Bush Detection for Vision-based UGV Guidance in Blueberry Orchards: Data Set and Methods

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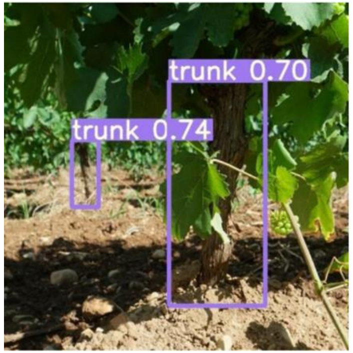
Introduction

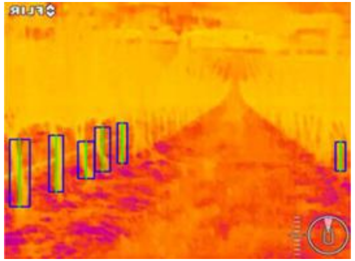
FLEXIGROBOTS (Horizon 2020)

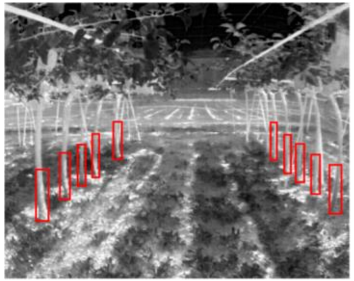
- Application of unmanned ground (UGV) and aerial vehicles(UAV) in agriculture
- Blueberry orchard monitoring in Serbia and Lithuania

Motivation:

- Bush detection is important in agriculture and forestry
- As far as we know, bush detection is an unexplored area
- The focus is mostly on trunk detection

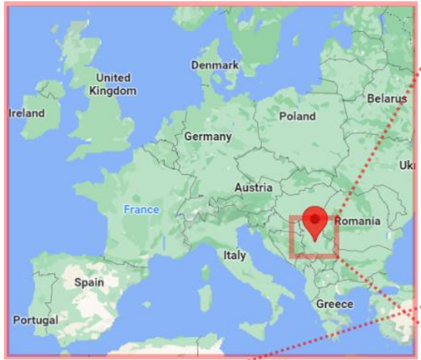


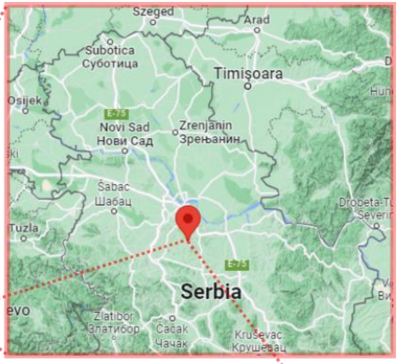




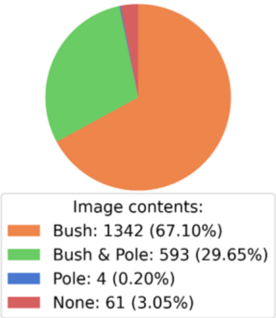
Data set - acquisition

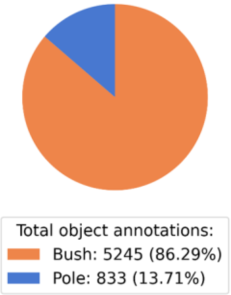
- Location: Babe, Serbia
- Robot platform “Gari”
- Total number of images: 2000
- OAK-D camera
- Modality - RGB images





Data set - description





- 20 image sequences that simulate UGV movement
- Objects important for guidance - bushes and poles

Sample sequence - translation

Sample sequence - rotation

Data set - variability

Scene variability (fig 4):

Good dataset needs to capture variability of real life conditions…

- Bush shape
- Pole types
- Contrast and shadows
- Occlusions
- Background (no objects)
- Irregular scenes (height, angle, out of context objects)

Limitations:

- Dataset is captured in one orchard, daylight, during the season… no night, snow etc.

Variation in bush shape: from young, sparse, and thin to mature, dense, and spread out

Different types of obstacles: hail netting pole, bumblebee hive legs, and lamp posts

Variation in contrast and shadows: from light and diffuse to dark and opaque

Various occlusions: different types of weeds and branches obstructing the bush

Data set - Labeling procedure

- Undefined object borders (unlike cars, dogs, and simpler objects)
- Focus on plant base (triangular shape, contact with ground…)
- Differences between 10 annotators
- Initial model trained on 400 images for pseudo labeling
- Semi-autonomous labeling, to make the labels converge
- Relabeling and manual correction on the rest of the dataset

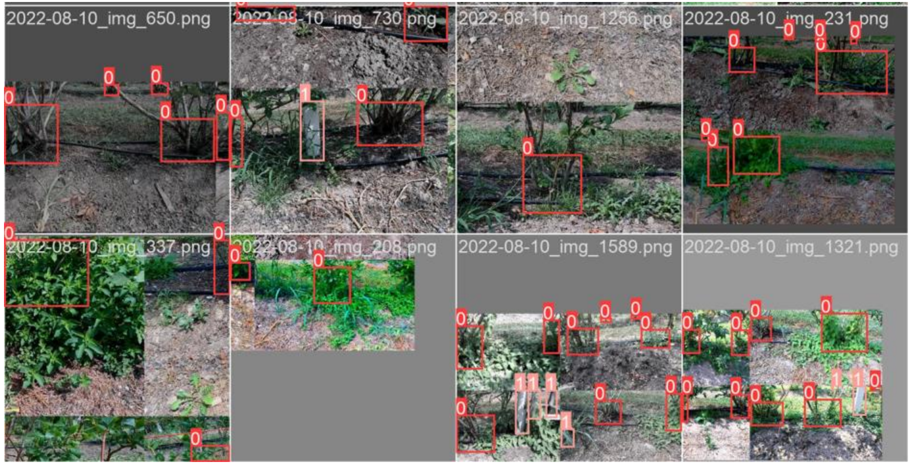
Difference in annotations between 5 different annotators (final labels shown in solid lines, individual annotations in dotted lines)

Baseline methods

YOLOv5 🚀 model is used in 3 complexity levels: nano, small, and medium

Dataset split based on sequences to prevent leakage, train val test = 75/10/15 %

Augmentation: horizontal flipping, HSV scaling, and mosaic augmentation



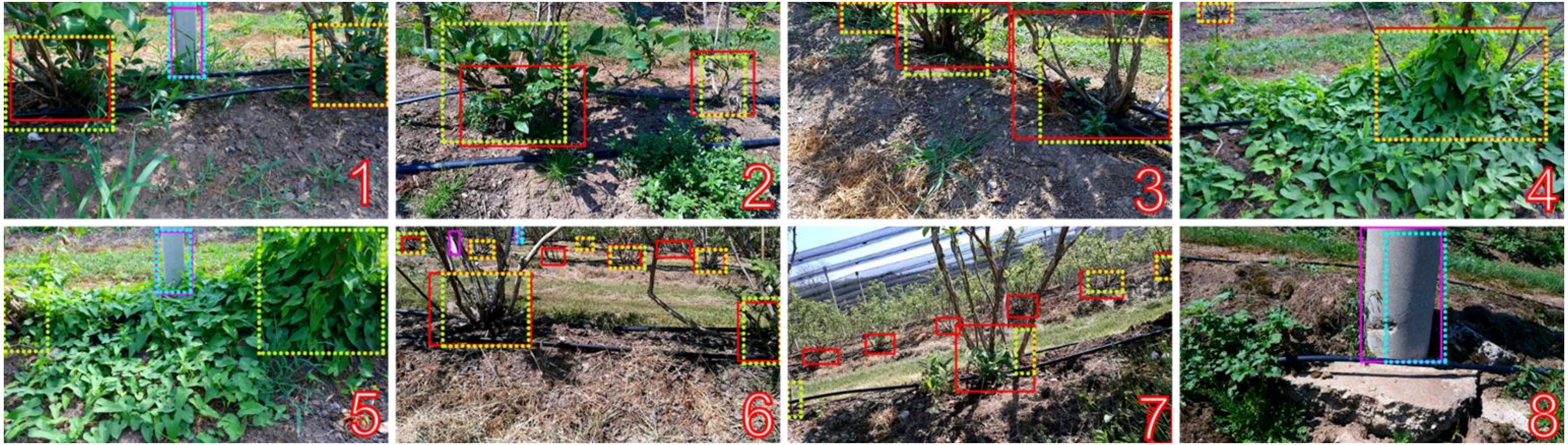
Baseline results - quantitative

Results showed that trained models achieved promising performance during evaluation on the considered task, thus setting a good basis for further work on improving the performance on the task of blueberry bush detection

Model	All				Bush				Pole				Param count	Latency [ms]
	P	R	mAP 50	mAP 50-95	P	R	mAP 50	mAP 50-95	P	R	mAP 50	mAP 50-95		
YOLOv5n	0.940	0.790	0.859	0.440	0.927	0.840	0.912	0.479	0.954	0.740	0.805	0.401	1.7M	96.4
YOLOv5s	0.892	0.800	0.873	0.472	0.882	0.871	0.909	0.500	0.903	0.730	0.838	0.444	7.0M	179.8
YOLOv5m	0.930	0.797	0.872	0.489	0.935	0.860	0.924	0.510	0.924	0.735	0.820	0.467	20.8M	313.2

Baseline results - qualitative

- Large number of instances detected correctly
- Good detection of occluded bushes, overperforming the labels
- Trouble with far, small detections and rotations
- Promising model performance in most cases, including shadows, weeds, and occlusions (ex. 1-4); trouble with ambiguity in annotations, far away objects and image rotation (ex. 5-7); good generalization abilities with unseen objects (ex. 8); detection speed suitable for real-time applications.



Conclusions and future work

- We proposed new data set for bush detection task
- It is possible to use YOLOv5 models for bush detection
- Models achieved promising metrics, setting a good basis for further work
- Dataset improvement, more images, more augmentations, further result analysis…

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