Convolutional Autoencoder for unsupervised representation learning of PolSAR Time-Series

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Context

Discriminative information contained in **SAR Multi-temporal images** can be leveraged for multiple tasks:

- Forest monitoring [1]
- Agriculture monitoring [2]

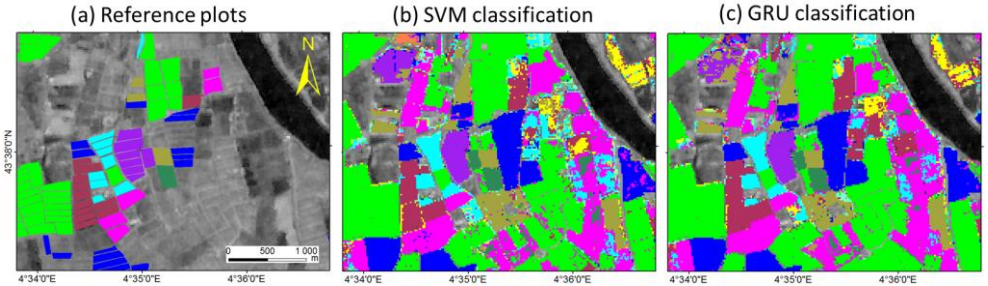


Fig 1. Agricultural classification of multitemporal SAR Sentinel-1 images (Source: [2])

Extraction of insights from SAR multitemporal images within the presented studies requires **labelled data** which can be:

- Difficult to obtain in an Earth Observation context;
- Insufficient or noisy;
- Restrictive regarding the information contained within multi-temporal SAR images

Definition of the task

Objective: finding a function f to project SAR Time-Series onto a latent space where separation in semantically relevant pseudo-classes is possible.

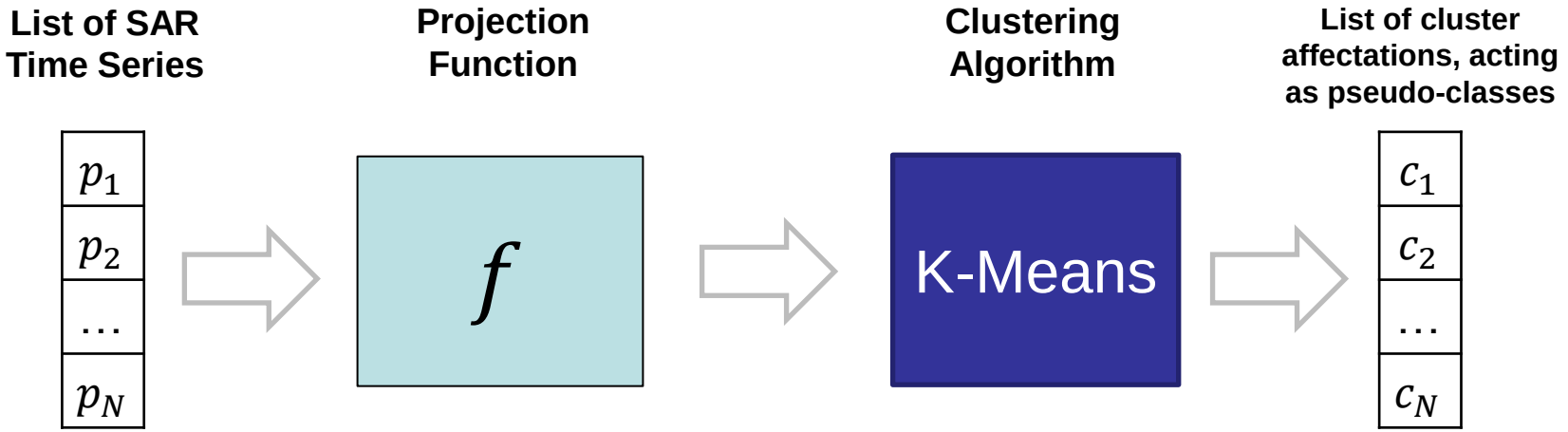


Fig 2. Graphical definition of the studied task

Our Method: using Convolutional AutoEncoder to unsupervisingly extract pseudo-classes

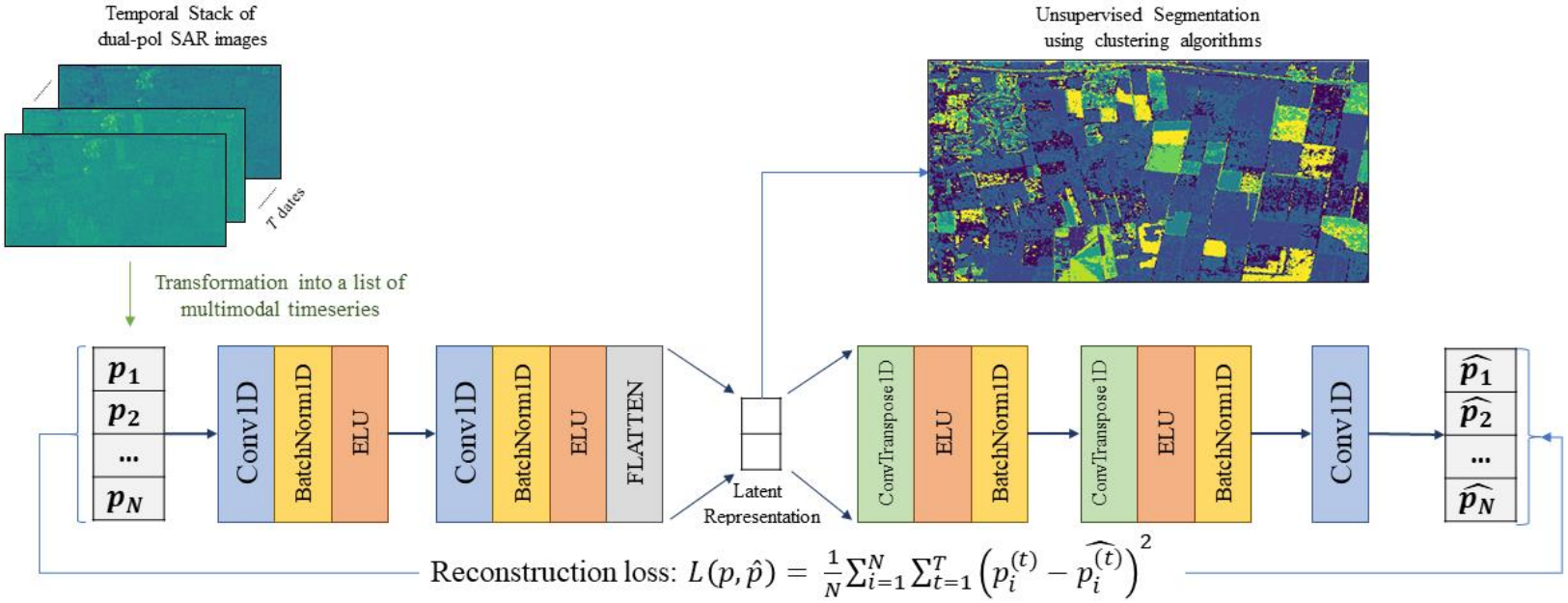


Fig 3. Our methodology involving a Temporal Convolutional Autoencoder model

Evaluation

Various projection methods were considered alongside our Convolutional AutoEncoder (CAE):

- Temporal Average
- PCA

They were tasked with the unsupervised retrieval of a farm outline, located in Forêt Nezer, France.

Fig 5. Sentinel 2 RGB imagery of the farm and surrounding forest

Fig 6. Farm Ground Truth Outline

Evaluation

Metric	TA	PCA	CAE
F1 Score	0.39	0.78	0.94

Table 1. F1 Score evaluation of each method's unsupervised clustering performance

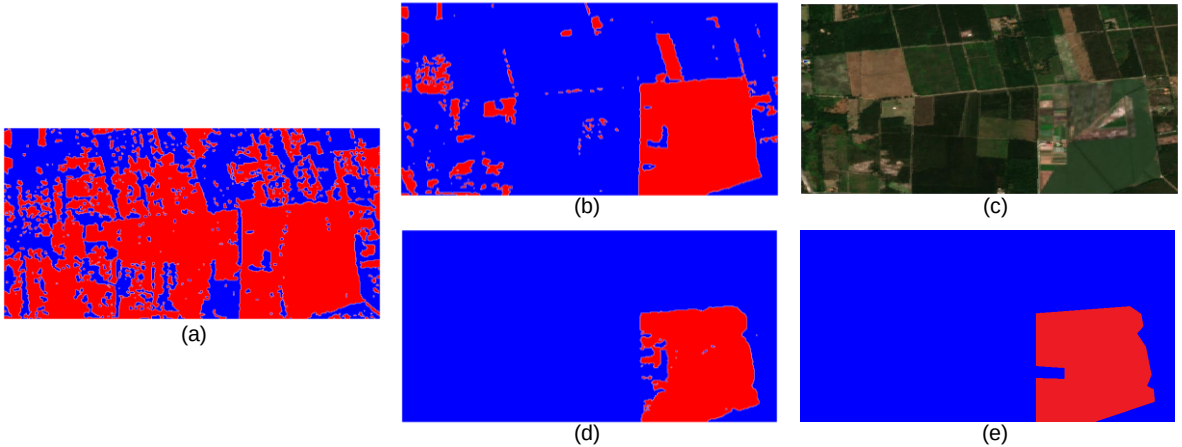
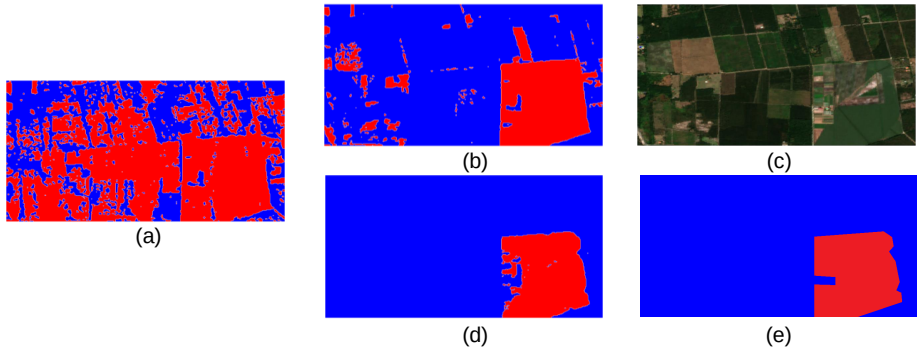


Fig 12. Binary K-Means for TA (a), PCA (b) and CAE (d) components (Red: Farm, Blue: Other) compared to ground truth label (e) and Sentinel 2 B4/B3/B2 RGB imagery (c)

Conclusion

In this paper, we:

- present a methodology to **extract varying temporal profiles** within multitemporal SAR images, **without the supervision** of labels.
- Introduce an **optimal projection method** that performs the best at the task of modelling SAR Time Series as low dimension vectors, the **Convolutional Autoencoder**.



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Bibliography

[1] A. Pulella, R. Aragão Santos, F. Sica, P. Posovszky, and P. Rizzoli, “Multi-Temporal Sentinel-1 Backscatter and Coherence for Rainforest Mapping,” *Remote Sensing*, vol. 12, no. 5, p. 847, Mar. 2020.

[2] E. Ndikumana, D. Ho Tong Minh, N. Baghdadi, D. Courault, and L. Hossard, “Deep Recurrent Neural Network for Agricultural Classification using multitemporal SAR Sentinel-1 for Camargue, France,” *Remote Sensing*, vol. 10, no. 8, p. 1217, Aug. 2018.