

Reporting Progress on

Semantic segmentation of agricultural parcels

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Date:
December 20, 2023



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Objectives

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Part 1:

Understanding

Semantic
segmentation of
agricultural parcels

Importance of satellite based land survey

- Crop mapping can be used to allocate fair subsidies for the produce.
- Land use planning.
- Water management.
- Weather and environment monitoring.
- Insurance and risk mitigation.
- Crop health and yield prediction.
- Help sustainable goals of government.

Objectives

01

Semantic segmentation:

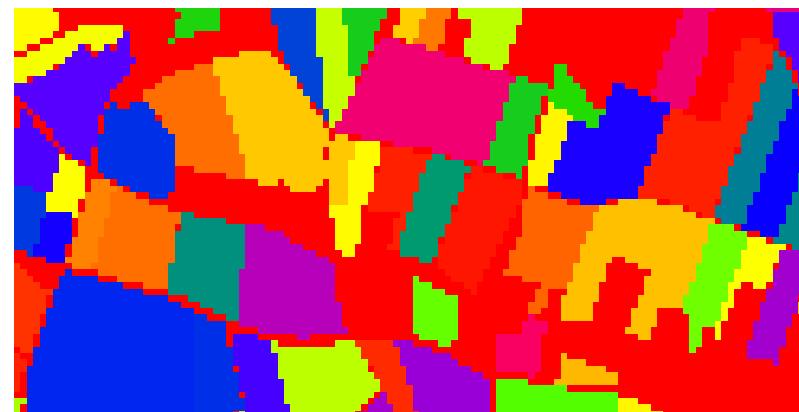
Classification of land pixels to distinct agricultural crop classes



02

Instance Segmentation:

Tracking each distinct agricultural land pixel.



03

Spatio-temporal understanding:

Delineates the land parcels using temporal information



Features

1

2433 patches with time-series, containing 18 distinct crop classes, 1 void, and 1 background class. Resolution 10m/pixel

2

Pixels not within the extent of any declared parcel are treated as background class.
Out-of-scope land pixels are treated as void class.
Performance metric does not account for these classes

3

Each time-series feature has a semantic and instance label.
Class imbalance among the crop types.
Occlusion due to cloud.

Semantic Segmentation



- Pixel-wise classification to one of the 20 classes.
- Semantic segmentation cannot count the number of instances of each class.
- Metrics used include Intersection over Union (IoU), and confidence metric.
- Commonly used models for semantic segmentation include U-Net and SegNet.

Instance segmentation

- It can detect each instance of a class and assigns it an unique identifier.
- For example it can detect Sunflower-1 and Sunflower-2 keeping a count on detected instances.
- Average precision metric for testing.
- Some of the models used for instance segmentation include Mask R-CNN, Faster R-CNN, Yolo.



Part 3:

Measurement

Sustainable
Development Goals

Date:
March 20, 2025



Progress Update

Semantic Segmentation

Trained U-NET 3D while used pretrained UTAE models for comparison.

Panoptic segmentation

Tested U-TAE for panoptic using the pre-trained weights.

UNET-3D semantic predictions

Model size ~ 18MB

| UNET TEST | Fold-1 | Fold-2 | Fold-3 | Fold-4 | Fold-5 |
|-----------|--------|--------|--------|--------|--------|
| Accuracy | 80.94 | 81.77 | 81.79 | 80.93 | 81.53 |
| CE Loss | 1.41 | 0.59 | 0.37 | 0.45 | 0.45 |
| Avg IoU | 57.66 | 59.23 | 58.84 | 56.88 | 58.94 |
| Time | 40.14 | 37.47 | 43.7 | 41.11 | 40.84 |

UTAE semantic predictions

Model size ~ 13MB

| UTAE-Sem | Fold-1 | Fold-2 | Fold-3 | Fold-4 | Fold-5 |
|----------|--------|--------|--------|--------|--------|
| Accuracy | 83.08 | 84.10 | 83.29 | 82.78 | 83.74 |
| CE Loss | 0.5 | 0.47 | 0.5 | 0.51 | 0.47 |
| Avg IoU | 62.37 | 65 | 60.01 | 61.59 | 65.39 |
| Time | 230.16 | 224.59 | 224 | 223.24 | 227.82 |

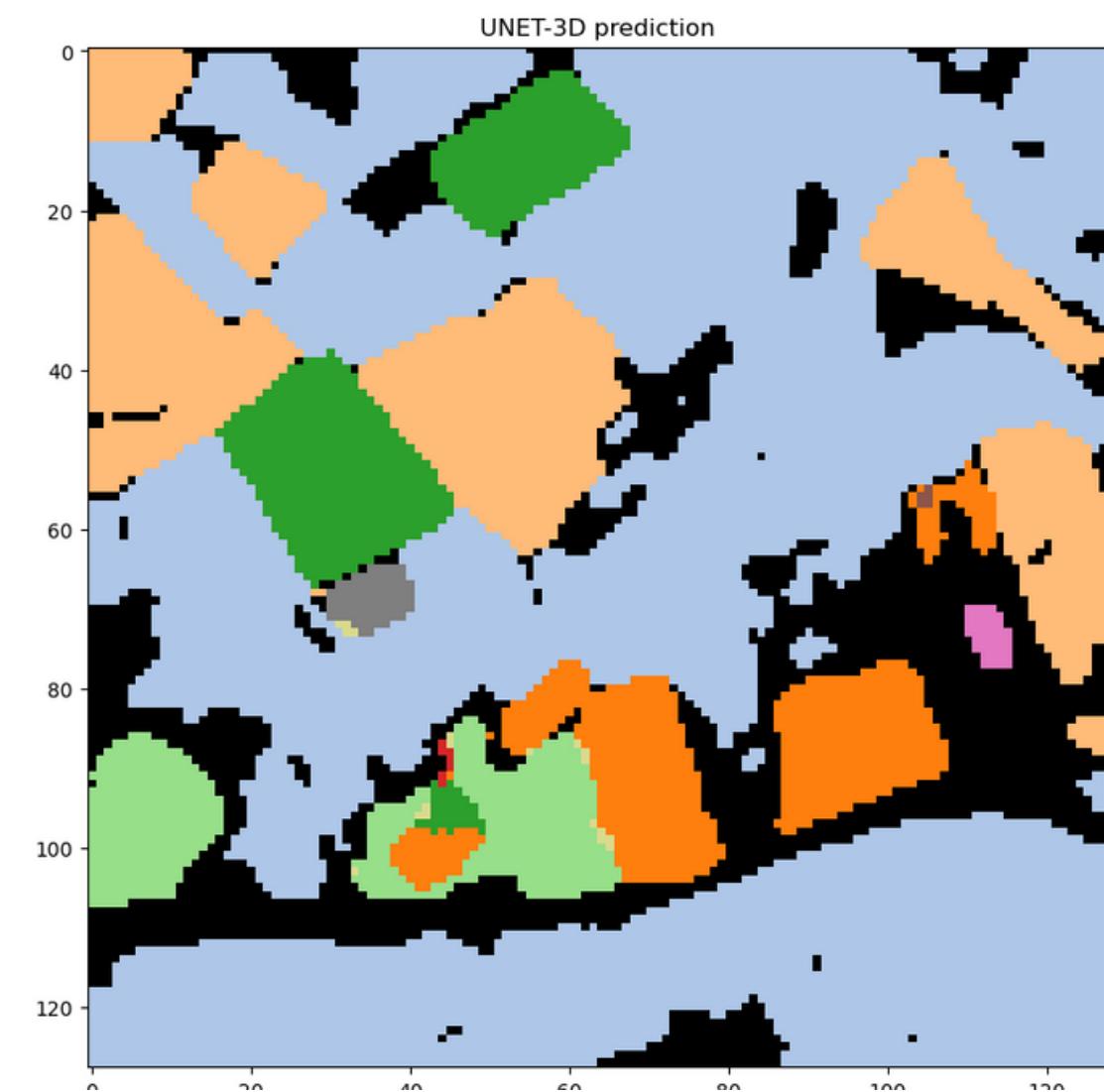
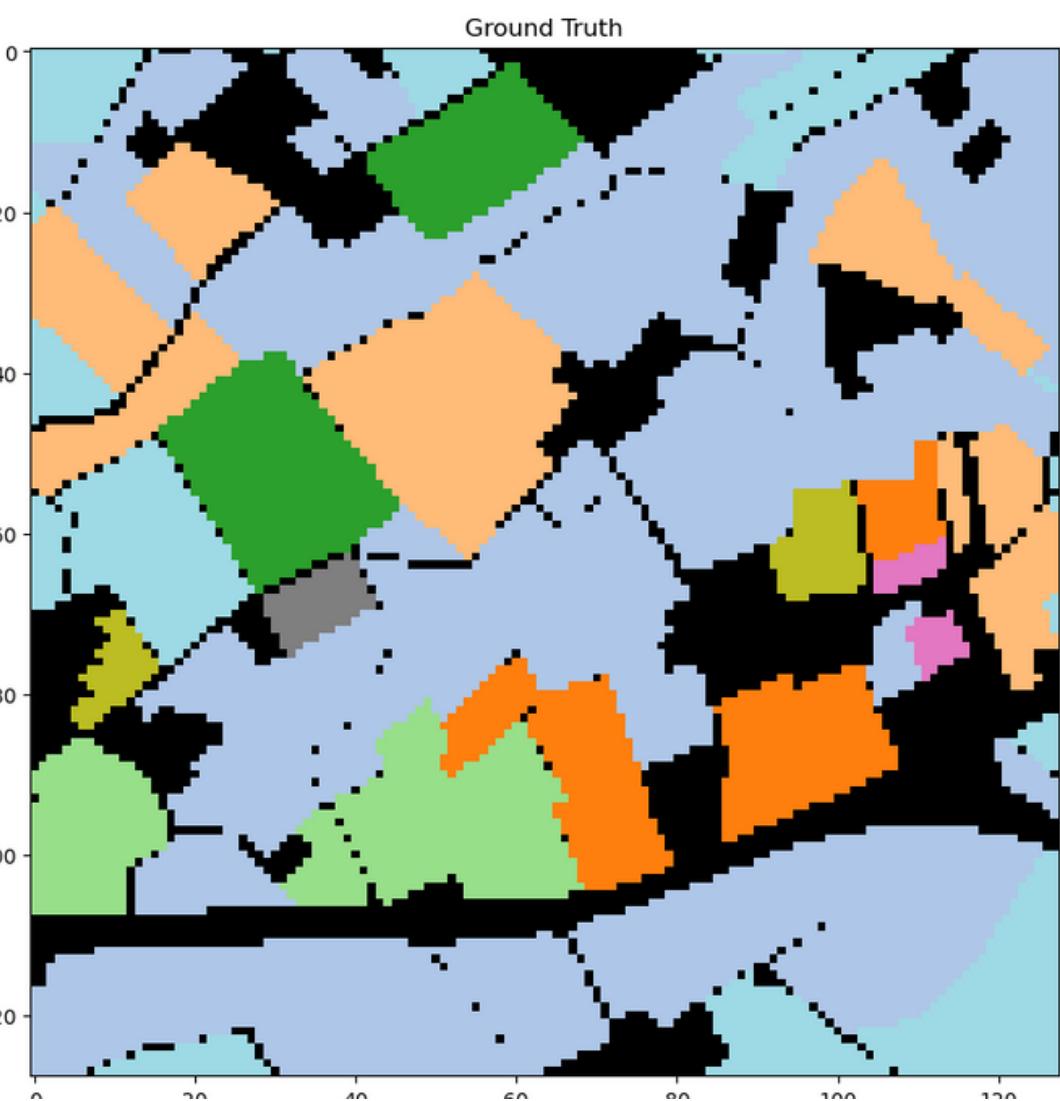
UTAE panoptic metrics

Model size ~ 15MB

| UTAE-PAP | Fold-1 | Fold-2 | Fold-3 | Fold-4 | Fold-5 |
|-------------|--------|--------|--------|--------|--------|
| PaP Loss | 7.87 | 7.59 | 8.08 | 7.52 | 7.78 |
| Center loss | 4.93 | 4.77 | 5.24 | 4.82 | 4.95 |
| Size loss | 0.99 | 0.95 | 0.95 | 0.97 | 0.95 |
| Shape loss | 0.54 | 0.54 | 0.54 | 0.54 | 0.54 |
| Class loss | 1.39 | 1.31 | 1.34 | 1.18 | 1.32 |
| Time | 298.58 | 326.93 | 293.65 | 320.43 | 341 |
| SQ | 0.81 | 0.81 | 0.82 | 0.821 | 0.81 |
| RQ | 0.48 | 0.5 | 0.47 | 0.496 | 0.49 |
| PQ | 0.39 | 0.41 | 0.39 | 0.41 | 0.4 |

UNET-3D Observations

- UNET-3D is not good at segmenting smaller regions.
- UTAE is better than UNET-3D for delineating the smaller regions.
- Inference time is relatively less.



UTAE-PAP Observations

- UTAE segmentation is still less accurate for smaller regions
- Few misclassifications and false detections are also present.
- Inference time on higher end.



References

- UTAE Repo:
- Panoptic Segmentation paper:
- Panoptic vs. semantic vs instance