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Optimizing Country-Scale Crop Type Classification: A Comprehensive Study on Preprocessing Techniques and Deep Learning Classifiers within the Copernicus Data Space Ecosystem

Jędrzej Bojanowski[1], Jan Musiał[1], Jan Małaśnicki[1], Jacek Chojnacki[1], and Wojciech Bylica[1,2]
[1]CloudFerro S.A., Warsaw, Poland (jbojanowski@cloudferro.com)
[2]Inter-faculty Individual Studies in Mathematics and Natural Sciences, University of Warsaw, Warsaw, Poland

Identification of crops over large areas is necessary for monitoring agricultural production, establishing food security policies, or controlling compliance with the Common Agricultural Policy. Data acquired by Sentinel-1 and Sentinel-2 satellite constellations with a combination of high temporal and spatial resolutions has already demonstrated, separately or fused, its ability to classify crops. However, here we propose a methodology for crop type classification based on Sentinel-2 data focusing on a few specific aspects that have been often not addressed simultaneously in the previous works:

- Comparison of processing steps when single field representation is generated, i.e. multiple-pixel representation (Pixel-Set Encoder, https://doi.org/10.48550/arXiv.1911.07757) vs zonal statistics
- Application of various machine and deep learning classifiers, from Random Forest as a background, through Long Short-Term Memory and Gated Recurrent Unit, to novel Transformers
- Providing reliable full probability distribution of all crops for each classified crop field that allow for flexible user-specific minimalization of omission or commission errors
- Applicability in operational mode on a large beyond-country-scale i.e. for tens of millions of crop fields
- Efficient use of EO-data open cloud infrastructures such us the Copernicus Data Space Ecosystem or CREODIAS

The methodology has been already implemented and validated for Austria and Poland using Land Parcel Information System as a reference, but the list of countries will continue to grow. For Poland, 41 crops were successfully classified in 2022, for which the precision ranged from 0. 64 (pepper) to 0.97 (maize, beetroot, winter rape), and the overall classification accuracy (kappa) was 0.88. However, using a threshold of 0.85 on the probabilities allowed kappa of 0.95 and a range of accuracy (precision) for crops from 0.88 to 1.00, with 26 crops classified with an accuracy above 0.95. For Austria, for the years 2018-2021, a kappa coefficient of 0.85 to 0.9 was obtained without applying thresholds on probabilities. For Poland, classification was also carried out during the

growing season reaching kappa of: 0.78 (in May), 0.84 (in June), 0.87 (in July) and 0.88 at the end of the season.

With this approach, we also demonstrate how to use the Copernicus Data Space Ecosystem to efficiently extract information from big volumes of satellite data - here from Sentinel-2 and tens of millions of agricultural parcels.