A TEST OF A COMMON SUPER-RESOLUTION ALGORITHM. Z. A. Musselman and M. K. Shepard, Department of Geography and Earth Science, Bloomsburg University, Bloomsburg, Pennsylvania 17815, zmussel@planetx.bloomu.edu, and mshepard@bloomu.edu.

Abstract: We tested a super-resolution algorithm first proposed and used by T. Parker [1] to enhance images of the Pathfinder and Viking Lander landing sites. We took 25 digital images of a resolution test chart and combined them into groups of 4, 9, 16, and 25. Although the combined images are all significantly better than any individual image, a quantitative examination of the final products reveals that the resolution enhancement is minimal, if existent at all. Instead, the dramatic improvement in image quality is the result of a reduction in image signal-to-noise, and the entire process is comparable to “stacking” seismic data. We suggest that a more accurate term for these products be found and used; possibilities include “image-stacks” or “super-SNR” images.

Introduction: Super-resolution is a term given to single image products which have been produced by combining many images of the same scene, using an algorithm that purports to increase the resolution of the final product. The theory is that subtle sub-pixel shifts in each image will, when combined, provide a sharper point spread function in the final product, *i.e*., improve the resolution. There are numerous algorithms available to perform this task [1,2,3], and in this work, we tested only the algorithm developed and used by Parker [1].

Algorithm. Individual images are imported into Adobe Photoshop™ and enlarged by a factor of 10 using bicubic interpolation. Each image is filtered using the Unsharp Mask with the following parameters: amount 100%; radius 5.0 pixels; and threshold 0. This latter operation is essentially an edge enhancement. Images are then stacked (using the layering tool) and opacities are set to 1/*n* %, where *n* is the layer number, to make each image equally visible. As each image is stacked, it is aligned by eye to the image below it. Although this part of the algorithm is qualitative, the eye is capable of very precise adjustments, and the 10x enlargement assures accurate subpixel alignment. When all images have been filtered, stacked, and aligned, they are merged (i.e., averaged) into a single image.

Test Methodology. We generated a resolution test chart made up of alternating dark and light line-pairs, arranged both horizontally and vertically. Resolutions on the chart ranged from 4 to 6 line-pairs per cm (lpc) in half line-pair increments. A Kodak™ DC50 digital camera was used to acquire the images. Several test images were taken at varying distances to find the distance at which 4 lpc were easily resolved and 6 lpc were not. At this distance, we took 25 images, varying the camera position slightly (laterally) between images to ensure adequate sub-pixel movement. These images were downloaded and split into RGB components. Only the green component (the brightest) was retained and utilized in the algorithm. This latter step was performed to avoid potential subpixel artifacts that might have been created in the camera during the formation of the original color image. Additionally, we utilized only TIFF or BMP image formats throughout the process to avoid artifacts that might be generated from compressed image files.

Results: Figure 1 shows a typical individual image after the edge enhancment filter has been applied. Note that the 4 lpc image is readily resolved, but the 6 lpc image is not. Figure 2 shows the result of processing and combining 13 images. The image quality is obviously better, and we appear to be resolving detail in the 5.5 lpc image that is not visible in the original. However, examination of a DN slice through the image shows this not to be the case (Fig. 3). (Note that DN lows correspond to dark lines, and DN highs correspond to light lines.) The detail that is becoming discernible in the processed image is present in the original (see arrows), but often masked by noise. Combining the images enhances similarities, but suppresses the noise. Examination of a slice through the 6 lpc image confirms this interpretation; variation in the original image is entirely due to noise, all of which has been essentially removed in the processed image.

Conclusions: If any enhancement in resolution occurs from this algorithm, it is minimally responsible for the dramatic improvement in image quality. The dominating process that occurs is one of reducing image signal-to-noise. Detail that is present in any single image is often masked by noise. Reducing signal-to-noise allows these finer image details to be more readily discerned, thus giving the appearance of improved resolution. We suggest that the “super-resolution” label is a misnomer, and a better descriptor would be “image-stacks” or “super-SNR.”

References: [1] T. Parker (personal comm., 1998) [2] Hunt B. R. (1995) *Int. J. Imaging Sys. Tech.*, *6*, 297-304. [3] Keren, D. et al. (1988) *Proc. CVPR 88 Comput. Soc. Conf. on Comput. Vision*, 742-746.

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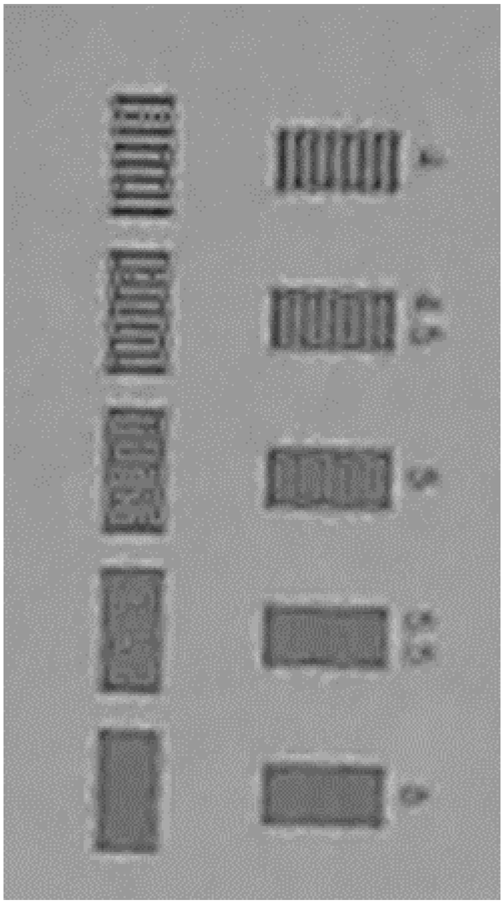

Figure 1

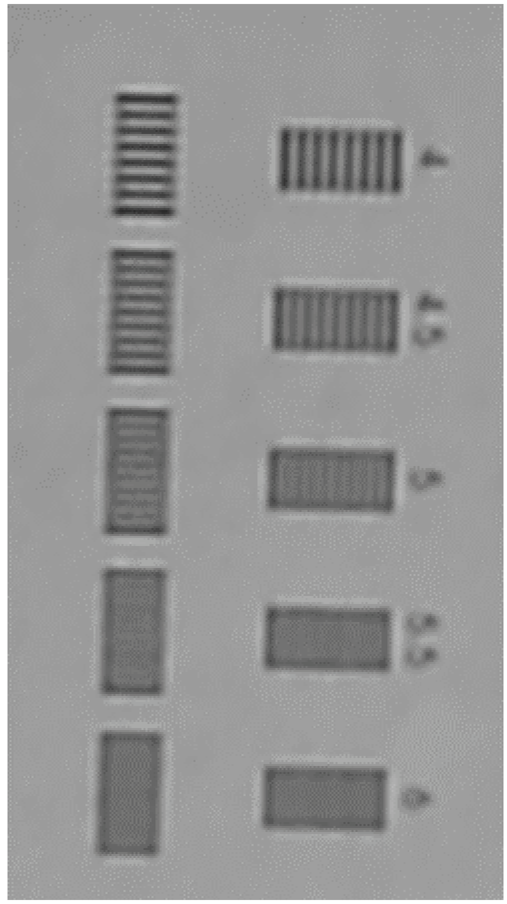

Figure 2

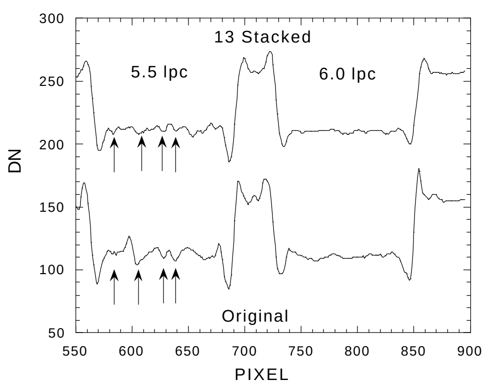

Figure 3