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3D Construction of Brain using 2D MRI Slices

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Abstract: ***Medical image analysis plays a more and more major role in medicine. Detection and analysis of risks causing cancer and other medical issues in early-stage help to prevent death. PET, CT, X-ray and MRI are the medical imagining techniques used. There have been a number of researches have done on constructing the 3D model for better analysis of the structure. The paper is proposed about the construction of a 3D brain model using 2D slices of MRI. The 3 different images of the brain are considered (T1, T2 and PD). The image registration is applied to T1, T2 and PD and fusion is done. The fused image includes of the complete detail of the brain, these 2D slices are used to construct the 3D model. The 3D map is created and surface to volume construction is applied to build the 3D model.***

Keywords: Reconstruction, Affine Transformation (AT), DWT, CTDWT, B-Spline, Tri-linear interpolation.

I. INTRODUCTION

The death rate due to the tumour has been increasing enormously over the past three decades. The major disease cause to the brain is a tumour and it can emerge in the intracranial structure because of irregular and unstructured growth of cells. Once the abnormal tissue is developed, it is very dangerous to human life and it is necessary to diagnose it in an early stage. Tumour part grows in a brain in different parts and in a different size. By analysis, its growth stage of the tumour is decided.

3D is a more demanding topic in the medical field. Analyzing a 3D model helps in diagnosis in a better way and also it increases the accuracy of diagnosis. Many medical imaging techniques like X-ray, MRI etc., Needs an alignment. 3D images help in a better understanding of the health state of the patients.

2D brain MRI images are visualized by the doctor to analyze the brain tumour, but it is quite difficult to visualize and study tumour growth. Hence 3D model development is necessary. The doctor was disadvantaged from the exact visualization of the tumour from the 2D images, 3D visualization or 3D model development become the most significant of the medical diagnose.

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II. LITERATURE SURVEY

Ch. Rajasekhara Rao et.al [01] have presented 3D reconstruction and segmentation of tumour part for better diagnosis. In the brain MRI detection of tumour stage benign or malignant. The MRI slices are considered and segmented slices are considered to re-construct the 3D model.

The MRI images which are considered are pre-processed and histogram and object-based thresholding techniques are applied to detect the tumour. To visualize the detected tumour part, the 3D model is more effective. Qeethara Kadhim Ai-shayea et.al [02] have presented a visualized in 3D using standard techniques. Constricting the 3D using 2D images is important. Here it is explained that the system is approach is a useful method for effective 3D visualization. It consists of 4 steps, pre-processing, image enhancement, contour and reconstruction and visualization. Sudipta Roy et.al [03] has presented 3D structuring of the tumour by using the 2D slices of the MRI. In the MRI slices detecting the abnormalities and creating a stack, using that stack construct a 3D cube within which it includes the 3D constructed brain abnormality. Zhao Liang Lun et.al [05] has proposed a technique for the construction of the 3D model by considering 2D slices. The system considered single or multiple sketches and output, a dense cloud point represents 3D construction of the input sketch and then it is converted into a polygon mesh

III. METHODOLOGY

Figure 1 shows the proposed system for the reconstruction of the 3D model. Three different images are considered as an input to the system, 3 different types of images are MRI brain images but which are taken at different time such as T1, T2 and PD images. To register T2, T1 is considered as a reference and done using AT and registered T2 is fused by the DWT technique. The PD image is registered using the B-Spline transformation by considering the T1T2 fused image. T1T2 image is fused with a registered PD image using the CTDWT technique. The final fused image T1T2PD images are used for the reconstruction of the 3D model.

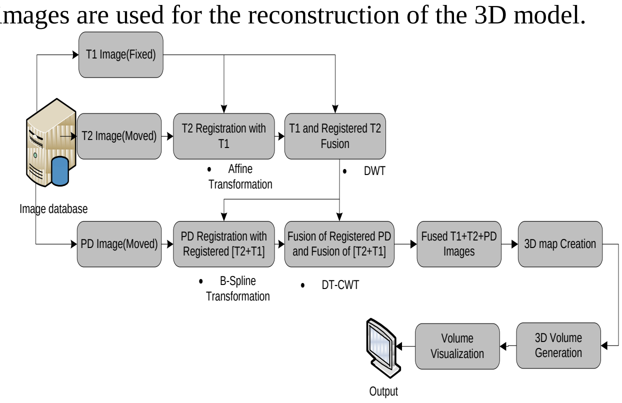


Figure 1: Proposed System Block Diagram

In the construction of the 3D model, 3D map creation is done first to fit all 2D slices. The 2D slices are used to create a volume. The constructed volume is visualized in the created 3D map.

IV. 3D MAP CREATION

Mesh grid cartesian grid in 2-D/3-D space

$$[x,y,z] = meshgrid(1{:}size(V,2),1{:}size(V,1),1{:}size(V,3)); \qquad (06)$$

$[x,y,z] = = meshgrid\ (xgv,ygv,zgv)$

replicates the grid vectors xgv,ygv,zgv to produce the coordinates of a 3D rectangular grid (X,Y,Z). The grid vectors xgv,ygv,zgv form the columns of X, rows of Y, and pages of Z respectively. (X,Y,Z) are of size

$$numel(ygv)-by-numel(xgv)-by(numel(zgv). \qquad (07)$$

2-D and 3-D the coordinates output by each function are the same, the difference is the shape of the output arrays

$$hslices = slice\left(x,y,z,V,\frac{size(V,2)}{2},\frac{size(V,1)}{2},\frac{size(V,3)}{2}\right); \qquad (08)$$

Slice volumetric slice plot:

$slice\ (X,Y,Z,V,Sx,Sy,Sz)$ draws slices along the x,y,z directions at the points in the vectors Sx,Sy,Sz. The arrays X,Y,Z define the coordinates for V and must be monotonic and 3-D plaid (as if produced by $meshgrid$).

$slice\ (X,Y,Z,V,XI,YI,ZI)$ draws slices through the volume V along the surface defined by the arrays XI,YI,ZI.

$$moveitX(hXslice,V); \quad \%\ move\ a\ graphical\ object\ in\ 3D\ in\ x\ direction \quad (09)$$

$$moveitY(hYslice,V); \quad \%move\ a\ graphical\ object\ in\ 3D\ in\ y\ direction \quad (10)$$

$$moveitZ(hZslice,V); \quad \%\ move\ a\ graphical\ object\ in\ 3D\ in\ z\ direction \quad (11)$$

V. 3D VOLUME CONSTRUCTION

Tri-linear Interpolation: By considering a number of 2D point 3D model is constructed. All the slices of the 2D MRI brain images are considered and then the 3 coordinates of (x,y,z) are build to represent the 3D model of the brain. The 3D brain image is constructed to analyze the problem inside the 3D brain part at any angle [8]. To calculate the pixels between the slices, a tri-linear interpolation method is used.

In this method, the value of an approximate point of the 2D images in the spatial domain (u,v,w) as shown in the rectangular box of F is calculated using the following Eq. (06)

$$\begin{aligned} P_{uvw} = {} & P_{000}(1-u)(1-v)(1-w) + P_{100}u(1-v)(1-w) + P_{010}(1-u)v(1-w) \\ & + P_{001}(1-u)(1-v)w + P_{101}u(1-v)w + P_{011}(1-u)vw + P_{110}uv(1-w) \\ & + P_{111}uvw \end{aligned} \qquad (06)$$

in which $puvw$ is the intensity of the pixels at coordinates (u,v,w).

Surface2volume convert a surface volume to a solid volume

$$OV = surface2volume(fv) \qquad (07)$$

Creates a volume block (logical) in which every voxel which is inside the given surface fv is set to 1. The structure fv defines the surface by vertices and faces. The output block has the dimension $[M,N,P]$ where

$$M = round((max(Xpos)-min(Xpos)/GRIDSIZE)+2 \qquad (08)$$

$$N = round((max(Ypos)-min(Ypos)/GRIDSIZE)+2 \qquad (09)$$

$$P = round((max(Zpos)-min(Zpos)/GRIDSIZE)+2 \qquad (10)$$

$Xpos,Ypos,Zpos$ are the Coordinates of the given vertices in the fv structure. The default grid size is 1

First, the surface will be rasterized on the grid. Therefore it determines the location of each point which lies in the surface in a finer resolution as defined by the input grid. Indexing method is used to transfer the calculated points to surface

$$startGridPosX = min(inputGrid\{1,1\}(:)); \qquad (11)$$

$$startGridPosY = min(inputGrid\{1,2\}(:)); \qquad (12)$$

$$startGridPosZ = min(inputGrid\{1,3\}(:)); \qquad (13)$$

$$endGridPosX = max(inputGrid\{1,1\}(:)); \qquad (14)$$

$$endGridPosY = max(inputGrid\{1,2\}(:)); \qquad (15)$$

$$endGridPosZ = max(inputGrid\{1,3\}(:)); \qquad (16)$$

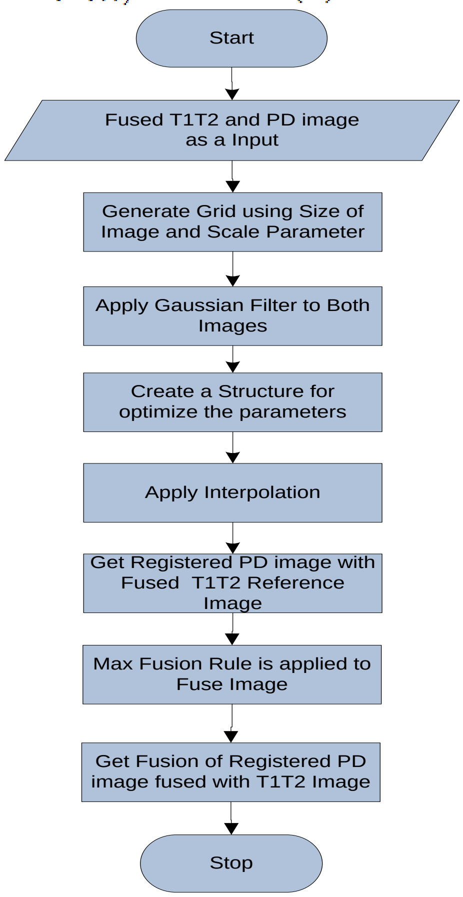
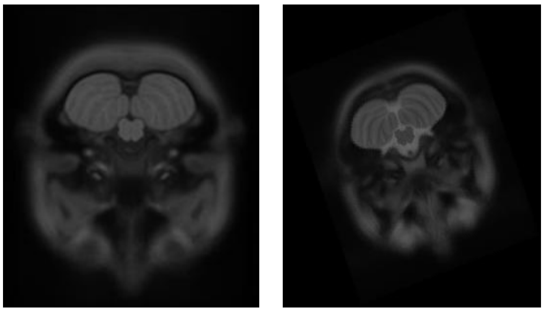


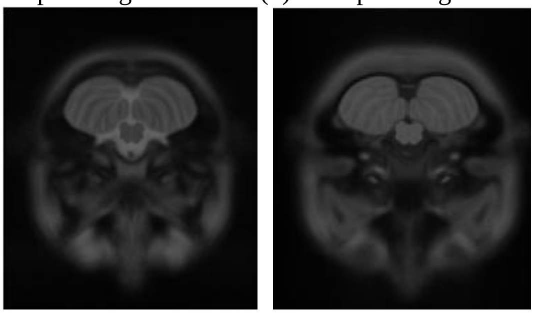
Figure 2: Flow chart of B-Spline Image Registration.

VI. EXPERIMENTAL RESULTS

MATLAB R2012a tool is used to evaluate. The 2D slices of the MRI brain images are considered which are taken from different times such as PD, T1 and T2 images. T1 layered image is considered as a reference to register the T2 image. The registered T2 image is fused with a T1 image. PD image is registered by using a T1T2 registered and fused image as a reference. Finally T1T2 and registered PD image is fused to get. The T1T2PD fused image consists of complete information of the brain. The complete information images are used to construct the 3D model.



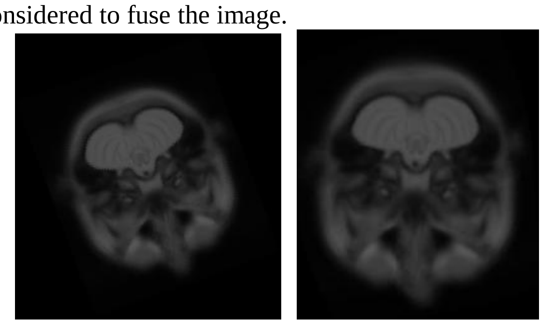
(a) T1 Input Image (b) T2 Input Image



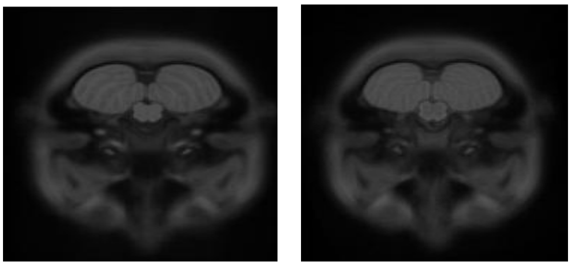
(c) Registered T2 Image (d) Registered T2 Image Fused with T1 Image

Figure 3: T1 and T2 Input Image and Registered T2 Image

Figure 3(a) and (b) shows the different slice of brain T1 and T2 image and registered T2 image. To align the T2 image, T1 image is considered as a reference image. To register the T2 image affine transformation is used, The registered T2 image is fused with the T1 input image shown in figure 3(d). DWT is applied to the registered T2 image and the T1 input image, the DWT divides the given image into four different sub-bands (LL, LH, HL and HH). In all the four sub-bands max value is considered to fuse the image.



(e) PD Input Image (f) Registered PD Image



(g) Registered T2 Image Fused with T1 Image (h) Fused T1T2 Image Fused with Registered PD Image

Figure 3 (e) shows the input PD image, b-spline transformation technique is applied to register PD image with considering fused T1T2 image as a reference image. Figure 3 (f) shows the registered PD image. The DT-CWT technique is applied to a registered PD image and also a fused T1T2 image for fusion.

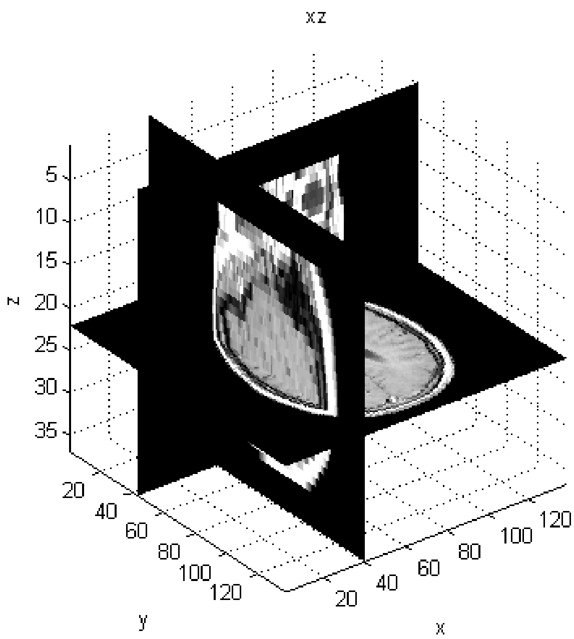


Figure 4: 3D model of Brain

Figure 4 shows the 3D model brain, the 3D model of the brain is constructed using 2D slices of MRI brain images.

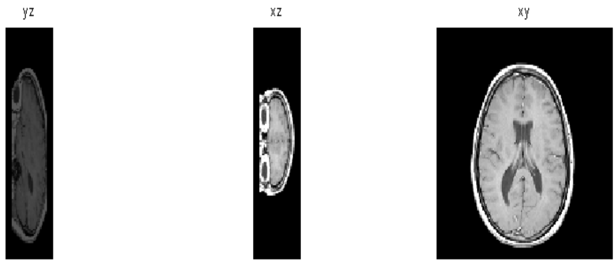


Figure 5: Co-ordinates display YZ, XZ, and XY

Figure 5 shows the slices of 2D MRI brain images, in the 3D reconstructed module 2D slices of the XY, XZ and YZ coordinates are displayed. Figure 8 shows the 3D model slices of brain images

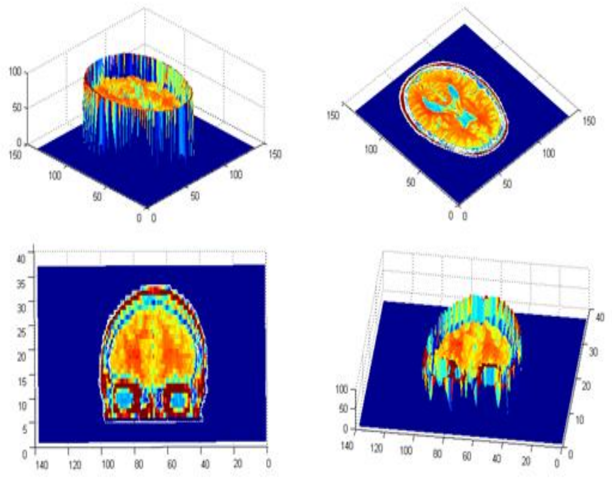


Figure 6: the 3D display of Slices

Performance of the System: the performance of the proposed system is calculated using parameters Entropy MI and NCC

Entropy: Entropy defines the degree of useful data contained in the fused image. It is the mediocre number of bits needed to quantize the pixel strength in the image and is given in Eq. (17)

$$Entropy = \sum_{g=0}^{N-1} X_g \log_2 X_g \qquad (17)$$

Table 1: Entropy Calculation for Set 1 Images

Images	Entropy
MRI T1 Image (3T1S.png)	5.755255
MRI T2 Image (3T2_20.png)	4.315452
MRI PD Image (3PD_20.png)	4.224435
Fused T1T2PD	5.168265

MI: MI represents the measures of dependency of the two input images. The input images are MA and MB. MI defined as given in Eq. (01). Table 2, shows the MI calculated values, and comparison of MI values.

Table 2: MI Calculation for set 1 Images

Images	MI (Before Registration)	MI (After Registration)
T1-T2 (3T1S.png)	0.8460	1.3488
T1-PD (3T2_20.png)	0.4707	1.7389

NCC: The normalized correlation for the two-time series is given in Eq. (03). Table 3 shows NCC's calculated value compare with other methods and figure (10) shows the graph of the comparison of NCC value.

Table 3: NCC Comparison of Fused T1T2PD Image

Sl.No	Author	Methods	NCC
1	Mengchao Su et.al [15]	MI	0.98
2	Hina Shakir et.al [16]	Wavelet	0.89
3	Proposed System	DT-CWT	0.98

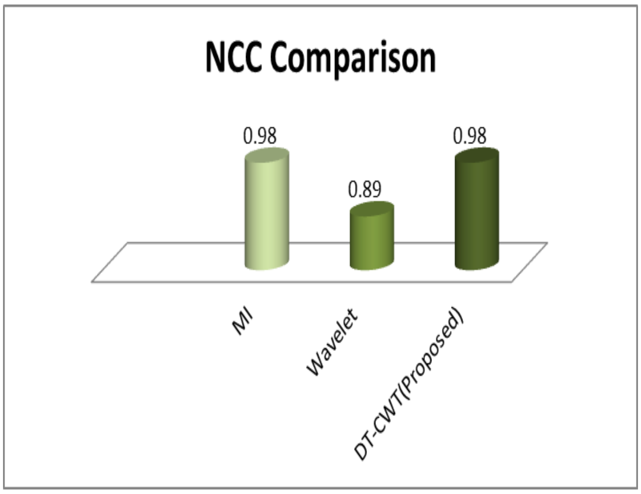


Figure 7: NCC Comparison of Fused T1T2PD Image.

VII. CONCLUSIONS

3D is a more demanding topic in the medical field. Analyzing a 3D model helps in diagnosis in a better way and also it increases the accuracy of diagnosis. We have proposed a system using three different images as an input (T1, T2 and PD), to register the T2 image T1 image is considered as a reference image, registered is done using AT and registered T2 image is fused using DWT technique. The PD image is registered using the B-Spline transformation by considering the T1T2 fused image. T1T2 image is fused with a registered PD image using the DTCWT technique. The final fused image T1T2PD images are used for the reconstruction of the 3D model. MI, NCC and Entropy parameters are calculated and the result shows a better performance for image registration and fusion.

REFERENCES

1. Ch. Rajasekhara Rao, M. N.V. S. S. Kumar, and G. Sasi Bhushan Rao, “Mri Brain Tumour Segmentation and It is 3d Construction”, ARPN Journal of Engineering and Applied Sciences, Vol. 12, No. 17, 2017
2. Qeethara Kadhim Al-Shayea and Muzhir Shaban Al-Ani, “An Efficient Approach to 3D Image Reconstruction”, IJCSNS International Journal of Computer Science and Network Security, Vol. 16, No.8, 2016
3. Roy, S., Sadhu, S. and Bandyopadhyay, S.K., “A useful Approach towards 3D Representation of Brain Abnormality from its 2D MRI Slides with a Volumetric Exclamation”, In Proceedings of the 2015 Third International Conference on Computer, Communication, Control and Information Technology (C3IT), IEEE, pp. 1-6, 2015
4. Zhu, Y., Zhou, Z., Liao, G., Yang, Q. and Yuan, K., “Effects of Differential Geometry Parameters on Grid Generation and Segmentation of MRI Brain Image”, IEEE Access. 2019.
5. Lun, Z., Gadelha, M., Kalogerakis, E., Maji, S. and Wang, R., “3D Shape Reconstruction from Sketches via Multi-View Convolutional Networks”, In 2017 International Conference on 3D Vision (3DV), IEEE, pp. 67-77, 2017
6. Singla, J. and Goyal, R., “A systematic way of Affine Transformation using Image Registration”, International Journal of Information Technology, Vol. 5, No. 2, pp.239-243, 2012.
7. García, H.F., Torres, C.A., Cardona, H.D.V., Álvarez, M.A., Orozco, Á.Á., Padilla, J.B. and Arango, R., “3D Brain Atlas Reconstruction using Deformable Medical Image Registration: Application to Deep Brain Stimulation Surgery”, In2014 XIX Symposium on Image, Signal Processing, and Artificial Vision, pp. 1-5, IEEE. 2014

8. Cam, Q. and Nguyen, T., "Trilinear Interpolation Algorithm for Reconstruction of 3D MRI Brain Image", Am. J. Signal Process., Vol. 7, Issues 1, pp.1-11, 2017
9. Piccinini, F., Tesei, A., Zoli, W. and Bevilacqua, A., "Image Processing Method for 3D Volume Rendering from one 2D Projection: Application to Cancer Spheroids", In2014 4th International Conference on Image Processing Theory, Tools and Applications (IPTA), pp. 1-6, IEEE, 2014
10. A. Farzana, Dr. M. Mohamed Sathik "Analysis of 2D to 3D Reconstruction Techniques over Brain MRI", International Journal of Innovative Research in Computer and Communication Engineering, Vol. 5, Issue 5, May 2017
11. Talbi, H. and Kholladi, M.K., "Predator-prey optimizer and DTCWT for Multimodal Medical Image Fusion", In2018 International Symposium on Programming and Systems (ISPS), pp. 1-6, IEEE. 2018,
12. Bhavana, V. and Krishnappa, H.K., "Multi-Modality Medical Image Fusion using Discrete Wavelet Transform", Procedia Computer Science, Vol. 70, pp.625-631, 2015.
13. Xu, X., Wang, Y. and Chen, S., "Medical Image Fusion using Discrete Fractional Wavelet Transform", Biomedical signal processing and control, 27, pp.103-111, 2016.
14. Vidhya K and Dr. Mala C Patil, "An Efficient MRI Brain Image Registration and Wavelet-based Fusion", International Journal of Recent Technology and Engineering (IJRTE), Vol. 8. Issues - 4, pp. 10209-10218, 2019
15. Vidhya K and Dr. Mala C Patil, "A Systematic Analysis of 3D Reconstruction Techniques over 2D MRI Brain Image",
16. Vidhya K and Dr. Mala C Patil, "Survey on Various 3D Brain Image Reconstruction Methods based on MRI", IJIIRCCE, pp. 5870- 5876, Vol. 6, Issue 5, 2018

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