Report for 2017 Scientific Initiative: ISPRS Benchmark Challenge on Large Scale Classification of VHR Geospatial Data

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Summary and goal

Remote sensing data offers the unique possibility to continuously monitor the Earth's changes over large areas. Nowadays, we are facing an unprecedented growth in the number of satellites with embedded sensors characterized by always increasing spatial, spectral and temporal resolutions. This drastically increases the amount of available data, particularly very high resolution data (VHR), allowing both a high spatial and high temporal resolution coverage of the entire globe.

In order to analyze and interpret the sheer size of data, automated machine learning methods are necessary which shall be efficient and applicable to large-scale scene analysis to reliably solve these Earth monitoring tasks. A typical bottleneck of supervised learning approaches is the availability of (manually) labeled training data, which is particularly important to train state-of-the-art (deep) learning methods.

The goal of our scientific initiative was the generation of a publicly available, large-scale, VHR, multi-spectral benchmark dataset for training and evaluation of sophisticated machine learning models. We were especially aiming in on the provision of a complex and realistic benchmark which acts as test bed for these methods on challenges which have been rarely considered before such as instance segmentation or VHR change detection, and foster the development of ad-hoc systems relying on recent advances in machine learning. The benchmark should address interested researchers from various communities such as photogrammetry and remote sensing, but also computer vision and machine learning.

During the period of this project funded by the ISPRS Scientific Initiative we have prepared the benchmark `SemCity Toulouse`, which will be released in the context of a benchmark challenge within the next weeks. Our tasks were the preparation of the data, labeling reference data, as well as the design and implementation of the evaluation.
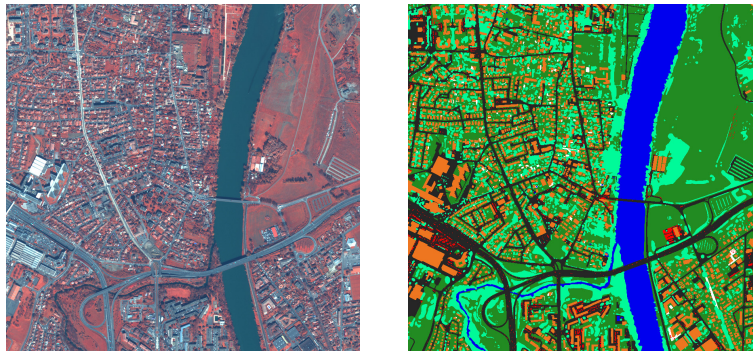
Activities

During the funding period we were involved in the following activities. Some of them will continue thereafter, and are denoted with a star (*):

- Negotiations with European Space Imaging (EUSI) regarding the provision of a high-quality and high-resolution multispectral dataset;
    - Two Worldview II satellite images from April 2011 and February 2016, covering an area of 50km^2 of the greater city center of Toulouse;
    - Orthorectified 1:12.000 Bundle (8 Band), 16 bit, 50cm GSD;
- Subdivision of the area into 16 tiles of size 3452×3504 pixels, where each tile has a georeference;
- The images were annotated into 6 land cover classes relating to other well-known benchmarks (e.g. ISPRS WG II 4 Semantic Labeling challenges), namely 'impervious surface', 'building', 'pervious surface', 'high vegetation', 'cars', and 'water'. Moreover, buildings are annotated as single objects for semantic instance segmentation (*). All image tiles will be made available to participants, whereas only 8 tiles with reference data will be provided. The remaining 8 tiles will be used for evaluation only.
- Set up a website with information about the data set, user registration and for submission of the results;
- Implementation of a fully automatic evaluation tool for a comprehensive accuracy assessment for semantic instance segmentation. The evaluation tool comprise criteria such as the confusion matrix, overall accuracy, average accuracy, Kappa coefficient, as well as several criteria derived from the intersection over union.
- Implementation of a fully automatic evaluation tool for change detection (*).

One training tile (illustrated in RGB) along with its annotation can be seen in Fig. 1(a) and 1(b).

The benchmark challenge contains sub-challenges, where we decided to start with the sub-challenge semantic instance segmentation containing the single building instances and the sub-challenge semantic segmentation without single instances. We will add further challenges such as change detection in near future. The website for the challenge can be assessed via `https://semcity.ipb.uni-bonn.de/` and the evaluation scripts via `https://github.com/isprs-semcity`, ensuring a fully transparent framework.

(a) Satellite image tile (pseudo-color illustration)

(b) Annotation

Figure 1: One tile of our benchmark dataset; colors in the right image indicate the land cover class: 'impervious surface' (dark gray), 'building' (brown), 'pervious surface' (dark green), 'high vegetation' (light green), 'cars' (red), and 'water' (blue).

Current state and next steps

The release of the website is planned for spring 2018, which is, however, later than originally planned, since the annotation of the data is still ongoing.

Our SI will be presented at the mid-term symposium of ISPRS TC II in June 2018. As soon as the challenge has started, a cover paper will be prepared for publication in ISPRS Journal of Photogrammetry and Remote Sensing. It will comprise baseline results of state-of-the-art methods and submitted results to the challenge, which will be prepared in summer 2018 and submitted in fall 2018.

Justification of money spent (9000 CHF/8269 EUR)

- Data from EUSI: 1469 EUR
- Annotations: 6800 EUR