The European Commission’s science and knowledge service

Joint Research Centre
Machine Learning for Crop Type Identification using Country-wide, Consistent Sentinel-1 Time Series

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Remote sensing data have been used for EU Common Agricultural Policy monitoring and control for 25 years.

Member States use on the spot checks (OTSC) to verify compliance of the farmer’s area aid application. Remote sensing used as major OTSC method.

New EU-wide availability of Sentinel-1 and -2 data combined with mature, high quality land parcel identification systems, allow new sampling approaches.

Full country high resolution (10-20 m), high density (5-6 days) time series with 100K-5M parcels per “Paying Agency”, requires Big Data Analytics.
Stubble burning

Sensor = S1 and S2, zone = region, relevant period = Apr-Sep, practice of interest = grassland mowing.
Copernicus Sentinel-1

S-1 provides calibrated, consistent time series

2-8 acquisitions per 6 days, 4 for most EU

Weekly country mosaics

Easy in Google Earth Engine

Alternative: interpolated signatures per parcel
Machine learning

Extract time series stack for all (approx. 700,000) vectors.

Weekly (Apr-Aug) mean VV, VH, declared crop as feature vector.

In this study, select only arable crops (170K), making up 95% of arable crop area (eliminate minor crops) and > 0.3 ha.

Split in 20% training, 80% testing (5 times).

Run tensorflow (tflearn) DNN with 2 fully connected 32 node layers, softmax activation and gradient descent.

100 epochs (<5 mins on a 8 core Intel Xeon E3-1505M v6 @ 3.00 GHz, with 64 GB RAM).
Machine learning

<table>
<thead>
<tr>
<th>Crop</th>
<th>MAI</th>
<th>POT</th>
<th>WWH</th>
<th>SBT</th>
<th>ONI</th>
<th>SBA</th>
<th>FLO</th>
<th>sum</th>
<th>PA</th>
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<td>1549</td>
<td>7</td>
<td>25</td>
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<td>11</td>
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<td>65</td>
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<td>94.7</td>
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<td>95.9</td>
<td>95.7</td>
<td>91.5</td>
<td>89.3</td>
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</table>

OA single classification 96.1%
Compare predicted label, 4 times
4% “outliers”
(i.e. approx. 6800 parcels)

Categorization (size, shape, confusion, yellow, impact)

Links to automatic report generation
On **DIAS**:  
S1: 1750 images in 2018  
1M agricultural parcels with declared practice  
Machine learning applied to S1 time series  
Identify “outliers”  
Follow up with S1 coherence and S2 analysis  
Automated reporting
➢ National Land Parcel Identification Systems (trend towards open access!)
➢ Tests developed on Google Earth Engine now migrating to Copernicus DIAS
➢ Large potential of data re-use in other national application contexts
Data for the year 2018 or 2017, 2016
in USA and Europe

Total size of fields, ha: 376.8M
Total number of fields: 60M

Countries ranking:

<table>
<thead>
<tr>
<th>#</th>
<th>Country</th>
<th>Size</th>
<th>Number</th>
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<td>1</td>
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<td>16M</td>
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<td>2</td>
<td>Ukraine</td>
<td>35.9M</td>
<td>2M</td>
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<tr>
<td>3</td>
<td>France</td>
<td>27.5M</td>
<td>7M</td>
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<td>4</td>
<td>Germany</td>
<td>18.2M</td>
<td>4M</td>
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<td>5</td>
<td>Poland</td>
<td>14.8M</td>
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<tr>
<td>6</td>
<td>Spain</td>
<td>12.0M</td>
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</table>

Show all 44 countries

Crops ranking:

<table>
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<th>Crop</th>
<th>Size</th>
<th>Leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>USA</td>
</tr>
<tr>
<td>2</td>
<td>Grass</td>
<td>83.8M</td>
<td>USA</td>
</tr>
<tr>
<td>3</td>
<td>Wheat</td>
<td>67.1M</td>
<td>USA</td>
</tr>
<tr>
<td>4</td>
<td>Soybeans</td>
<td>52.6M</td>
<td>USA</td>
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<tr>
<td>5</td>
<td>Alfalfa</td>
<td>14.9M</td>
<td>USA</td>
</tr>
<tr>
<td>6</td>
<td>Barley</td>
<td>13.8M</td>
<td>Germany</td>
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</tbody>
</table>

Show all 27 crops

Popular crops in largest countries
Open!

• Copernicus Sentinel data are **full, free and open**.
• The land parcel identification system is **open access** in several EU Member States, and will increasingly open up in others (DG AGRI legal opinion).
• The code to extract data from GEE and tensorflow code is **open** (see paper, reference [4])
• Docker-swarm based DIAS tests will be **open**.

We need more open data on crop phenology.
Next steps

• “Checks by Monitoring” is part of CAP Regulation since May 2018.
• 5 Member States have opted for monitoring, for some schemes, in 2019.
• Probably the fastest ever track from conception to CAP policy implementation.

• Onboarding Member States on DIAS.
• Further work on classification improvement (outlier reduction).
• Transfer learning: across agro-ecological regions, across seasons (LPS19).
• Crop phenology analysis: markers, time-invariance, anomaly detection (e.g. summer 2018).
Data collected in the growing season 2018

NIKON
4056 Pictures

SONY
350 000 Pictures

FIELD DATA

LPS session D.2.08
Thanks!

Any questions?

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