P7 - Detection of different bee types at the beehive entrance on a video dataset

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Problem Overview

- Monitoring bee activity is important for assessing hive health and productivity

- Existing system only provides basic detection

- Need detection for multiple bee types:
    - Drones (male)
    - Worker bees (female)
    - Worker bees with pollen

Project goal:

- Build an improved bee detection and classification model that
    - Operates in real time
    - Is lightweight enough for edge deployment

Gratheon Beehive Entrance-Observer Setup
(https://gratheon.com/about/products/entrance_observer/)

Sample Frame From the Entrance Observer Dataset
(https://drive.google.com/drive/folders/18zLbdjOEggdYYuQuja1KirkFgzzz6en5)

Methods

- Weakly supervised learning approach

- Yolov11x trained on Mississippi University dataset

- Supervised learning approach on manually labeled data

- Subset of client's data was annotated with CVAT

- Trained multiple Yolov11n models:

  - Mississippi dataset

  - Manually labeled dataset

  - Auto-labeled datasets with different confidence levels

Sample From the Manually Annotated Dataset

Datasets

Dataset name	Total Images	Worker Bee No Pollen	Worker Bee Pollen	Drone Bee
Mississippi	4590	93.87%	5.42%	0.71%
Manual	1353	78.47%	21.20%	0.33%
Auto-labeled Conf=0.3	30639	99.01%	0.91%	0.08%
Auto-labeled Conf=0.5	28098	99.50%	0.46%	0.04%
Auto-labeled Conf=0.7	29865	99.81%	0.17%	0.02%

Yolov11n trained on Mississippi dataset

Class	Precision	Recall	F1-score	mAP@50	mAP@50-95
Worker-Bee-Pollen	0	0	0	0	0
Worker-Bee-No-Pollen	0.24	0.86	0.38	0.26	0.12
Drone-Bee	1.0	0.01	0.03	0.34	0.19

Yolov11n trained on manually labeled dataset

Class	Precision	Recall	F1-score	mAP@50	mAP@50-95
Worker-Bee-Pollen	1.0	0.33	0.5	0.67	0.47
Worker-Bee-No-Pollen	0.97	0.96	0.97	0.99	0.73
Drone-Bee	0.95	0.97	0.96	0.99	0.81

Yolov11n trained on auto-labeled data, confidence 0.3

Class	Precision	Recall	F1-score	mAP@50	mAP@50-95
Worker-Bee-Pollen	0	0	0	0	0
Worker-Bee-No-Pollen	0.14	0.45	0.21	0.11	0.04
Drone-Bee	0	0	0	0	0

Yolov11n trained on auto-labeled data, confidence 0.5

Class	Precision	Recall	F1-score	mAP@50	mAP@50-95
Worker-Bee-Pollen	0	0	0	0	0
Worker-Bee-No-Pollen	0.15	0.47	0.22	0.12	0.05
Drone-Bee	0	0	0	0	0

Yolov11n trained on auto-labeled data, confidence 0.7

Class	Precision	Recall	F1-score	mAP@50	mAP@50-95
Worker-Bee-Pollen	0	0	0	0	0
Worker-Bee-No-Pollen	0.16	0.36	0.22	0.11	0.04
Drone-Bee	0	0	0	0	0

Results

- All of the models were evaluated on a subset of manually labeled dataset

- Model trained on manually labeled client's data gets good results

- Not sure how well it would actually perform

- Model trained on Mississippi University datasets gets worse results

- Data is different

- Weakly supervised learning approach gets bad results

- Relies heavily on Mississippi dataset

Lessons Learned

- Dataset quality and annotations strongly limit achievable performance

- Manual labeling is time-consuming

- Differences in dataset specific circumstances wildly affect the final result of a model

- Real-time solutions involve trade-offs between accuracy, speed and supervision

- Hard to train classification models on data that is very weighted towards one class

Team

Norman Tolmats
- Implemented auto-annotation and generated large amounts of labeled data
- Led model training and experimentation (YOLO-based detection)

Mihkel Kulu
- Searched for datasets and evaluated their viability
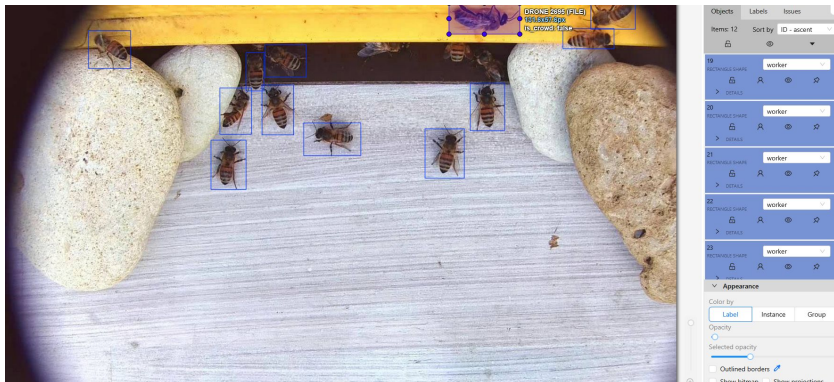- Assisted with model iteration and validation

Joonas Tiitson
- Built the initial YOLO pipeline using the Roboflow dataset
- Evaluated alternative architectures and tooling (e.g. RF-DETR)

Markus Kivimäe
- Performed manual annotation of the validation dataset
- Ensured label quality for model evaluation

Thank you!

Yolov11n trained on manually labeled dataset

Class	Precision	Recall	F1-score	mAP@50	mAP@50-95
Worker-Bee-Pollen	1.0	0.33	0.5	0.67	0.47
Worker-Bee-No-Pollen	0.97	0.96	0.97	0.99	0.73
Drone-Bee	0.95	0.97	0.96	0.99	0.81

Github: https://github.com/bukyt/beeDetection/tree/main