PatchCut: Data-Driven Object Segmentation via Local Shape Transfer

Jimei Yang[1], Brian Price[2], Scott Cohen[2], Zhe Lin[2], Ming-Hsuan Yang[1]
[1]UC Merced. [2]Adobe Research.

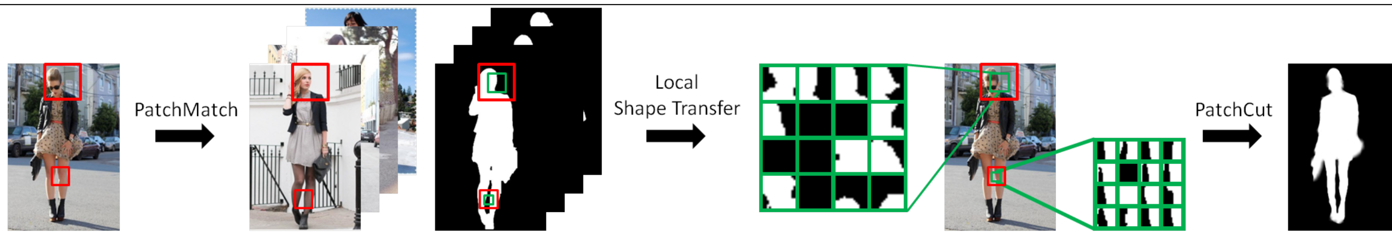

Figure 1: Overview of proposed object segmentation algorithm using examples. Given a test image and a set of segmentation examples, our algorithm first performs multiscale image matching in patches by PatchMatch. The local shape masks within the matched patches are then transferred to represent the patch-wise segmentation candidates for the test image. Finally, local mask candidates are selected based on an MRF energy function to produce the segmentation in a coarse-to-fine manner.

Overview. We propose a data-driven object segmentation algorithm by using a database of existing segmentation examples. Our algorithm requires neither offline training nor design of category-specific shape models. Instead, it transfers shape priors by image matching. Compared to existing nonparametric algorithms [1, 2] that match images by large window proposals, we develop a multi-scale dense image matching scheme to achieve local shape transfer. Specifically, at each scale, we obtain a pool of local shape mask candidates for every pixel of a test image. By analyzing the mean and upperbound quality of local shape mask candidates in multiscale as demonstrated in Fig. 2, we observe that those candidates indeed constitute an online structured label space where segmentation solutions can be gradually obtained. This motivates a coarse-to-fine strategy where a blurry shape mask at the coarse scale guides the selection of right label patches at the fine scale, which leads to a clearer shape mask.

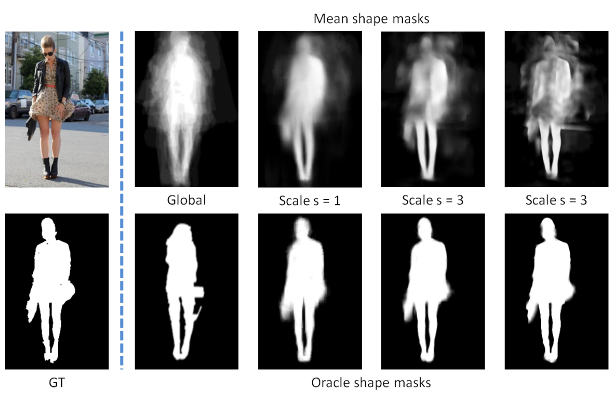

Figure 2: Shape prior masks estimated from mean masks (top row) and best masks (bottom row) at different scales. At the coarse scale, the object is well located but its boundary is blurry in the mean shape masks. Moving towards finer scales, the quality of mean shape mask (legs) become divergent in different areas. Meanwhile, both location and boundary qualities of oracle shape masks keep getting better and better from coarse to fine scales.

Algorithm. We thereby develop a novel cascade algorithm for example-based object segmentation, as shown in Fig. 3. At each scale, we define a nonparametric high-order MRF energy function with the coarse shape mask from the previous scale, and the patch potentials on transferred local shape mask candidates. Under some conditions, the minimization of this energy function can be decomposed into 1) a series of independent slave subproblems of candidate selection on patches, and 2) a master problem to aggregate the selected local masks. This patch-wise decomposition provides an approximate solution to global energy minimization, but a solution which is easier to solve in parallel. We carry out this patch-wise segmentation while updating the foreground/background color models. This iterative procedure shares a similar idea with GrabCut, but it operates patch-wise in a structured label space that consists of local mask candidates. Thus we name our method *PatchCut*.

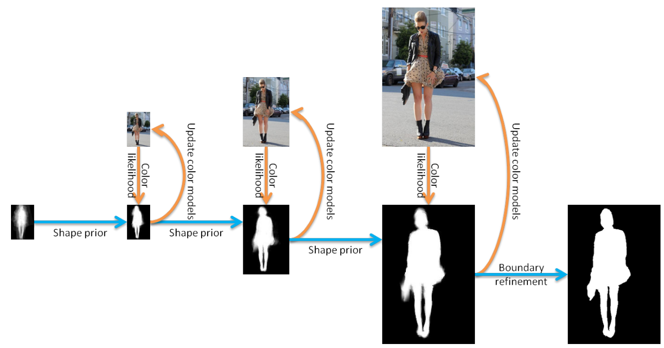

Figure 3: PatchCut cascade for coarse-to-fine object segmentation.

Results. We carry out experiments on four object segmentation benchmark datasets: Fashionista, Weizmann Horse, Object Discovery and PASCAL, and achieve better results in comparisons with leading example-, learning- and saliency-based algorithms in Table 1. Below lists some representative segmentation results by PatchCut in various object categories.

Table 1: Evaluating object segmentation by Jaccard scores (%).

Dataset	PatchCut	Previous Arts
Fashionista	88.33	64.23 (GrabCut)
Weizmann Horse	84.03	80.10 (Kernelized Structured SVMs)
Object Discovery	73.26	63.73 ([1])
PASCAL	64.97	60.75 (CPMC_GBVS)

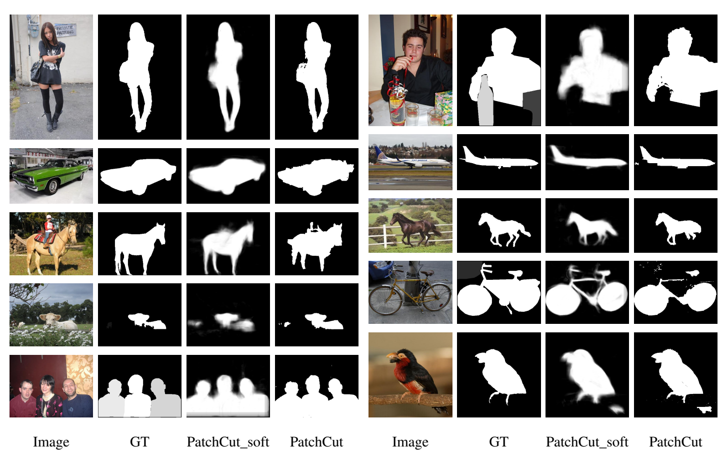

Figure 4: Representative PatchCut results on various object categories.

[1] Ejaz Ahmed, Scott Cohen, and Brian Price. Semantic object selection. In *CVPR*, 2014.

[2] Daniel Kuettel and Vittorio Ferrari. Figure-ground segmentation by transferring window masks. In *CVPR*, 2012.