Superpixel Segmentation of Remote Sensing Images using Waterpixels in Commodity Hardware

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Abstract

The high spatial dimensionality of the remote sensing images that are captured by modern hyperspectral sensors prevents many algorithms from being computationally feasible. Superpixel segmentation is a process that groups pixels into connected regions that are uniform according to one or more similarity measures. Once the superpixels are obtained, many processing stages can be computed over them instead of over all the pixels, thus reducing the number of operations and making the application of a broad range of algorithms possible. Currently, superpixel algorithms have turned into standard tools in low-level image processing.

WaterPixel (WP) segmentation is a particular case of superpixel segmentation based on the watershed transform. Superpixel segmentation algorithms based on clustering iteratively compute distances. In contrast, WP segmentation separates the computation of the distances from the segmentation process itself. As a consequence, the computation cost is decreased. Another advantage of WP is that it explicitly enforces connectivity unlike the case of clustering-based superpixel segmentation algorithms, which require a postprocessing stage for achieving connected sets of pixels.

The computational advantages of waterpixels need to be reinforced by an adequate parallel implementation. This is particularly true when hyperspectral images with hundreds of bands of information and high spatial resolution are processed, as the information available in the different bands of the images needs to be exploited.

In this paper an efficient implementation of the WP algorithm for the segmentation of remote sensing hyperspectral images on multi-core CPUs and programmable GPUs is explored. The proposed approach focuses on reducing the cost of the morphological gradient and the watershed segmentation, which are the two most costly steps of the algorithm. The GPU code is based on the Compute Unified Device Architecture (CUDA) developed by NVIDIA, exploiting the asynchronous computation by blocks of threads. Experiments performing waterpixel segmentation followed by classification on real datasets are carried out. The analysis of the implementation shows the efficiency of the computation by blocks carried out on GPU and how commodity hardware is an adequate platform for WP segmentation of hyperspectral images.