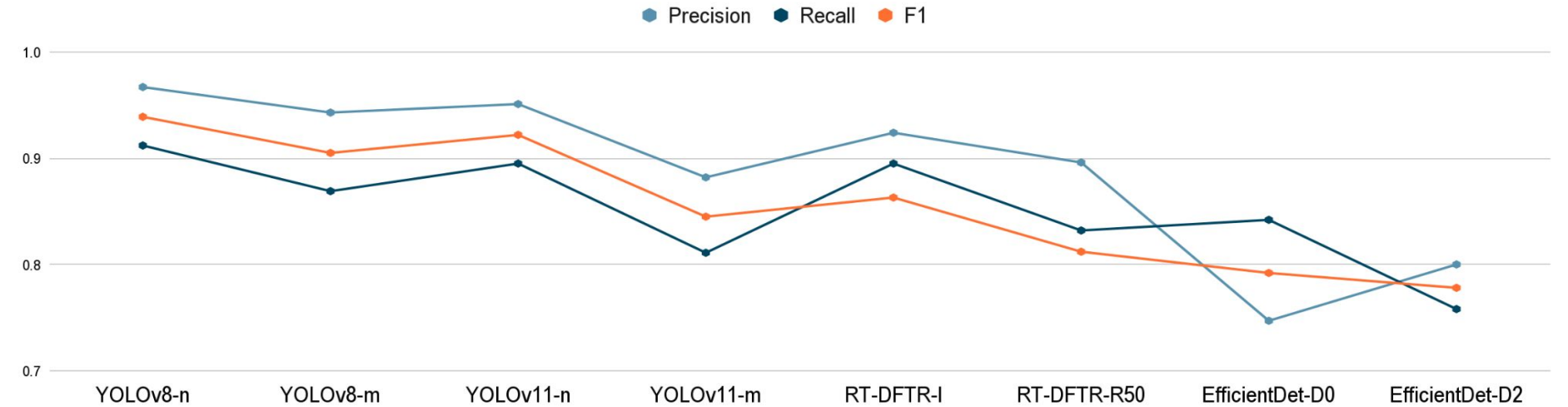
Examples

Examples

Results and future

- A working YOLO-v8-nano model with 96.7% precision and 91.2% recall on our test data
- Setup guide and code to use the model on a Nvidia Jetson (edge) device
- Only images are supported for now but model could be plugged in to existing projects that support YOLO models
- Testing the model on a Jetson device and at an actual beehive will be the final test for this project

Lessons

- Data collection and processing is time-consuming
- Manual labeling is fun but tedious
    - our recommendation: invest in a mouse!
- Staying organized helps keep the team on track and speeds up progress

Thank you for listening!

GitHub repository

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Total images processed: 1140
Images with hornet detections: 39
Percentage of false positive images: 3.42%
 - 25% quantile: 0.53, FP count 30, FP percentage 2.63%
 - 50% quantile: 0.57, FP count 20, FP percentage 1.75%
 - 75% quantile: 0.60, FP count 10, FP percentage 0.88%
 - 85% quantile: 0.64, FP count 6, FP percentage 0.53%
Max conf: 0.80
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Roboflow labeler

- Trained a labeling model that achieved **95%** precision and **85%** recall
- *Adding images annotated by this model to our training dataset did not improve the metrics of our final model*