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Unsupervised Learning for Data Fusion

C1.09.1 Representation learning in remote sensing: from unsupervised, to self-and meta-learning

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Living Planet Symposium, Bonn (Germany)

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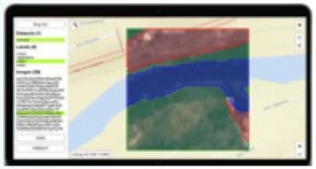
AI powered satellite analytics

The solution to easily integrate satellite analytics in the developers work practice, extracting the Earth Observation value through Artificial Intelligence effortless.

Build your AI ready datasets

SCAN

AI assisted labelling tool



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A full AI environment ecosystem over satellite data

Build your AI powered analytics

SPAI

no-code | low-code processing tool

Build your AI model

PytorchEO

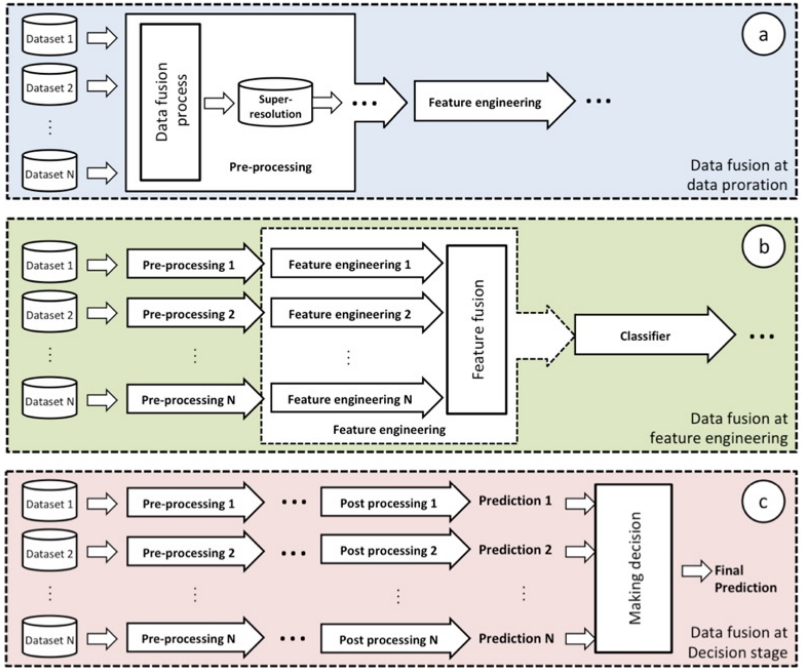
Open source library
Ready to train on EO

Unsupervised Learning

- Labelling a dataset is expensive, especially for EO applications (cost of imagery, experts for labelling, in-situ campaigns, lack of effective tools, …).
- There are far more concepts in the world than a dataset can cover.
- Self-Supervised Learning (SSL): predict some part of the data from the rest (contrastive learning, clustering, distillation, redundancy reduction, …).
- Potential to leverage full EO catalogues for pre-training NNs and then fine-tune on downstream tasks with great label efficiency.

Data Fusion

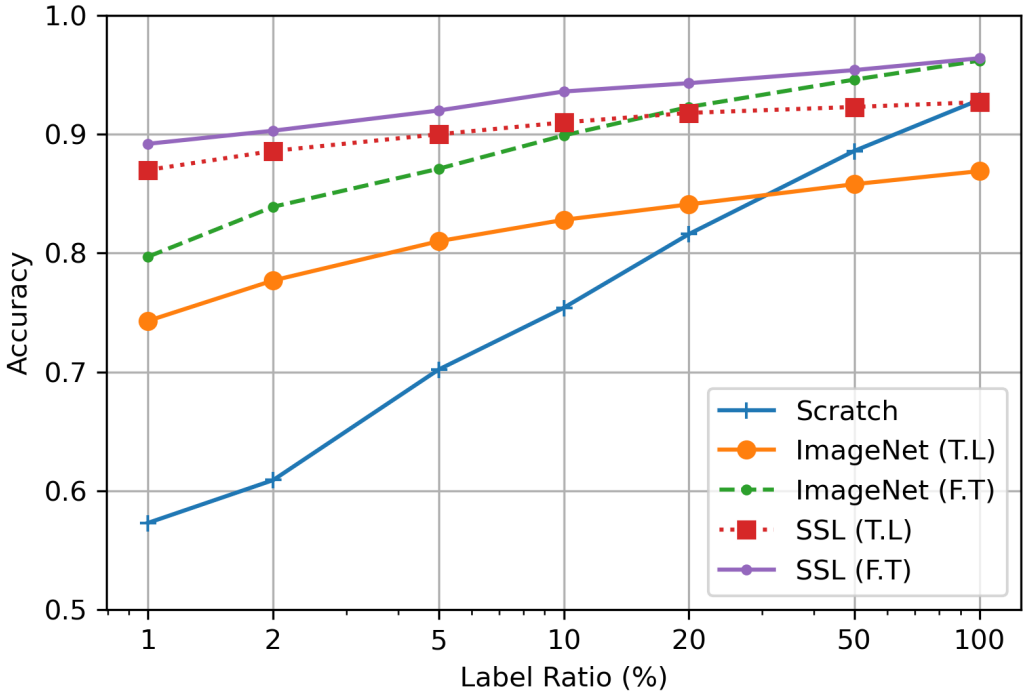
- Leverage information from multiple data sources at the same time (image availability, low visibility, …).

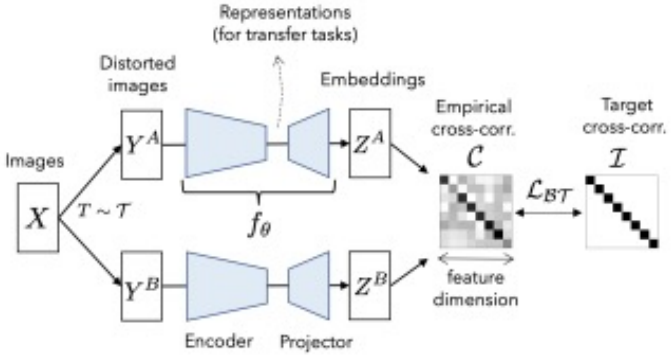


Extracted from Ava Vali et al. *Deep Learning for Land Use and Land Cover Classification Based on Hyperspectral and Multispectral Earth Observation Data: A Review*. 2020

Unsupervised Learning

Previous work





Barlow Twins: https://arxiv.org/abs/2103.03230

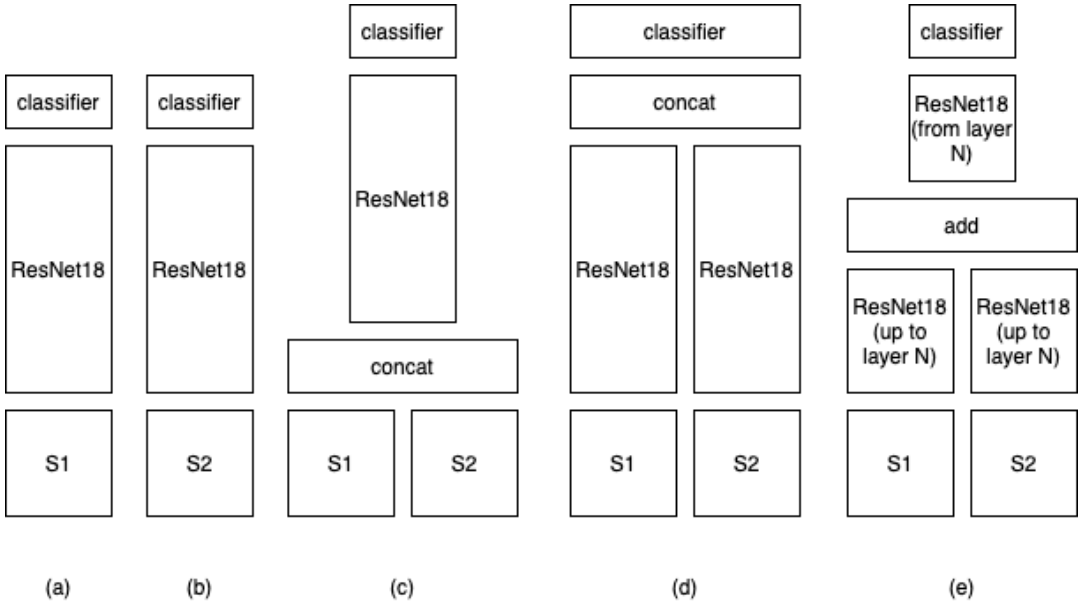
- Accuracy on EuroSAT dataset using different pre-training strategies.
- Unsupervised Learning is more data efficient (better accuracy with few labels).

Data Fusion

Previous work

Experiment	10%	100%
a (no fusion)	0.696	0.836
b (no fusion)	0.652	0.795
c (early)	0.722	0.855
d (feature)	0.734	0.853
e1 (feature)	0.723	0.858
e2 (feature)	0.732	0.862
e3 (feature)	0.730	0.864

Data source	Validation (20%)		Clouds and shadows (10k)	
	10%	100%	10%	100%
S2	0.696 (-5.17%)	0.836 (-2%)	0.469 (-31.5%)	0.778 (-5.23%)
S1	0.652 (-11.17%)	0.795 (-6.8%)	0.624 (-8.9%)	0.723 (-11.94%)
DF (S1+S2)	0.734	0.853	0.685	0.821



- Mean Average Precision on BigEarthNet dataset.
- Data Fusion always improves results, especially in low visibility conditions.

Unsupervised Learning for Data Fusion

This work

- Pre-train two Resnet18s on the BigEarthNet dataset for both S1 and S2 with Barlow Twins.
- Train two single source models and one feature fusion model for the downstream task.
- Compare results.

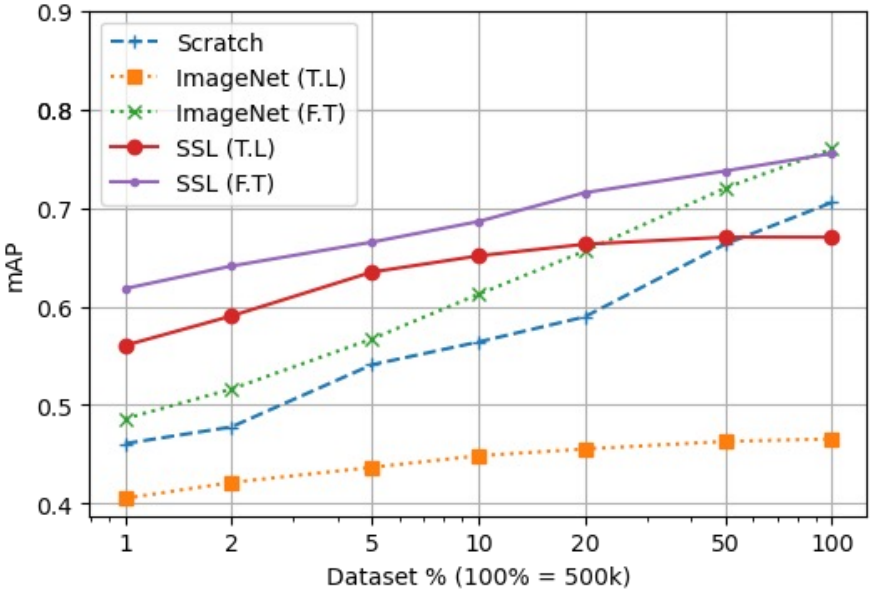
- Pre-training setup:
  - 1000 epochs, batch size of 1024, Adam optimizer with a learning rate of 1e-3 (warmup for 10 epochs and decay with cosine).
  - S1 using two bands, S2 using RGB (to compare with ImageNet, but all bands could be used).

- Code coming soon to **PytorchEO**: https://github.com/earthpulse/pytorch_eo

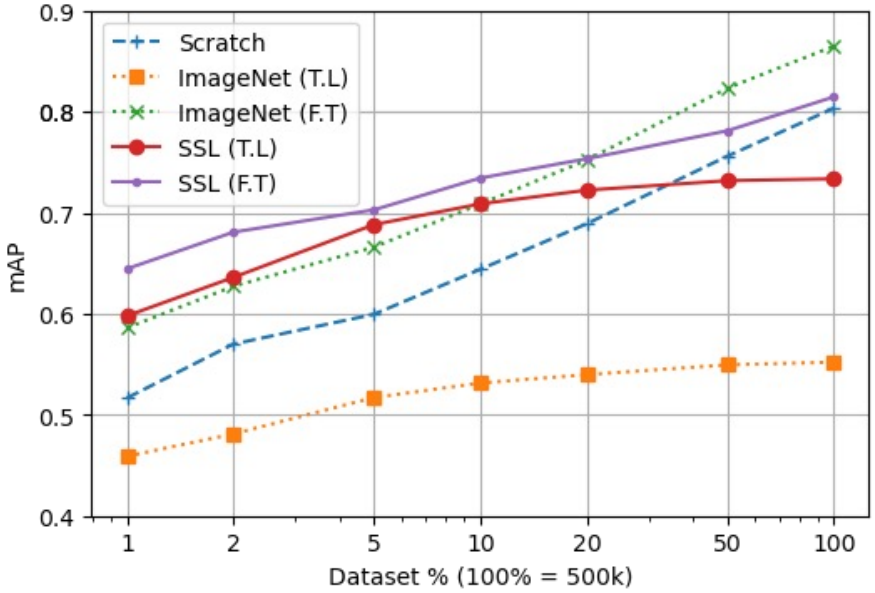
Results

No Data Fusion

S1

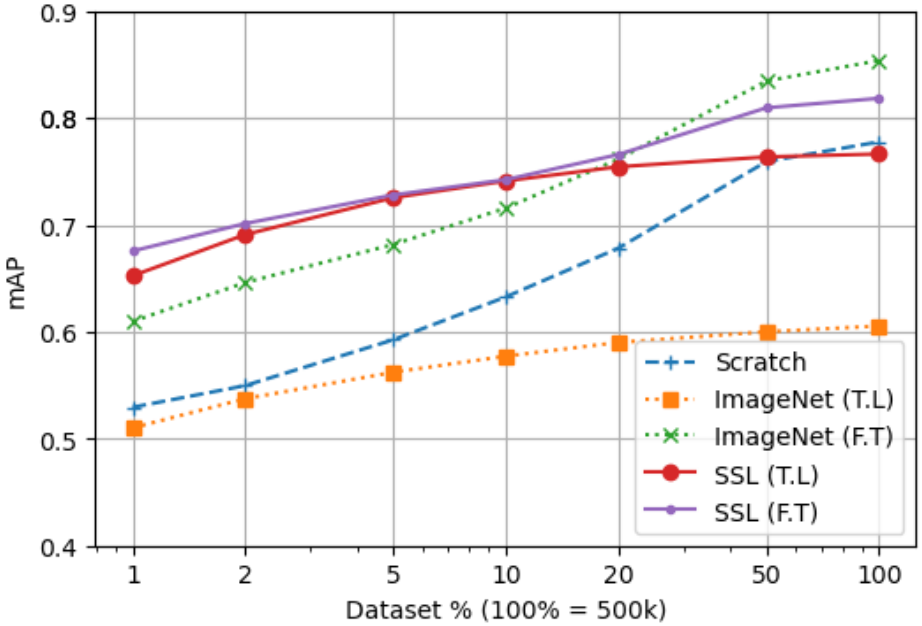


S2



Results

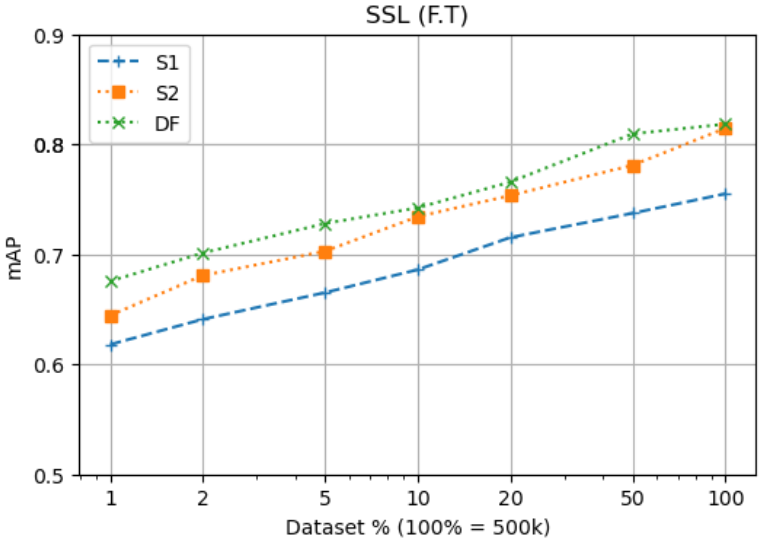
Data Fusion

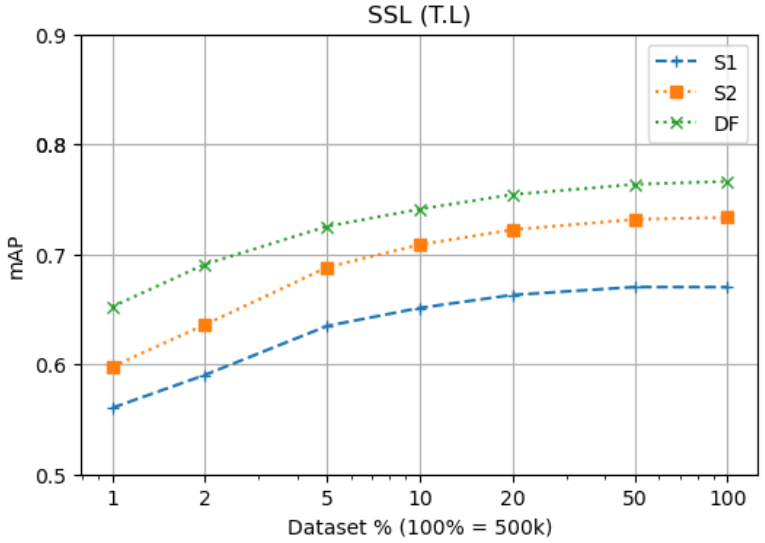


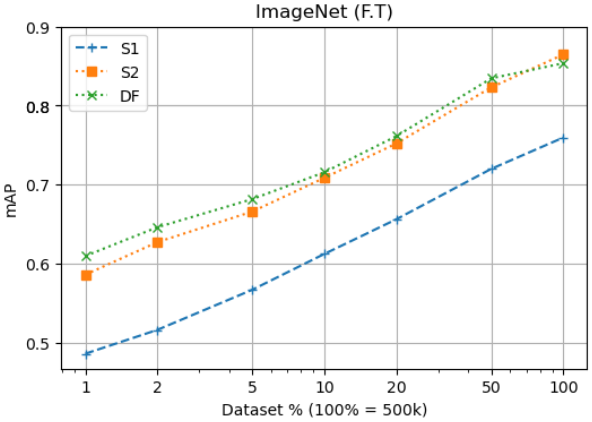
- SSL improves alternatives in the low label regimen.
- SSL TL and FT are very close up until 20%, reinforcing the idea of good initial feature representation.
- ImageNet and scratch results will never change, but SSL can still in theory improve (more data, better pre-training methods).
- Transfer learning is always better than training from scratch.
- SSL is the way to go for label efficiency, and fully compatible with Data Fusion.

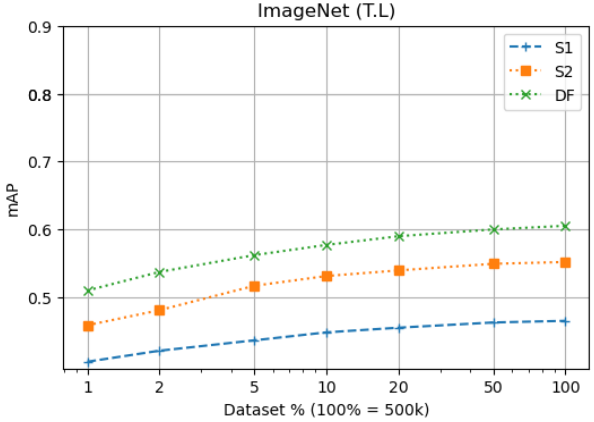
Results

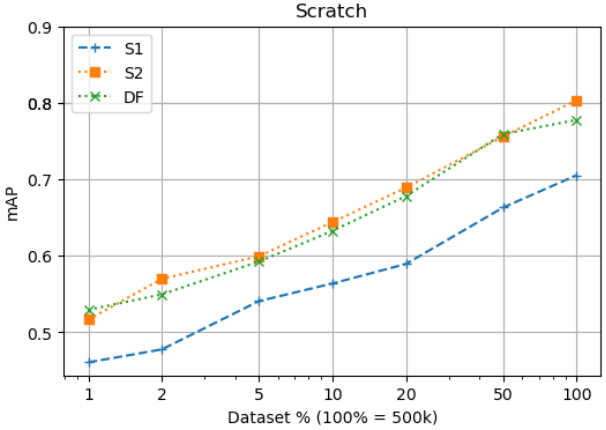
Data Fusion











Conclusions

- Unsupervised Learning and Data Fusion have the potential of unlocking the vast amounts of available EO data.

- Unsupervised Learning is a good technique for pre-training NNs with large EO data archives, but some labelling is still required to fine tune the models on the downstream tasks.

- Data Fusion is a good technique to leverage different sensors (and data sources in general) to obtain accurate and timely information overcoming current barriers of single-source models (data availability, cost, revisit time, visibility, etc.).

- Together, Unsupervised Learning and Data Fusion have the potential to greatly improve AI4EO applications, by pre-training custom architectures with different data sources and using data fusion with high label efficiency (no need to label as much data) and availability.

- **GOING FORWARD**: build large datasets for pre-training models with different data sources, share pre-trained models and encourage open research in SSL and DF techniques.

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THANKS ! QUESTIONS ?

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