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Noise Reduction in DECT Images using spatial neighboring density method using bilateral filter

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Abstract— the Dual-energy computed tomography (DECT) has got high popularity in the field of medical. By using DECT we can easily check or capture the body organs. Noise reduction is the premier process in the x-ray field or the medical imaging field. In this analysis we present the study of DECT images. The images which have the high material density they have more noise as well. To make image appearance better the noise reduction should be done. The use of filter is a primary tool in image noise correction. The non-linear filter removes the noise problem in the image. We are using bilateral filter to remove the noise in DECT images. This paper enlights different method of noise reduction in DECT images and the result will compare with the help of MATLAB software. ImaSim Software provides ability to present and manipulate CT data.

Keywords*— DECT, SNR, CNR , Bilatral filter ,Non-linear filter.*

I. INTRODUCTION

The advance CT provides single density data set of attenuation coefficients, whereas DECT provides two separate data sets, which combined to give more accurate density estimation and material differentiation. However, a superimposed data set from DECT exhibits a more noise. Hence, estimating the accurate Density of a specific tissue is a difficult process, as described in the work of pervious research paper. In order to use advantages of both DECT data sets the goal of this work is to survey, test and analyze algorithms with the aim to reduce noise. These algorithms should preserve valuable details from both images, such as fine distinction between soft tissues of approximately the same density.

Bilateral filter removes the noise and preserver the edge. To get the merits of DECT images the bilateral filer can be applied. The resulting data set is smoothed and noise is decreased, but simultaneously edges are preserved. This task was completed by bilateral filter by seeing spatial (neighboring densities) and range (density differences) domains, in the low energy and high energy images respectively, during filtering.

CT errors in imaging object are unfaithful representations of the test object. Examples of such errors are noise, beam hardening, Compton effect, motion artifacts, etc. Noise in the DECT data sets is related that can reduce by various algorithms that recover the impotent information. The spectral-error is a specific type of CT error defined as the deviation from expected trends of material attenuation. The noise in data set of CT can remove with the attenuation of highly dense materials decreases more rapidly than the attenuation of materials with lower density, with increasing energy level of recent CT device.

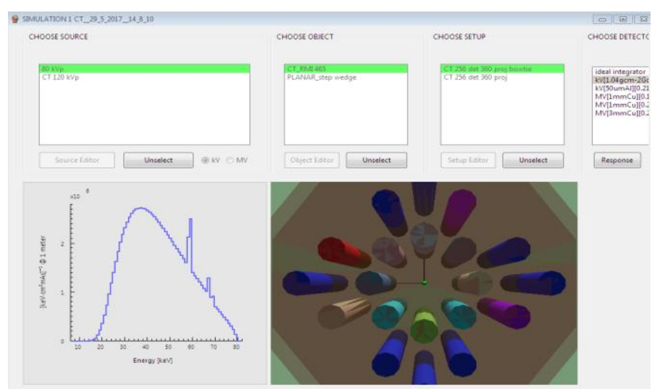


Figure 1 Imasim simulation window

We implemented our work in the **ImaSim Software** as a plugin that provides a graphical user interface for setting parameters and performing the aforementioned correction operations. The parameters of all operations are adjust the desired medical examination. Figure 1 covers the main simulation window has fours section as they are source, object, setup, detection option respectively. They tend to generate final test image of different energy level.

II. RELATED WORK

Literature survey of any research filed or subject is Must required, before contributing to the research of that field. It gives a precise study of existing published article for clear understanding of that field.

[1] Computed tomography (CT) is the workhorse of medical visualizing world, accounting for almost 6.5 cores adult scans happens in the USA every year. One Technical advances such as very quick scan time period; multilane reformatting, thinner slices and 3D rendering have revolutionized the scope of Computed tomography. An exciting improvement that gives great assurance to more increase the modality's potential is DECT.

[2] In DECT, with various x-ray levels two Computed tomography datasets are collected. We can use various tube potentials to make these spectra, partially also with further filtration at 140 kVp. Spectral data can also be fixed by layer locator or quantum-counting locators.

[3] The projection information measured in CT imaging and that is why, the slices rebuild from these information are noisy. The proposed work present the method with wavelet transform -protection technique for noise minimization in medical images which will be employed in addition with completely different reconstruction methods. The approach relies on the belief that information would be dissolved into data and temporally uncorrelated noise.

[4] The proposed work shows that the pathway for segmenting bone & marrow construction from DECT images is fully-automatic. The image of medical takes a multi-material decomposition model (MMD) computed from a triplet of physical equipment at 2 particular power attenuation levels.

[5] DECT images can bear a two-material decomposition methodology which ends up in two images carrying material density data. Equipment density images acquired by that procedure lead to pictures with maximized pixel noise. Noise minimization in those pictures is fascinating for enhancing image quality.

6] Many promising Medical applications for DECT in medical image area are described. Twin energy CT not solely provides wonderful morphologic detail however can also provide material-specific and quantitative info which will be significantly helpful in medical imaging. Dual-energy CT has distinctive capabilities for characterizing renal lesions by quantifying iodine content and serving to determine the mineral contents of renal stones, info that's essential to care of patient.

The rest paper is arranged as: section II presents the principle of CT data set. The noise removal technique is described in section III. The methodology is given in the section IV. The work is concluding in 5th section with future work.

III. PRINCIPLE OF CT IMAGES

A. Computed Tomography

The CT is mostly employed in medicine as imaging method for medical diagnostic. Most medical surveys classify CT among the best 5 medical improvement in previous 50 years.

Standard radiographic methods of imaging have few significant restrictions which may be surpassed by using CT. One important restriction of normal energy level image of x-ray is that we are picturing a 3D object however we project it (by superimposition) to a single 2D plane, known as a photograph therefore losing the volumetric demonstration of image.

Radiography isn't able to capture fine contrast totally differentiation between different tissues. Therefore the tiny variations in X-ray attenuation aren't captured. CT is ready to produce a 3 dimensional sample of objects and second images or axial slices of the anatomy. High contrast and resolution could be a vital characteristic of CT and therefore important for medical diagnostic. CT is capable of differentiating between varied sorts of tissue if they exhibit a difference in their physical density.

CT scan data are relied on the absorption of X-rays as they go through completely different elements of human body. Build upon on section of body that's scanned, totally completely constellations of tissues are present and so different amounts of X-rays are consumed.

Once it involves single energy and twin energy CT, each generate information sets with the CT numbers at each voxel position. Those numbers represent special linear attenuation parameter, for the standardization they are given within the Units of Hounsfield.

B. Dual Energy Computed Tomography

Dual source imaging tomography and it is an extension of conventional CT device. Theoretically the concept of DECT is relied on separation of the spectrum into 2 parts, a high &

low level of energy part and the projection from two x-ray sources respectively.

Both dual energy approaches will generate dual data set, one recorded at a low level energy and a second recorded at a higher energy level. The energy levels for both level sources are often set at 80kV and 140kV respectively, but other configurations are possible, depending on the current study.

A virtual 120kV data set is reference when comparing the DECT results with the features of a standard CT 120kV data set. This data set is generated as the weighted sum of the low and high energy data sets with 30% of 80kV and 70% of 140kV intensity values an example is shown in Figure 2

As shown in Fig two, the x-ray will be detected solely from one detector, placed on another aspect. The body is radiated with to both energy levels; in this example Fig 2, the low energy state is ready at 100kV and also the energy high state is ready at a 140kV. With this technology energy level with different pictures area unit created among one scan.

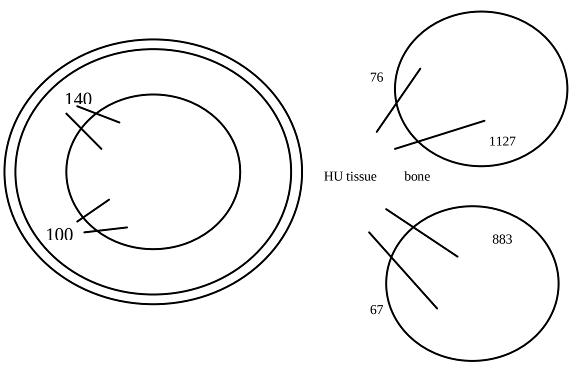


Figure 2 signal from x ray tube

IV. TYPES OF FILTER

A. Noise Reduction

In the image processing noise is very unique issue. After removing noise we can easily check the CT images and can get more details. The noise reducing in the CT data set is an important process. The some filters like Gaussian median are not considering the pixel intensity distant with the process. The filters generate some issue like losing the contrast and edges. But the other non-linear filter can work in both conditions.

B. Median Filter

The median filter is non-linear type filter but do not account pixel intensity as liner combination. As per the name it takes mid pixel value for calculation means the kernel filter arrange same arrangement. That middle pixel is a output value of image with central pixel. The output value depends on the kernel filter size.

C. Gaussian Filter

The linear filter Gaussian is LPF and mostly used to noise correction in CT images. The kernel filter vales are calculated as linear arrangement of pixel intensity. This filter work in specific section that is known as spatial domain that process lowering the noise persistently. This filter calculate standard deviation in some case it blur the image due to big sigma value.

D. Bilateral Filter

The bilateral filter maintains edge during image preprocessing of CT data sets. The Gaussian filter uses spatial derails of image it consider pixel intensity difference of medical imaging. Whereas it considers each value in kernel filter with spatial value in Gaussian filter with intensity weighted. The higher range pixel value not affects the output value with normal intensity value.

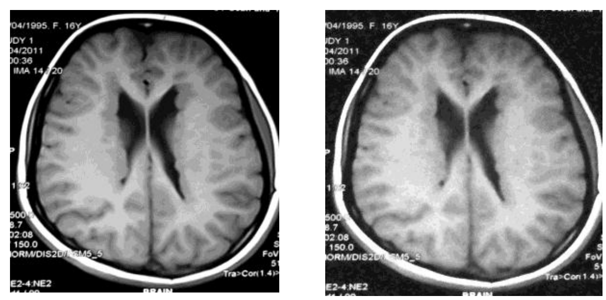


Figure 3 Bilateral Filter a) shows original image b) shows filtered image

This saves edges and thin structures. Because of the intensity weighting is the section of the bilateral filter, edges do not influence surrounding homogeneous regions during smoothing process, and the image not losses contrast. Usually, this filter worked on a single image but it can be easily expanded to two images that depict the image but with different extrinsic properties such as surrounding light intensity, with distinct angle or for the DECT images. We design bilateral filter that is also known as joint or cross filter.

V. METHODOLOGY

Noise in images can be capably deceased by employing distinct sharper filters. Anyway, in many condition the required information should not loss in process, like thin edges or sharp tissue boundaries. The question is how many points should recover, because smoothing does not only remove noise but information too. This undesirable effect partly originates from the design of traditional smoothing filters. Most of the traditional smoothing filters work in the spatial domain, i.e., they look only at differences of the distance to the central pixel.

Smoothing filters, as well as the bilateral filter, are frequently based on convolution. During the convolution, a smoothing filter checks only for intensity values in the nearby of a central pixel. The filter kernel size is calculated according to central pixel of nearby filter. As a 3 x 3, 5 x 5 or 7 x 7

Convolution means that a two dimensional filter kernels and an image and the filter checks only for values in the nearby of the set pixel, where the nearby is characterize by the filter kernel size. As a 3 x 3, 5 x 5 or 7 x 7). Commonly the kernel size is odd, meaning central pixel will be there. The output of the filter operation at certain location is given as adequate average of the neighborhood intensity values. As already mentioned, the nearness of the mid pixel is better condition to achieve good result.

The bilateral filter is also used for image smoothing and noise reduction but in addition it preserves edges. This is possible because in inclusion to the nearest area of image it operates in the range domain, as described by Tomasi and Manduchi. This means that not only the nearest of the central pixel in the is important, but bilateral filter also accounts for pixels with similar intensity values. Neighbors of the central pixel that vary significantly in their intensity value are taken less into account during filtering. This method greatly succeeds in preserving edges of objects in the image, as shown in figure 4. The bilateral filter is a non-reparative nonlinear method implemented for single image filtering. However, it can easily be extended for two images.

DECT uses 2 distinct X-ray energy levels and it generates two images which are registered to each other; image registration in DECT is valuable because the intensity values at the image pixel position in the low level energy image and the high energy image should correlated to each other. The bilateral filter helps from this correlation by using information from both images in order to reduce noise without smoothing the edges. An image with low X-ray level has a large intensity range similar to what we get when we are capture image by camera in a half-dark environment. In the low X-ray energy image we can easily distinguish various types of tissue, but it has a more noise. The image with high X-ray level is like an image captured in light, we get better details but the image has a narrower intensity range. The idea is now to combine these two images and thus gain a large scale of intensity values (contrast) from the low energy image, and details from the high energy image.

We implemented the bilateral filter for volumetric CT data, by taking neighborhood voxels along every axis. In the spectral part of the bilateral filter smoothing is done on the low energy images in order to remove noise, but in its range part the bilateral filter checks for pixel intensity value of high image, it maintain the image edges and information.

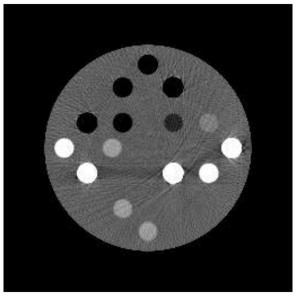
VI. RESULTS AND DISCUSSION

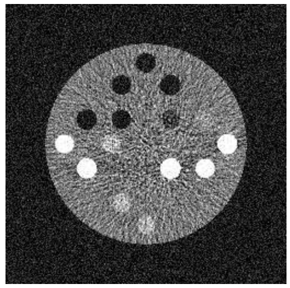
In this section, I have carried some experiments to check the achievement of the suggested work quantitatively and visually. Here we carried test image from ImaSim software that is of 80 keV. To do a quantitative contrast, I simulated some standard test on images of 80kV CT data set with some noise into the original image. The code run on Matlab software on 2013 version I got some image quality parameter. The Image Enhancement factor (IEF), the Peak Signal to noise ratio value, Mean Square error, and Mean structural similarity index values these all parameter is given in table1. The PSNR shows the maximum possible power of a signal. However a higher PSNR indicates that the reconstruction is of higher quality. It is the approximation of reconstruction quality for human perception. The PSNR is generally defined by mean square error that gives a noise free M X N monochrome image. The image enhancement process improves the original image for further operation. It removes noise, brighten and sharpen of an image, it makes easier to identify key features. The last image quality parameter is mean structural similarity index that measure the similarity of two images in term of luminance. Contrast and structure that is design to give a better approximation of image quality.

Table 1 shows the image quality parameter

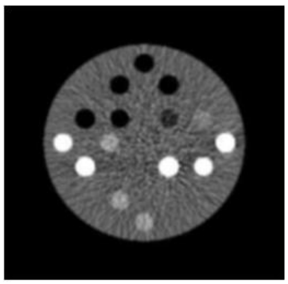
Filter Type	PSNR (dB)	NMSE	FSSIM
Bilateral Filter	29.9089	0.0142	0.99
Anistropic Filter	28.44	0.0198	0.98

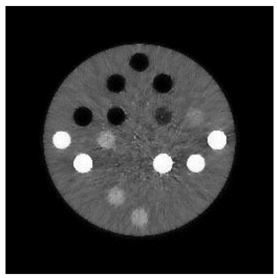
The proposed method of research work with bilateral filter removes noise and same time it keeps sharper image than other filter. As a result, the quality of reconstruct image is more precisely improved. The proposed filter is capable to design and to give most decent and soundness to image correction. It is been presented that the bilateral filter works well DECT images. We create a images from ImaSim software of 80kv CT image. The image is feed to Matlab as raw image. The code uses bilateral filter with Gaussian filter and kernel matrix. The result obtained by the filtering process is given in figure 5.





a) Original Image *b) Noisy Image*





c) Anisotropic filtered image d) bilateral filtered image

Figure 4 show the resultant image of input and filtered image

The bilateral filter maintains the information of image during removing of Gaussian noise and basic noise from image.

VII. CONCLUSION AND FUTURE SCOPE

The capability to get fundamental unenhanced images and material-specific data gives DECT strong advantages past conventional CT for assessment of the system tract. However, a perspective of the principles of DECT data processing and image creation is essential to get most benefit from the DECT dataset. Further clearance in data processing methods, reduction in image noise, and adaptation of dual-energy CT rules conceding decreased radiation doses will likely lead to more broad use of this bright method in the future. The review method exhibits that are an easy to-implement work flow, and vast significant analyzes were made to confirm the quality of the images after noise correction.

As one possible future avenue of the research, the application of several segmentation techniques after our noise reduction. An example for such technique would be CT angiography. Some of the implemented noise removal algorithms like the bilateral filter tend to be very slow when applied to large volumetric data, because our implementation is done on the CPU. Hence, a possible improvement with the speed would be to implement a sequential thing of the DECT bilateral filter (possibly on the GPU).

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Authors Profile

Mrs. Pallavi Sharma pursued Bachelor of Engineering from RGPV University ,Bhopal in 2014 in Electronics and Communication and currently pursuing Master of Engineering from RGPV University,Bhopal in Digital Processing. She has published one survey paper initially and now her main focus is on research work in the field of image processing. She has also worked on cryptography in her major project during her bachelor of engineering.

Ms. Vibha Tiwari received the Bachelor of Engineering in Electronics Engineering from B.A.M.U., Aurangabad, India, in the year 1999 and Master of Engineering in Digital Techniques and Instrumentation from Shri G.S. Institute of Technology and Science, Indore, India, in 2002. She is pursuing Ph.D. from Devi Ahilya University, Indore, India. She is currently working as Associate Professor in Medi-Caps University, Indore, India. She has around 14 years of teaching experience. Her research interests include medical image compression, compressive sensing, color image compression, image restoration, enhancement and denoising.