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The application of band pass filter technique for metal artifacts reduction on the quality of anatomical image in paranasal sinuses (PNS) MSCT

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ABSTRACT

Background

The current development of the medical world is very rapid especially radiodiagnostics field has begun to change into the era of computerization or digitization of medical images. One use of the most advanced modalities in radiodiagnostics is CT Scan which has been widely used in hospitals. There are some 16 slices CT Scans which do not have software artifact correction, then the application of spatial filter technique on CT Scan image processing can be done by using matlab programming with band pass filter for metal artifacts reduction. Matlab (matrix laboratory) programming is a program for image processing and image analysis using raw data or image results already obtained.

Study objective (s)

Identify the difference of image results with anatomical image quality analysis on PNS MSCT before and after band pass spatial filter using Matlab.

Study design

The type of study used here was quasi experiment with Pre Test- Post Test only Group Design. This study aims to determine the changes before and after the treatment (post-test). There was 1 treatment group which used spatial filter technique.

Results

There was a significant difference in the treatment group before and after spatial filter use to the anatomical assessment with p value of <0.05 or p value of 0.000. This showed the optimal quality of Paranasal Sinuses (PNS) MSCT image and the reduction of metal artifacts which could help to establish anatomical diagnosis.

Conclusion

There was a reduction of metal artifacts after reduction with the use of spatial filter. Then Band Pass filter could be used to reduce metal artifacts in PNS MSCT examination.

Keywords: Band pass spatial filter, PNS MSCT, Artifact

INTRODUCTION

The current development of the medical world is very rapid especially radio diagnostics field has begun to change into the era of computerization or digitization of medical images. One use of the most advanced modalities in radio diagnostics which has been widely used in hospitals is CT Scan and it even has become a minimum requirement for type B hospitals. The quality of CT Scan image generated differs depending on the level of sophistication of existing modalities. In general, the quality of CT Scan image generated is influenced by spatial resolution, contrast, noise and artifacts. [1] CT imaging technique is different from conventional radiological imaging technique, CT is a diagnostic imaging modality to produce an overview of cross-section (Trans-axial) of the patient's body. Through the development of existing technology on CT, the resulting digital image can then be processed and presented in the form of volume/3 dimensional information.

At this time there are many uses of CT Scan and almost every hospital has this modality to support the diagnosis, generally CT Scan with 16 slices. Artifacts on the CT scan often cause distortions in image quality as they produce shadows such as star beam rays on CT scan reconstruction. The resulting metal artifact file covers the surrounding area so as to interfere with the pixel assessment (CT number) on the tissue around the metal and the value is used to determine whether the tissue is normal or there is an abnormality. So the artifact needs to be reduced to help more precise diagnosis and improve the quality of medical services. Paranasal sinuses examination often shows artifacts that disturb the CT scan. In general the artifact is a disturbance in the CT image display or the presence of something in the image. The artifact is defined as the contrast or difference between the CT number reconstruction in the image with the actual attenuation coefficient of the object being examined. [2]

To avoid such artifacts on Paranasal Sinuses examination, the examination can be performed with gantry tilting to obtain a better and accurate image. In CT scan there are various factors that affect image quality, such as range, investigation volume, expose factor, field of view, gantry tilt and slice thickness. The best selection of slice thickness in paranasal sinuses is 3 mm because the details of anatomical abnormalities of the organs and osteomeatal complexes can be seen clearly and spatial image resolution is better. [3]

Large hospitals typically use 64 slices with several three-dimensional reconstruction software applications including, nerve marking, smartcore, noise and artifact correction, multi-planar volume rendering. But even though CT has used computer in its imagery and is much more sophisticated than conventional radiography, it still remains unintended images that do not actually relate to the object being examined and it becomes serious problem because it seriously disrupts the diagnosis. Even at a certain level, the image results cannot be diagnosed at all. [4] There are some 16 slices CT Scans which have not had artifact correction software, then it can be corrected with the application on CT image with image processing using spatial filter technique using matlab programming with band pass filter for metal artifacts reduction. Matlab (matrix laboratory) programming is a program for image processing and image analysis using raw data or image results already obtained. Spatial filter filter process technique passes the image component with high intensity and dampens the image component with a low intensity so that it can reduce metal artifacts on the MSCT images. [5]

METHODS

This study was a field study with the study method used of experimental method using quasi experiment design, with Pre Test-Post Test only Group design. This study aims to determine the changes before and after the treatment (post-test). There was 1 treatment group with the use of spatial filter technique. The study population was all PNS MSCT patients with metal artifacts in the Radiology Department. The sampling technique was purposive sampling where this technique is a technique in determining the sample with certain consideration according to the desired purpose of the study. Determination of the number of samples used federer formula. In this experimental study there were 6 groups with a sample size of 4 patients in each group, then there were 24 PNS MSCT patients as the samples. This study used 16 slices Philip Brilliant CT SCAN. Identification of CT Scan image used MATLAB version 7.10 and was conducted by looking at histogram graph, pixel

value which formed metal artifacts by testing using band pass spatial filter and then the results were analyzed subjectively and objectively. [6-12]

Results of raw data of SPN patients were assessed objectively by calculating histogram and pixel values and subjective evaluation as visual assessment of CT Scan was performed by the practitioners by scoring each MSCT image. In this study, the authors asked for a study permit from the education institution (Post Graduate Program of Master of Applied Health of Semarang Health Polytechnic number 069/KEPK/Poltekkes-Smg/EC/2017 and Semarang District General Hospital number: 035/RSUD-dk/23/2017 to conduct the study. Besides, Informed concent was also done to each respondent which contained the willingness of respondents as study subjects by filling out the questionnaires provided by the authors.Data collection was conducted by storing raw data of PNS MSCT patients by filling in histogram, pixel, noise values and anatomical information. The anatomical information assessment of PNS MSCT images was conducted by 3 radiologists with inter-observer test.

Univariate analysis used Shapiro Wilk test, then bivariate analysis was conducted with Paired T-test to test anatomical information with spatial filter technique. Multivariate analysis was performed to test the difference of PNS MSCT images between each group. To determine the optimal image quality after obtaining the best image in multivariate analysis, analysis with spatial filter was performed using matlab. [13-20]

RESULTS AND DISCUSSION

Difference of histogram value analysis in each image after spatial filter with 3mm slice thickness on PNS MSCT image.

Table 1

	Mean	SD	Correlation
Pre	2010.29	369.582	
Post	2362.25	435.951	0.406
Value	0.049	0.001	

The output table showed the mean of histogram before spatial fiter of 2010.29 standard deviation of 369,581 and the mean after spatial filter of 2362.25 with standard deviation of 435.951. The correlation value before and after was 0.406 with p value of 0.001. The mean value after spatial filter was higher than beforespatial filter. The output table showed t count of -3898 with p value = 0.001. This value was smaller than 0.05 (p = 0.001 <0.05), then Ho was rejected. Conclusion: There was an effect of histogram on metal artifacts reduction on PNS MSCT examination.

Analysis of pixel values before and after spatial filter with 3 mm slice thicknes on Paranasal Sinuses MSCT examination

Table 2

	Mean	SD	Correlation	t count
Pre	2571.08	215.575		
Post	2928.36	268.295		-4.119
Value			0.000	0.000

The obtained mean value before spatial filter was 2571.08 with standard deviation of 215,575, and the mean value after spatial filter was 2928.36 with standard deviation of 268,295. This result showed that there was an increase in the value afterspatial filter. Correlation after spatial filter was conducted had p value of 0.000 where 0.00<0.05, then Ho was rejected. Conclusion: There was a difference in the value before and after spatial filter and it can be interpreted that there was an effect of pixel value to metal artifacts reduction by using spatial filter. [21-24]

Difference in noise value after spatial filter with 3mm thickness slice on Paranasal Sinuses MSCT examination

Table 3

	Mean	SD	Correlation	T count
Pre	52.24	0.254		
Post	54.20	0.352		-12.413
Value			0.000	0.000

The output table showed the mean value of noise before being filtered of 52.24 with the standard deviation of 0.254 and the mean value of noise after being filtered was 54.20 with the standard deviation of 0.351. The correlation value was 0.000 and t count was -12.413 with p value of 0.000. The table showed that p value = 0.000 <0.05, then Ho was rejected. Conclusion: There was a difference before and after the reduction with spatial filter which meant that there was an effect of noise on spatial filter.

MSE value with Noise after spatial filter

Table 4

	Mean	MSE	Correlation
Pre	52.24	0.153	
Post	54.20	0.202	
Value		0.000	0.00

Difference in artifact value after spatial filter.

Table 5

	Mean	SD	Correlation	T count
Pre	1.88	0.133		
Post	3.04	0.147		-5.432
Value			0.445	0.000

Based on Table 5 it can be seen that in the treatment group there was significant difference before and after spatial filter use to the anatomical assessment with p <0.05 ie p value of 0.000. This showed the optimal quality Paranasal Sinuses(PNS) MSCT image result and there was a reduction of metal reduction artifacts which could help to establish anatomical diagnosis.

Histogram Differencein the reduction of metal artifacts on PNS MSCT.

The study result stated that there was ahistogram difference in the application of spatial filter. In this study, histogram value increased along with the increase of x and y axis values in histogram. The study result is in accordance with the previous study of the histogram form of panthom acquisition image with metal and no metal was visible in the change of number of pixels. [25]

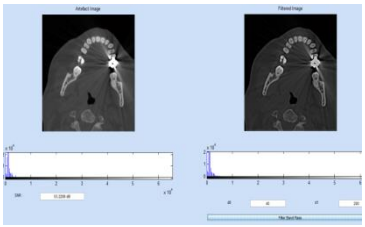

Fig1. Changes in image and histogram after being filtered

In picture 1 we can see the difference of image and histogram. The histogram is an overview of pixel intensity value variations as a whole or shows the frequency distribution of image data pixel values. The image histogram which is evenly distributed across all gray levels has a good contrast. An image histogram which is collected in a dark area has a dull image. An image histogram collected in bright areaor concentrated in high image intensity displays bright images. According

to Leggett (2008) medical images generally had a histogram that tended around dark values at the gray level so that the utilization of digital image processing needs to be optimized and assist the radiologist in determining the diagnostic of a disorder due to tissue damage. In this study the image histogram before and after spatial filter was different and showed an increase in the y and x axis.

Difference in pixel values after spatial filter with 3mm thickness on Paranasal Sinuses MSCT examination.

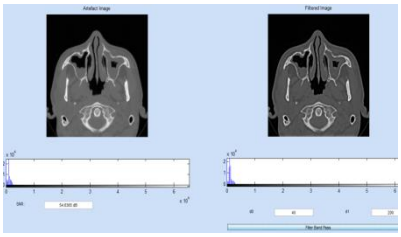

Fig. 2 PNS MSCT image with pixel

The result of this study concluded that there was a difference between after and before reduction with spatial filter and it could be interpreted that there was an effect of pixel value on metal artifacts reduction by using spatial filter. Pixel pixel was influenced by FOV and matrix size. The larger the pixel size, the less the noise, but the spatial resolution would decrease.

The result of previous study stated that metal artifacts pixel to see and count the number of pixels that made up metal artifacts were conducted with magnification on phantom images with metal. Metal artifacts in the form of a beam of white stripes in the imageformed 2-3 pixels using 3x3 windows and only part of the artifacts lines were filtered. [8]

Difference in noise value after spatial filter with 3mm thickness slice on Paranasal Sinuses MSCT examination

The result of this study showed that there was a difference before and after reduction using spatial filter which meant that there was an effect of noise to spatial filter. Noise is a fluctuation (standard deviation) value of CT number on a tissue or homogeneous material. Noise depends on several factors namely mAs, scan time, kVp, slice thickness, object size and algorithm. For example is CT Number of 0, the higher the standard deviation of CT number value on the measurement of water points, the higher the noisenya. This noise will affect the contrast of the resolution, the higher the noise the lower the contrast of the resolution. The enhancement of SNR of the resulted image associated with the quality of output results after spatial filter. The higher the SNR the better the image.

Previous study showed that filtering had a value close to zero. Two approaches can be used to manage filtering results which values are beyond the existing gray level (ie 0 - 255). The first is making a negative value to be a positive one. This approach do solve the problem of a negative value on the filtering result but do not solve the problem if there was a value above 255. So this approach is only used in special circumstances only, for example when there are only a few negative values and the values are close to zero. The second way is Clip values. This approach applies a thresholding operation to the value of the filtering gray level so that its value is in the range of 0 – 255. [26]

Low noise causes low spatial resolution. Reduces spatial resolution will create a gap between 2 different objects and the objects become blur, low spatial resolution for 2 small objects can not be separated. Filtering especially spatial filter used here was Band pass filter which could reduce but could not eliminate noise. [27]

Previous study showed that CT numbers varying above or below the average are referred to as noise. Noise describes parts of CT Scan images that contain useless information (lowering the image quality). If all the pixel values are equal then the noise will be "zero", while the too large variation in the pixel value will produce a high noise value. High noise values will cause artifacts that can interfere with the contrast resolution of CT Scan images and finally will affect the diagnosis. [28]

In this study the higher the MSE value the smaller the SNR, the lower the MSE the better the quality of MSCT image.

Anatomical image quality difference after spatial filter with 3 mm slice on PNS MSCT examination.

Previous study showed that the reduction of metal artifacts on CT Scan images was followed by the decline in image quality so that the organs would appear to be more blurred than the original, the more the reducedmetal, the worse the image quality as well. This is due to the greater MSE value obtained. There were limitations of subjective visual analysis influenced by the ability of the eyes and the experience of viewing the image details. [8]

The result of previous study showed that the quality of the filtered image was decreased, while for the geometric size the seed was getting better. Therefore, it can be concluded that the median filter was suitable for seed a the geometry size, but not for image quality.

In this study, the Paranasal Sinuses image could be assessed and analyzed by the radiologist to produce a good assessment or interpretation. There was a reduction in the appearance of the artifact after spatial filter was performed. In other studies all the original image filter process would experience image blurring as the limitaion and the highest MSE value would be selected which did not remove the existing organ shape on the CT scan image.

CONCLUSIONS AND RECOMMENDATIONS

The use of spatial filter technique on PNS MSCT to reduce metal artifacts using matlab was able to produce better MSNS SPN image quality, so spatial filter matlab program could be used for MSCT examination alternative on CT Scan with 16 slices. The use of spatial filter with 3mm slice thickness on the PNS examination might be considered to be a fixed procedure of PNS MSCT examination as it could produce MSCT images to reduce metal artifacts. Utilization of matlab software can be used not only in artifact reduction alone, but it can be used to assess or diagnose another medical organ disorder. Further assessment needs to be arranged for spatial filter utilization in other cases of MSCT examination

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