Automatic Field Boundary Detection

Automatic field boundary detection using AI

Main topics

1	Crop field detection using graph-based image segmentation and contrastive learning
2	Exploring techniques to collect training samples
3	Exploring deep learning models suitable for this application
4	Exploring segmentation methods

Crop field detection using graph-based image segmentation and contrastive learning

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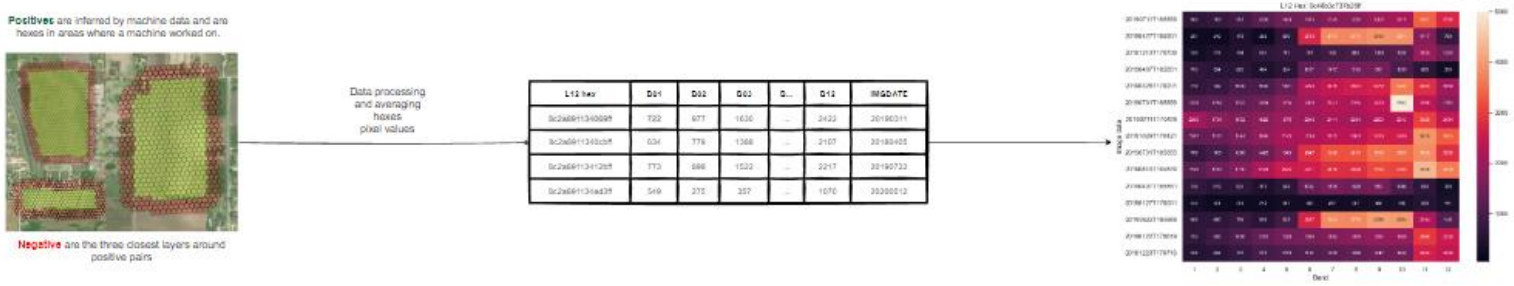
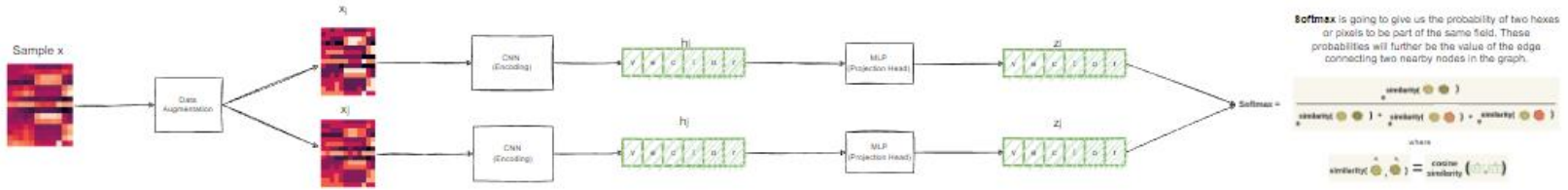
University Advisors: Tiago Almeida (NLP expert), Jurandy Almeida (Image/DL expert)

Crop field detection using graph-based image segmentation and contrastive learning

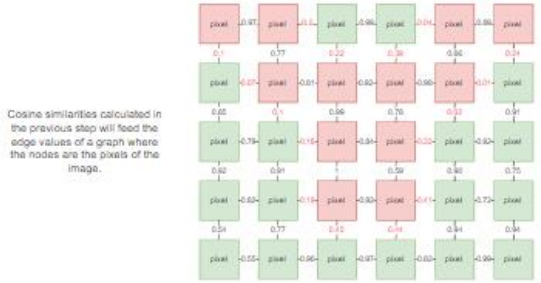
1. Data Processing



2. Contrastive Learning Model Training

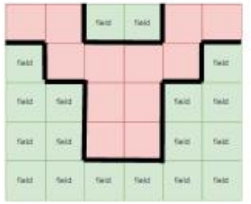


3. Graph-based Segmentation

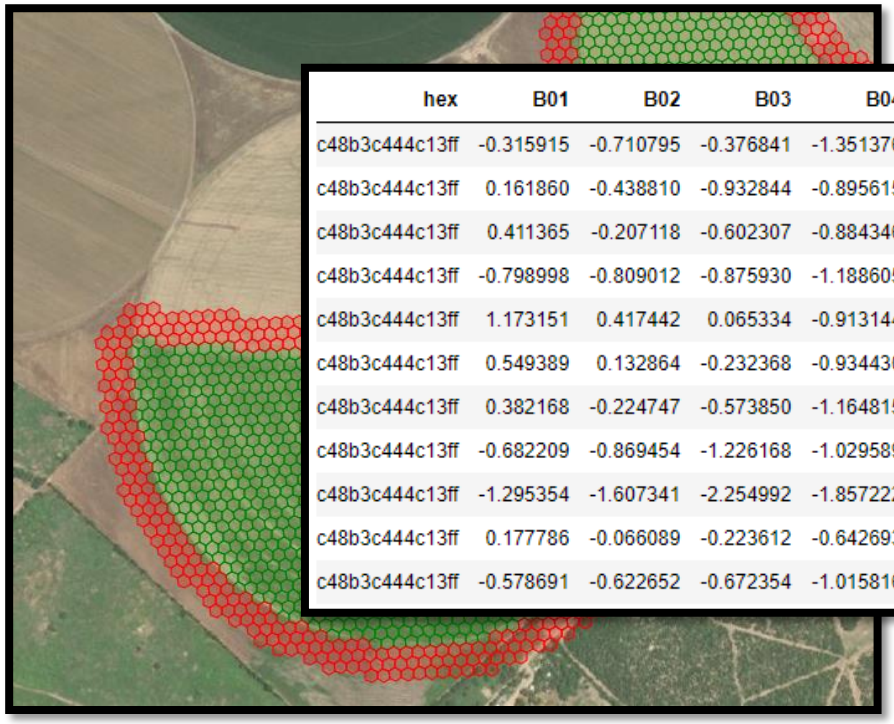


Cosine similarities calculated in the previous step will feed the edge values of a graph where the nodes are the pixels of the image.

Boundaries can be inferred by connecting the edges with lower probabilities. Edges with low probabilities are edges that connect pixels that are not similar, i.e a field and a non field pixel.



Crop field detection using graph-based image segmentation and contrastive learning



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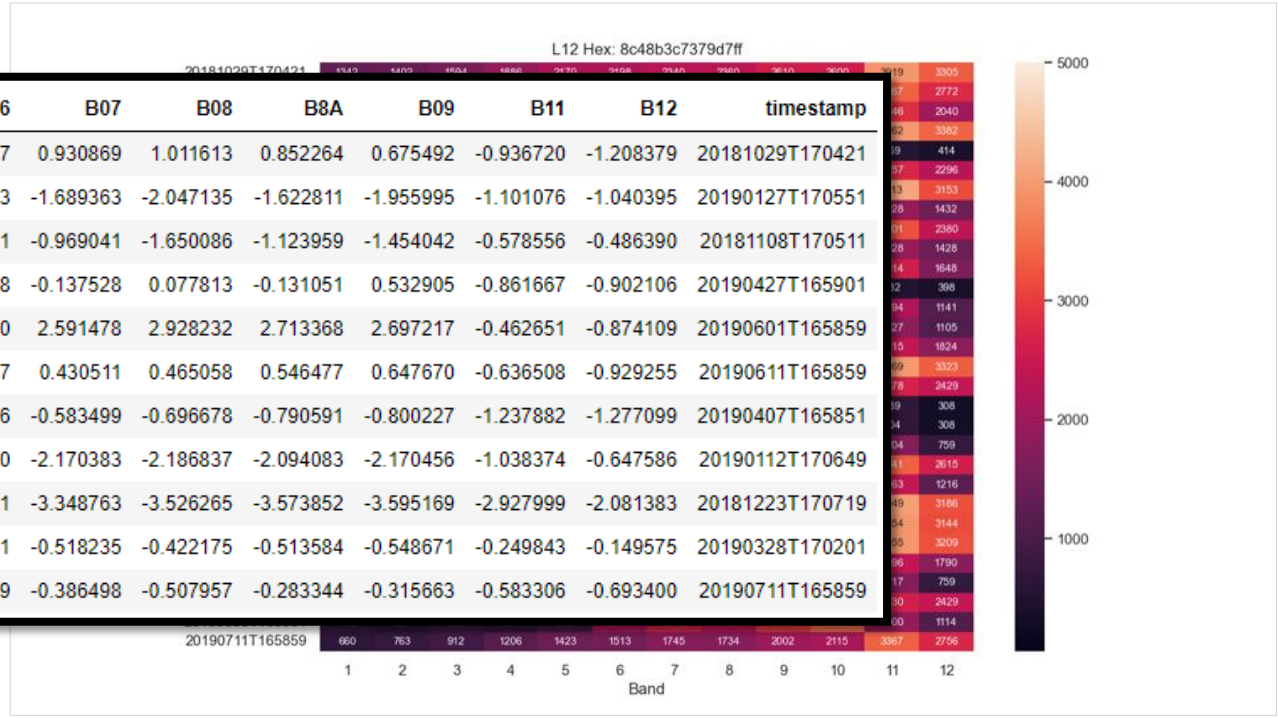

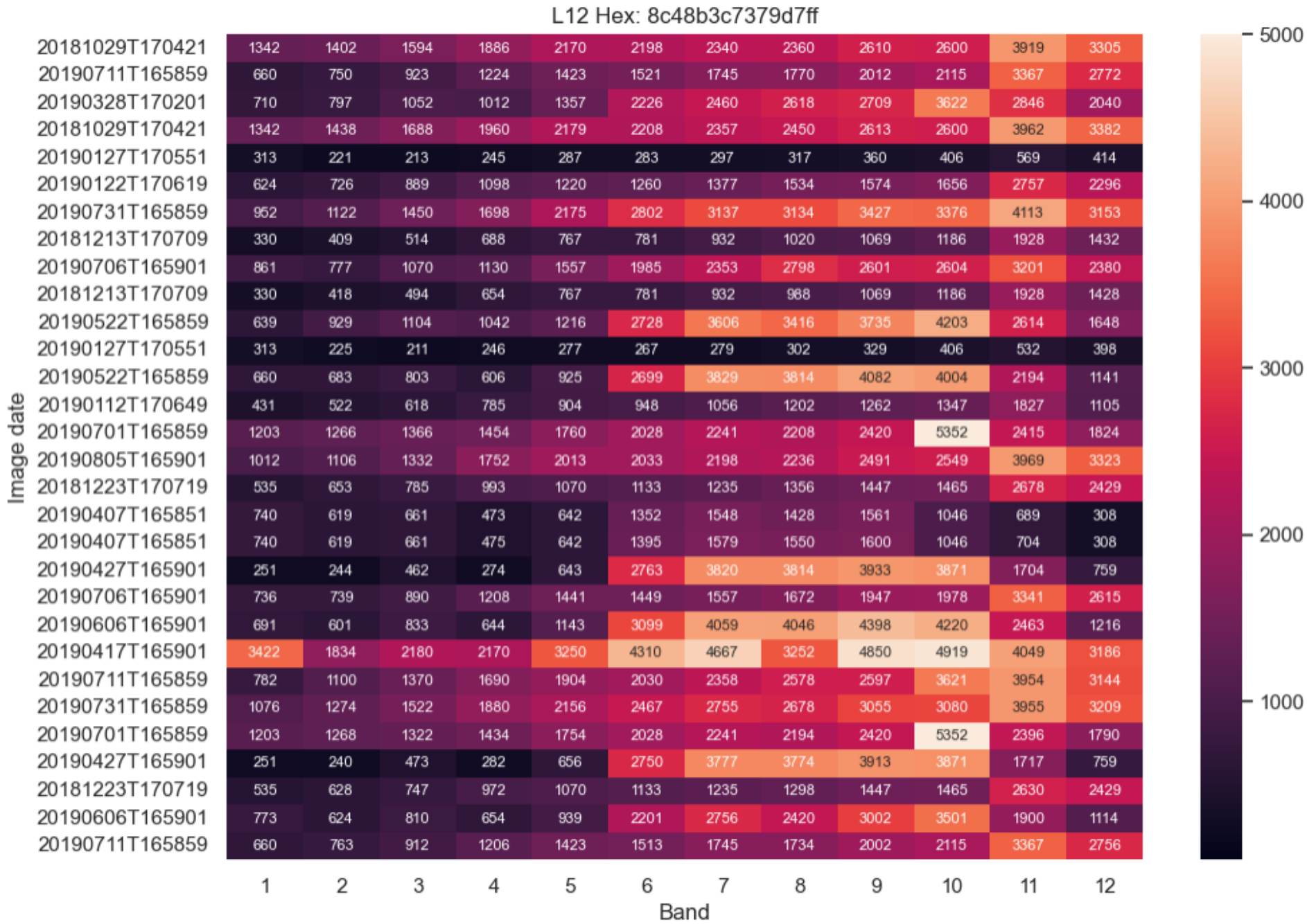
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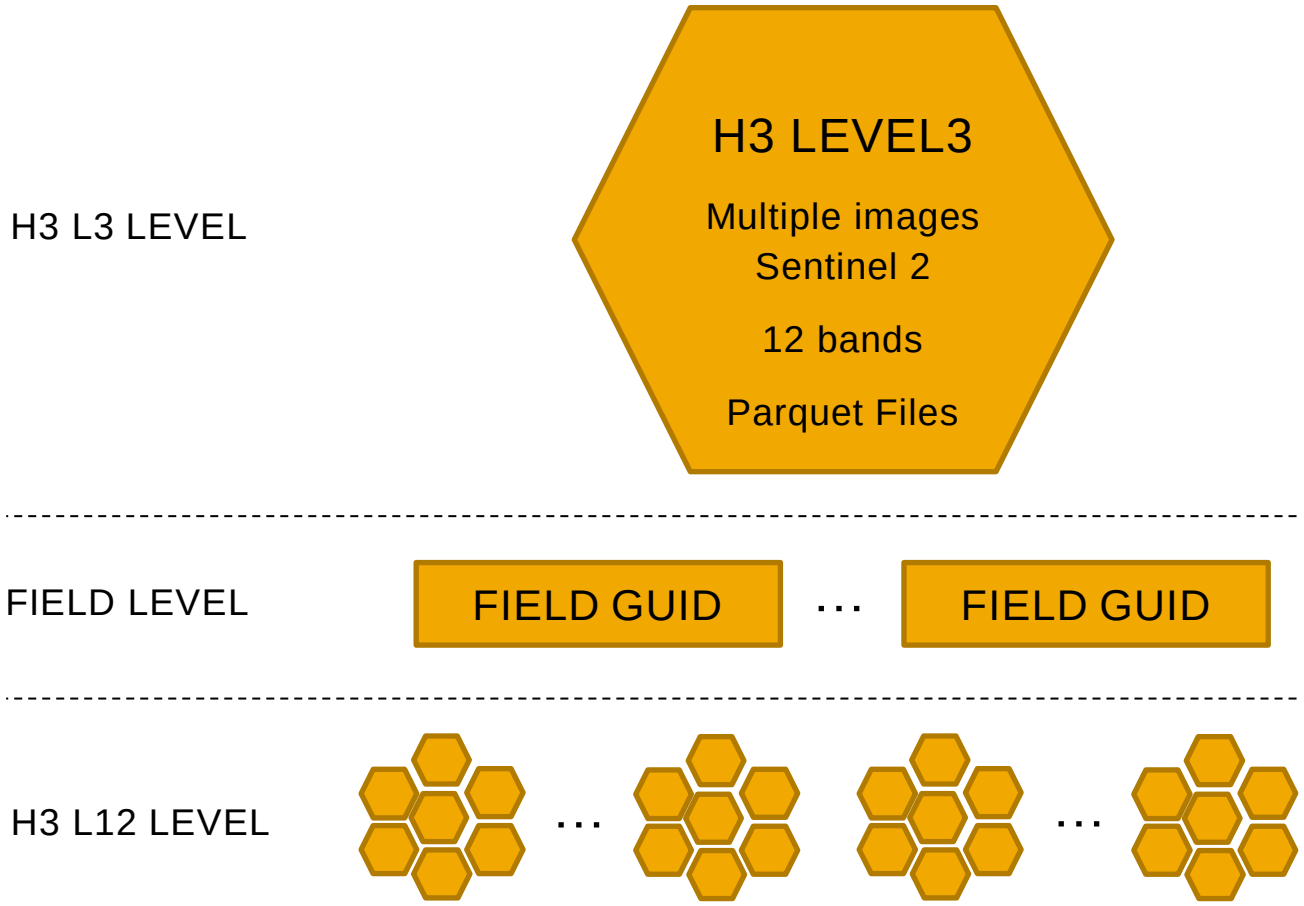
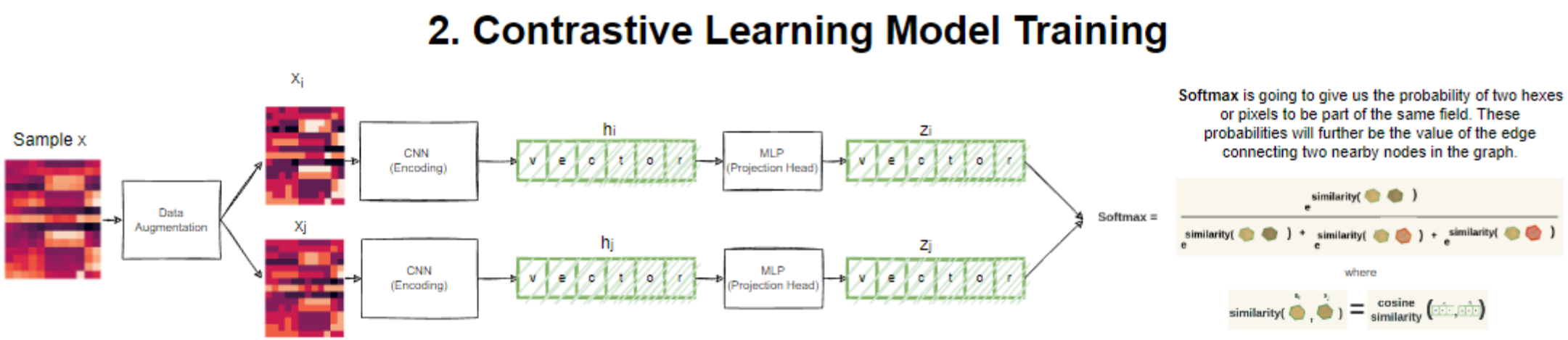
Crop field detection using graph-based image segmentation and contrastive learning

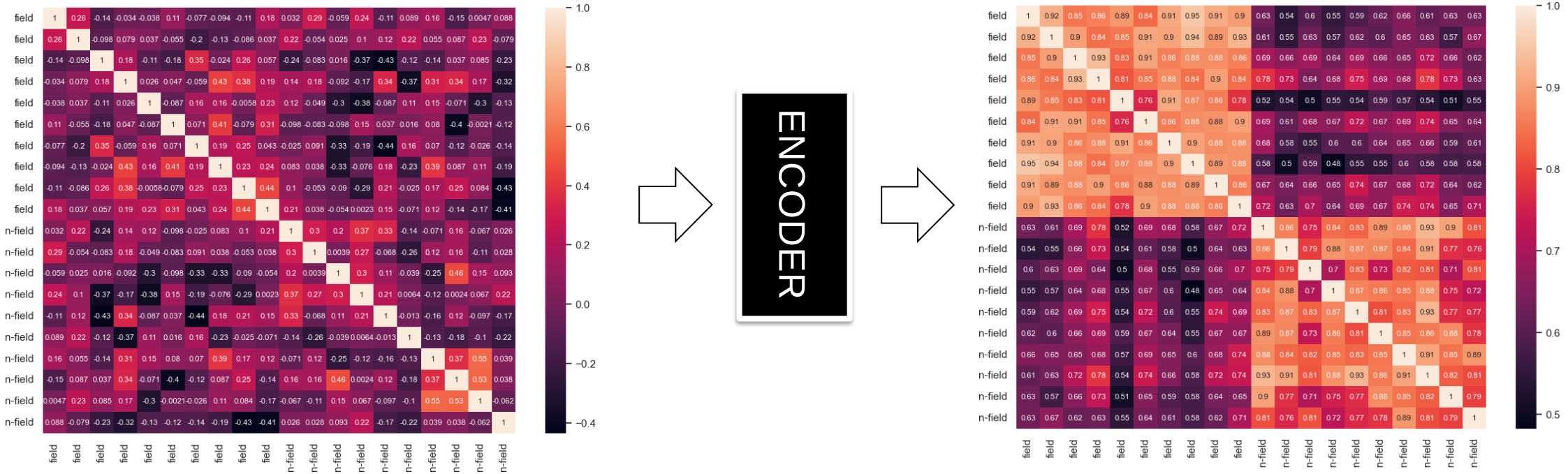


- TensorFlow **tf.data API** to manipulate large datasets.
- Selection of number of images per sample.
- Randomized time series sequence in the samples.
- Selection of number of hexes per field.

Crop field detection using graph-based image segmentation and contrastive learning



Crop field detection using graph-based image segmentation and contrastive learning

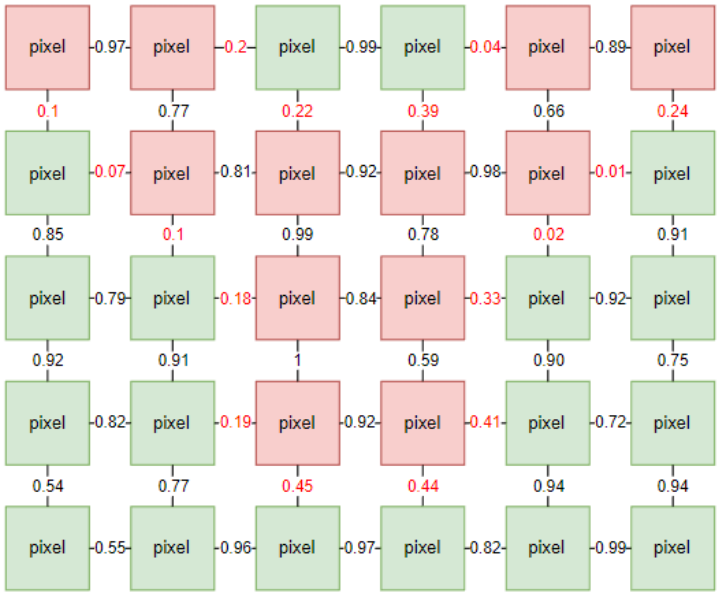


Cosine Similarity Matrix of 10 positive and negative samples

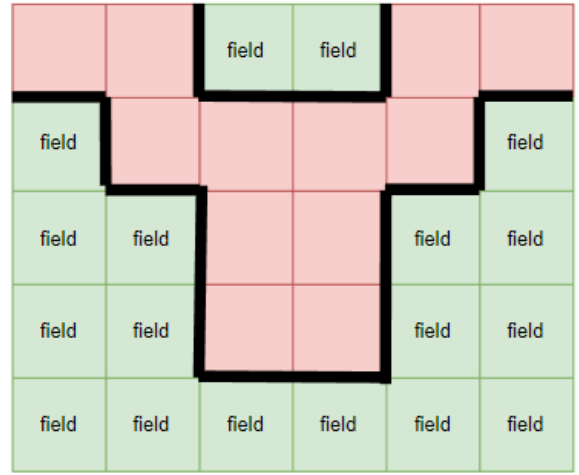
Increase the similarity between samples from the same class while repealing samples from different classes

Crop field detection using graph-based image segmentation and contrastive learning

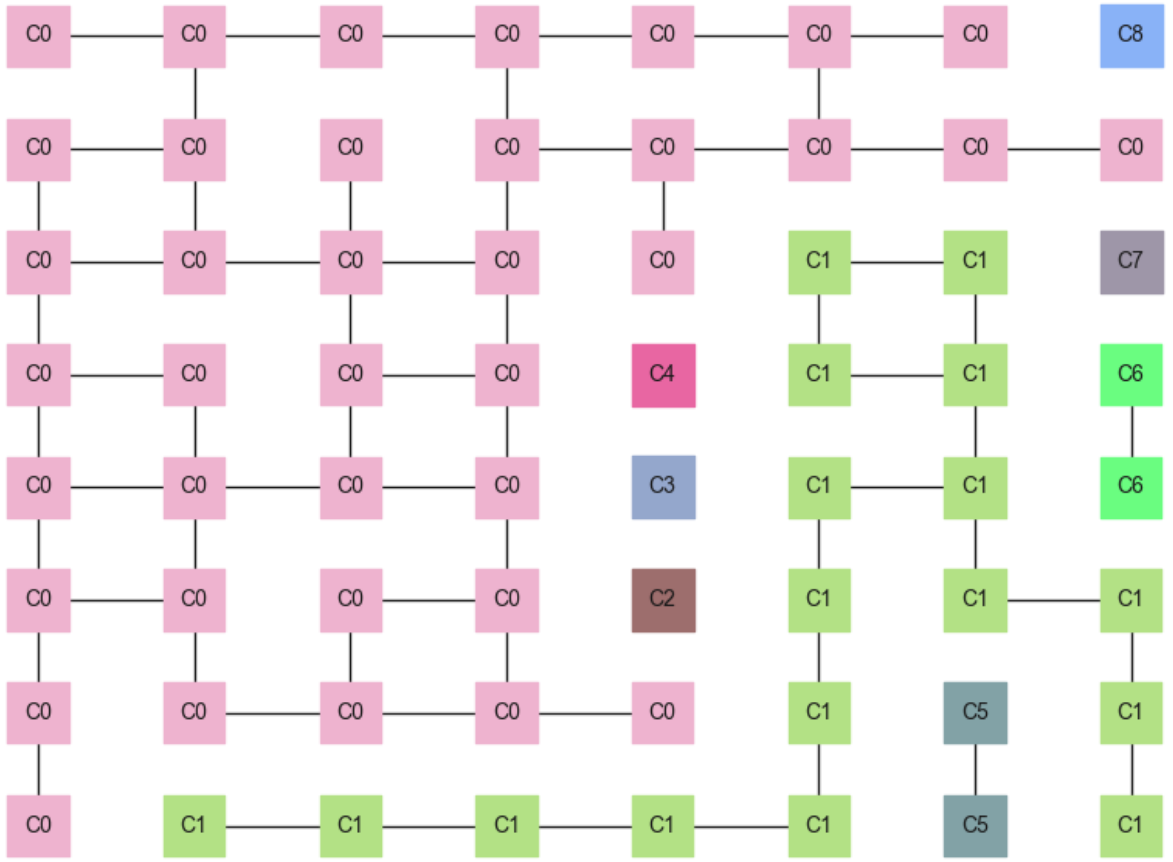
Cosine similarities calculated in the previous step will feed the edge values of a graph where the nodes are the pixels of the image.



Boundaries can be inferred by connecting the edges with lower probabilities. Edges with low probabilities are edges that connect pixels that are not similar, i.e a field and a non field pixel.

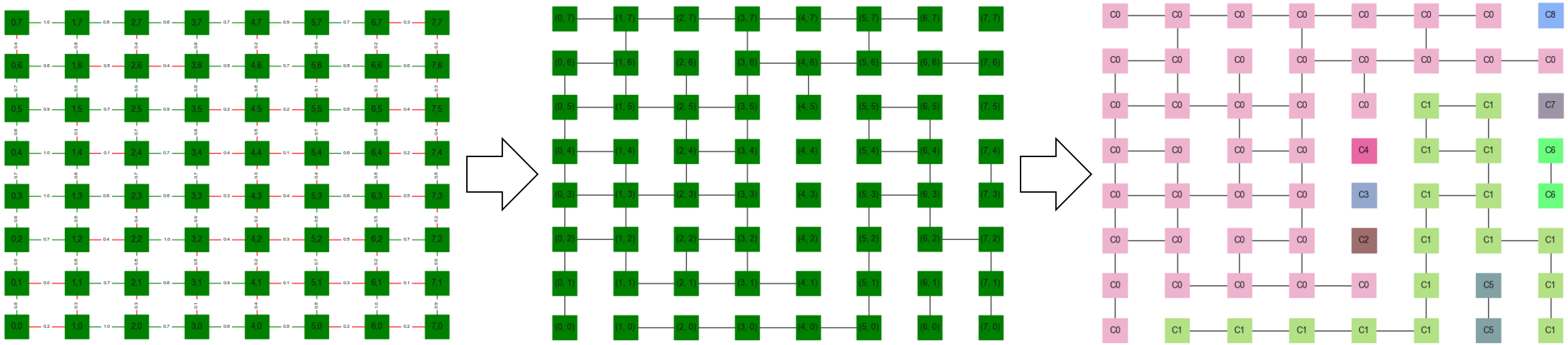


Crop field detection using graph-based image segmentation and contrastive learning



Connected Components

Crop field detection using graph-based image segmentation and contrastive learning



Connected Components

Crop field detection using graph-based image segmentation and contrastive learning

Different methods evaluation

SimCLR

NNCLR

Siamese Triplet Loss

OneClass / Few-shot Classification

Exploring different alternatives

Brainstorm of different approaches that can be used to automatically detect field boundaries

Dataset

Different options to be used to create a dataset with training samples

Field Boundaries created by customers as labels

Evaluation of the quality of boundaries created by customers

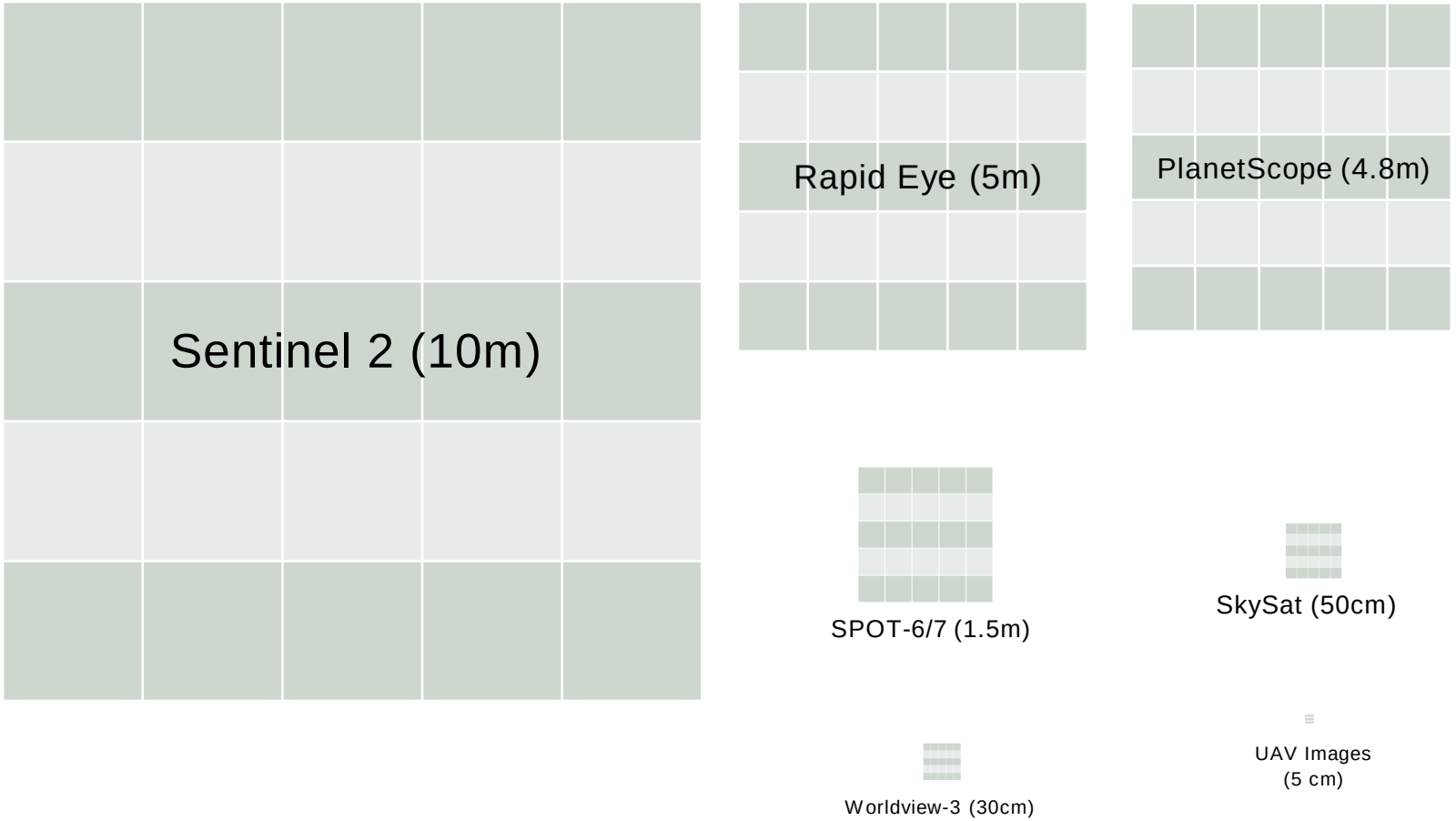
1. Size anomalies

2. Complexity anomalies

There are different approaches to filter inaccurate field boundaries that could be leveraged to use these boundaries for training.

High-Resolution Imagery

Options of high-resolution imagery (5x5) pixels representation

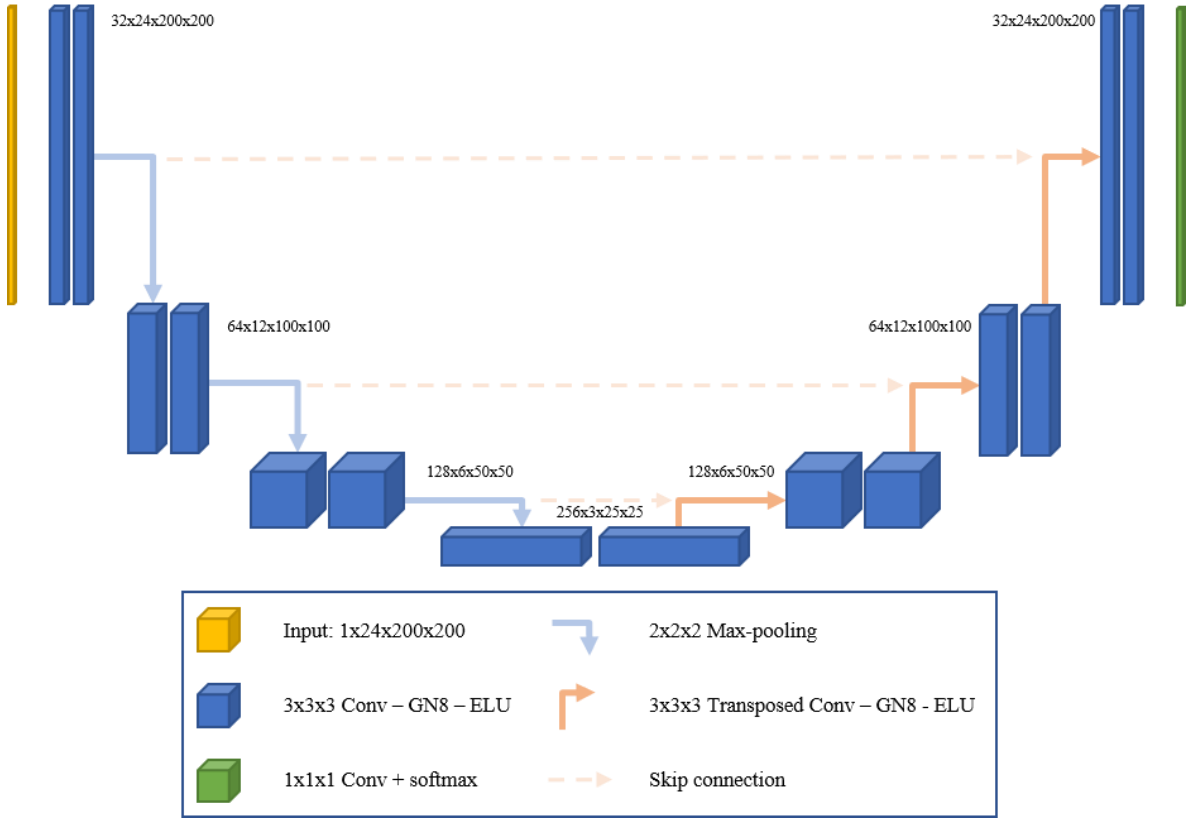


Models

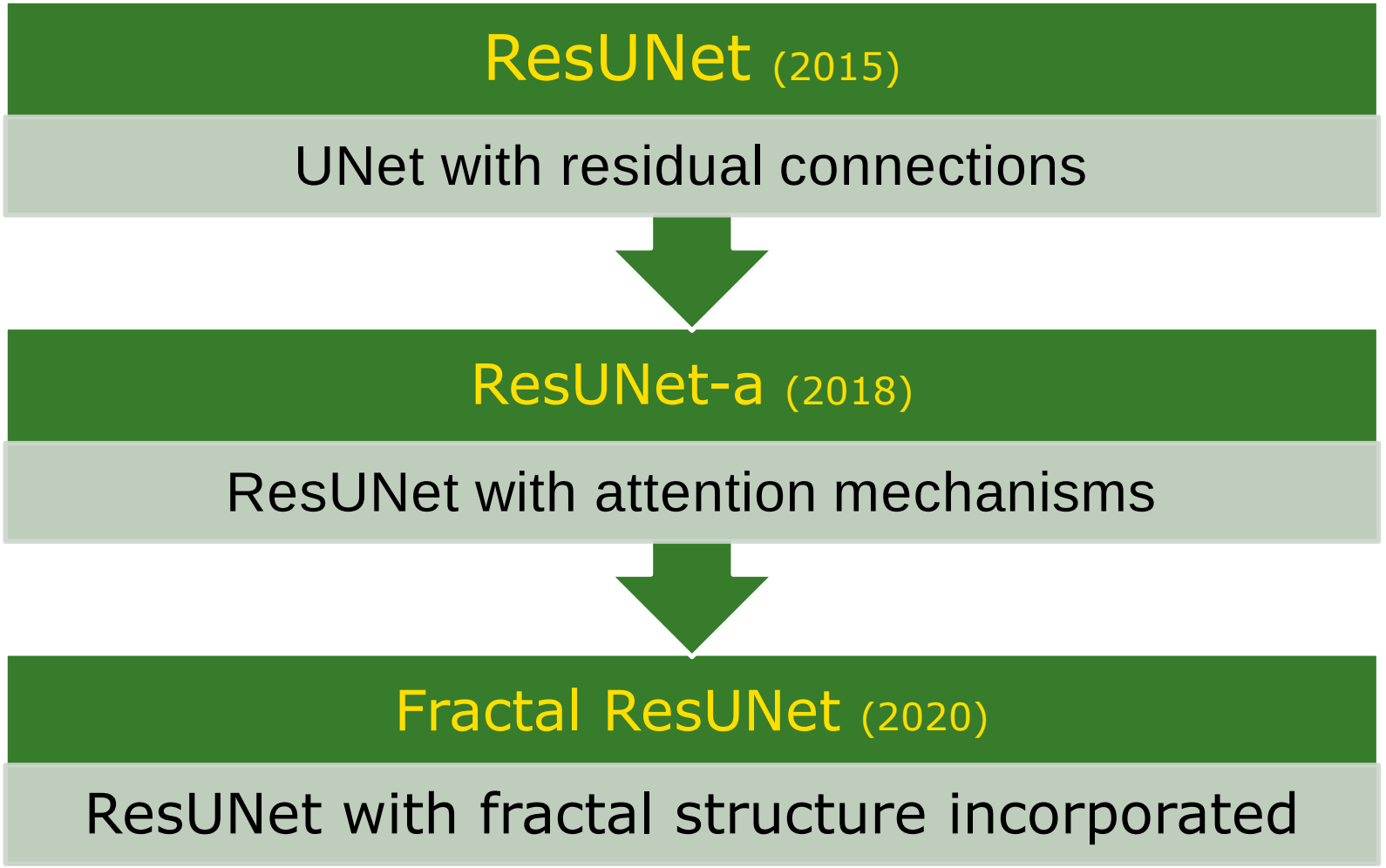
Different options of machine/deep learning models suitable for this application

U-NET (Semantic Segmentation)

Deep learning segmentation originally proposed for medical imaging



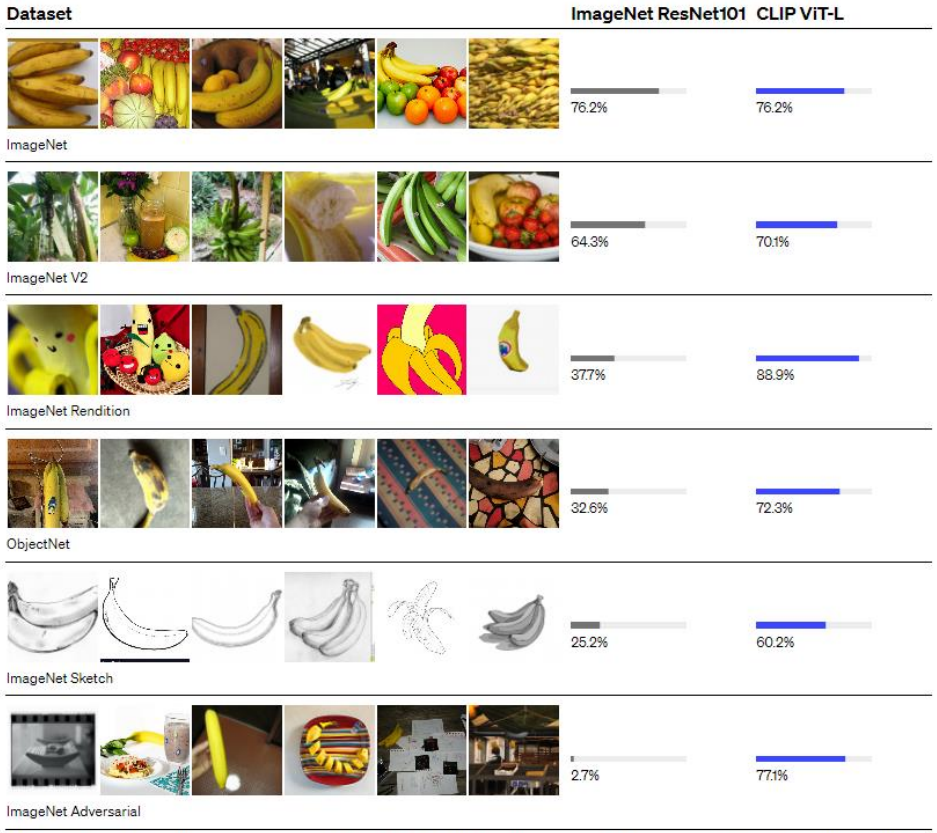
U-NET improvements



Transfer Learning

CLIP

OpenAI : Contrastive Language–Image Pre-training



Although both models have the same accuracy on the ImageNet test set, CLIP's performance is much more representative of how it will fare on datasets that measure accuracy in different, non-ImageNet settings. For instance, ObjectNet checks a model's ability to recognize objects in many different poses and with many different backgrounds inside homes while ImageNet Rendition and ImageNet Sketch check a model's ability to recognize more abstract depictions of objects.

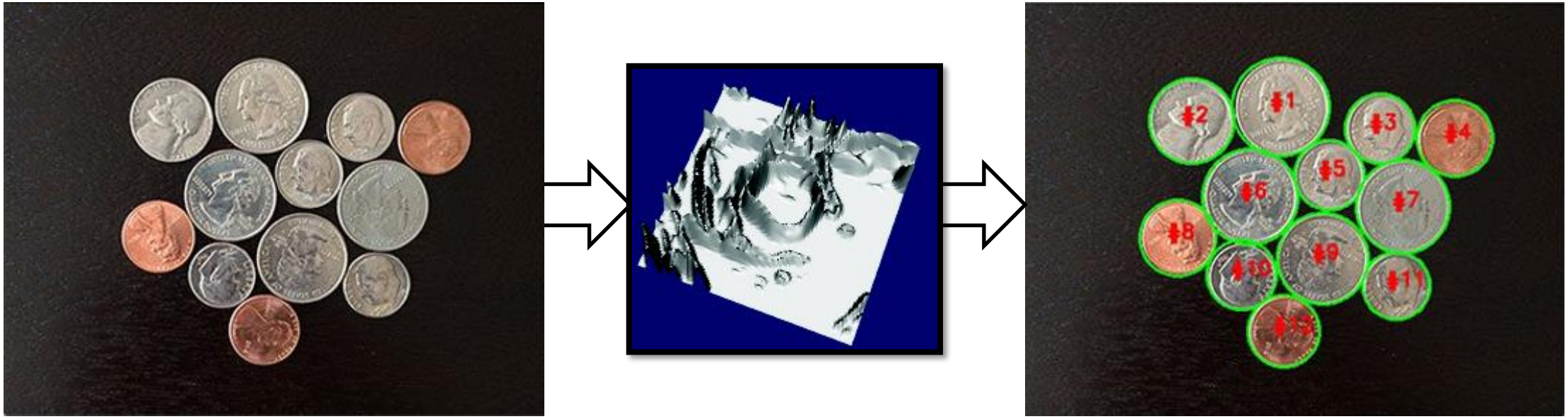
https://openai.com/blog/clip/

Segmentation

Different techniques to convert the output of the model into shapes of detected fields / boundaries

Watershed Segmentation

Segmentation technique that treats an image as a topographic surface



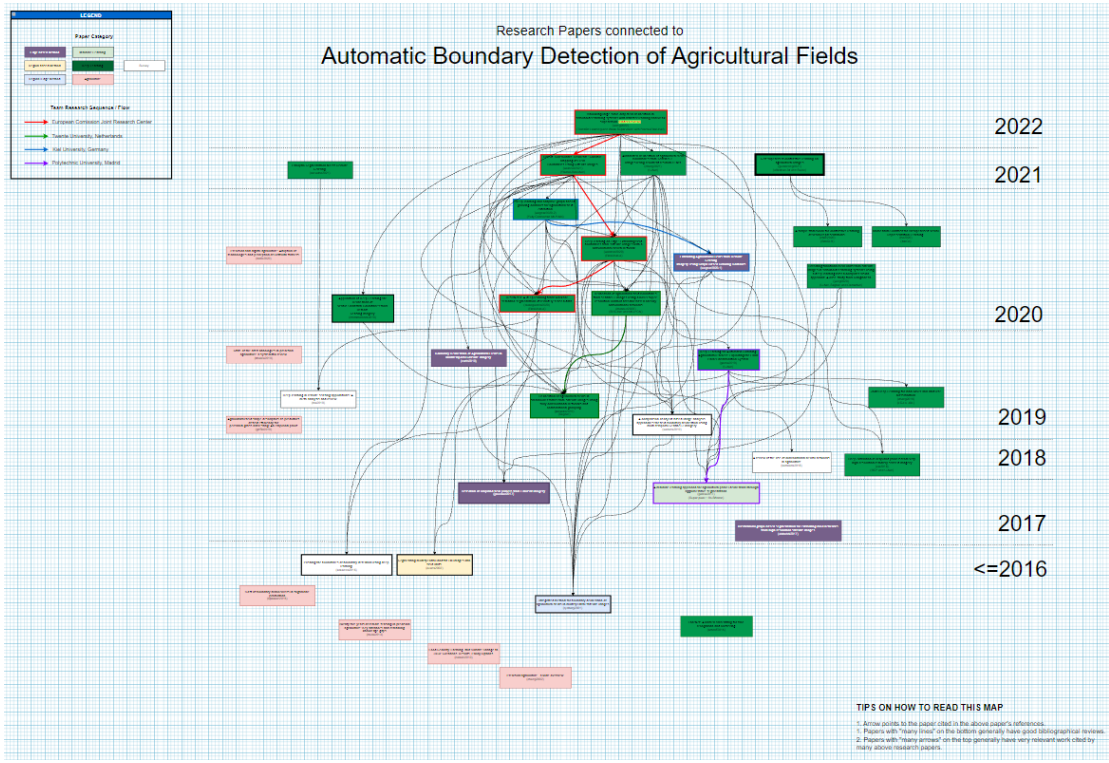
Bibliography & Resources

Bibliography documented in different ways to facilitate future research

Bibliography documentation

Paper	Dataset	Model	Segmentation	Year	tag	Notes
Unlocking large-scale crop field delineation in smallholder farming systems with transfer learning and weak supervision	Airbus SPOT SPOT-6/7 (1.5m resolution) Planet Scope (4.8m resolution)	FracTAL-ResUNet ResUNet-a U-Net	Watershed	2022	wang2022	
Agricultural Field Boundary Delineation with Satellite Image Segmentation for High-Resolution Crop Mapping: A Case Study of Rice Paddy	CNES/Airbus Pléiades satellite (0.5m) Timeseries Sentinel 1 (10m)	U-Net ResNet34-based U-Net SeresNet34-based U-Net		2022	mowang2022	https://github.com/qubvel/segmentation_models
Global and Local Contrastive Self-Supervised Learning for Semantic Segmentation of HR Remote Sensing Images	ISPRS Potsdam Dataset 4 bands (5cm) Deep Globe Land Cover Classification Dataset (DGLC) (0.5m) Hubei Dataset (2m) Xiangtan Dataset	SimCLR MoCo GLCNet		2022	haifeng2022	https://github.com/EarthNets/RSI-Segmentation
Automated delineation of agricultural field boundaries from Sentinel-2 images using recurrent residual U-Net	Sentinel 2 Images (10 m, 20 m and 60 m)	ResU-Net R2U-Net				
Detect, Consolidate, Delineate: Scalable Mapping of Field Boundaries Using Satellite Images	Sentinel 2 Images (10 m, 20 m and 60 m)	FracTAL ResUNet	Hierarchical Watershed Segm			
Advanced Fully Convolutional Networks for Agricultural Field Boundary Detection	Sentinel 2 Images (10 m, 20 m and 60 m)	ResU-Net				
Deep Learning for Detection of Visible Land Boundaries from UAV Imagery	UAV images (5 cm)	U-Net ENVINet5				
Panoptic Segmentation Meets Remote Sensing	Aerial Images from government (0.24m resolution)	Panoptic-FPN				
Detecting functional field units from satellite images in smallholder farming systems using a deep learning						

Table with 30 related papers listing the dataset, model and segmentation technique applied.



Taxonomy of the related papers in a vertical timeline colored by approach and research group


JOHN DEERE