**Image Analysis**

**Critical Analysis – Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation**

Submitted for the MSc in

Advanced Computer Science

April 18

By

**Alexander C Whitehead**

Word Count: 0

Table of Contents

[1 Introduction 4](#_Toc512388768)

[2 Critical Analysis 5](#_Toc512388769)

[2.1 Title 5](#_Toc512388770)

[2.2 Authors 5](#_Toc512388771)

[2.3 Acknowledgements 5](#_Toc512388772)

[2.4 Abstract 6](#_Toc512388773)

[2.5 Introduction 6](#_Toc512388774)

[2.6 Materials and Methods 6](#_Toc512388775)

[2.6.1 Table 1 6](#_Toc512388776)

[2.7 Results 7](#_Toc512388777)

[2.7.1 Figure 1 7](#_Toc512388778)

[2.7.2 Table 2 8](#_Toc512388779)

[2.7.3 Figure 2 8](#_Toc512388780)

[2.7.4 Table 3 9](#_Toc512388781)

[2.7.5 Table 4 10](#_Toc512388782)

[2.7.6 Figure 3 11](#_Toc512388783)

[2.7.7 Table 5 12](#_Toc512388784)

[2.7.8 Table 6 13](#_Toc512388785)

[2.7.9 Figure 4 13](#_Toc512388786)

[2.7.10 Figure 5 14](#_Toc512388787)

[2.7.11 Figure 6 15](#_Toc512388788)

[2.7.12 Figure 7 16](#_Toc512388789)

[2.8 Discussion 17](#_Toc512388790)

[2.9 References 18](#_Toc512388791)

[3 Conclusion 19](#_Toc512388792)

[References 20](#_Toc512388793)

Table of Figures

[Figure 1: This image shows the first table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017). 7](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388794)

[Figure 2: This image shows the first figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “The autocorrelation function normalised to the maximum pixel value: (a) 2D image, (b) display of matrices of weight for the first level. Diagonal orientation (top) and horizontal (bottom).” (Huerga, et al., 2017). 7](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388795)

[Figure 3: This image shows the second table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017). 8](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388796)

[Figure 4: This image shows the second figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “A profile plot for the cylindrical phantom with nominal (injected) activity of 39.0 kBq ml−1. The profile was taken horizontally, from the middle of the phantom.” (Huerga, et al., 2017). 9](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388797)

[Figure 5: This image shows the third table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017). 10](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388798)

[Figure 6: This image shows the fourth table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017). 11](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388799)

[Figure 7: This image shows the third figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “A visual evaluation in the LOW-CONTRAST case. Top: image without post reconstruction filter (left), standard Gaussian filter processing (middle), wavelet filter processing described (right). Bottom: profiles through smaller spheres (peaks corresponding to the spheres of diameters 13 mm, 17 mm, 10 mm and 22 mm, left to right).” (Huerga, et al., 2017). 12](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388800)

[Figure 8: This image shows the fifth table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017). 13](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388801)

[Figure 9: This image shows the sixth table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017). 13](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388802)

[Figure 10: This image shows the fourth figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “A comparison of the SUVmean (top) and SUVmax (bottom) reduction rates (%) in more than 40 lesions from different patients.” (Huerga, et al., 2017). 14](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388803)

[Figure 11: This image shows the fifth figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “Example patient 1; coronal slice with liver lesions. Top: image without post- reconstruction filter (left), standard Gaussian filter processing (middle), wavelet filter processing described (right). Bottom: the profiles for each image through the lesion are shown.” (Huerga, et al., 2017). 15](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388804)

[Figure 12: This image shows the sixth figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “Example patient 2; coronal slice with mediastinum lesion. Top: image without post-reconstruction filter (left), standard Gaussian filter processing (middle), wavelet filter processing described (right). Bottom: profiles are shown for each image throughout the lesion.” (Huerga, et al., 2017). 16](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388805)

[Figure 13: This image shows the seventh figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “Example patient 3; head and neck segmentation (top). Example patient 4; liver segmentation. The images on the left were processed with a 3D extension, the ones on the right were processed without.” (Huerga, et al., 2017). 17](file:///C:\Temp\!!!Work!!!\Semester%202\Image-Analysis\Report\Critical%20Analysis%20–%20Denoising%20of%20PET%20Images%20by%20Context%20Modelling%20Using%20Local%20Neighbourhood%20Correlation.docx#_Toc512388806)

# Introduction

This is a report critically analysing the paper; Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation.

This report will first generally state the overall effect of the paper before moving on to critically analyse the title and authors of the paper. Then, in turn, each section of the paper, in an orthodox order, will be critically analysed stating any major strengths and weakness of the section found.

This order is:

1. Acknowledgements
2. Abstract
3. Introduction
4. Materials and Methods (containing analysis of select tables and figures)
5. Results (containing analysis of select tables and figures)
6. Discussion
7. References

# Critical Analysis

This paper is written regarding the development of a new noise reduction algorithm for PET image data. As is stated in the paper, there is already a vast body of research into this field, however new methods are always required as technology is always improving.

This paper is quite recent and was published in a high profile journal.

Throughout the version of the paper supplied the layout is generally unpleasant, as there are few distinct paragraph and figures appear in locations which are seemingly illogical, for instance, after it has already been referenced on another page.

However, upon further research, online versions of this paper do not suffer from the same pitfalls.

## Title

The main strength of the title is, that it is short and to the point, this means that anyone browsing through a list of papers may choose to read this paper, in particular, because its title is easy to parse and inoffensive.

However, a major weakness of the title is, the fact that it doesn’t adequate describe the content of the paper. The vast majority of the paper references wavelet decomposition and this is not mentioned in the title at all, whereas the phrase “neighbourhood correlation” from the title is not repeated once in the body of the paper.

## Authors

A main strength of the authors of this paper is, that between them they have written numerous papers in the past, some authors having written more than others and some having written none, however as a collective they are quite well experienced. In addition, the authors are from a good spread of institutions and roughly equally represent both genders.

However, the main weakness of the authors is, that they are not geographically diverse, all of the institutions that are represented among the authors are situated within a few miles of each other in Madrid, Spain.

## Acknowledgements

The main strength of the acknowledgements/funding section of this paper is, that because the research was not funded by an external body it can be assumed that there may be less bias in the research and thus, by stating that the research was not funded, anyone reading the paper can come to the same conclusion, this conclusion may make people more willing to read the rest of the paper.

However, the main weakness of the acknowledgements/funding section is, that it is located at the end of the paper, in order for the strength above to be applicable this section has to be read before the rest of the paper.

## Abstract

The main strength of the abstract is, that it makes a good case as to why this research is worthwhile conducting. It states that in PET imaging there is a low signal-to-noise ratio (SNR) and to get the best images out of this device the SNR needs to be reduced, this is exactly what the rest of the paper then goes on to detail.

However, a weakness of the abstract is, that it doesn’t discuss the rationale behind why the method, explored in the rest of the paper, is different or better from the methods already used for this function. An additional weakness of this section is, that it fails to lay out a concrete hypothesis which the paper as a whole addresses.

## Introduction

The main strength of the introduction is, that a large amount of background research into other solutions and references to other solutions have been included, this can be seen from the line starting “There are different approaches for removing noise in PET images”. Another strength would be, that the case as for why this research is relevant has been expanded upon from the abstract.

Some of the weaknesses of the introduction include, the fact that wavelet decomposition is discussed at length throughout the entire introduction but no effort is made to explain what wavelet decomposition is or how it functions. In addition, the authors go on to use first person language towards the end of the introduction in the sentence “Our method is proposed”. In a similar place the authors also make a forgone conclusion as to the effectiveness of the proposed solution in the sentence “The proposed noise-reduction technique is able to maintain uptake values”.

## Materials and Methods

The main strength of the materials and methods is, the fact that this section contains enough information to recreate the study itself, this section is very information dense giving details on the exact procedures used at every instance. In addition, the research has been performed on a large sample of regions of interest (ROIs) (1800), however this information is not revealed until later in the discussion section.

Also, the preliminary research is performed on readily available phantoms which can be acquired easily, the fact that these phantoms are quite old (2001) is both a strength and a weakness. Because they are so old there should be a large body of research performed with the phantoms, legitimising this research further. However, because the phantoms are old they may be outdated and better options may now be available.

The main weakness of the materials and methods is, that although this section provides enough information to reproduce the actual study itself it does not give any detail on the incidental tests that were performed during the main study, this is demonstrated in the following sentence “The photometric error has been checked (after the whole filtering process) and found to be within the limits of diagnostic utility.”, there is no information on how to test this photometric error nor what would be within the limits of diagnostic utility. In addition, there is no information on how participants were selected for the study. Finally, certain images were acquired using only one bed position while others were acquired using multiple bed positions, there is no justification for this.

## Table 1

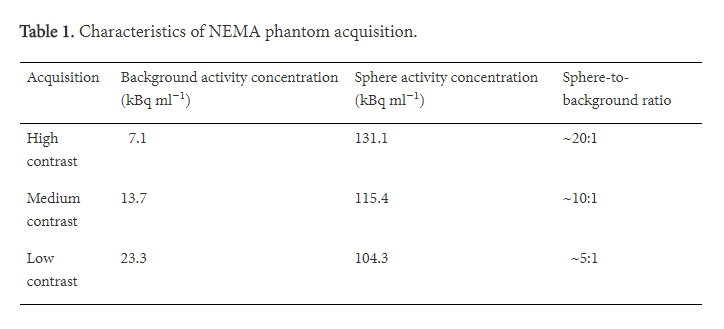


Figure 1: This image shows the first table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017).

The main strength of table 1 is, that the acquisition labels are quite detailed, meaning that the rest of the data in the table is more relevant with context.

However, the main weakness of table 1 is, that the ratio of the spheres size to background size is an approximation, by obscuring the actual ratio the data in the rest of the table becomes less relevant.

## Results

## Figure 1

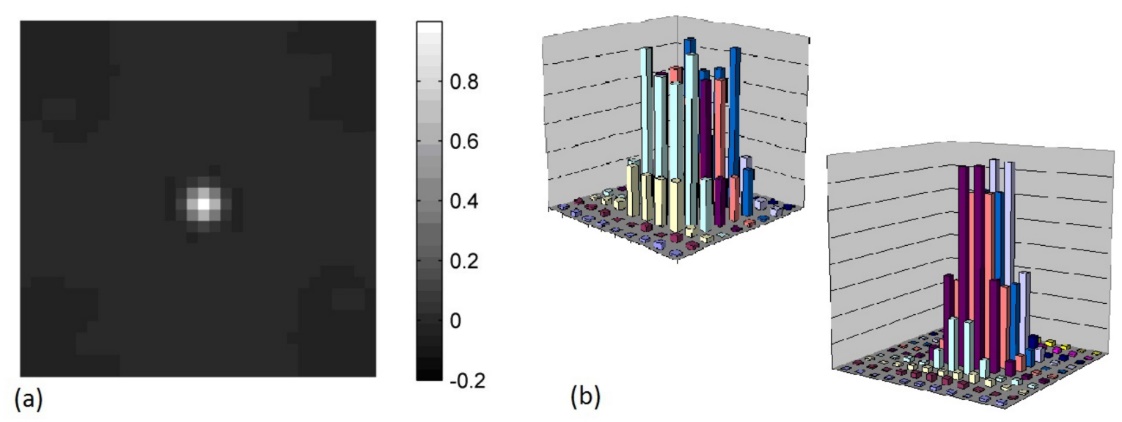


Figure 2: This image shows the first figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “The autocorrelation function normalised to the maximum pixel value: (a) 2D image, (b) display of matrices of weight for the first level. Diagonal orientation (top) and horizontal (bottom).” (Huerga, et al., 2017).

## Table 2

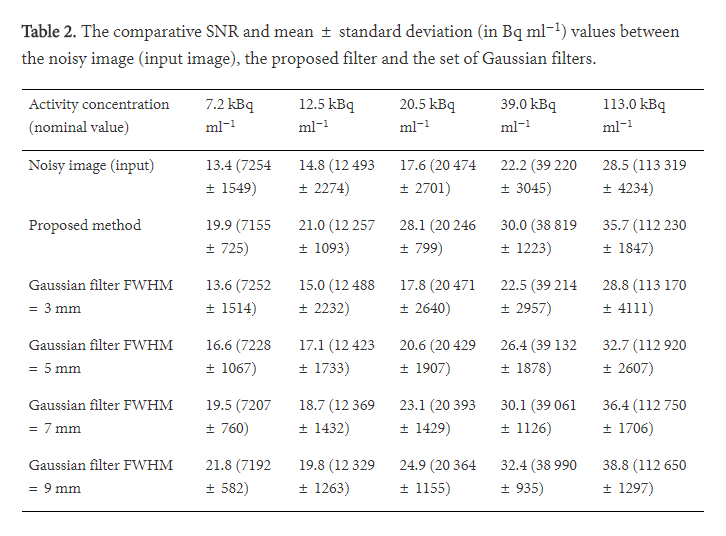


Figure 3: This image shows the second table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017).

## Figure 2

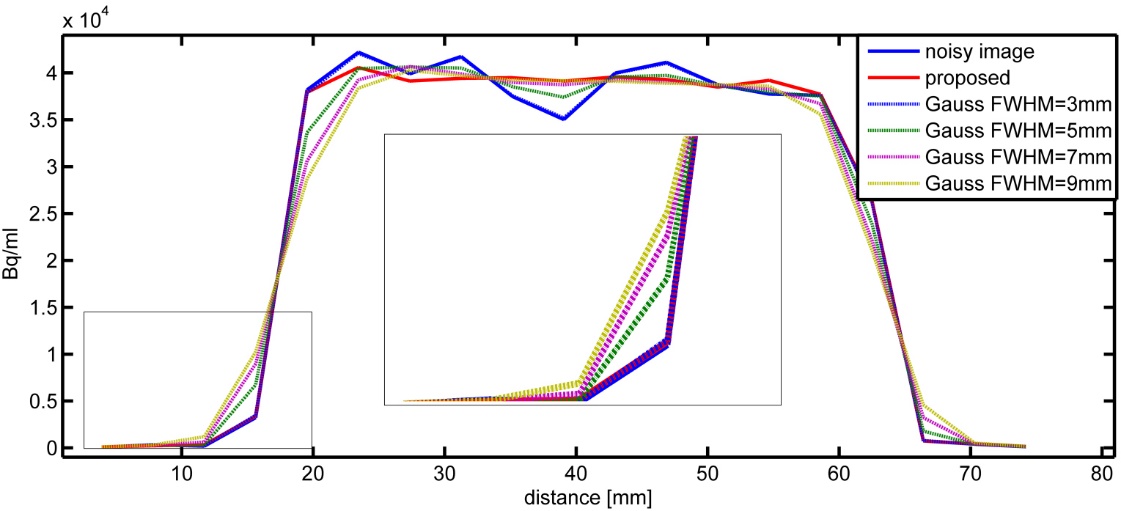


Figure 4: This image shows the second figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “A profile plot for the cylindrical phantom with nominal (injected) activity of 39.0 kBq ml−1. The profile was taken horizontally, from the middle of the phantom.” (Huerga, et al., 2017).

## Table 3

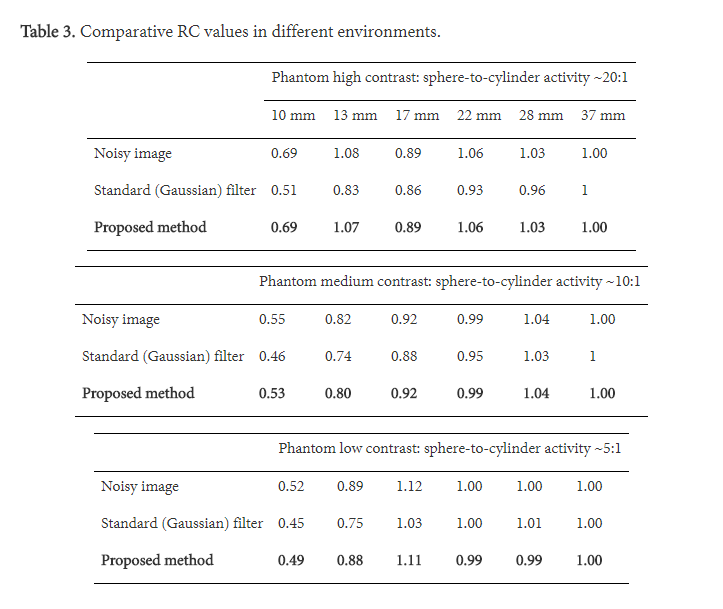


Figure 5: This image shows the third table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017).

## Table 4

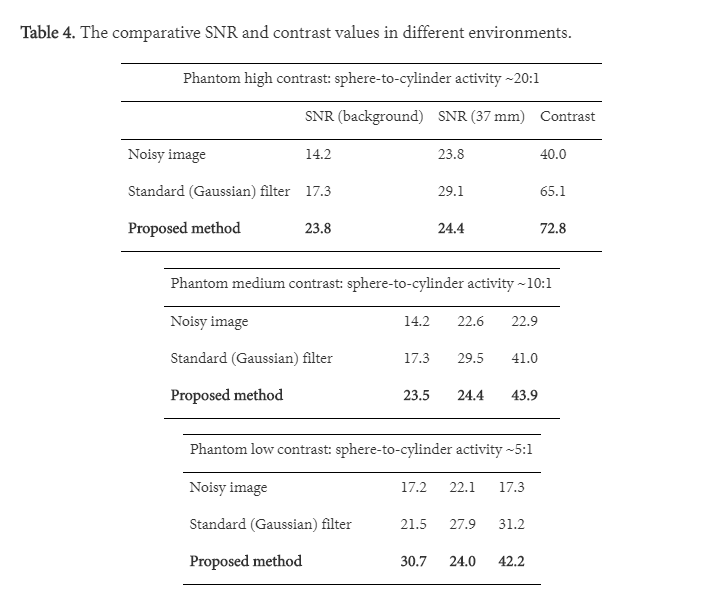


Figure 6: This image shows the fourth table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017).

## Figure 3

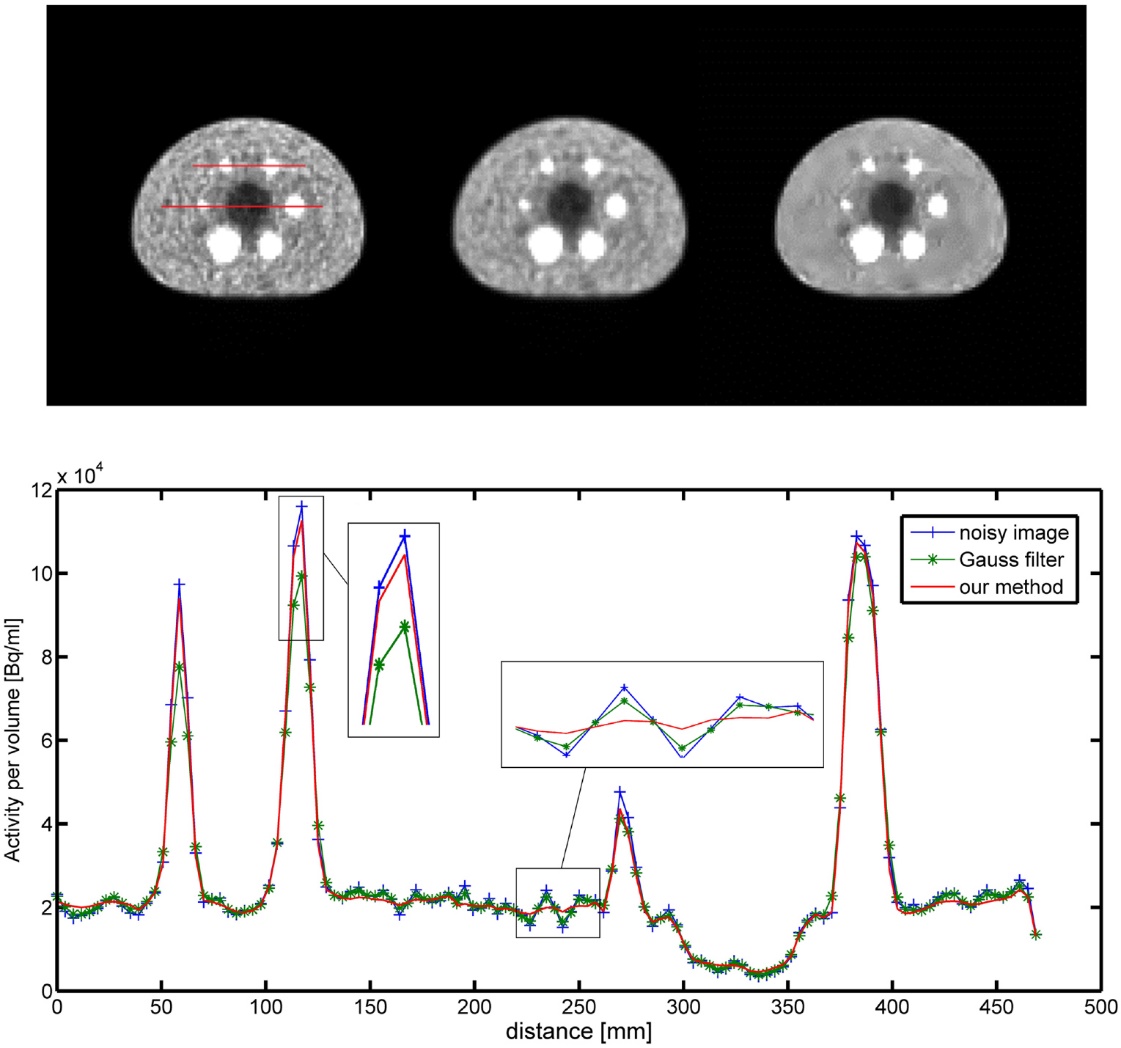


Figure 7: This image shows the third figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “A visual evaluation in the LOW-CONTRAST case. Top: image without post reconstruction filter (left), standard Gaussian filter processing (middle), wavelet filter processing described (right). Bottom: profiles through smaller spheres (peaks corresponding to the spheres of diameters 13 mm, 17 mm, 10 mm and 22 mm, left to right).” (Huerga, et al., 2017).

## Table 5

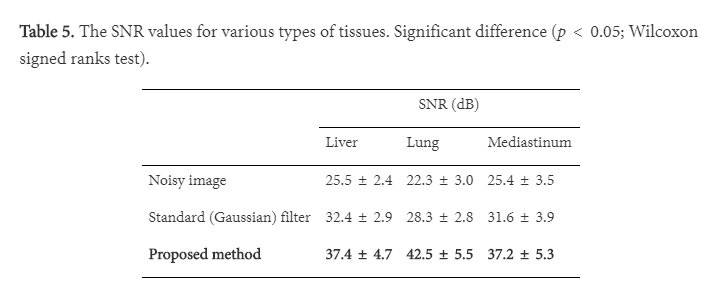


Figure 8: This image shows the fifth table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017).

## Table 6

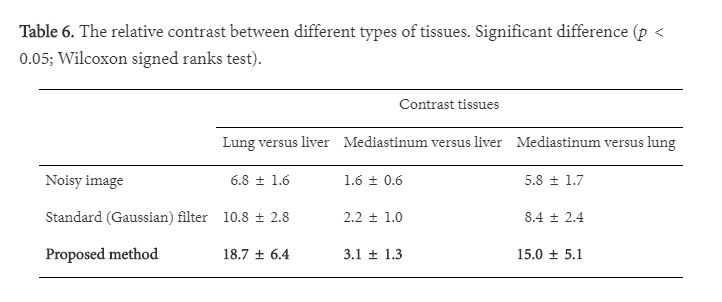


Figure 9: This image shows the sixth table used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation (Huerga, et al., 2017).

## Figure 4

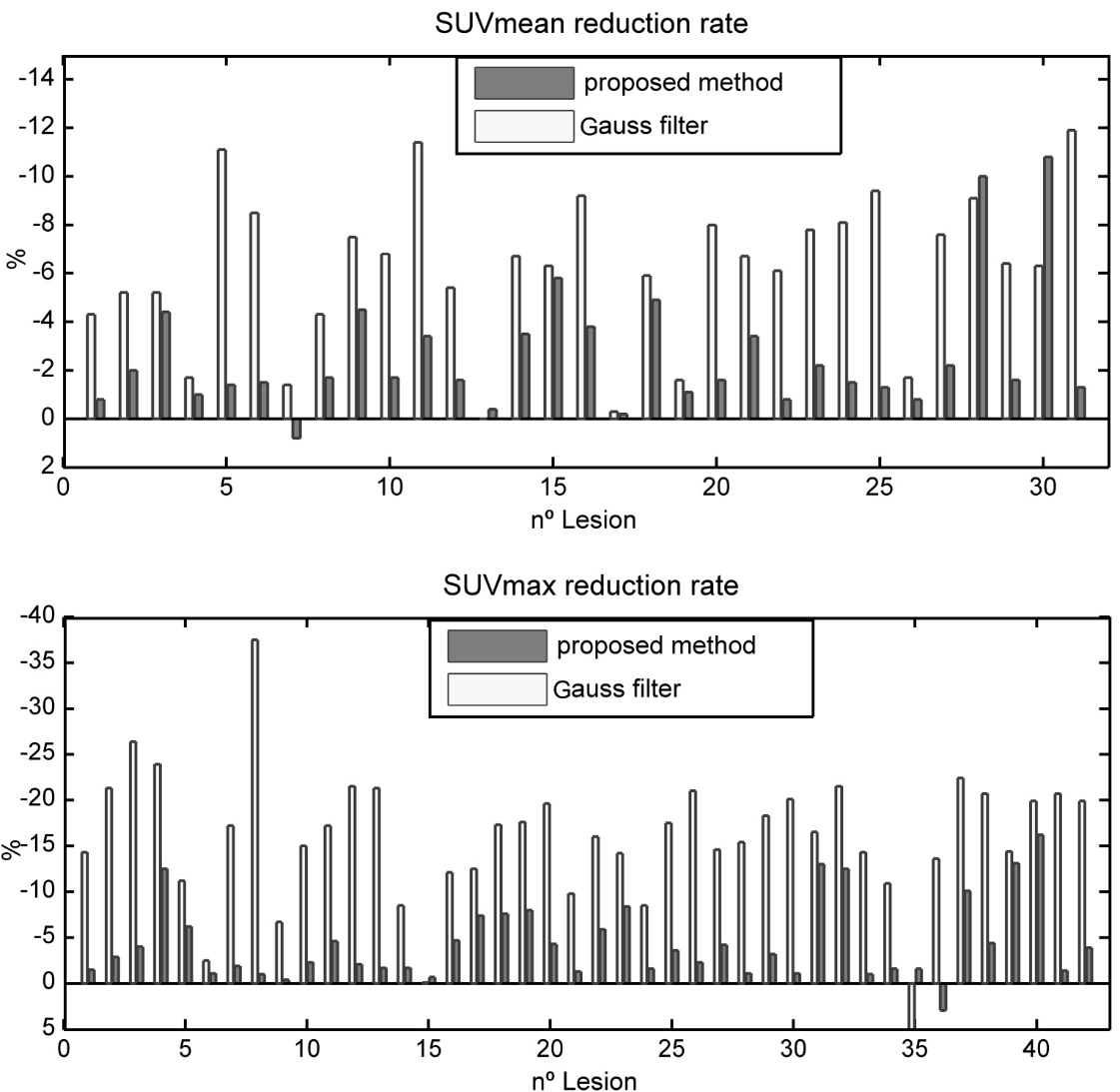


Figure 10: This image shows the fourth figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “A comparison of the SUVmean (top) and SUVmax (bottom) reduction rates (%) in more than 40 lesions from different patients.” (Huerga, et al., 2017).

## Figure 5

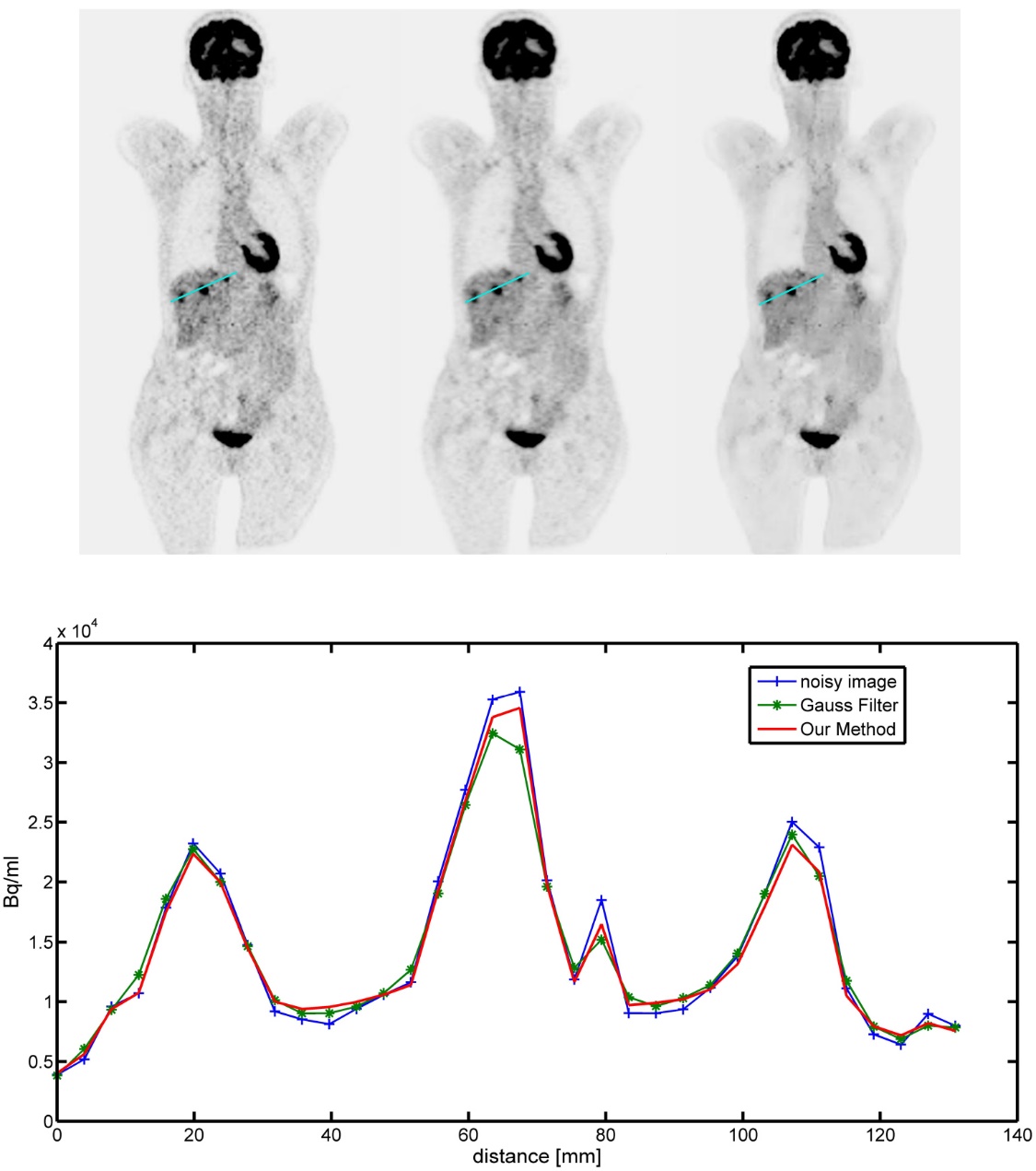


Figure 11: This image shows the fifth figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “Example patient 1; coronal slice with liver lesions. Top: image without post- reconstruction filter (left), standard Gaussian filter processing (middle), wavelet filter processing described (right). Bottom: the profiles for each image through the lesion are shown.” (Huerga, et al., 2017).

## Figure 6

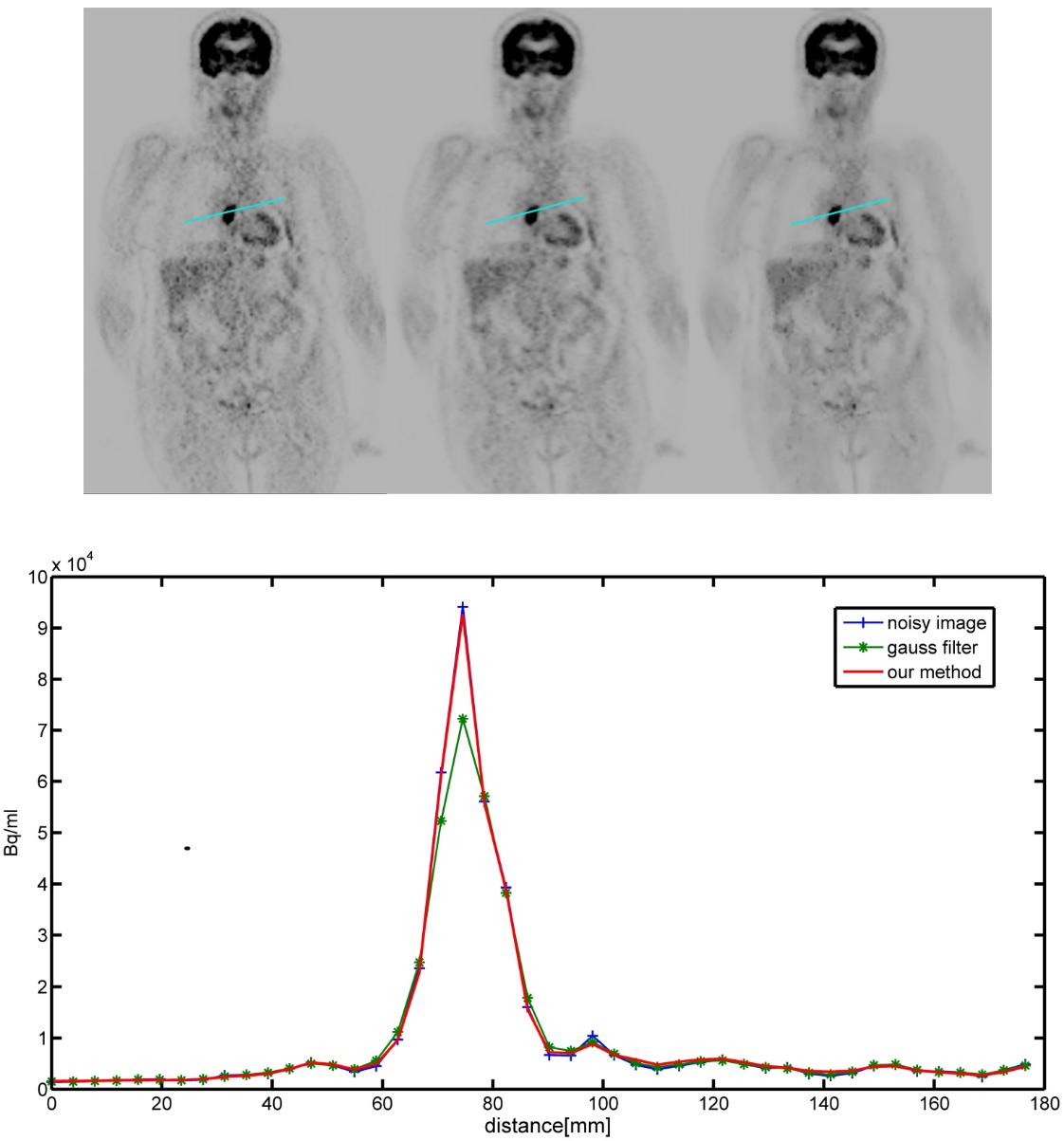


Figure 12: This image shows the sixth figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “Example patient 2; coronal slice with mediastinum lesion. Top: image without post-reconstruction filter (left), standard Gaussian filter processing (middle), wavelet filter processing described (right). Bottom: profiles are shown for each image throughout the lesion.” (Huerga, et al., 2017).

## Figure 7

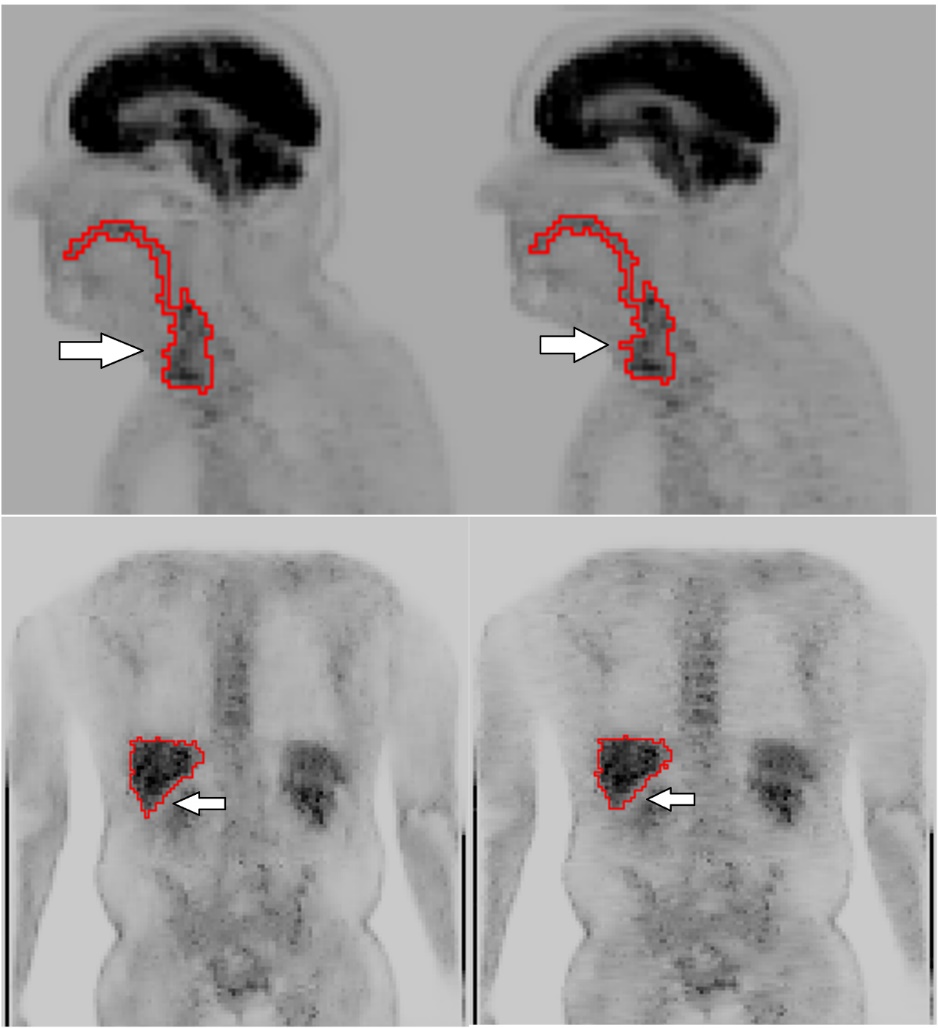


Figure 13: This image shows the seventh figure used in the paper Denoising of PET Images by Context Modelling Using Local Neighbourhood Correlation with the caption of “Example patient 3; head and neck segmentation (top). Example patient 4; liver segmentation. The images on the left were processed with a 3D extension, the ones on the right were processed without.” (Huerga, et al., 2017).

## Discussion

The main strengths of the discussion/conclusion is, that it performs quite an in depth recap on what has already been read, before moving onto concluding the results of the paper. Also, towards the bottom of the discussion it is mentioned that this research is compliant with additional research conducted by the European Association of Nuclear Medicine. Having research which falls in line with something performed by such a large official body provides legitimacy to this research.

However, one weakness with this section is, the fact that as with other sections in this paper first person language is used throughout the discussion section. Additionally, it is mentioned in this section that 20% of computation time spent performing the algorithm is used solely on the new addition which has been proposed, it is never mentioned how this figure is calculated.

Also, in the conclusion section it is determined that this solution is “good” but never describes what is meant by this term or really how this conclusion has been reached, this could be solved by tying this conclusion back into what was written in the discussion section. Finally, as mentioned in the abstract, there is no hypothesis to be confirmed or rejected.

## References

The main strength of the references is, that there are quite a lot of references which have been used thoroughly throughout the paper.

The main weakness is, that a lot of the references are quite old, at one point the paper references that a piece of research is “state of the art” and then backs this up with a reference from 1999 which at this point is nearly 20 years ago. Another weakness is that a lot of the references are from the same people, for instance S.G. Chang, D.L. Donoho, S.G Mallat and F.E Turkheimer all appear twice.

# Conclusion

References

Huerga, C. et al., 2017. Denoising of PET images by context modelling using local neighbourhood correlation. *Physics in Medicine & Biology,* 62(2), pp. 633-651.