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Computer Aided Tomography for Reconstruction of Medical Images Using Ramp Filter

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ABSTRACT: The main objective of this project is reconstruction of medical images using computerized tomography. A basic problem in imaging with x-rays (or other penetrating radiation) is that a 2Dimensional image is obtained of a 3Dimensional object. This means that structures can overlap in the final image, even though they are completely separate in the object. This is particularly troublesome in medical diagnosis where there are many anatomic structures that can interfere with what the physician is trying to see. To solve this problem, several cross sectional views are taken and then reconstruct the final image from these views or slices. In this project we implement the image reconstruction from the cross sections tomographic views in MATLAB. We will use algorithm called Filtered Back Projection technique during reconstruction. In less technical terms, a back projection is formed by smearing each view back through the image in the direction it was originally acquired. The final back projected image is then taken as the sum of all the back projected views. The input for the algorithm is cross sectional radiation views. These views can be downloaded from online data bases and the output is the reconstructed image.

KEYWORDS: Cross sectional views, Filtered Back Projection, Smearing and Reconstruction.

I. INTRODUCTION

Medical imaging refers to visualize the internal organs of the body which are hidden by the skin and bones to diagnose and treat diseases. Computerized tomography is used for identifying the hidden or inner defects of human body parts and also objects. Tomography is imaging by sections or sectioning through the use of any kind of penetrating waves. This method is used in radiology, archaeology, biology, materials science and other areas of science. Computerized tomography makes use of computer processed combinations of many images taken from different angles to produce cross sectional images of specific areas of a scanned object or body part, allowing the user to see inside the object without cutting. First we are implementing the 1Dimensional samples/slices from a 2Dimensional image using Fourier slice theorem for multiple angles. These 1Dimensional samples are back projected by summing up all the back projected views of different angles to obtain the 2Dimensional back projected image. This back projected 2Dimensional image is the projected image with blurriness and noise. To remove the noise we use the filter. Since Ramp filter is a linear high pass filter it increases high frequency and suppress the low frequency to reproduce the image exactly.

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II. RELATED WORK

1. Fourier slice theorem:

The projection slice theorem, central slice theorem or Fourier slice theorem in two dimensions states that, the 2D Fourier transform can be reconstructed from 1Dimensional projections/slices [1].

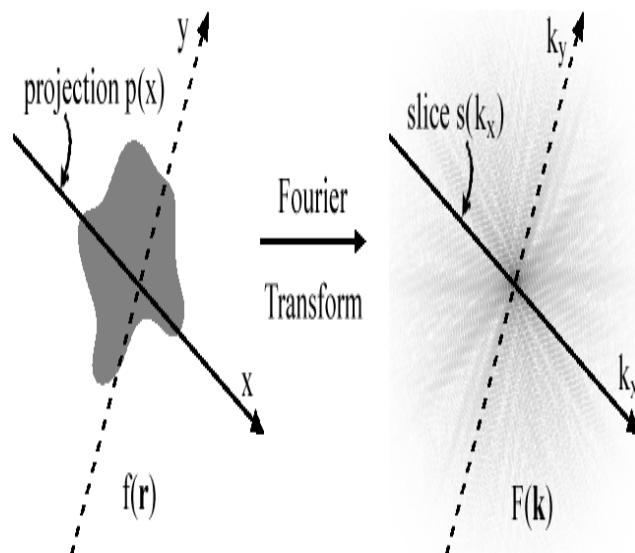


FIG: 1(a)

If $f(x, y)$ is a two-dimensional function, then the projection of $f(x, y)$ onto the x axis is $p(x)$ where

$$p(x) = \int_{-\infty}^{\infty} f(x, y) dy.$$

The Fourier transform of $f(x, y)$ is

$$F(k_x, k_y) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x, y) e^{-2\pi i(xk_x + yk_y)} dx dy.$$

The slice is then $s(k_x)$

$$\begin{aligned} s(k_x) &= F(k_x, 0) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} f(x, y) e^{-2\pi i x k_x} dx dy \\ &= \int_{-\infty}^{\infty} \left[\int_{-\infty}^{\infty} f(x, y) dy \right] e^{-2\pi i x k_x} dx \\ &= \int_{-\infty}^{\infty} p(x) e^{-2\pi i x k_x} dx \end{aligned}$$

FIG: 1(b)

FIG 1(a): A graphical representation of the Fourier slice theorem in two dimensions. $f(r)$ and $F(k)$ are 2-dimensional Fourier transform pairs. The projection of $f(r)$ onto the x -axis is the integral of $f(r)$ along lines of sight parallel to the y -axis and is labelled $p(x)$. The slice through $F(k)$ is on the k_x -axis, which is parallel to the x -axis and labelled $p(x)$.

FIG 1(b): Proof of Fourier Slice theorem

2. Back projection:

The standard method of reconstructing CT slices is Back projection. This involves “smearing back” the projection across the image at the angle it was acquired. By smearing back all of the projections, you reconstruct an image. This looks similar to the real picture but is blurry. We smeared bright pixels across the entire image instead of putting them exactly where they belong [8].

Determine the back projected image from each projection and then reconstruction by summing different number of back projection. The simplest method for reconstructing an image from projections along the angle is by Backprojection. Apply inverse Fourier Transform of the 1D Projections. Compute all the 2D points from the projection. Take that same function, but do a two dimensional Fourier transform first, and then slice it through its origin, which is parallel to the projection line.

3. Filtered Back projection:

Back projection method has several disadvantages; first it produces an image which has a high density in the center. This is due to the fact that many different images are being overlapped in this area. Secondly, the resulting image is severely blurred [7]. For reconstructing the image we need filter. The combination of Back projection and Ramp filtering is known as Filtered Back Projection [9]. Filter is used to suppress the low frequency density at the

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midpoint. When we are rotating the image the low frequencies are coming close to the midpoint due to this the density of low frequencies at the midpoint increases and high frequency density is too low. For suppressing low frequencies we are using Ramp filter. Ramp filter linearly increases the low frequency components and high frequency components for reproducing the image exactly.

III. METHODOLOGY

Projection Flowchart:

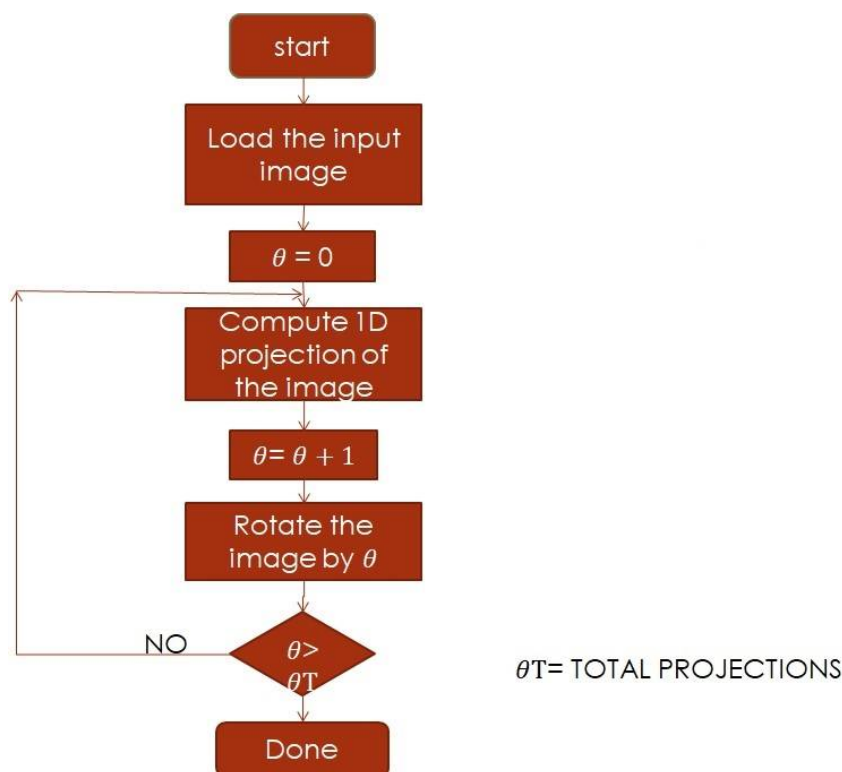


FIG: 2 Projection Flowchart

The above shown flow chart transforms a 2Dimensional image to 1Dimensional projections for one angle. By increasing the angle we can compute projections for different angles. Here initially we are taking the 2dimensional input image from online database which is taken as $n \times n$ resolution. Then for one angle we are taking the projection by increasing angle up to the total projections. Finally by this flow chart projections are obtained.

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Back projection Flowchart:

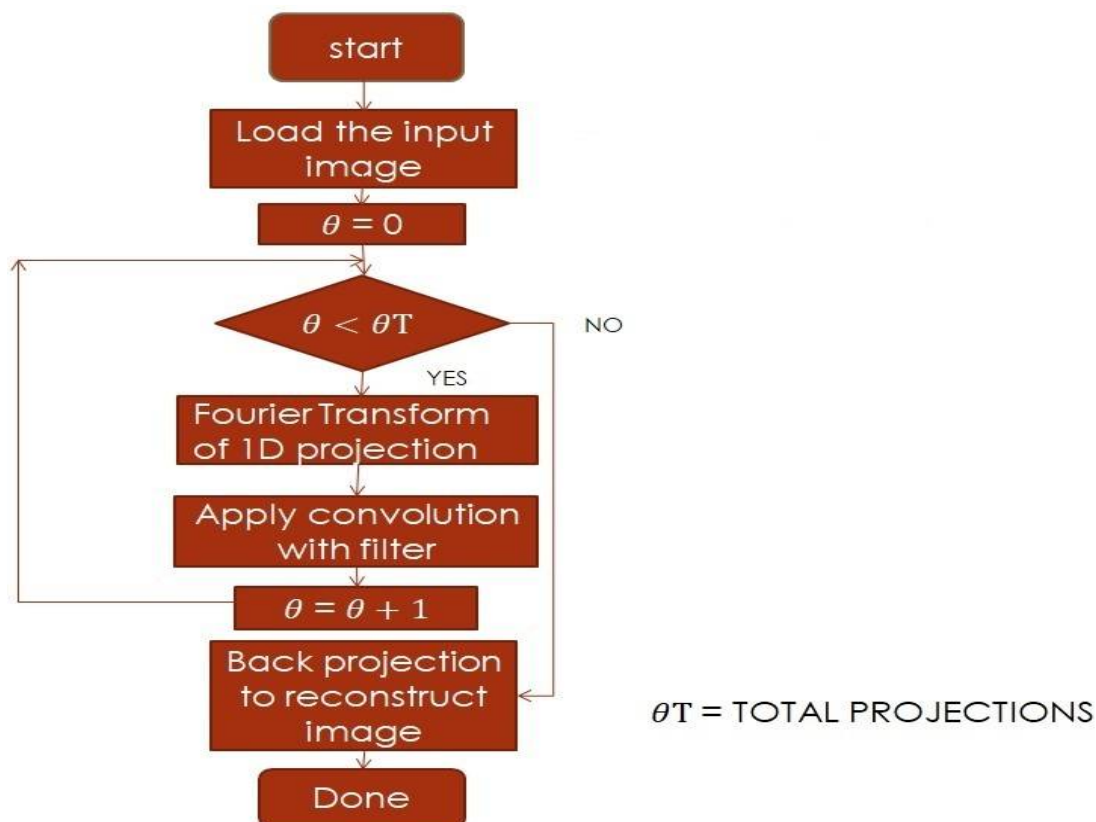


FIG: 3 Back Projection Flowchart

Initially we computed 1dimensional projections. We saved those projections and projection angle vector (it is the matrix that contains the no. of different angles we have in the vector)for those projections.We are applying Fourier transform and applying filter and then summing up all those we get the filtered back projection image. This process continues until the projection count is below the total projections. By this flow chart we reconstructed the 2 Dimensional image from 1Dimensional projected images.

IV. EXPERIMENTAL RESULTS

An $n \times n$ 2 dimensional image is the input of the project as shown in FIG: 4.By applying Fourier slice theorem we computed 1dimensional slices of 2dimensional image for one angle by rotating it in circular motion as shown in FIG:5.By applying back projection on those 1dimensional slices for multiple angles we computed an projection image for 180 degrees as shown in FIG(6).Back projection image contains some noise so this the image becomes blurred. For removing, those noise we are applying ramp filter to produce the image exactly. For reconstructing the image we are using Ramp filter that it eliminates the noise resulting from simple back projection image and the resulting images for different angles are shown in FIG:7,FIG:8,FIG:9,FIG:10,FIG:11,FIG:12,FIG:13.

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FIG: 4 INPUT

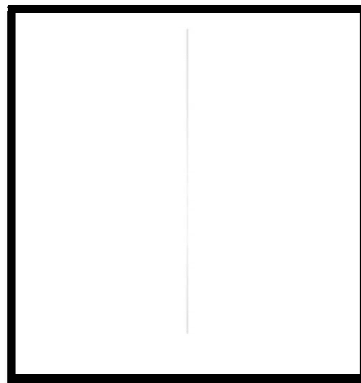


FIG: 5 1 PROJECTION

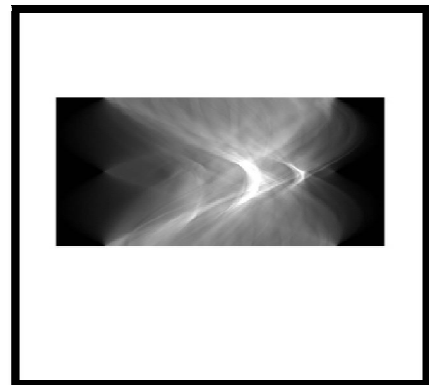


FIG: 6 180 PROJECTIONS

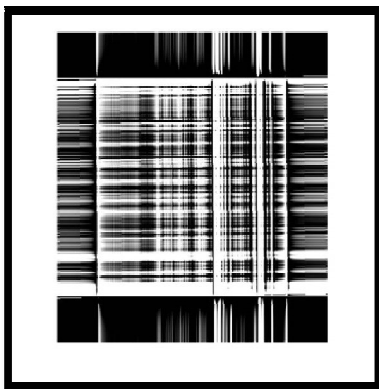


FIG: 7 3DEG



FIG: 8 30 DEG

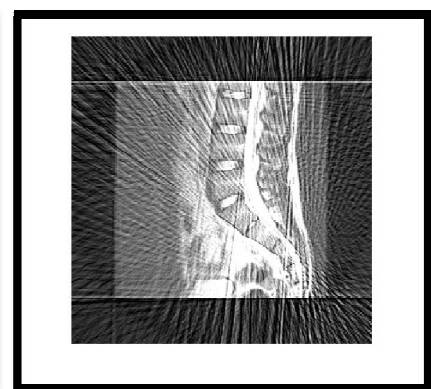


FIG: 9 60 DEG

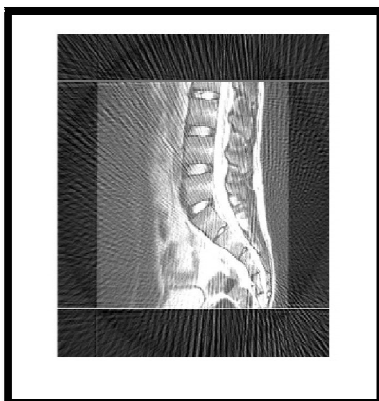


FIG: 10 90 DEG

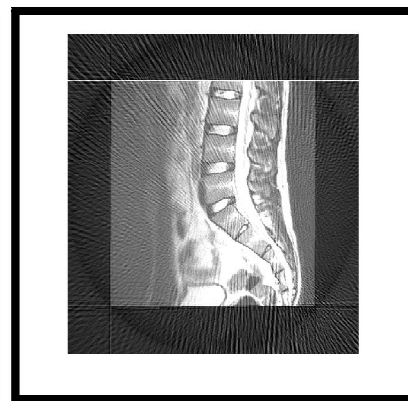


FIG: 11 120DEG



FIG: 12 150 DEG

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Vol. 7, Issue 3, March 2018

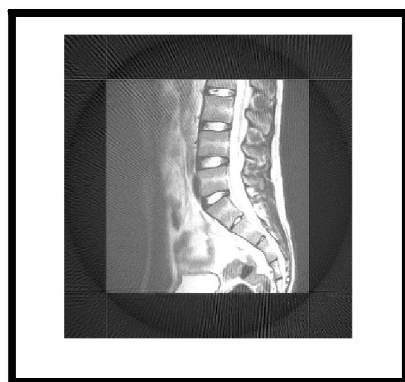


FIG:13 180 DEG

V. CONCLUSION

We have implemented the 2dimensional image reconstruction from 1Dimensional projections. By using tomography technique we obtained 1dimensional slices and the back projection image. For removing noise, obtained from back projection we applied ramp filter to remove noise and to restrict the low frequency component strength to reproduce the image exactly. We have successfully implemented image reconstruction with MATLAB. We have implemented the image reconstruction for 2Dimensional image .It can be extended to 3 Dimensional images.

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