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Editorial: Advances in deep learning approaches applied to remotely sensed images

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Editorial on the Research Topic
Advances in deep learning approaches applied to remotely sensed images

Artificial intelligence (AI) crosses the history of mankind in a visionary way since Antiquity, with the figures of Golem and Prometheus (Banga, 2019), but it could only be materialized, although in a primitive form, nearly in the second half of last century (Kelleher, 2019). Remote sensing witnessed the onset of AI when shallow neural networks, fuzzy systems, evolutionary computing, expert systems and alike came into scene in the 1980s. Ever since, AI approaches were progressively refined and, in the specific domain of image analysis, led to the consolidation of machine learning methods, of which deep learning emerged as a new paradigm targeted to data-intensive science.

To date, there is a myriad of Earth observation satellites orbiting our planet, able to daily deliver huge amounts of data with an order of magnitude of over a hundred petabytes (La Beaujardière, 2019; Giuliani et al., 2020). This impending increase in remotely sensed data volumes is enhanced by the launch of multiple decameter resolution satellite-based hyperspectral sensors in the next few years (e.g., NASA SBG, ESA EnMap). In parallel to this, the growing use of low altitude platforms, with extremely high spatial resolution, generate as well massive data for digital processing. We are then faced with the requirements of robust and computationally cost-effective algorithms for handling high-dimensional datasets in an efficient manner. Deep learning meets the big data processing demands in remote sensing and is a fast growing trend in image analysis, still far from being exhausted.

The papers included in this Research Topic cover manifold examples of the usage of deep learning in a varied scope of applications. The three initial ones approach technical questions, while the two remaining ones are concerned with specific environmental Research Topics. Lee and Lee explore training data of different spatial resolutions, both from aerial and Sentinel-2 imagery, meant to efficiently analyze and predict (quasi-) real-time land cover and land use changes. Distinct AI algorithms based on convolutional neural networks (CNN) were tested (SegNet, U-Net, and DeeplabV3+), and the results indicated that for both datasets, U-Net outperformed the other two classifiers in general terms, although for specific targets, the accuracy tends to vary from one algorithm to another.

Gütter et al. are committed to assess the impact of training set size on the predictive performance of deep neural networks (DNNs). The authors utilized a dataset of aerial images for building segmentation and created several versions of the training labels by introducing different amounts of omission noise so as to simulate limited labels in crowdsourced datasets. They then trained a model on subsets of varying size of such versions and concluded that a large training set improves the robustness of the model against omission noise.

In turn, Ulman et al. as well investigate the binary segmentation of building footprints, but specifically focus on exploiting uncertainty to identify omission noise. According to the literature, detecting uncertainty during training can help achieving the exact point between generalizing well and overfitting to label noise. In this work, different levels of omission noise were used to evaluate the impact of the noise level on the performance of DNNs, and the authors found out that the currently available uncertainty-based methods to identify noisy labels are not yet good enough. Nevertheless, they noticed some promising differences between noisy and clean data for some noise levels, which may lead to refined methods in the future, capable of selecting reliable samples.

Using DNNs to detect above-aircraft clouds by means of airborne cameras is the Research Topic handled by Nied et al. The authors conceived a two-dimensional CNN to detect cirrus and high-level clouds from airborne-based camera images. The identification of such clouds is important since their presence contaminates the measurements of nadir-viewing passive sensors. Two field campaigns were accomplished–over the Western Atlantic region and in the Philippines – using a camera mounted inside the aircraft cockpit. In the case of human-labeled validation data, a high accuracy was reported in detecting clouds in testing datasets for both zenith viewing and forward-viewing models. When the obtained data were compared to the use of an all-sky upward-looking camera mounted outside the fuselage on top of the aircraft, the authors reached a comparatively higher accuracy for the zenith viewing than for the forward-viewing. This work concluded that CNNs enable cost-effective detection of clouds above the aircraft using an inexpensive camera installed in the cockpit, representing an alternative to upward-looking instruments mounted outside the aircraft and which require expensive and time-consuming adaptations.

Finally, the paper of Thomas et al. is dedicated to mapping debris-covered glaciers integrating a CNN and object-based image analysis (OBIA). The experiments comprised not only contemporary (Landsat-8 thermal, Sentinel-1 interferometric coherence, and ALOS/PRISM-derived geomorphometric datasets), but also historical imagery (Panchromatic Corona KH-4B satellite data from the 1970s), covering mountainous regions in South-central Asia. Only the supraglacial debris heatmap generated by the CNN was further used for the debris-covered glacier OBIA classification, since all other land cover classes (non-glacial material, vegetation, lakes, clean ice glacier, snow cover, shadow) were classified according to fixed thresholds applied to satellite images. In both cases, high accuracies were achieved using a manually delineated glacier inventory as reference data.

In brief, this Research Topic approaches themes in deep learning for remotely sensed image classification both from the operational and applications perspectives. Different sensors have been explored and diverse methodologies have been reported in this Research Topic, aiming at giving a representative sample of ongoing remote sensing research associated with deep learning. We truly expect that the reading of these papers may be an important reference for those engaged with the continuous advancement of deep learning in remote sensing and we wish they may as well provide insights to cutting-edge research initiatives in the coming years.

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