An introduction to image denoising

Image acquisition comes with unavoidable and unwanted noise acquisition due to camera hardware limitations and illumination challenges, making image denoising a fundamental task in image processing.

The term ¨denoising¨ comes from the 1980s when it was used to describe the removal of noise from signals using wavelet transform-based algorithms. Currently, the term is used generally for any method of noise reduction. There are many different techniques such as spatial and transform domain filtering, hybrid methods, sparse representations, and deep learning methods.

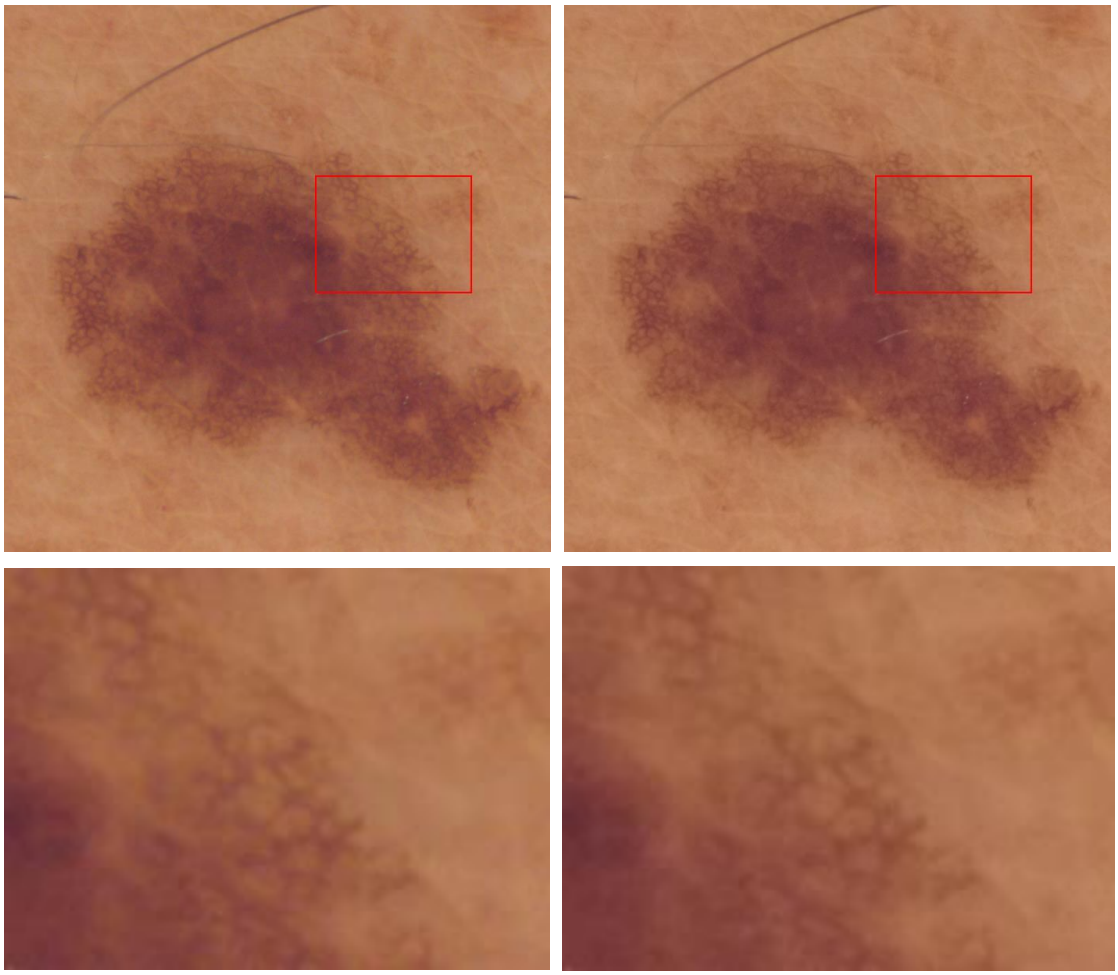

Fig. *1* An example of a real-noise image denoising. First row: Left, original image of moderate noise level. Right, image denoised with NL-Means method [1] applied on the left RAW image after conversion to the YCbCr colour space for a more effective chroma noise removal. Second row: Details from top row images.

Denoising an image is a challenging ill-posed problem as noise is tied to the high frequency component in an image represented by details. The goal is to do noise reduction while minimizing loss of relevant information that can cause blurriness and without introducing artifacts.

In practice image denoising has been often modelled as: $I = I_{clean} + n$, with I_{being} the observed noisy image, I_{clean} is the clean unknown image that we want to recover, and n is additive white Gaussian noise. However, this synthetic noise model is highly simplistic, as real noise is highly complex and irregular.

In digital RAW sensor data, the noise can be more realistically modelled by two independent components: a Poisson signal-dependent component caused by the photon counting process and a Gaussian signal-independent one due to electric and thermal noise [2]. After applying the image processing pipeline (colour correction, white balance, gamma correction) on the RAW image, the noise model becomes extremely complex, making denoising a very challenging task.

For optimal results, a denoising method should be applied to RAW data whenever available.

Author

Gabriela Ghimpeteanu, Coronis Computing.

Bibliography

[1] Buades, A., Coll, B., and Morel, J. (2011). Non-local means denoising. Image Processing Online, 1.

[2] Mäkitalo, M. and Foi, A. (2013). Optimal inversion of the generalized Anscombe transformation for Poisson-gaussian noise. IEEE Transactions on Image Processing, 22(1):91–103.