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PROBABILISTIC CHANGE DETECTION ON SATELLITE IMAGES THROUGH A NOVEL GLCM-PCA-SFCM WORKFLOW

Abstract

Change detection is the process of identifying differences in the state of an object or phenomenon on Earth, by comparing earth observation images collected at different times. The main applications of change detection are: monitoring of deforestation, urban changes, ice and sea cover variations and evaluating the impact of natural disasters such as floods and wildfires.
The main objective of this work is to propose a new workflow algorithm, which differs from the most common studies on change detection for providing as output not a binary image, which shows if the pixel is changed or not, but rather a probabilistic image, which assigns to each pixel the probability of change. The proposed workflow algorithm takes in input two satellite images of the same portion of the Earth surface but at different times. For each image the following steps are performed. First, a Gray Level Co-occurrence Matrix (GLCM) with 9 different textures images is generated. Various studies proved that GLCM texture analysis scheme is effective to extract useful textural features which can be used to better characterize built-up urban areas, soil, rock, water and vegetation. Then, the 9-bands texture image produced at the previous step is passed through a Principal Component Analysis (PCA) algorithm, which is used to reduce the dimensionality from 9-bands to 3-bands which still contains most of the information of the large starting 9-bands image. After that, the PCA processed image is given in input to a Spatial Fuzzy C-Means (SFCM) clustering algorithm, which performs a probabilistic segmentation of the image in N classes taking in account both the pixel values and the spatial relationship among the pixels. Finally, the two segmented probabilistic images provided as output of SFCM step are compared to obtain a probabilistic change detection image, which for each pixel identifies the probabilities that the pixel has changed to one of the other classes.
The proposed workflow algorithm has been tested with both optical Sentinel-2 and SAR Sentinel-1 images to detect changes in two different scenarios: the 2021 Sardinia wildfire and the 2018 Piave river flood. The results show how the proposed approach can provide a more informative change detection analysis with respect to the deterministic traditional approach since the change map is accompanied by a probability that this change has occurred, thus helping to evaluate the validity of the change and to better distinguish false positives.