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SEMANTICSUGARBEETS: A MULTI-TASK FRAMEWORK AND DATASET FOR INSPECTING HARVEST AND STORAGE CHARACTERISTICS OF SUGAR BEETS

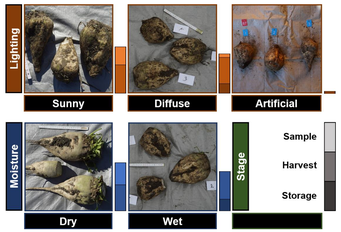
https://github.com/semanticsugarbeets/semanticsugarbeets

SemanticSugarBeets Dataset

Designing a **multi-task dataset** for automating the visual quality assessment of **post-harvest** and **post-storage sugar beets**

Image Acquisition

- Monocular **RGB** images
- Three processing **stages**
  - Manually **Sampled**
  - Mechanically **Harvested**
  - After 90-day **Storage**



Stage	Loc	Rec	Img	Beets	B/I	Ratio
Sample	A	5	209	717	3.4	24.6
Harvest	B|C|D	3	601	1803	3.0	61.7
Storage	E	2	143	400	2.8	13.7
	5	**10**	**953**	**2920**	**3.1**	

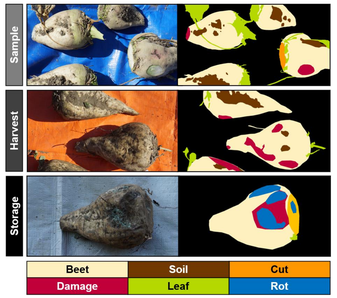
Table 1. Dataset statistics for individual **Stages** including capturing **Loc**ations, numbers of **Rec**ording sessions, **Img**es and **Beets**, as well as average **B**eets per **I**mage and **Ratio**s of overall beets in percent.

Meta-Annotation

- Five recording **locations**
- **Lighting** conditions and sugar-beet **moisture**
- Two types of reference objects for **absolute scale**

Semantic Annotation

- Six relevant **label classes** for semantic segmentation
- Derived **beet-instance annotations**
- First **semantic-segmentation dataset** for visual inspection of sugar beets

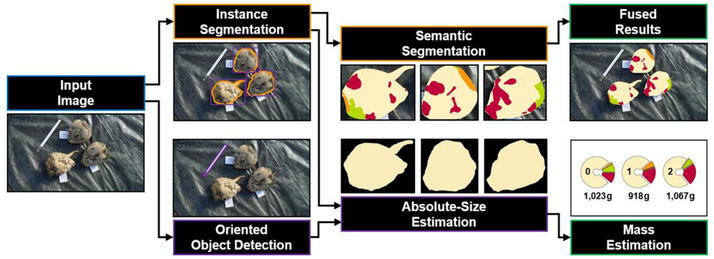


Methodology and Evaluation

Introducing a two-stage approach for **detecting** and **segmenting** sugar-beet instances combined with **absolute size** and **mass estimation**

Learning Tasks

- **Instance segmentation** for coarse sugar-beet detection
- **Semantic segmentation** of each instance
- **Oriented object detection** for reference markers of known size

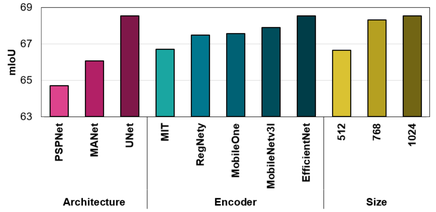


Beet Delineation

- Instance segmentation with multiple **variants** of **YOLO11**
  - Best **mAP$^{50-95}$** of **98.8**

Beet Segmentation

- Model ablation
  - Three **architectures**
  - Five **encoders**
  - Three **input sizes**



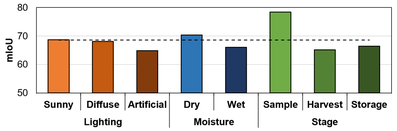
- Best **mIoU** of **64.0** for **U-Net**, **EfficientNet** and input size **1024** pixels

Impact of Environmental and Beet Conditions

Analyzing the best-performing semantic-segmentation model in varying **scenarios** and processing **stages**

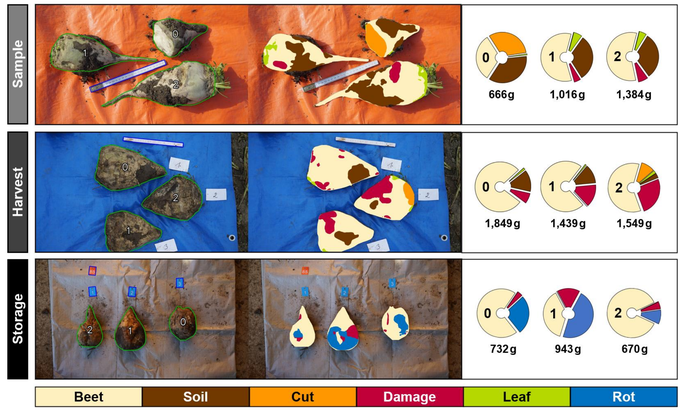
Performance Analysis

- **Artificial lighting** and **wet soil** are most challenging



Results and Conclusion

Proof-of-concept pipeline produces **accurate segmentation** of beet areas as well as **plausible mass estimates**



Outlook

- Adding further real and semi-synthetic **scenarios** and **backgrounds**
- Adapting to other **agricultural crops** and additional **sensor modalities**