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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 fileds 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 interprets, 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 developped 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 transfered for aerial and satellite images. It allowes 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, Pleïades) 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 of 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 ressources. 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). This thesis is also co-funded by CNES (CNES correspondant: Victor Poughon).

Short bibliography

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[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 ,

DCT/SI/2A team at CNES

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