Bee Living Sensor

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Bee Living Sensor

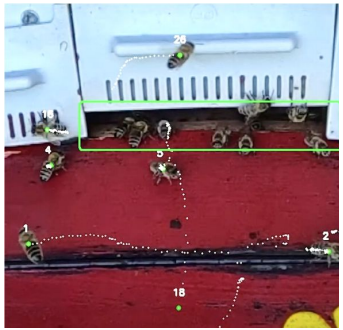
- Bees are vital for the ecosystem
- Insect numbers are declining
- Hive health is difficult to monitor

Bee Living Sensor: Setup

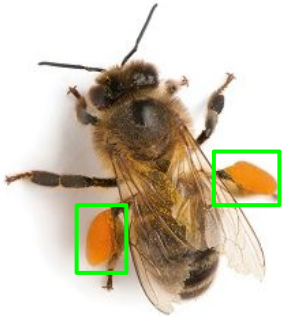
- **Capture** hive entry using camera
- **Upload** video onto web platform
- **Inspect** hive analytics

Analytics Tasks

1) Bee detection



2) Bee tracking



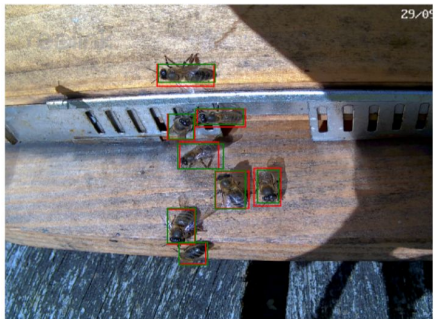
3) Pollen detection

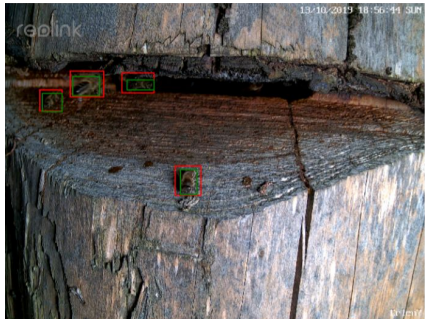
4) Pollen clustering

Data challenges

- Overlap & quantity
- Video & lighting issues
- Hive layouts

Dataset: 1800 images, 12 hives

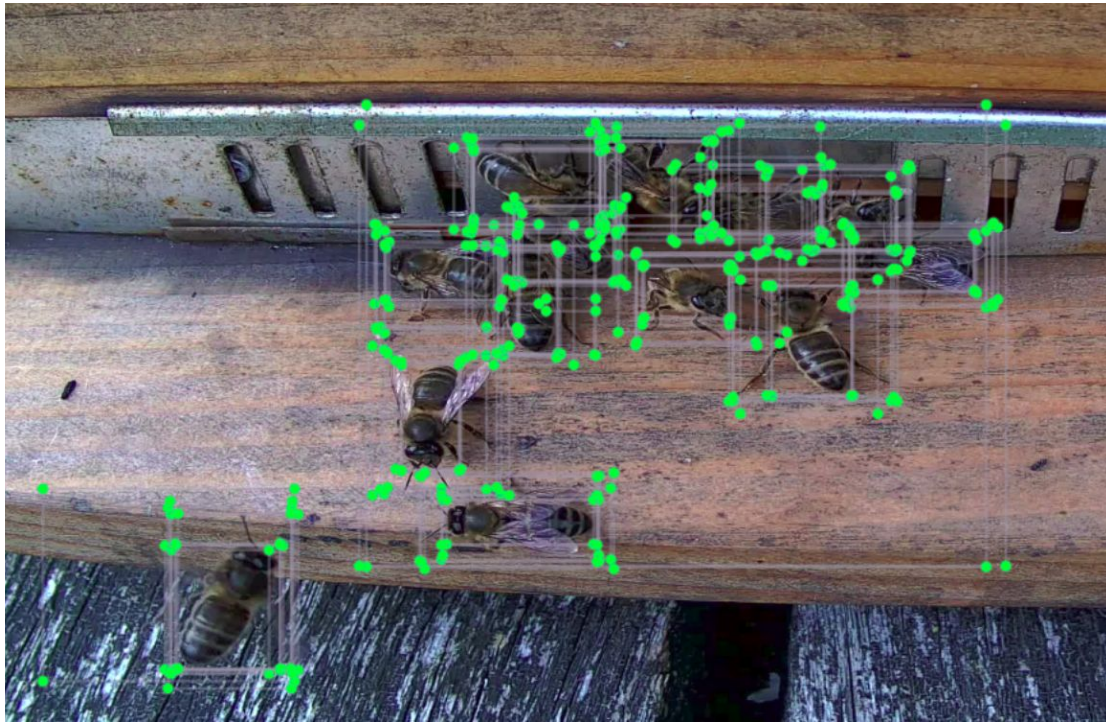


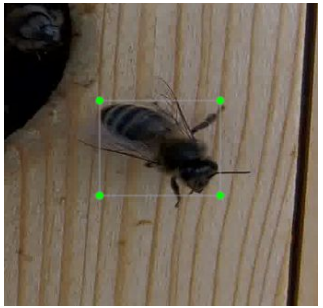


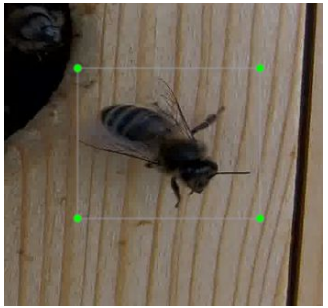
Mechanical Turk

- **1300 images** labeled
- Custom rates
- Price & Quality correlation

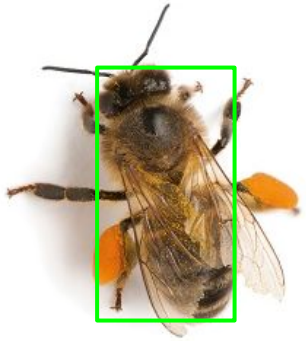
Mechanical Turk







Bee detection



Data:

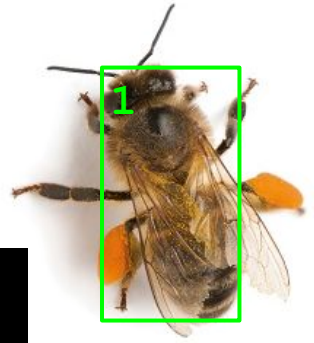
- Train images: 1700 (+ 1300 from MTurk)
- Test images: 400

Model: YOLOv4

- 40 FPS on Tesla P100
- Simple deployment

Model	mAP@0.50
Ours	0.93
Ours (no MTurk)	0.91
Previous	0.86

Bee tracking



Algorithm: SORT[1]

MOTA score

	Original data	**Cleaned data**
Custom	91.2%	92.2%
SORT	90.3%	**93.8%**

(1) Bewley, Alex, et al. "Simple online and realtime tracking." *2016 IEEE International Conference on Image Processing (ICIP)*. IEEE, 2016.

Multi-task Architecture

Tasks:

- Pose Estimation
- Pollen Detection
- Genus detection

Goal: Meaningful latent space

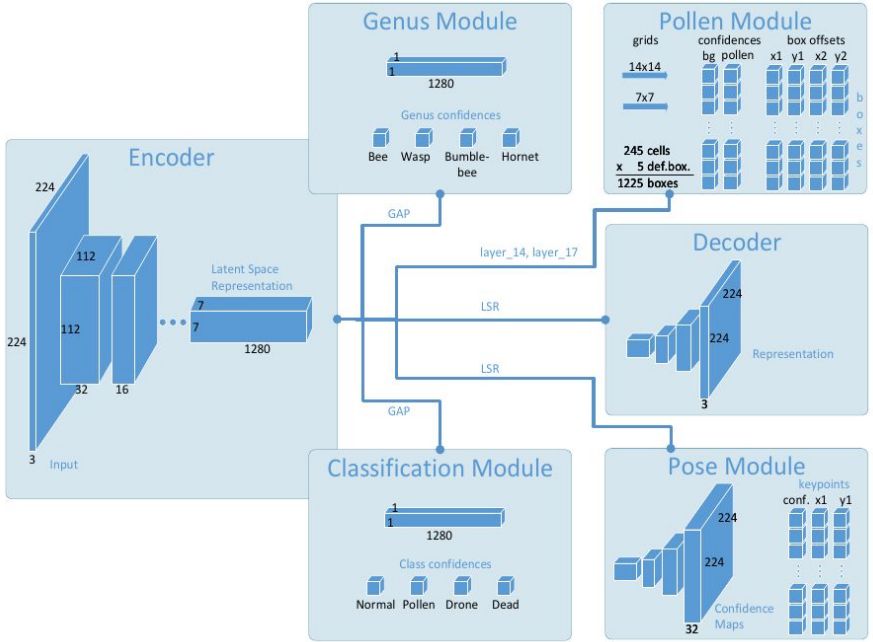


Image credit: Marstaller, Julian, Frederic Tausch, and Simon Stock. "Deepbees-building and scaling convolutional neuronal nets for fast and large-scale visual monitoring of bee hives." *Proceedings of the IEEE International Conference on Computer Vision Workshops*. 2019

Multi-task Architecture: Issues

- Few supervised tasks available
- No gains from unsupervised tasks
- Pollen detection easy to label

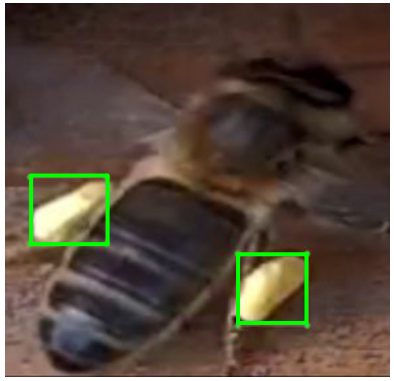
Pollen detection

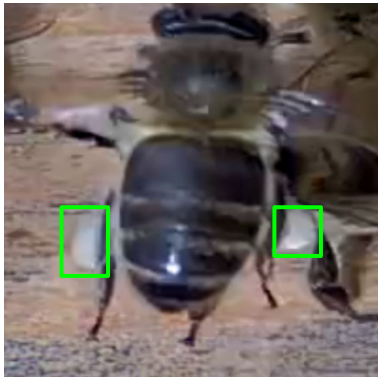
Data:

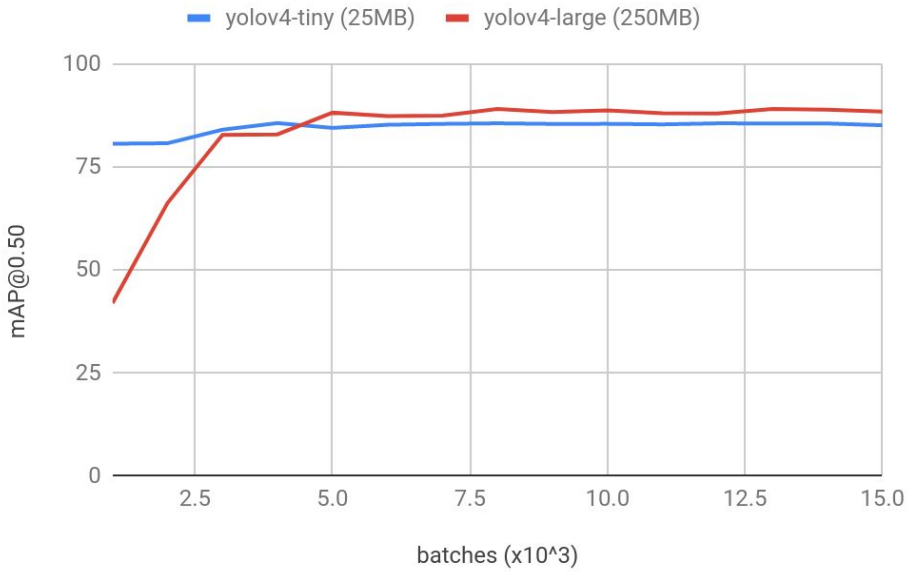
- 60.000 images
- Hybrid labelling

Model: YOLOv4-tiny

- 0.83 mAP@0.50
- 400 FPS on Tesla P100

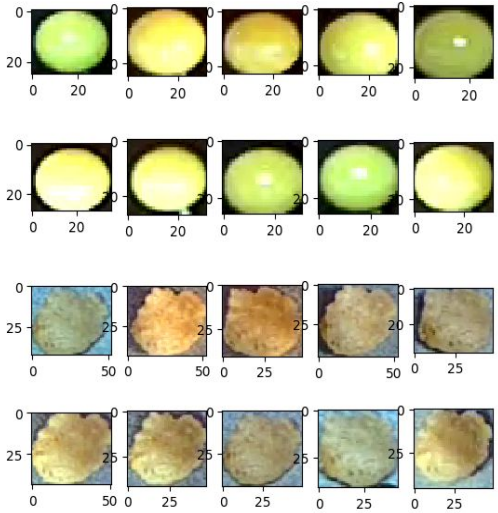




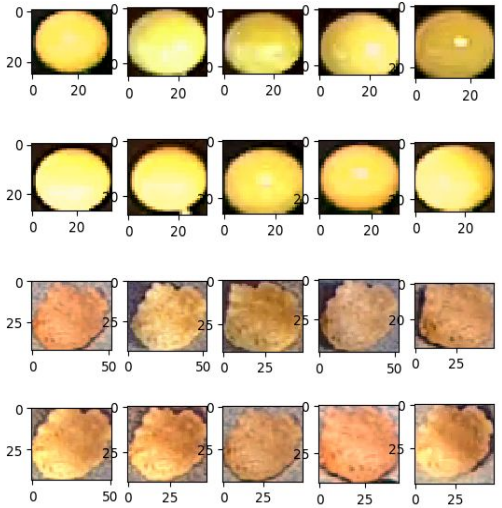


Color detection

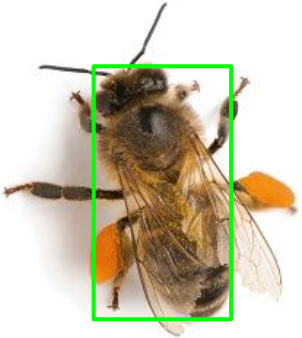
Clustering pollen after color normalization



Normalizing



Complete Pipeline Summary



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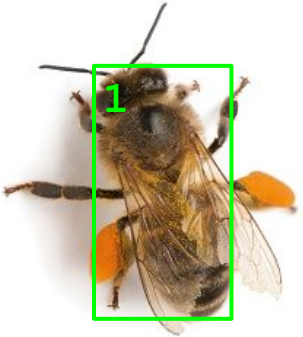

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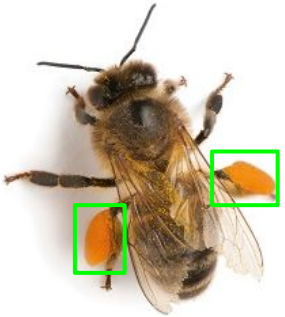

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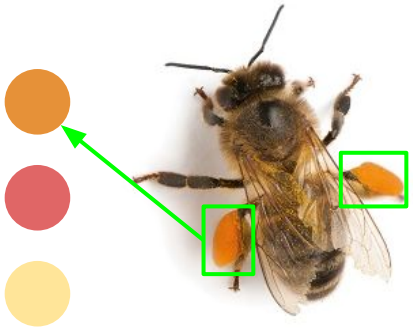

4) Pollen clustering

Project takeaways

- Simple models worked better than MultiNet
- Automated labeling was time-intensive
- Containerizing deployment simplified experiments

https://en.beelivingsensor.org/