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Proposal for a Master thesis topic (DE/EN)

Developing strategies to handle imbalanced class-distributions in the land cover classification based on Convolutional Neural Networks

Classification of land cover is a standard task in remote sensing, in which each image pixel is assigned a class label indicating the physical material of the object surface (e.g. *grass*, *building*). This task is highly relevant for applications such as the detection of changes or rapid mapping. Recent work has focused on Convolutional Neural Networks (CNN), delivering considerably better results than traditional classifiers. This is mainly due to the fact that, unlike traditional classifiers using hand-crafted features, CNNs provide a framework in which these features (and, thus, a representation of the image) can be learned from training data. CNNs for land cover classification use an encoder-decoder structure, that use convolutions and pooling in the encoder part and transposed convolutions or other upsampling methods in the decoder part to obtain per-pixel predictions. A major problem of CNN for land cover classification is the class imbalance in the training data: in a training mini-batch, some classes may have a very large number of samples, yet others may have very few. This can prevent the CNN from learning a good representation for under-represented classes.

The goal of this master thesis is to develop strategies to compare and expand strategies for coping with class imbalance in the procedure for training an existing CNN structure. A popular approach is the use of loss functions that focus on the underrepresented or difficult classes. At the Institute of Photogrammetry and GeoInformation (IPI), there exist implementations of two such loss functions, the weighted cross-entropy and the extended focal loss for multiclass classification. They should be compared to each other and can also serve as methods of comparison for new methods developed in the course of this M.Sc. thesis. After setting up a baseline without any class-balancing strategy and a comparison of the loss functions already available at IPI to this baseline, the student shall extend these methods to further mitigate the negative influence of class imbalance. The first direction of research is an expansion of the loss functions, e.g. a combination of the weighted cross-entropy and focal losses, or the inclusion of additional loss function terms that require feature vectors corresponding to the same classes to be similar. Another option is an extended data augmentation strategy that adapts the degree of data augmentation to the number of training samples of a class, so that more synthetic samples for underrepresented classes are generated for training. In the course of his M.Sc. thesis, the student shall investigate such methods and compare them to existing ones to show which strategy is the most promising one to solve the problem of unbalanced class distributions.

The required methods shall be implemented in a PyTorch development environment for CNN. In this context, the student shall use an existing CNN architecture for which the source code is available at IPI. The developed methods shall be evaluated using test datasets for which a reference is available. At IPI, there are satellite images from Sentinel-2 with GSD of 10m. Moreover, high-resolution aerial images such as Vaihingen and Potsdam benchmark dataset (GSD < 10cm) from the ISPRS semantic labelling challenge are also available for usage.

This thesis will be supervised by Mirjana Voelsen, M.Sc.

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