PhD Thesis subject: integration of ad-hoc combinatorial post processing in learning architectures

Supervised by: Hugo Raguet, Julien Mille and Romain Raveaux (Hugo.Raguet@univ-tours.fr, Julien.Mille@univ-tours.fr and Romain.Raveaux@univ-tours.fr) from the LIFAT laboratory of Tours in France (https://lifat.univ-tours.fr/).

Description:

Many prediction tasks exhibit some kind of spatial regularity, e.g. semantic segmentation of images or 3D point clouds since most neighboring pixels or points belong to the same class. In cases for which state-of-the-art methods involve deep neural networks, it is common to resort to a postprocessing regularization step to enhance the quality of predictions. In contrast, we would like to investigate the integration of such regularization step within the neural network architecture.

This is motivated by two potential benefits. First, this would make the neural network aware of the regularization process during the learning phase, possibly leading to better prediction but more importantly to learn from smaller or corrupted training data. Second, this would enable the learning of the regularization parameters themselves, making the regularization step more adaptive.

This approach can be generalized to other kind of regularization or post processing, which are currently used in situations where experts must introduce prior knowledge for learning adequate representations, typically due to lack of data. More often than not, such regularization are combinatorial by nature.

The main difficulty is to find regularization methods with acceptable computational load and that can be differentiated with meaningful derivatives. Sometimes, the combinatorial nature can be relaxed to continuous formulations, for instance $\ell 1$ regularization for feature selections or total-variation regularization for spatial regularity, leading to a process that is essentially differentiable. Recently, new techniques [1] introduced ways of differentiating through the actual combinatorial solver. Our goal is to explore and compare both techniques.

The starting point of our investigation would be graph-based spatial total variation regularizations, solved using our parallel cut-pursuit approach [2]. This would the opportunity for close collaboration with Loic Landrieu at IGN (Paris), being a still pending task at the heart of his project READY3D [3].

This work might also lead to collaborations within the LIFAT, given its ties with a current research interest of Romain Raveaux (RFAI), and the ongoing investigation about the integration of machine learning algorithms within operational research algorithms, by Vincent Tkindt and Ronan Bocquillon (ROOT).

The PhD will be paid with legal allowances.

References:

[1] Pogančić, M. V.; Paulus, A.; Musil, V.; Martius, G. & Rolínek, M. Differentiation of Blackbox Combinatorial Solvers, International Conference on Learning Representations, 2020

[2] Raguet, H. & Landrieu, L. Cut-Pursuit Algorithm for Regularizing Nonsmooth Functionals with Graph Total Variation, International Conference on Machine Learning, PMLR, 2018, 80, 4244-4253

[3] Real-Time Analysis of Dynamic LiDAR 3D Point Clouds – READY3D, ANR-19-CE23-0007