Article

Automated object-based satellite image time series classification using dynamic time warping

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Abstract: Satellite image analysis can support efficient monitoring of crops by providing timely and relevant spatial and temporal information products and tools. However, analyzing satellite image time series (SITS) needs to address some challenges, like the shortcoming of samples availability, irregular temporal sampling of images or the temporal variability of the phenomena of interest. Dynamic Time Warping (DTW) method is able to address these challenges by comparing the similarity between two temporal sequences, finding their optimal alignment and providing a dissimilarity measure between the evaluated temporal sequences. In this paper, we present an automated implementation of DTW for processing Sentinel-2 SITS within an object-based image analysis framework, implemented as a ready-to-use parameter-free algorithm in eCognition software. Adapting the DTW to perform on objects, we solve one of the main challenges of DTW, namely a reduction in computational time. We tested the developed tool on Sentinel-2 SITS in south-eastern Romania, using 11 images of 5192x4367 pixels. The red, green, blue and near-infrared bands of 10m spatial resolution were used in the segmentation process. To speed up the segmentation, we have used SLIC superpixels for an initial oversegmentation of the images, followed by applying multiresolution segmentation on the resulted superpixels using ESP2 tool, for an automated selection of scale parameter. We used 30 training samples per class, with five classes of interest (wheat, maize,

sunflower, forest, water), to extract the NDVI temporal pattern to be used in DTW. The tool compares the temporal pattern of an object with the training temporal patterns, classifying the object into the class to which it had the minimum DTW dissimilarity value. The overall accuracy for resulted classification was 90.27%, with kappa index of 0.87. Besides the categorical classification of SITS, the tool delivers also a map of DTW dissimilarity values, which is useful to understand which objects have a strong similarity with the assigned class (values closer to 0) or can have a doubtful assignment to one of the five classes used (the largest values). This tool represents the first operational implementation of the DTW method at the object-level. Therefore, it can successfully support manual digitization of crop fields from satellite imagery. The availability of this kind of operationalized approaches dedicated to turning data into information are increasingly necessary as we move into imagery-dense workflows with satellite constellations providing increasing spatial and temporal resolutions.

Keywords: Sentinel-2; eCognition; DTW; OBIA; satellite image time series; land use/land cover mapping; superpixels; segmentation; crop mapping.