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Tree Filtering: Efficient Structure-Preserving Smoothing With a Minimum Spanning Tree

Abstract:

We present a new efficient edge-preserving filter-"tree filter"-to achieve strong image smoothing. The proposed filter can smooth out high-contrast details while preserving major edges, which is not achievable for bilateral-filter-like techniques. Tree filter is a weighted-average filter, whose kernel is derived by viewing pixel affinity in a probabilistic framework simultaneously considering pixel spatial distance, color/intensity difference, as well as connectedness. Pixel connectedness is acquired by treating pixels as nodes in a minimum spanning tree (MST) extracted from the image. The fact that an MST makes all image pixels connected through the tree endues the filter with the power to smooth out high-contrast, fine-scale details while preserving major image structures, since pixels in small isolated region will be closely connected to surrounding majority pixels through the tree, while pixels inside large homogeneous region will be automatically dragged away from pixels outside the region. The tree filter can be separated into two other filters, both of which turn out to have fast algorithms. We also propose an efficient linear time MST extraction algorithm to further improve the whole filtering speed. The algorithms give tree filter a great advantage in low computational complexity (linear to number of imagepixels) and fast speed: it can process a 1-megapixel 8-bit image at ~ 0.25 s on an Intel 3.4 GHz Core i7 CPU (including the construction of MST). The proposed tree filter is demonstrated on a variety of applications.