**Adaptive Bilateral Filter for Sharpness Enhancement and Noise Removal**

**ABSTRACT**

In this paper, we present the adaptive bilateral filter (ABF) for sharpness enhancement and noise removal. The ABF sharpens an image by increasing the slope of the edges without producing overshoot or undershoot. It is an approach to sharpness enhancement that is fundamentally different from the unsharp mask (USM). This new approach to slope restoration also differs significantly from previous slope restoration algorithms in that the ABF does not involve detection of edges or their orientation, or extraction of edge profiles. In the ABF, the edge slope is enhanced by transforming the histogram via a range filter with adaptive offset and width. The ABF is able to smooth the noise, while enhancing edges and textures in the image. The parameters of the ABF are optimized with a training procedure. ABF restored images are significantly sharper than those restored by the bilateral filter. Compared with an USM based sharpening method—the optimal unsharp mask (OUM), ABF restored edges are as sharp as those rendered by the OUM, but without the halo artifacts that appear in the OUM restored image. In terms of noise removal, ABF also outperforms the bilateral filter and the OUM. We demonstrate that ABF works well for both natural images and text images.

**Index Terms**—Bilateral filter, de-blurring, noise removal, range filter, sharpness enhancement, slope restoration.