



Use of spatial filter method to reduce streaking ARTEFACT on abdomen CT Image Non-Contrast media

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ABSTRACT

Background

One of the drawbacks of the 32 slice CT-Scan is that it has not optimally reduced streaking artifacts on abdominal non-contrast media images. Spatial filter based on computer programming is one solution to reduce streaking artifacts on CT-Scan images to improve the quality of CT-Scan images.

Objective

To examine the application optimization using the Spatial filter method based on computer programming on CT images of Non-Contrast Abdomen Media by searching for SNR, CNR, and anatomic information after artifact reduction.

Method

This type of research is a quasi-experiment with a pre-post test only without control group design. The research samples were 17 Abdomen slice thickness CT images 5 mm and 10 mm with purposive sampling. Quantitative measurements of SNR and CNR by analysis using the Shapiro Wilk test, followed by using the Wilcoxon test. Assessment of anatomical information was carried out qualitatively by 2 radiologists, analysis with the Kappa test and continued with Mann Whitney.

Results

There were differences in SNR (p-value <0.001), CNR (p-value <0.001) and anatomical information (p-value <0.001) after the application of the Spatial filter method based on computer programming.

Conclusion

The use of computer programming-based spatial filter method for CT-Scan 32 slice can be used to reduce the reduction of streaking artifacts

Keywords: Spatial Filter, reduction of streaking artifacts, Abdomen CT-Scan

INTRODUCTION

Image processing in the medical world plays a very important role in patient diagnosis. However, it is often not realized the importance of information displayed in image processing. Image is a representation, similarity or imitation of an object as the output of a data recording system that can be optical or digital and can be stored in a storage medium [1].

Medical imaging technology such as Computed Tomography (CT) enables the imaging of internal organs or tissues of the human body by producing better spatial resolution and contrast and faster image acquisition times. This condition makes the medical imaging device become one of the main diagnostic support devices, especially in the radiology section [2]. The results of recording data from CT are used to see, know or give a diagnosis based on the anatomical slices presented on the image. The resulting CT-Scan images vary in quality depending on the level of sophistication of the existing modalities. In general, the quality of CT-Scan images produced is influenced by spatial resolution, contrast, noise and artifacts [3].

Artifacts are the difference between the CT number reconstruction in the image and the actual attenuation coefficient of the object being examined [4]. One cause of artifacts is due to patient factors or metal material present in the patient. (Patient-based artifacts). Metal artifacts are produced at the time of data acquisition on CT scan because the emitted x-rays are fully absorbed by the metal so that they are not captured by the detector and produce shadows such as streaking beam images on the CT-Scan reconstructed image. The resulting cover the surrounding area so that it can interfere with the assessment of pixel prices (CT numbers) in the tissue around the metal and the value is used to determine whether the organ tissue is normal or there is an abnormality so that the metal artifacts need to be reduced to help more precise diagnosis. Metal objects can be Intrauterine Devices. Intrauterine Device is a device made of metal-wrapped plastic that is inserted into the uterus [6]. Intrauterine metal artifacts are often found on CT-Scan images in the abdomen

CT-scan Abdomen non-media contrast is the imaging of the abdominal cavity and internal organs using CT-Scan to find out the anatomy

and abnormalities in the abdominal cavity and the organs contained therein without requiring contrast media to the patient. Abdomen scans attached to the IUD metal often have streaking artifacts in their image, so that they can interfere with the CT Abdomen image, even at a certain level can make the results of the image not diagnosed at all [20]. Another weakness of streaking artifacts on CT-Scan Abdomen is that the resulting image has a high noise level [9]. This CT-Scan examination uses axial cuts so that if there is a streaking artifact then the artifact is a disturbance in the appearance of the CT image.

In type C hospitals that have 32 slice CT-Scan tools, there are still many who do not have artifact correction software, so it can be done with image processing applications using Matlab programming, a spatial filter method to reduce streaking artifacts on CT-Scan images. Matlab programming is a program for image processing and image analysis using raw data or image results that have been obtained. Spatial filter method is a filter process that skips image components with high intensity and absorbs image components with low intensity so that it can reduce streaking artifacts on CT-Scan images [5].

Referring to previous studies using smartrecon metal reduction software and screening of metal artifacts with a band spatial filter devoted only to the head object can reduce metal artifacts in the head region¹⁰, then in this study using different variables, namely using the Spatial filter method on 2 variations of Slice Thickness 5 mm and 10 mm are focused on reducing the beam streaking artifact beam on the CT-Scan Abdomen image.

The purpose of this study is to identify differences in SNR, CNR and anatomical information on CT images of the abdomen before and after using spatial filters based on computer programming, and determine the most optimal image after the application of computer programming based spatial filters between slice thickness 5 mm by 10 mm.

METHOD

Type and Design of Research

This type of research is a quasi comparative experiment, categorical numerical paired with pretest-posttest without control group design

research design.²⁷ The study was conducted on CT images of non-abdominal abdominal CT-mounted media mounted on axial pieces of IUD with examination parameters kVp 120, mA 50, slice thickness 5mm and 10mm, Scan Type: Helical full, Scan range: Superior - Inferior, Detector coverage: 20-40, Coverage: Upper Diaphragm - Lower Symphysis Pubis, Scan Collimation: 0.6 mm, and 512 x 512 matrix.

Population and Samples

The study population was patients at Bhayangkara Hospital Bengkulu with a large sample of 17 women who had an IUD metal attached to their uterine organs which were examined for axial CT-scan Abdomen Non-Contrast media.

DATA ANALYSIS

Analysis of Qualitative

Qualitative data analysis of information on CT images of the Abdomen Non Contrast Media axial section between before and after the spatial filter method was performed, performed by two observers (radiology specialists) with a score of 1: Organ Anatomy Images appearing Very Poor due to Line Artifacts, 2: Organ Anatomy Imagery Looks Poorly Due to Line Artifacts, 3: Organ Anatomy Imagery Looks Good Enough due to Line Artifacts, 4: Organ Anatomy Imagery Looks Good Due to Line Artifacts, 5:

Organ Anatomy Images Looks Very Good Due to Line Artifacts. Then the conformity testing (interobserver agreement test) was conducted using the Cohen's Kappa Test at a good agreement level, followed by a bivariate test using the Wilcoxon Test both overall and per anatomic criteria. Taking conclusions, the hypothesis is accepted if the p-value <0.05, which means that there is a significant difference in information on CT-Scan Abdomen Non Contrast Media axial pieces between before compared after the spatial filter method, while to get the most optimal image between slice thickness images 5mm compared to 10mm, using the mean rank from the Mann-Whitney test results.

Quantitative Analysis

Quantitative data analysis was performed by calculating the SNR and CNR values of the CT-Scan Abdomen Non-Contrast Media images of axial pieces before and after the spatial filter method

RESULTS

Quantitative Analysis

Qualitative image assessment is done by calculating the SNR and CNR values, compared to the SNR and CNR values between before and after the spatial filter. The following calculation results are as in Table 1.

Table 1. The results of the calculation of SNR values on CT-Scan Abdomen Non Contrast Media axial pieces of the image before and after the spatial filter method

| Image | SNR Pre 5mm | SNR Post 5mm | SNR Pre 10mm | SNR Post 10mm |
|-------|-------------|--------------|--------------|---------------|
| 1 | 140.23 | 139.05 | 137.31 | 136.74 |
| 2 | 89.21 | 88.56 | 93.51 | 93.47 |
| 3 | 124.49 | 123.86 | 125.45 | 125.22 |
| 4 | 119.71 | 119.45 | 125.14 | 123.82 |
| 5 | 119.65 | 119.51 | 125.99 | 125.51 |
| 6 | 116.06 | 115.64 | 126.05 | 125.78 |
| 7 | 127.28 | 126.74 | 145.01 | 144.25 |
| 8 | 127.65 | 127.51 | 123.71 | 123.32 |
| 9 | 121.91 | 121.57 | 124.39 | 124.28 |
| 10 | 123.61 | 122.68 | 126.23 | 126.13 |
| 11 | 133.61 | 132.68 | 126.94 | 125.97 |
| 12 | 123.48 | 123.33 | 123.75 | 123.61 |
| 13 | 126.61 | 126.08 | 126.28 | 125.92 |
| 14 | 119.31 | 118.88 | 137.31 | 136.74 |
| 15 | 131.97 | 131.19 | 93.51 | 93.47 |
| 16 | 142.47 | 140.33 | 125.45 | 125.22 |

| | | | | |
|-------|--------|--------|--------|--------|
| 17 | 125.37 | 123.58 | 125.14 | 123.82 |
| Means | 124.27 | 123.56 | 126.03 | 125.62 |

From table 1, the Wilcoxon test is performed, so we get the data in table 2.

Table 2. Analyst differences in SNR values in each image after a spatial filter with slice thickness of 5mm and 10mm in CT-Scan Abdomen images

| N O | Image | Mean | Standard Deviation | Shapiro Wilk | Significance Wilcoxon | Percentage Decrease |
|--------|-----------|--------|-----------------------|-----------------|--------------------------|------------------------|
| 1 | Pre 5mm | 124.27 | 11.53 | 0.011 | | |
| 2 | Post 5mm | 123.56 | 11.29 | 0.006 | 0.000 | 0.57 % |
| 3 | Pre 10mm | 126.03 | 10.06 | 0.011 | | |
| 4 | Post 10mm | 125.62 | 9.95 | 0.006 | 0.000 | 0.32 % |

From table 2 above it can be seen that the image SNR results before the spatial filters for 5mm and 10mm are 124.27 and 123.56, while after spatial filters each have an average value of 126.03 and 125.62. The SNR calculation results

have decreased, for 5mm is 0.57% and for 10mm is 0.32%. While the calculation of CNR values between before and after the spatial filter is shown in Table 3.

Table 3. The results of CNR calculations on CT-Scan Abdomen Non Contrasts Media axial pieces of the image before and after the spatial filter method

| Image | CNR Pre 5mm | CNR Post 5mm | CNR Pre 10mm | CNR Post 10mm |
|-------|-------------|--------------|--------------|---------------|
| 1 | 114.76 | 115.94 | 117.69 | 118.25 |
| 2 | 165.79 | 166.43 | 161.49 | 161.52 |
| 3 | 130.51 | 131.13 | 129.54 | 129.77 |
| 4 | 135.28 | 135.54 | 129.85 | 131.18 |
| 5 | 135.34 | 135.48 | 117.69 | 118.25 |
| 6 | 138.93 | 139.35 | 161.49 | 161.52 |
| 7 | 127.71 | 128.25 | 129.01 | 129.48 |
| 8 | 127.34 | 127.49 | 128.95 | 129.22 |
| 9 | 133.08 | 133.42 | 109.99 | 110.74 |
| 10 | 131.39 | 132.31 | 131.28 | 131.67 |
| 11 | 121.46 | 122.31 | 130.61 | 130.71 |
| 12 | 131.51 | 131.66 | 128.76 | 128.86 |
| 13 | 128.39 | 128.91 | 128.05 | 129.02 |
| 14 | 135.68 | 136.11 | 131.24 | 131.39 |
| 15 | 123.02 | 123.81 | 128.71 | 129.07 |
| 16 | 112.52 | 114.66 | 127.64 | 127.95 |
| 17 | 129.62 | 131.04 | 128.14 | 128.81 |
| Means | 130.72 | 131.40 | 128.96 | 129.36 |

From table 3, Wilcoxon test is performed, so we get the data in table 4.

Table 4. Analyst differences in CNR values in each image after a spatial filter with slice thickness of 5mm and 10mm in CT-Scan Abdomen images

| NO | Image | Mean | Standard Deviation | Shapiro Wilk | Significance Wilcoxon | Percentage of increase |
|----|--------------|------------|-----------------------|-----------------|--------------------------|---------------------------|
| 1 | Pre 5mm | 130.72 | 11.53 | 0.011 | | |
| 2 | Post 5mm | 131.40 | 11.29 | 0.006 | 0.000 | 0.52 % |
| 3 | Pre 10mm | 128.96 | 10.06 | 0.011 | | |
| 4 | Post 10mm | 129. 36 | 9.95 | 0.006 | 0.000 | 0.31 % |

From table 4 it can be seen that the image CNR values before the spatial filter method for 5mm and 10mm are 130.72 and 128.96, while after spatial filters have an average value of

131.40 and 129.36. The CNR calculation results have increased, for 5mm is 0.52% and for 10mm is 0.31%, the results of the SNR and CNR calculations are shown in Figure 1.

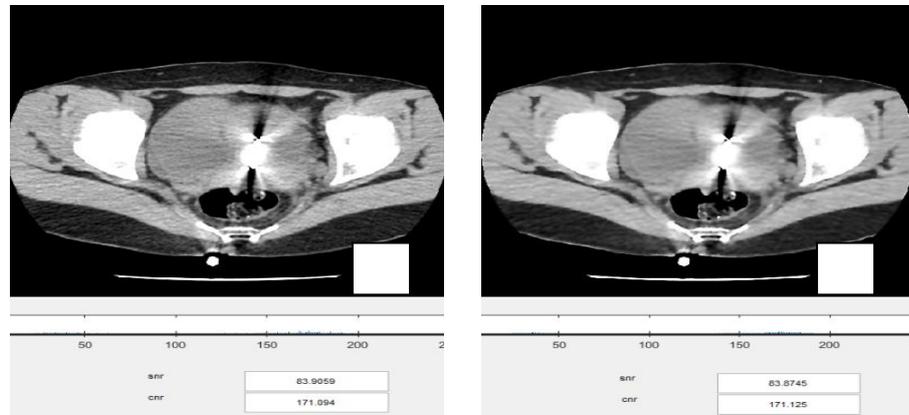


Figure 1. The results of CT-scan Abdomen Non Contrasts Media axial pieces, A) before the spatial filter method, the SNR and CNR values appear in the GUI column below and B) after the spatial filter method, the SNR value decreases 0.57% and the CNR value increases 0.52% in the GUI column below [17].

Analysis of Qualitative

While the qualitative image assessment is done by looking at the differences in information

on CT-Scan Abdomen Non-Contrasts Media axial pieces between before and after the spatial filter method is done visually grading by a specialist in radiology with the following assessment:

Table 5. Results of Anatomical Information calculations on CT images of the Abdomen Non Contrasts Media axial section of the image before and after the spatial filter method

| Image | Pre 5mm | Post 5mm | Pre 10mm | Post 10mm |
|-------|---------|----------|----------|-----------|
| 1 | 2 | 3 | 3 | 4 |
| 2 | 3 | 4 | 2 | 3 |
| 3 | 3 | 4 | 2 | 3 |
| 4 | 2 | 3 | 2 | 3 |
| 5 | 2 | 3 | 3 | 4 |
| 6 | 3 | 4 | 2 | 3 |
| 7 | 3 | 4 | 2 | 3 |
| 8 | 2 | 3 | 2 | 3 |
| 9 | 2 | 3 | 3 | 4 |
| 10 | 3 | 4 | 2 | 3 |
| 11 | 2 | 3 | 2 | 3 |
| 12 | 2 | 3 | 2 | 3 |
| 13 | 2 | 3 | 3 | 4 |
| 14 | 3 | 4 | 2 | 3 |
| 15 | 3 | 4 | 2 | 3 |
| 16 | 2 | 3 | 2 | 3 |
| 17 | 2 | 4 | 2 | 3 |
| Means | 130.72 | 131.40 | 128.96 | 129.36 |

Note: Score 1: Very Poor, Score 2: Poor, Score 3: Fair, Score 4: Good, Score 5: Very Good

From table 5 above shows the tendency of score assessment 3 (good) to dominate the image after the spatial filter method compared to before the spatial filter method.

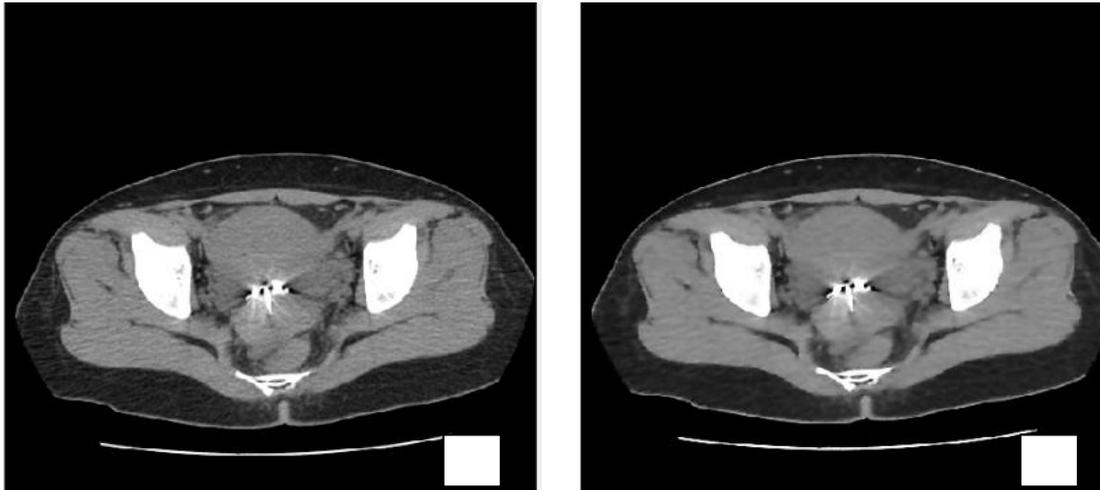


Figure 2. The results of CT images of Abdomen Non Contrast Axial media pieces, A) before the spatial filter method is performed Streaking Artifacts appear in the anatomical part of the uterus and B) after the spatial filter method is done there appears to be reduced Streaking Artifacts in the uterine anatomy with the appearance of boundaries and image structures clearer and clearer

The assessment of CT-Scan Abdomen Non-Contrast image media information on axial cuts between before and after the spatial filter method

is carried out with the Wilcoxon test, the results of the statistical tests are shown in Table 6.

Table 6. Wilcoxon Test Results for anatomical information on CT images of the Abdomen Non Contrast Media axial section between before and after the spatial filter method.

| NO | Image | Mean | Standard Deviation | Significance <i>Wilcoxon</i> | Percentage of increase |
|----|-----------|------|--------------------|---------------------------------|------------------------|
| 1 | Pre 5mm | 2.41 | 0.507 | | |
| 2 | Post 5mm | 3.47 | 0.514 | 0.000 | 43.98% |
| 3 | Pre 10mm | 2.24 | 0.437 | | |
| 4 | Post 10mm | 3,24 | 0.437 | 0.000 | 44.64% |

From table 6, the above shows that there are significant differences in anatomical information on CT-scan Abdomen Non-Contrast Media axial pieces between before and after the spatial filter method. Anatomical information calculation results according to the visual doctor Radiologist have increased, for 5mm is 43.98% and for 10mm is 44.64% Image information after the

spatial filter method has more optimal image information with the highest mean compared to before the spatial filter method.

Whereas to determine the most optimal CT-Scan Abdomen image between the 5mm slice thickness with 10mm after the application of the spatial filter is to use the Mann-Whitney test, as shown in table 7.

Table 7. Mann-Whitney test results on two CT images of the axial abdominal cut between the 5mm thickness slice compared with the 10mm thickness slice about the most optimal anatomic information after the spatial filter method.

| No | CT scan images of the abdomen | Mean Rank | Standard Deviation |
|----|-------------------------------|-----------|--------------------|
| 1 | Citra Post 5 mm | 19.50 | 0.485 |
| 2 | Citra Post 10 mm | 15.50 | 0.508 |

Table 7 shows that the mean rank of anatomic information on CT images of Non-Contrast Media Abdomen, for post 5mm is 19.50, with a

standard deviation of 0.485 and post 10mm the mean rank is 15.50, with a standard deviation of 0.508, it can be concluded that the value of

anatomic information in the image at 5mm post is higher than the post 10mm image, and post 5mm standard deviation is lower than the post 10mm image, meaning that the anatomic information of the post 5mm image is optically clearer than the post 10mm image.

DISCUSSION

The spatial filter method is applied to CT images of the Abdomen Non-Contrast Media axial section, resulting in the image SNR values before the spatial filters of 5mm and 10mm are 124.27 and 123.56, while after spatial filters each has an average value of 126.03 and 125.62. The SNR calculation results have decreased, for 5mm is 0.57% and for 10mm is 0.32%, but despite the decline in SNR values 0.57% and 0.32%. Based on research [19] Tugwell et al in 2014 stated that the decline in the value of SNR still produces an adequate image quality because the value is below 36%.

Signal to Noise Ratio (SNR) is defined as the ratio between the size of the object's signal with the amount of noise. SNR value is influenced by signals that carry object information and noise. The signal that carries this information is represented in the form of grayscale values in the image. This SNR is also strongly related to the amount of X-ray energy used per pixel in the image, in this case, the SNR in the abdominal image of the Non Contrast Media after the spatial filter method is decreased because it is caused by smoothing when the Spatial filter on the image has caused a signal the object decreases, and fewer energy X-rays will pass through each voxel, and therefore the SNR per pixel will drop.

Based on the Wilcoxon test results on the CNR value of the CT-Scan Abdomen Non-Contrast Media before and after the spatial filter, the p-value is 0.00. The results of this study indicate that there are significant differences between the image before it is reduced and the image after it has been reduced with a spatial filter. The results show an increase in the average CNR value, ie between the CNR value before the spatial filter is carried out and the CNR value after the spatial filter. The percentage increase in CNR value, after spatial filtering for 5mm images, was 0.52%, while for 10mm images an increase of 0.32%. According to [20] Kawashima et al., A digital image with a higher

CNR level indicates that the image quality is better [20].

The increase in CNR value in the image after spatial filtering is caused due to the decrease in the noise value in the image after it is reduced, whereas the CNR value is influenced by the value of the object's contrast against the background and the resulting noise.

So in this study, there are differences before and after being reduced using a spatial filter, meaning that there is an effect of a spatial filter on noise. Noise is a fluctuation (standard deviation) of CT number values on homogeneous tissue or material. Noise depends on several factors mAs, scan time, kVp, the thickness of slices, object size and algorithm, for example, having CT Number 0, the lower the standard deviation of the CT number value on the measurement of water points means the noise is lower. This noise will affect the contrast resolution, if the noise is lower then the contrast resolution will increase. Low noise causes high spatial resolution. Spatial resolution that will increase between 2 different objects will be clear and firm. Filtering specifically the spatial filter used is a spatial filter that can reduce noise but can not eliminate it.

CT numbers that vary above or below the mean are called noise. Noise describes the part of the CT-Scan image that contains useless information (degrades image quality). If all pixel values are the same then the noise will be worth "zero", while too large variations in the pixel value will produce a high noise value. A high noise value will cause artifacts that can interfere with the contrast resolution of the CT-Scan image which ultimately affects the results of the diagnosis.

Based on the Wilcoxon test results on the anatomical information of CT-Abdomen Non-Contrast Media before and after the spatial filter, the p-value is 0.00. The results of this study there are significant differences in anatomic information between images before being reduced to images after being reduced with a spatial filter. The results show an increase in the value of CT anatomical abdominal information, meaning that the Organ Anatomical Image after spatial filtering looks better than the anatomic information of the organ before spatial filtering.

Figure 2 shows the picture before and after the spatial filter changes. On the CT image of the

Abdomen Non-Media Contrasts axial section after spatial filtering, the streaking artifact image is reduced so that it can be anatomically assessed for the picture of the uterine organs. The anatomical picture of the uterine organ is visible after a reduction in the streaking artifact. The CT images of the Abdomen Non-Media Contrasts axial section after the spatial filter also showed an increase in the CNR value, this means that it can be concluded that there is an influence of the CNR value on the quality of the CT Abdomen image information after using spatial filters based on computer programming. The average value of anatomic information after a spatial filter is higher than before. The percentage increase in value, after a spatial filter for 5mm images, was 43.98%, while for 10mm images an increase of 44.64%. According to [20] Kawashima et al., A digital image with a higher level of information value indicates that the image quality is better.

In this study, the reduction of metal artifacts on metal on CT-Scan images is followed by a decrease in image quality so that the organ will look more blurred than the original, the more streaking artifacts, the more the image quality decreases. This is due to the reduced value of the reduced Signal to Noise Ratio (SNR). There are limitations to subjective visual analysis influenced by the ability of the eye and the experience of seeing detailed images [5]. Uterine images in abdominal non-contrast media images can be assessed by a radiologist and analyzed to produce good judgment or interpretation. There is a reduction in the appearance of streaking artifacts after a spatial filter. In Kurniawan's 2013 study, all the original image filtering processes will experience image blurring as a filter boundary and not eliminate the shape of the organs present in the CT-Scan image [5].

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CONCLUSION

Based on the results and discussion in this study, it can be stated that the application of the spatial filter method to the CT-Scan Abdomen Non Contrasts image of axial pieces mounted on an Intrauterine Device (IUD) metal causes a significant difference in the SNR, CNR and image anatomical information compared to before the application of the spatial filter method, where CT-Scan Abdomen Non Contrasts media images of axial pieces mounted with metal Intrauterine Device (IUD) that apply the spatial filter method produce image information that is more optimal than before the application of the spatial filter method. While the value of anatomic information on the post 5mm image is higher than the post 10mm image, and the standard deviation of the post 5mm is lower than the post 10mm image, meaning that the anatomy information post 5mm image is more optimally clear than the post 10mm image.

RECOMMENDATION

This research is only focused on the use of spatial filters based on Matlab computer programming on Windows 5 x 5, for further research can be developed with a variety of windows and this research is only focused on the artifacts caused by the IUD in the examination of Abdomen Non Media Contrasts, while for the types of Other artifacts can be further investigated with different filters. The use of spatial filters in the examination of CT-Scan Abdomen Non-Contrasts Media can be considered to be a permanent procedure for examining the CT-Abdomen that is attached to the IUD because it can reduce streaking artifacts in the CT-Scan Abdomen image attached to the IUD.

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