COMBINATION OF OPENLANDUSE DATABASE AND SENTINEL DATA FOR AGRICULTURE PURPOSES

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Abstract

Creating an Earth's twin in sufficient detail and complex relations is a challenge for the future arising from strategies like DestinE or Green Deal. Enormous amount of geospatial data available these days leads to a necessity of a suitable data structure to provide understandable information to a general user. An OpenLandUse (OLU) database can serve as such a structure for integrating datasets of different themes, different spatial resolution, and different temporal validity. This paper shows an example of incorporating Earth observation data into the Open Land Use data model, to provide enhanced information about field blocks of a farm in Vyškov region in CZE with information about crop types planted in fields. The data for enhancing the OLU database were based on Sentinel-1 and Sentinel-2 images from 2020, analysed into the form of supervised classification of crop types and various indexes, especially Enhanced Vegetation Index (EVI) and Radar Vegetation Index for Sentinel-1 SAR data (RVI4S1).

Keywords: Open Land Use, database, crop, type, index, classification

INTRODUCTION

Land use and land cover information in combination with other thematic datasets related to detailed reference spatial data form an important dataset for different types of analyses in different domains. At present, when it comes to the strategy of the Green Deal, Destination Earth, and the construction of Earth's twins (Digital Twins), there is no model and database that would effectively gather information about the Earth's surface in sufficient detail and sufficiently complex relations. Our activity of creating a geographic database called OpenLandUse aims to be an effective step towards such a model. The OLU database combines various thematic data with the most detailed reference geometry available in each area of interest. Thematic datasets are focused primarily on the information of land use and land cover and additionally on other themes like soils, topographic characteristics, climatic parameters, vegetation indices of field blocks, etc. and in different time periods. In this case, analysed satellite data from the Copernicus programme were used as a thematic layer for OLU, as suggested in (Charvát et al., 2021a). Our aim is to enhance OLU data available in an area of interest with information raised from calculation of vegetation indexes and classification of satellite images, in our case adding crop type information. It can help to validate correctness of data from publicly available sources or having a space-time related overview about crops at an area of interest based on Earth observation data.

METHODOLOGY

OpenLandUse database

OpenLandUse (OLU) database is the second version of the OpenLandUse Map firstly described in Mildorf et al. (2014). The OLU database is created in a hierarchical database structure, it allows to integrate datasets of different themes, spatial resolution, and temporal validity. It can be used as a data source for different cross-section by different aspects, so-called spatio-temporal-thematic views. The main feature is an OLU object with geometry with more attributes from different themes and time epochs. OLU objects form the reference geometries layer that seamlessly covers the area of interest and are locators for thematic non-geometrical attributes. A typical representation of reference geometries are cadastral data or field blocks. When a reference geometry layer is used for accumulating thematic attributes in spatio-temporal thematic views, it is theme-dependent on the level of detail of the reference geometry. Some themes are relevant to cadastral data level, some themes are relevant mainly to medium scale reference geometries. An example of visualisation of the general reference geometry layer is shown in Figure 1.

The view-based reference geometry layer was built based on user provided field blocks and other thematic layers from the OLU database serving as the general reference layer. In case of the Czech Republic, it consists of the order of layers:

- thematic user provided dataset (in this case field blocks)
- field blocks - Land Parcel Identification System (LPIS)
- cadastral data - Registry of Territorial Identification, Addresses and Real Estate (RUIAN)
- Urban Atlas (UA)
- Corine Land Cover (CLC)

The view-based reference geometry layer is based on the order of layers defined by the user (see previous layers list). Geometries from the bottom level are omitted if they are completely covered by reference geometry features from the higher level. An example of the visualisation of the view-based reference geometry layer is shown in Figure 1. This view-based reference geometry layer was used for following experiments to integrate remote sensing data and indices.

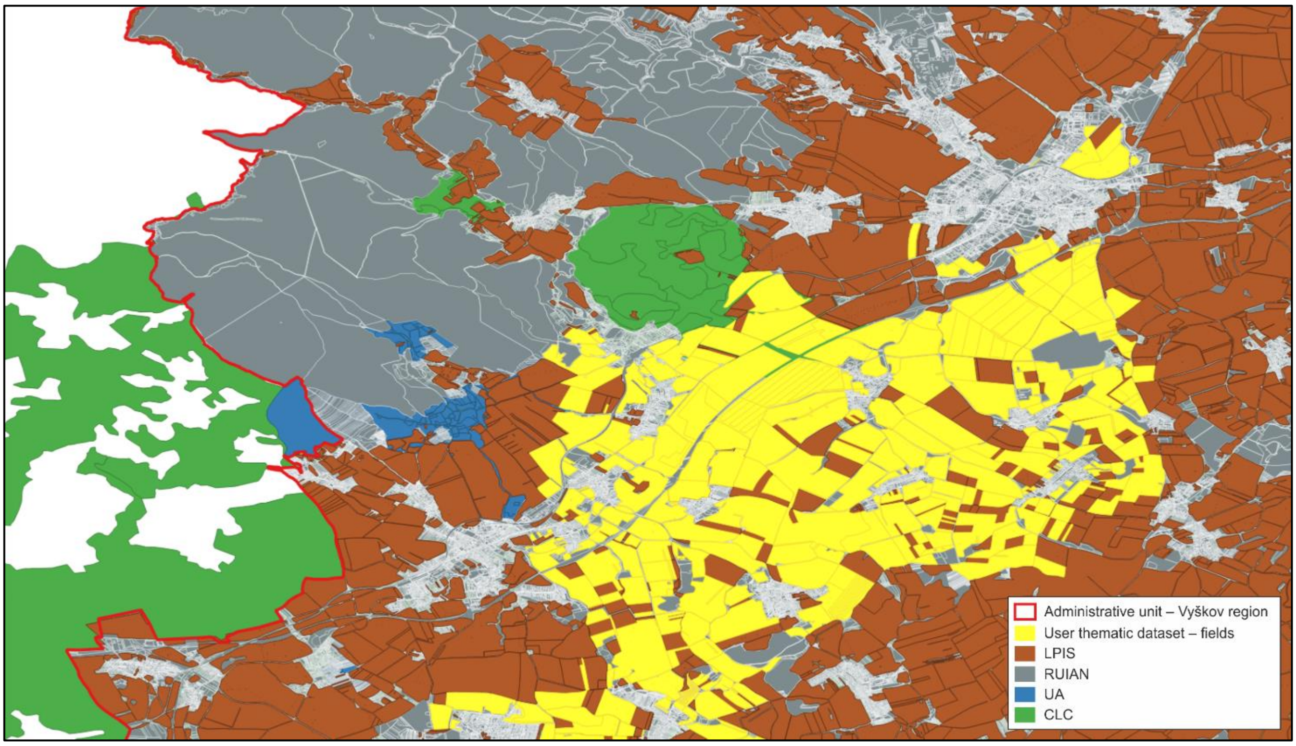

Fig. 1. Visualisation of view-based reference geometry layer, together with a general reference geometry layer (user-defined layer is highlighted in yellow)

Satellite data and methods used

Remote sensing methods in agriculture are currently used mainly for monitoring the use of agricultural land, estimating crop yields, plant breeding and monitoring ecosystem services such as soil, water resources or biodiversity. The potential for the combination of remote sensing archive data for identification of management zones and use of hyperspectral data for real-time decision support and refinement of management zones was utilised during this experiment (Charvát et al., 2021b). Satellite images used for the enrichment of OLU experiment were downloaded from the Lesprojekt cloud (Kvapil et al., 2021) and the Alaska Satellite Facility Data Search Vertex (ASF Data Search, 2022).

Phenological information of crops is collected from satellite images using indices developed from the available spectral bands. The calculated indices were mainly Enhanced Vegetation Index (EVI) calculated from the Sentinel-2 data and Radar Vegetation Index for Sentinel-1 (RVI4S1) from Sentinel-1 data, both for year 2020. On top of that a supervised classification of satellite images had been provided.

Field borders came from OLU and crop data from farmer. Seven most frequent crops have been chosen, covering 9 447 ha. The classifier had been trained on training sites having 1 175 ha that had been classified manually. Remaining 88% of the pixels had been classified using the Minimum Distance algorithm. Using farmer's crop data accuracy assessment of the supervised classification was carried out to determine classification accuracy development throughout the growing season.

RESULTS

Classification of satellite images

In the area of Rostěnice farm (Vyškov region, CZE) both supervised and unsupervised classification for radar and optical indices were calculated and also for a combination of both. The classification based on combination of S-1 and S-2 indices used more data, therefore, it showed better accuracy, as represented in Figure 3. Figure 2 shows a supervised crop classification on Rostěnice farm for the vegetation season in 2020 using data from March to July, comparing classification and the really used kind of crop. A map composition created within a digital innovation hub called FOODIE Agrihub.cz (FOODIE SmartAgriHub, 2021) is available on https://tinyurl.com/y67zwxsy.

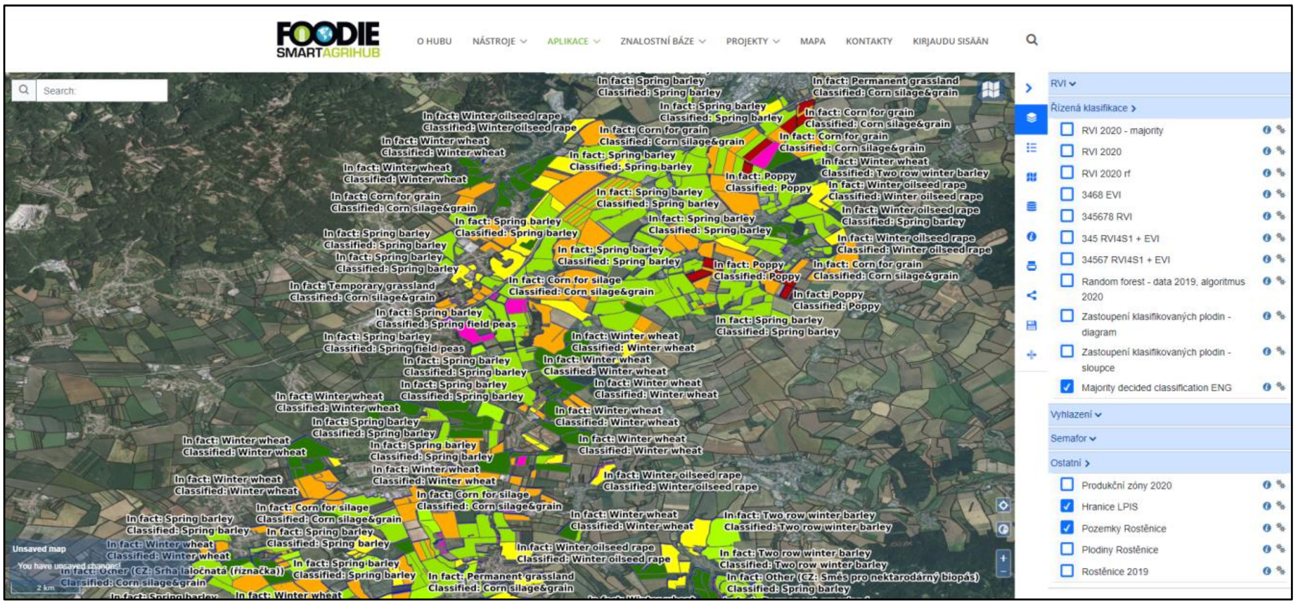

Fig. 2. A supervised crop classification on Rostě nice farm for vegetation season in 2020

Accuracy assessment

As expected, the more data is provided as an input, the higher the overall accuracy is. When the crop based on images from March was identified, there was only 52 % chance for the classification to be correct. When images from April to July were used, accuracy of 95% has been reached.

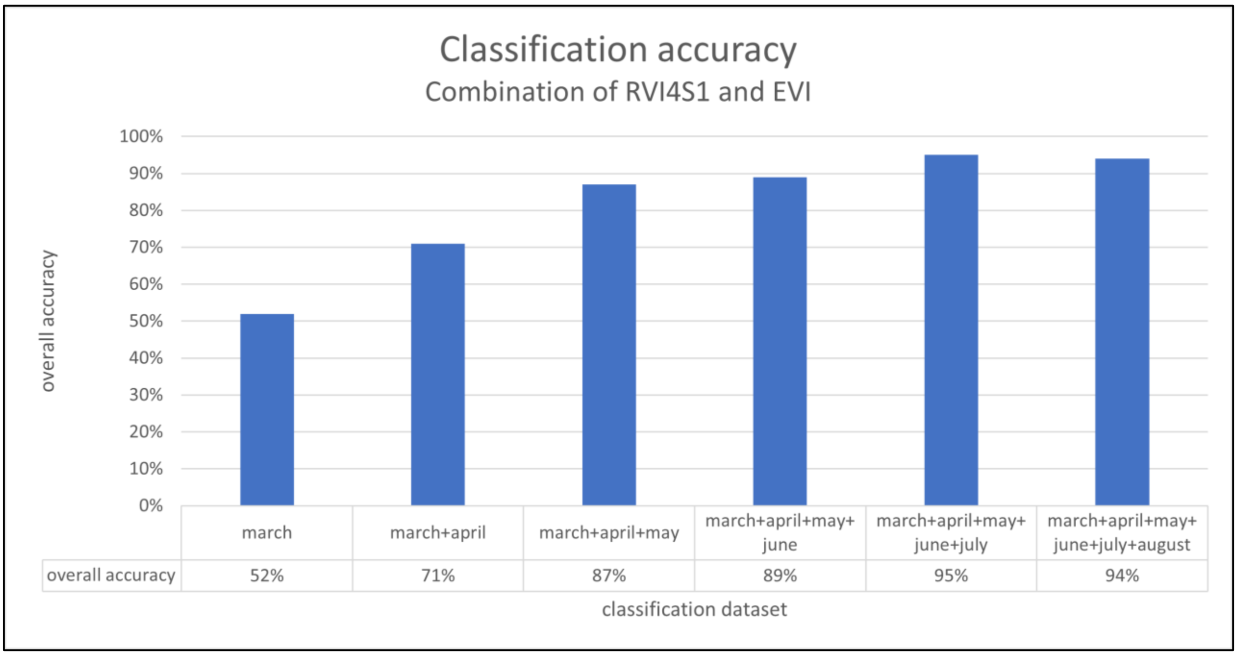

Fig. 3. Classification accuracy of RVI4S1 and EVI indices

Visualisation of histograms of classes distribution

A class distribution in objects by using a modified method of Geographic Object-Based Image Analysis (GEOBIA) using existing OLU vector maps and unsupervised classification was calculated. Then the results of the classification were assessed in individual OLU objects. That allows us to use more precise crop classification and also to detect changes in land use/land cover types. Figure 4 shows a Pareto diagram of different crop types categories and information about a particular field block from LPIS and from the analysed satellite images.

Fig. 4. Pareto diagram of classified crop types in the area of interest

CONCLUSIONS

The main result of the experiment was in adding crop type information as additional thematic attributes to the OLU features where such information is not available at all or are available with some level of reliability from other datasets (e.g., LPIS). It can be used as a validation of data from integrated data sources as well as development of general statistics of crops during the selected season. On the other hand, from the perspective of a farmer, regular integration of vegetation indexes to the OLU database provides a large-scale data layer with detailed thematic attributes.

From the multiple methods and algorithms of supervised and unsupervised classification that were being tested, the k-means method of unsupervised classification with the minimum distance algorithm seems the most promising. The accuracy assessment showed that working with time series is better than single date classification, the results were improved by 40 % just by adding more data.

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