GeoImageNet: a Collaborative Platform for Deep Learning Application to Very High Resolution EO Images

Yacine Bouroubi, Claude Chapdelaine, Samuel Foucher, David Byrns, Mario Beaulieu, Pierre-Luc St-Charles, Michael Germain, Pierre Bugnet, Nouri Sabo and Claire Gosselin

Extended abstract

Satellite images are the main source of information for map production and updating, land and natural resources management, environmental monitoring, urban planning, and many other economic, environmental and social applications. These images are often exploited using methods, algorithms and image processing tools to extract information automatically, rapidly and cost-effectively. Traditional image processing approaches can describe several properties of objects found in an image, such as colour, contour, texture or shape. However, they are unable to model the information about context or association that a photo-interpreter uses to identify geographic features.

Nowadays, the evolution of satellite sensors has made it possible to significantly improve the spatial resolution of images. Currently, at least nine satellites are aquiring multispectral images with spatial resolutions from 50 to 30 cm (Pleiades-1 and -2; GeoEye-1; Kompsat-3 and -3A; WorldView-1, -2, -3 and -4). These images contain information that largely exceeds what traditional algorithms, generally developed for moderate spatial resolution images (such as Landsat and SPOT), can extract.

The evolution of machine learning techniques led, in 2013, to the approach based on deep convolutional neural networks (DCN). This approach allowed achieving performances never obtained before in the field of image processing. Simply, we can say that a CNN is based on a first processing block that extracts, by multi-scale convolutions, the properties of the image at several levels of resolution; and a second processing block composed of a neural network with several hidden layers that 'learns' to recognize complex properties within images, such as context and associations. It must be said, however, that effective learning depends on a sufficiently trained CNN, which requires a training database (annotated patches) of about a thousand images per type of object or land use class.

The majority of current CNNs were developed for generic images. Their extension to remote sensing images poses several research challenges. The adaptation of CNNs to the nature and content of these images requires at least their re-training on annotated databases, and even possibly the development of new, better adapted and more efficient, architectures. One of the factors that has so far limited the penetration of deep learning in the field of remote sensing is the access to large open training sets, with enough classes and occurrences for each class.

The GeoImageNet project presented here, started in the fall of 2018, is a unique collaborative initiative involving remote sensing researchers, developers of digital research platforms, artificial intelligence experts and professionals dedicated to adding value to satellite imagery. This project is the result of a partnership between the Department of Applied Geomatics of Université de Sherbrooke, the Computer Research Institute of Montreal (CRIM), Effigis Géo-Solutions and the Canada Centre for Mapping and Earth Observation (CCMEO) of Natural Resources Canada. These organizations have carried out, separately or collaboratively, several projects demonstrating that

the application of CNNs to object detection, classification and mapping results in much higher success rates than traditional methods used in remote sensing.

GeoImageNet will be available to other research teams in Canada. It will be a collaborative research platform for researchers from different backgrounds who wish to develop innovative algorithms for the exploitation of very high resolution (VHR) satellite images for various applications. The platform uses some of the software components of the PAVICS platform (https://pavics.ouranos.ca/), in particular for authentication. The main part of the platform is based on OGC standards (WMS, WFS, WPS). Four categories of users are taken into account (guests, annotators, experts and administrators) giving access to the various functionalities of the platform. The annotation database has been designed to ensure maximum traceability of the creation, validation and quality control steps.

During the first phase, the platform will support annotation, the creation of a training database for deep learning and the testing of models developed by experts in the field. The project will help build a database of annotated images with a taxonomy adapted to the content of THR images, which will include 226 classes divided into two main categories: objects (178 classes) and land cover (48 classes). Annotations, made both automatically (guided by vector data) and manually, will be validated by domain users and may be subject to confirmation requests from expert users.

The training database will be composed of regions of interest including annotations, 90 % of which can be downloaded by users as a deep learning database while 10 % will be retained for testing models when they are uploaded to the platform. The imagery used to build the database includes more than 10,000 km^2 of Pleiades images and approximately 3,000 km^2 of WorldView-2 and -3 images acquired over Canada's major cities as well as various other natural and anthropic environments (forests, wetlands, mining sites, agricultural areas, etc.).

The platform for domain users as well as the general public home website will provide access to the trained models and their results on GeoImageNet test data. It will also include a security module that will validate access rights to data and operations. For example, an annotator will not be able to validate an annotation. Finally, the traceability module will provide statistics on the status of the platform in order to better manage annotation operations and user needs.

The second phase will focus on the development of deep learning algorithms for object detection and land use mapping from THR satellite images. It will also include the evolution of taxonomy, data augmentation for training sets and the parametrization of download options for these sets.

Opening the access of GeoImageNet to various Canadian organizations (universities, research centres, industry, etc.) conducting research in the fields of remote sensing and artificial intelligence will allow researchers from diverse institutions to collaborate in a more structured and effective manner for the application of deep learning in remote sensing and to develop new value-added products based on THR satellite images. This synergy will facilitate making more progress in research, both in remote sensing applications and in the development of learning algorithms.