

PROPOSITION DE SUJET DE THESE

Intitulé : Semi-supervised semantic segmentation for large-scale automated cartography

Référence : **TIS-DTIS-2018-02**
(à rappeler dans toute correspondance)

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Subject : Semi-supervised semantic segmentation for large-scale automated cartography

Context

The evergrowing satellite imagery data in the last two decades have allowed new developments in the fields of ecology, urban planning or natural disaster response. Those data are also more easily available, even openly as in the Copernicus program of the European Space Agency (Sentinel satellites). However, data exploitation requires human interpreters, for example to identify tree species to study deforestation in a local ecosystem or find new buildings to measure growth of urban areas.

Thanks to the new deep learning methods developed for processing multimedia images in recent years, it now becomes possible to automate most of these processings for Earth-observation data. Indeed, many state-of-the-art algorithms for object detection and image segmentation or classification [Audebert 2016, Rey 2017] have been successfully transferred for aerial and satellite images. It allows to produce quickly and without human intervention precise semantic mappings, in both urban and rural contexts.

This thesis project aims at large-scale, automated cartography, which raise several problems.

Problem 1: How to make semantic segmentation on a real large scale ?

Image data openly available are mostly from satellites (Sentinel, Pleiades) which implies extend the existing algorithms to new modes (for example multispectral) and new resolutions. Moreover, they should be multi-domain, which means obtain equal performances whatever the context or the location. In practice, imagine new neural network architectures for semantic segmentation [Audebert 2016, Audebert 2017, Volpi 2017] will be the main axis of this thesis, by taking into account progresses in computer vision and artificial intelligence.

Problem 2: How to deal with sparse, heterogeneous data?

Learning algorithms still rely mostly on the availability of large annotated image repositories. If collaborative, open-source maps such as OpenStreetMap can be used as annotations [Audebert

2017b, Maggiori 2017, Mnih 2012], they are spatially sparse (not uniformly distributed and even absent from some areas) and sometimes not reliable (either because too old or badly made).

A goal will be to benefit from unlabeled or weakly-labeled data to improve network performances for semantic segmentation, including for areas with few training samples. So we propose to define unsupervised or semi-supervised learning strategies [Rasmus 2015, Durand 2017, Khoreva 2017]. Semi-supervised learning consists in using unlabeled data to build a representation space for the satellite images while using labeled data to learn a classifier based on this representation.

Moreover, we will study joint learning from multiple image modalities, at various resolutions, and complementary data such as georeferenced streetview images [Lefèvre 2017].

Problem 3: How to predict maps with varying semantic levels?

Collaborative annotations are also poor in semantic variety (only roads, buildings, etc.) and might not correspond to application needs. An objective will be to be able to transfer learned representation from precisely-annotated areas to areas with less rich annotations [Redmon 2017]. In practice, the final semantic prediction could be structured in multiple levels of details depending on available resources. We will also study the relevance of one-shot-learning and zero-shot-learning strategies in this context [Sumbul 2017].

Problem 4: How to estimate which prediction is possible depending on the available data?

A recurring, practical problem is to foresee which kind of maps can be produced in a given location, which and how much data are required to produce these maps, and eventually how much training is needed. Moreover, an estimate of the relevance of the prediction is a crucial element for the one who has to take decisions based on such a map.

Practical information

This thesis will be carried out as part of collaboration between ONERA/DTIS (Bertrand Le Saux and Alexandre Boulch) and the OBELIX team of IRISA at University Bretagne Sud (Sébastien Lefèvre, PhD supervisor). It will take place mainly in the ONERA centre in Palaiseau (near Paris).

Short bibliography

[Audebert 2016] Semantic Segmentation of Earth Observation Data using Multimodal and Multi-scale Deep Networks; Audebert, N., Le Saux, B., Lefèvre, S.; Asian Conference on Computer Vision (ACCV), 2016.

[Audebert 2017a] Segment-before-Detect: Vehicle Detection and Classification through Semantic Segmentation of Aerial Images; Audebert, N., Le Saux, B., Lefèvre, S.; Remote Sensing, 2017.

[Audebert 2017b] Joint Learning from Earth Observation and OpenStreetMap Data to Get Faster Better Semantic Maps; Audebert, N., Le Saux, B., Lefèvre, S.; EarthVision - CVPR Workshop, 2017.

[Durand 2017] WILDCAT: Weakly Supervised Learning of Deep ConvNets for Image Classification, Pointwise Localization and Segmentation; Durand, T., Mordan, T., Thome, N., Cord, M.; IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2017

[Khoreva 2017] Simple Does It: Weakly Supervised Instance and Semantic Segmentation; Khoreva, A., Benenson, R., Hosang, J., Hein, M., Schiele, B.; IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2017

[Krizhevsky 2012] Imagenet classification with deep convolutional neural networks; Krizhevsky, A., Sutskever, I., Hinton, G.E.; Advances in neural information processing system (NIPS), 2012

[Lefèvre 2017] Toward Seamless Multiview Scene Analysis From Satellite to Street Level; Lefèvre, S., Tuia, D., Wegner, J.D., Produit, T., Nassaar, A.S.; Proceedings of the IEEE, 2017

[Maggiori 2017] Can Semantic Labeling Methods Generalize to Any City? The Inria Aerial Image Labeling Benchmark; Maggiori, E., Tarabalka, Y., Charpiat, G., Alliez, P.; IEEE International Geoscience and Remote Sensing Symposium (IGARSS), 2017

[Mnih 2012] Learning to Label Aerial Images from Noisy Data; Mnih, V., Hinton, G.; International Conference on Machine Learning (ICML), 2012

[Rasmus 2017] Semi-Supervised Learning with Ladder Networks; Rasmus, A., Valpola, H., Honkala,

M., Berglund, M., Raiko T.; International Conference on Neural Information Processing Systems (NIPS), 2015

[Redmon 2017] YOLO9000: Better, Faster, Stronger; Redmon, J. and Fahradi, A.; IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2017

[Rey 2017] Detecting animals in African Savanna with UAVs and the crowds; Rey, N., Volpi, M., Joost, S. and Tuia, D.; Remote Sensing of Environment, 2017

[Sumbul 2017] Fine-Grained Object Recognition and Zero-Shot Learning in Remote Sensing Imagery; Sumbul, G., Cinbis, R.G., Aksoy, S.; IEEE Transactions on Geosciences and Remote Sensing, 2017

Collaborations extérieures : OBELIX team of IRISA at University Bretagne Sud

PROFIL DU CANDIDAT

Formation :

Master of science or Engineering school diploma with outstanding results

Spécificités souhaitées :

Extensive knowledge of image processing and computer science with a specialization among: statistical learning, computer vision, remote sensing.

To apply for this position, please send an up-to-date CV, an covering letter and recommendation letters to the thesis director and supervisors.