Kernel Fusion for Better Image Deblurring

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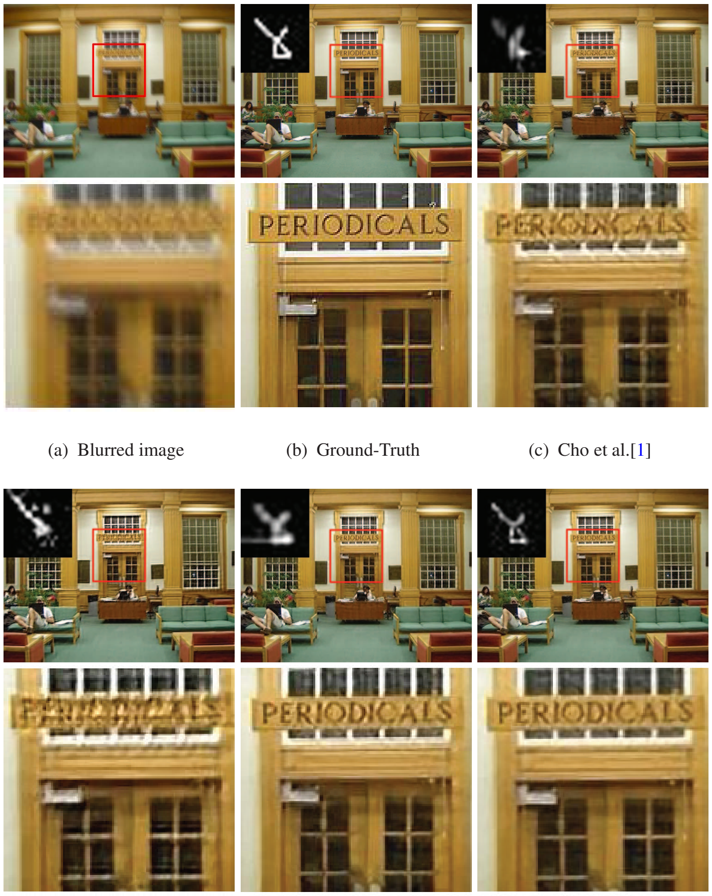

(a) Blurred image (b) Ground-Truth (c) Cho et al.[1]

(d) Goldstein et al.[4] (e) Xu et al.[7] (f) **Kernel Fusion**

Figure 1: Kernel fusion and image deblurring examples. By combing multiple kernel estimations from different image deblurring methods, our kernel fusion method can produce the final kernel that is more accurate and leads to better deblurring results than each individual one.

Images taken by consumer photographers often come out blurry due to camera shake caused by the sensor movement during the exposure time. In many cases, the problem is inevitable without using equipments like tripods, which are often not available. Removing the effect of camera shake from images has been an important research topic in computer vision and graphics.

There is now a rich literature on image deblurring [1, 2, 3, 4, 5, 6, 7, 8]. In this paper, we focus on *blind image deconvolution* where the blur kernel is unknown and needs to be recovered along with the sharp image. Over the past decade, remarkable research effort has been devoted to developing methods that can accurately recover blur kernels. While existing blind deblurring methods have shown significant improvement in terms of kernel estimation accuracy (and thus the deblurring results), their performance can still be improved. While each method can estimate good kernels for some images, none of the methods can perfectly recover the kernels in all the cases. More interestingly, we observed that as different methods often incorporate different prior knowledge into their deblurring framework, they often complement each other. Therefore, combining multiple kernels from different methods can lead to a better kernel, as illustrated in Figure 1.

This paper presents a method to leverage existing blur kernel estimation methods to better support image deblurring than these existing methods themselves. *Our idea is to fuse kernels from multiple existing deblurring methods such that the combined kernel outperforms each individual one.*

This is an extended abstract. The full paper is available at the Computer Vision Foundation webpage.

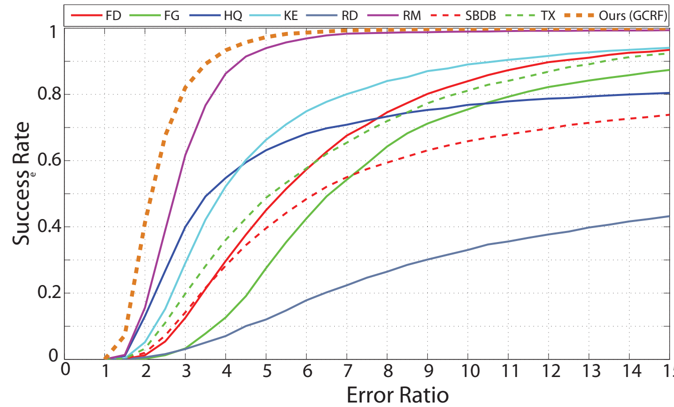

Figure 2: Error ratio curves. Our kernel fusion methods lead to kernel estimation results with significantly higher success rate compared to each individual method.

The problem is challenging in that the fusion process needs to capture the complex relation among individual estimations, as well as how they relate to the underlying true blur kernel. Classical fusion methods such as (weighted) averaging cannot lead to good fusion results. Therefore, we develop data-driven approaches to kernel fusion that learns how individual kernels contribute to the final fusion result and how they interact with each other.

In this paper, we develop data-driven approaches which can effectively learn the good kernel fusion models from training data. After examining various kernel fusion models, we find that kernel fusion using Gaussian Conditional Random Fields (GCRF) performs best. This GCRF-based kernel fusion method not only models how individual kernels are fused at each kernel element but also the interaction of kernel fusions among multiple elements. Our experiments show that our method can significantly improve image deblurring by combining kernels from multiple methods into a better one (Figure 2).

Acknowledgement. The source image in Figure 1 is used from Flickr user vanherdehaage under a Creative Commons license.

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