# **Denoising with Non-Local Means**

## The Non-Local Means Algorithm

Non-local means is an image denoising algorithm based on a simple principal – taking the average of similar pixels to that being denoised, this method is a relatively recent development in Image Processing algorithms and techniques, especially in comparison to more traditional local image denoising using kernels (taking weighted averages of directly neighbouring pixels).

On a continuous image, the non-local means algorithm filter is defined as

where is the Euclidian distance between the image patches and centred at points and respectively, is a decreasing function and is the normalizing factor (to prevent a change in brightness).

Sample space, patch and neighbourhood

## Implementations of Non-Local Means

Non-local means has two main implementations which yield slightly different denoising characteristics: pixel-wise and patch-wise.

### **Pixelwise N-L Means**

The pixelwise implementation runs on each pixel of the image. Given image at pixel location , the discrete algorithm is

such that

where and is the weight applied between pixel and each pixel that is an element of the neighbourhood being scanned.

### **Patchwise N-L Means**

The patchwise implementation of non-local means differs in that instead of just looking at a single pixel, the area (patch) around the pixel is taken also into account, this effectively applies a standard kernel filter to each patch fir further reduction in noise.

### **Asymptotic Complexity**

## **Algorithm Parameters**

* Size of sample space (or window of similarity)
* H-value
* Neighbourhood size

## **Strengths and Limitations**

Introduces its own noise, but has net removal, does not affect frequency space

## **Modifications of the Main Algorithm**

## **Applications of Non-Local Means**

Aside from the trivial use-case for non-local means in photography and videography as a filter to enhance image / video quality.

Image denoising is an integral part of computer vision, the more continuous the image the better the

Medical X-ray CT image processing and reconstruction.

# **References**

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| [1] | A. Buades, B. Coll and B. Morel, “Non-Local Means Denoising,” *Image Processing On Line,* 2011. |
| [2] | H. Zhang, D. Zeng, H. Zhang, J. Wang, Z. Liang and J. Ma, Applications of nonlocal means algorithm in low-dose X-ray CT image processing and reconstruction: a review, PMC, 2018. |