

AppleGrowthVision: A large-scale stereo dataset for phenological analysis, fruit detection, and 3D reconstruction in apple orchards

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Contributions

1. Heterogeneous dataset to improvements of 28% in apple detection accuracy
2. State-of-the-art BBCH growth stage prediction across all macro growth stages with > 95% accuracy
3. 3D Reconstruction pipeline for sparse-data reconstruction of orchards

1. Motivation

- ❑ State-of-the-art Datasets for Apple Detection are very homogenous regarding weather, lighting, seasonal changes
- ❑ Data requirements for robust models for reliable crop management and surveillance are not met
- ❑ Lack of Growth Stage Annotations
- ❑ Only Monocular Images available

3. Apple Detection

How does AppleGrowthVision (AGV) improve detection accuracy when combining it with MinneApple (MA) [1] and Monastery Apple Dataset (MAD) [2]?

AP: Avg Precision
AR: Avg Recall
mAP@0.5: Mean AP at IoU of 0.5

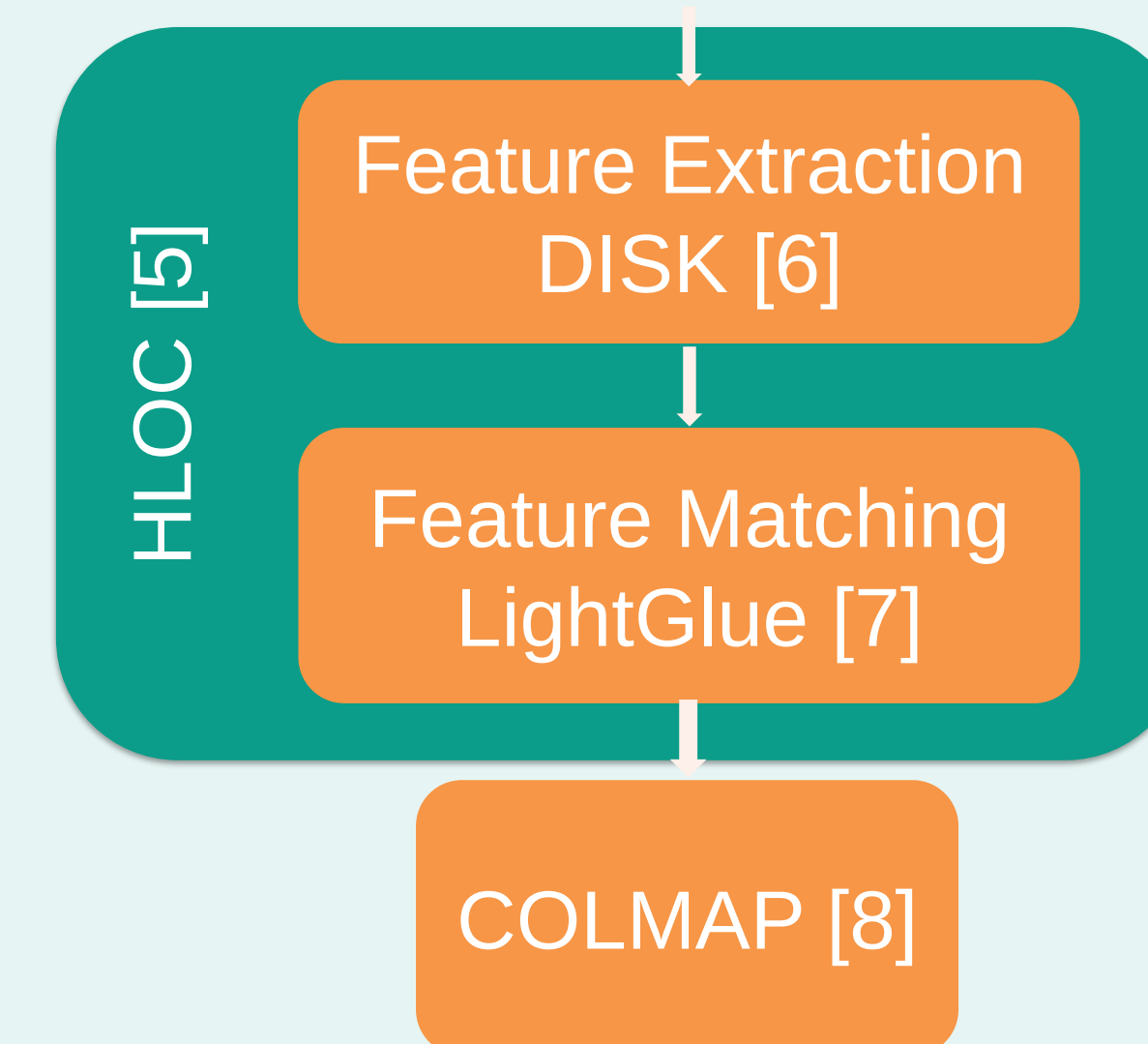
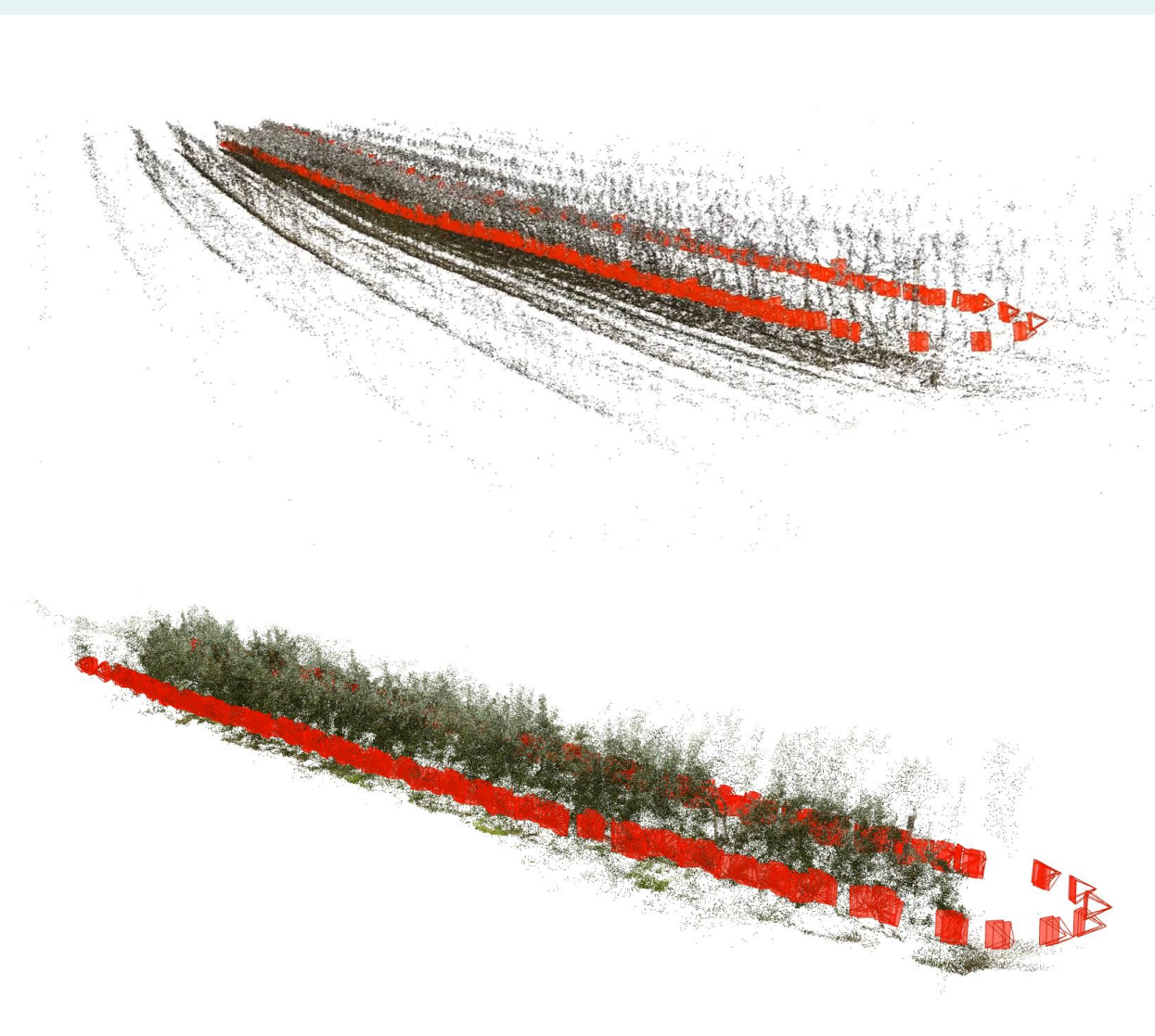
YOLOv8 [3]	AP	AR	mAP@0.5	F1
MA	.841	.637	.753	.715
MA + MAD	.81	.716	.805	.76
MA + AGV	.822	.701	.793	.757
MA + AGV + MAD	.811	.733	.81	.77

Faster R-CNN [4]	AP	AR	mAP@0.5	F1
MA	.766	.613	.694	.681
MA + MAD	.564	.497	.47	.668
MA + AGV	.789	.639	.721	.706
MA + AGV + MAD	.743	.648	.668	.692



4. Multi-View Stereo Reconstruction

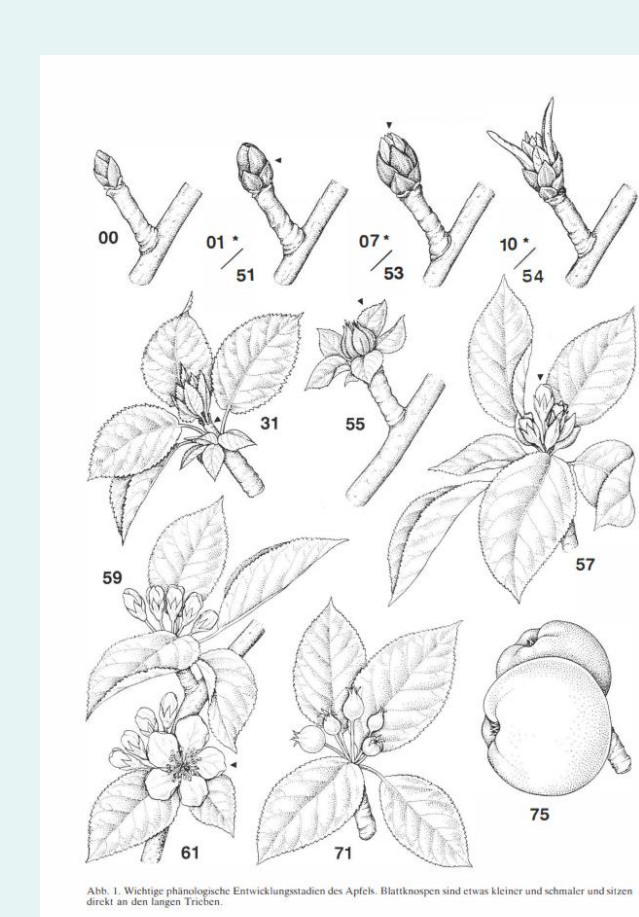
- ❑ Sparse Calibrated Stereo images
- ❑ Enables automated phenological measure and growth monitoring



2. Dataset Characteristics

Brandenburg	Saxony
9,317 high-resolution stereo images	1,210 smartphone images
6 BBCH growth stages	3 BBCH growth stages
1 growth cycle	2 growth cycles
3,293 annotated apples	31,084 annotated apples
18 occasions in 2022	5 occasions in 2023, 1 in 2024

5. BBCH Classification



[9]

BBCH macro stages

- | | |
|---------------------------|-------------------------------------|
| 0 Bud development | 6 Flowering |
| 1 Leaf development | 7 Development of fruit |
| 3 Shoot development | 8 Maturity of fruit and seed |
| 5 Inflorescence emergence | 9 Senescence, beginning of dormancy |

Model	Acc	AP	AR	F1
VGG16 [9]	.988	.988	.988	.988
ResNet152 [10]	.997	.997	.997	.997
DenseNet201 [11]	.999	.999	.999	.999
MobileNetv2 [12]	.999	.999	.999	.999

6. Conclusion

- ❑ Novel, large-scale dataset for advancing precision farming
- ❑ high-resolution calibrated stereo images over an entire growth cycle with expert-validated BBCH growth stages
- ❑ Outperforms state-of-the-art apple detection models
- ❑ high-precision prediction of principal BBCH growth stages
- ❑ Pipeline for sparse multi-view reconstruction for orchard scenes

