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# Efficient and Robust Restoration of High Resolution MRI

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## ABSTRACT

Imaging technologies for mapping of *in vivo* biological structures continue to advance at a fast pace and high resolution imaging is on the forefront of resolving the human anatomy with formidable accuracy and assist on treatments. Novel techniques in high resolution MRI of the human brain reveals small cerebral structures [2] which play an important role in the diagnosis of the diseased brain. Transitioning to higher magnet fields – 7.0 and 9.4 teslas – allows improvements in the resolution of generated images while filtering methods to boost their signal to noise ratio enhance the visualization of the anatomical parts of interest. Noise is persistent across field magnitudes.

We present a fast and robust algorithm to improve the quality of high resolution MRI using nonlocal filtering [1]. Visualization continues to play a critical role in the diagnosis process and thus it is of our interest to offer practitioners clean images to facilitate their work. Signal to noise ratios are substantially improved while preserving the fine structures present in the original noisy images (see figures). Besides visualization, denoising is, in many circumstances, a necessary step prior to segmentation. Unfiltered images may lead to unrealistic isosurface extractions and less sophisticated filters are in most cases not sufficient to render the image with the necessary quality for further processing.

In our experience and from recent comparative studies, nonlocal denoising has shown in many situations to be superior than other well known filters, e.g. anisotropic diffusion, median, bilateral, and total variation based methods. In our presentation we show supporting evidences and compare our results with those obtained using the original nonlocal mean filter proposed in [1], both in terms of quality and computational efficiency. Our approach has shown to be at least forty times faster than a straightforward implementation of [1].

## REFERENCES

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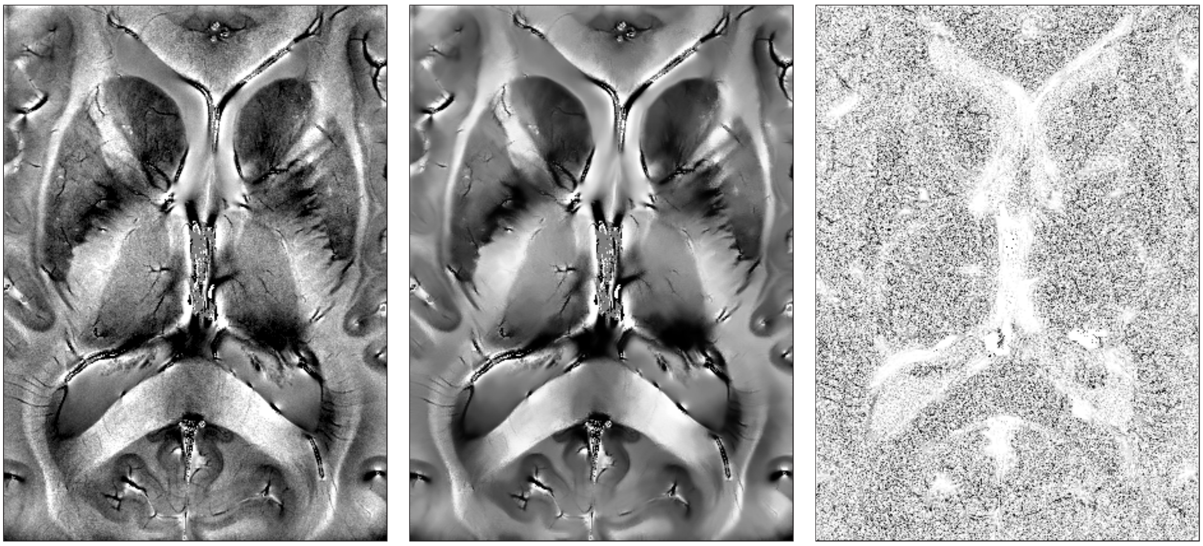
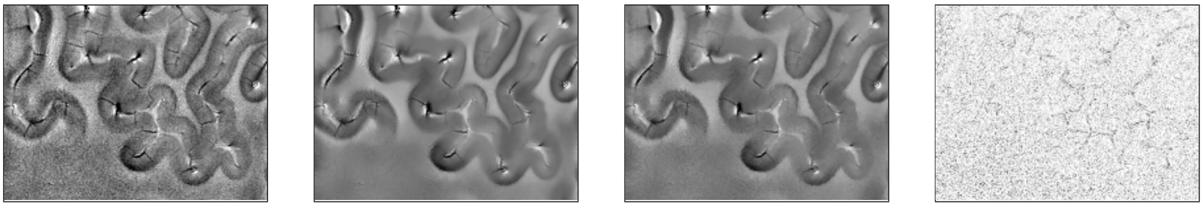


Gradient–echo MRI at 7.0 tesla | Filtered MRI | Extracted (scaled) noise

Figure 1: Filtering of MRI at 7.0 tesla of a central brain region. Many anatomical details are visible at high resolution, including veins shown in many areas of the brain (noisy image at left). Our filter was able to improve the signal–to-noise ratio while preserving the majority of thin structures (veins and alike) present in the original image. The image on the far right is a scaled version (to facilitate visualization) of the removed noise. Areas in white show the least amount of noise. Original noisy image courtesy of the Laboratory for Advanced MRI at National Institutes of Health.



Cortical area detail | Our result | Result after [1] | Extracted noise

Figure 2: A small portion of the brain cortical area is shown in the far left image. We compare here the result of our method (2nd image) with the one obtained after the nonlocal mean filter in [1]. Both methods generate good results, ours being much faster, preserving the fine structures in the cortical region, and eliminating the undesired noisy part, which is shown in the far right image (after our denoiser). The capability of preserving the fine details is very attractive to practitioners since analysis of detailed anatomy can reveal pathologies. Original noisy image courtesy of the Laboratory for Advanced MRI at National Institutes of Health.