論 文 の 内 容 の 要 旨

論文題目　Neighbor-Aware Approaches for Pixel Labeling
（近傍を考慮した画素ラベリング）

氏　名　古田　諒佑

Pixel labeling is one of the most classical and important problems in the field of computer vision because it has a variety of applications. In this thesis, we tackle two major challenges of pixel labeling: (i) how to deal with the large solution space, and (ii) how to learn the relationships between neighbor labels effectively.

For the first challenge, we propose two neighbor-aware fast optimization methods.

Neighbor-aware fast optimization for general MRF: One is the fast optimization method for general pixel-labeling problems based on Markov random field (MRF) models where the smoothness between the neighbor labels is forced. We focus on an optimization method called cost-volume filtering (CVF) and propose a coarse-to-fine strategy for CVF that efficiently and accurately addresses pixel-labeling problems with a large label space size. Experimental results show that our algorithm achieves much higher efficiency than the original CVF method while maintaining a comparable level of accuracy on stereo matching and optical flow estimation.

Neighbor-aware fast optimization for special MRF: The other is the fast optimization method for special case of pixel-labeling problems where the neighbor labels are forced to be connected. We propose a fast optimization method named “multi-pass dynamic programming” for this optimization problem, which is approximately 90 times faster and consumes 8 times less memory than conventional graph cuts methods. The main application of this optimization problem is volume seam carving (seam carving for 3D cost volume), which is applied to various of image processing tasks such as video retargeting, tone mapping, and contrast enhancement.

For the second challenge, we propose two novel neighbor-aware learning methods that boost the performance of pixel labeling.

Learning neighbors with convolutional neural network: We reveal the mathematical relationship between the fixed point iteration of dense CRF and recurrent convolution. Based on this interpretation, we propose a new model based on dense CRF, which automatically learns the relationships between neighbor labels from training data and enables jointly train with deep neural networks. The proposed dense CRF can be incorporated into fully convolutional network (FCN) as a module and trained end-to-end. Experimental results show that our method obtains better results on semantic segmentation, compared with the existing methods based on hand-crafted CRF.

Learning neighbors with deep reinforcement learning: We propose a completely novel problem setting (pixelRL) and an effective neighbor-aware learning method for pixelRL named reward map convolution. PixelRL is a novel pixel-labeling problem combined with reinforcement learning, where the label is a sequence of actions at each pixel, and its objective is to maximize the accumulated total rewards at all pixels. We apply the proposed method to three image processing tasks: image denoising, image restoration, and local color enhancement. Our experimental results demonstrate that the proposed method achieves comparable or better performance, compared with the state-of-the-art methods based on supervised learning at each task.