

# Software methodologies: Image processing: A report on Non-Local Means Denoising

James Goodall

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## 1 The non-local means denoising algorithm.

Non-local means is an algorithm for denoising images, based on the principle of replacing a pixel of an mean of all the pixels in the image weighted by how similar their surroundings are to the surroundings of the original pixel.

As the introduction of [3] states, the goal of image denoising methods is to recover the original image from a noisy measurement.

As described in [4], the value of a pixel can be thought of as the sum of the original value plus a random noise element e.g.

$$P = P_0 + N$$

because of this, we can take multiple similar areas in the image we are trying to denoise, each with a different noise added to it but the same original value e.g.

$$P_1 = P_0 + N_1$$

$$P_2 = P_0 + N_2$$

$$\vdots$$

$$P_n = P_0 + N_n$$

finding the mean of  $P_n$  results in the sum of  $P_0$  and the average of  $N$ . Since  $N$  can be modeled with a mean of 0, for large values of  $n$  the mean of  $P_n$  tends towards  $P_0$

### 1.1 The Algorithm

the algorithm is defined by [2] to be:

$$NL(v)(i) = \sum_{j \in I} w(i, j) v(j)$$

with  $w(i, j)$  being the similarity function, which is the square of the euclidian distance between the two areas surrounding the pixels  $i$  and  $j$ , calculated by:

$$\|v(\mathcal{N}_i) - v(\mathcal{N}_j)\|_{2,a}^2$$

with  $\mathcal{N}_i$  referring to the pixels surrounding  $i$

A useful property of this similarity function is that, as explained in [2] is that the Euckudean distance preserves the order of similarity between pixels, which is to say, that the similarity of  $a$  to  $b$  is the same as the similarity of  $b$  to  $a$ .

## 2 Implementations of the algorithm and their efficiency.

There are two main implementations of the algorithm, pixelwise and patchwise:

## 2.1 Pixelwise

The pixelwise implementation is as described in section 1.1, however due to computational limitations, in [1], the search windows, instead of being the entire image, is limited to a  $21 \times 21$  square around the pixel in question for small values of  $\sigma$  and to a  $35 \times 35$  square for large values.

## 2.2 Patchwise

**3 The influence of the algorithmic parameters on the output.**

**4 The strengths and limitations of non-local means compared to other denoising algorithms.**

**5 Modifications and extensions of the algorithm that have been proposed in the literature.**

**6 Applications of the original algorithm and its extensions.**

## References

- [1] Jean-Michel Morel Antoni Buades, Bartomeu Coll. Non-local means denoising. *Image Processing On Line*, 2011.
- [2] A. Buades, B. Coll, and J. M. Morel. A review of image denoising algorithms, with a new one. *Multiscale Modeling & Simulation*, 4(2):490–530, jan 2005.
- [3] Antoni Buades, Bartomeu Coll, and Jean-Michel Morel. A non-local algorithm for image denoising. In *IN CVPR*, pages 60–65, 2005.
- [4] Alan Saberi. Digital image processing: p020 - non-local means. <https://www.youtube.com/watch?v=9tUns4HYtcw>, 2013.

