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DIAGNOSIS OF AGENESIS OF THE CORPUS CALLOSUM PROBLEM BY USING THE FUSION TECHNIQUE

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ABSTRACT

Agenesis literally means a (not)-genesis (developed). This is a condition in which the corpus Callosum of a fetus does not develop or only partially develops. If the corpus Callosum does not develop during the critical gestational stage, it will not develop later. In this case the child either has complete agenesis, meaning a complete absence of the corpus Callosum, or partial agenesis meaning that part of the corpus Callosum developed. Both complete and partial callosal agenesis carry the title of Agenesis of the Corpus Callosum (which abbreviated ACC or AgCC).All of these conditions (complete agenesis, partial agenesis, hypoplasia, and dysgenesis) fall under the larger designation of Disorders of the Corpus Callosum (DCC). This problem of AGCC is well diagnosed by Doctors by using the Fusion Technology. The fusion of Diffusion MRI (Structural) AND Functional MRI (Functional Details) will give better visualization and diagnosis for the treatment by the doctors. In this paper I propose a new method for fusion - Fast Discrete Curvelet Transform using Wrapper algorithm based image fusion technique, has been implemented and analyzed. The diagnosis and treatment of AGCC is one of the challenging works for Doctor, Hence, to assist the diagnosis part for the Doctor this paper came into existence by using Fusion of Structural and Functional MRI images using new technique, which will surely help the doctor community.

Keywords: *Image Fusion, Corpus Callosum, Fast Discrete Curvelet Transform, Wrapping Technique.*

INTRODUCTION:

The corpus Callosum is the main transverse tract of fibers that connects the two cerebral hemispheres. It is made of more than 200 million nerve fibers. The primary function of the corpus Callosum is to integrate motor, sensory, and cognitive activity between the left and right hemispheres. A cross-section of the corpus Callosum looks somewhat like a ball-peen hammer. The anterior portion of the corpus callosum is the genu, which curves ventrally and forms the rostrum. Continuing posteriorly the callosum becomes the body and then ends with the enlarged splenium. The corpus Callosum develops during the 12 - 16th week of fetal gestation. Once formed, the Callosum thickens with increasing myelination, except during a period of axonal elimination near birth. Postnatally the corpus callosum undergoes a burst of growth during the first four years of life. By the time a child is approximately 12 years of age, the corpus callosum functions essentially as it will in adulthood, allowing rapid interhemispheric interaction. However, callosal myelination continues into an individual's teens, so interhemispheric transfer may also improve. Although the corpus callosum is not the only path connecting the hemispheres, it is by far the largest and most important. Other interhemispheric connections include the anterior commissure which is about 50,000 fibers, as well as the posterior commissure and the hippocampal commissure, both of which are smaller even than the anterior commissure.

Often individuals with AgCC have some other much smaller interhemispheric connections (eg. the anterior commissure). While this may allow for some information transfer between the hemispheres, no other commissure has the same functionality as the corpus Callosum. Individuals with complete AgCC are likely to have Probst Bundles, which are large intra-hemispheric nerve bundles that are not seen in typical brains. If the corpus callosum does not form prior to birth, it will never form. If there are some corpus callosum nerves crossing between the hemispheres at birth, these may continue to develop but new fibers/nerves won't develop. Since AgCC is congenital (occurs before birth), all the rest of the brain connections are organized accordingly.

While AgCC cannot be cured, it can be treated. Behavioral and cognitive interventions from early childhood on may be helping the individual with AgCC maximize his or her abilities and learn ways to compensate for deficits. Treatments may involve occupational therapy, speech therapy, social skills training, academic assistance, job coaching, as well as medical interventions for complications such as seizures. Neuropsychologists, educational psychologists, physicians, and allied health professionals should be consulted for individual evaluations and recommendations regarding treatment.

2. STRUCTURAL DETAILS:

Brains with callosal agenesis have other concomitant structural changes, which we are characterizing through multiple methods. All research participants receive high-resolution structural magnetic resonance images, using the 3-tesla scanner .It is use to characterize the surface structure and volumetric ratios in these images. There are high angular resolution diffusion imaging and probabilistic tractography to characterize white matter structures, such as the Probst bundles, which are a structure unique to AgCC. These Details are well shown in the Diffusion MRI (Structural).

3. FUNCTIONAL DETAILS:

This is the first large group multiple case study using functional magnetic resonance imaging in patients with AgCC. Functional magnetic resonance imaging allows us to examine relative involvement of brain regions during specific tasks. To date, research has interpreted the behavioral findings in AgCC studies with the assumption that the parts of the brain that are present are also functionally intact. Our studies are designed to evaluate that assumption and to characterize any unique patterns of brain activation in these participants. These studies are a critical component to deciphering the mechanisms that cause behavior problems and cognitive difficulties in AgCC. It is possible to have similar behavior patterns but with unique causal mechanisms. Understanding the mechanisms involved will greatly enhance development of intervention. These Details are well shown in the Functional MRI (Functional Details).

4. FAST DISCRETE CURVELET TRANSFORM (FDCT):

The Curvelet transform has gone through two major revisions. The first generation curvelet transform used a complex series of steps involving the ridgelet analysis of radon transform of an image. The performance was exceeding slow. The second generation Curvelet transform discarded the use of the ridgelet transform, thus reduced the amount of redundancy in the transform and increased the speed considerably. Two fast discrete curvelet transform algorithm were introduced in. The first algorithm is based on unequally-spaced

FFT while the second is based on the wrapping of specially selected Fourier samples. In this paper, we focus on the "wrapping" version of the Curvelet transform ·

Fusion Algorithm Based on FDCT:

Among the fusion methods such as pixel level, feature level and decision level, pixel level fusion methods are the most mature ones. The algorithm in this paper is a pixel level fusion method. One of most important characteristic of Curvelet transform is anisotropy, which can represent the contour of image more sparsely and provide more information for image processing. At the same time, in order to compare the results of different methods, we will adopt means for the coefficients in high frequency, and adopt the maximal absolute value for the coefficients in low frequency in the wavelet transform.

In the Curvelet transform, means will be adopted for the coefficients in the coarse scale, and maximal module absolute value for the coefficients in fine scale. The fusion procedure takes the following steps.

Wrapping DCT Algorithm:

1. Take FFT of the image.
2. Divide FFT into collection of Digital Corona Tiles (Fig. 1).
3. For each corona tile:

(a) Translate the tile to the origin (Fig. 2).
(b) Wrap the parallelogram shaped support of the tile around a rectangle centered at the origin (Fig. 3).
(c) Take the Inverse FFT of the wrapped support.
(d) Add the Curvelet array to the collection of Curvelet coefficients.

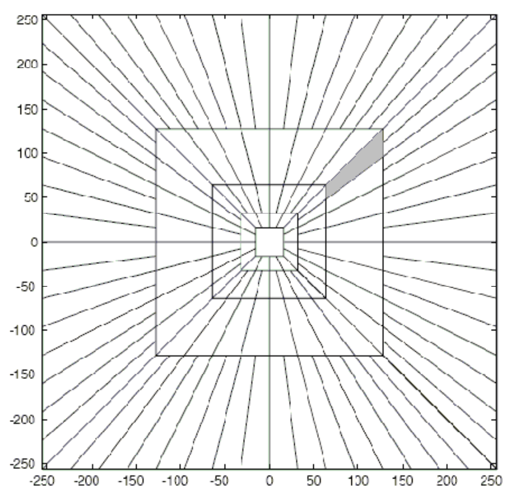


Figure 1. Digital Corona of the Frequency Domain

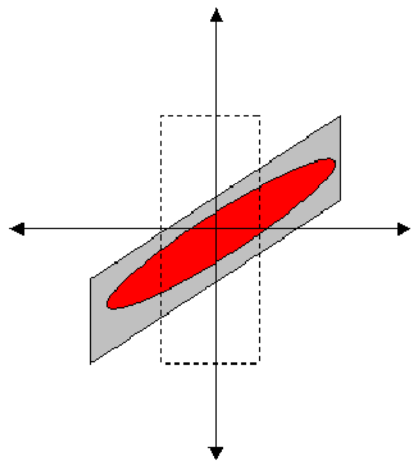


Figure 2. Support of Wedge before Wrapping

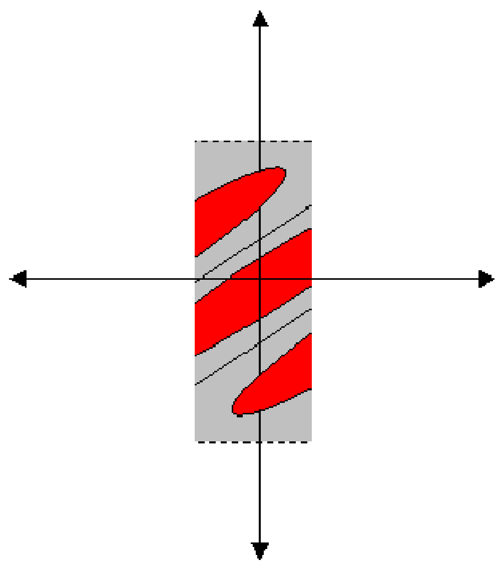


Figure 3. Support of Wedge after Wrapping

Inverse Wrapping DCT Algorithm:

1. For each Curvelet coefficient array:
   (a) Take the FFT of the array.
   (b) Unwrap the rectangular support to the original orientation shape.
   (c) Translate to the original position.
   (d) Store the translated array.

2. Add all the translated Curvelet arrays.
3. Take the inverse FFT to reconstruct the image.

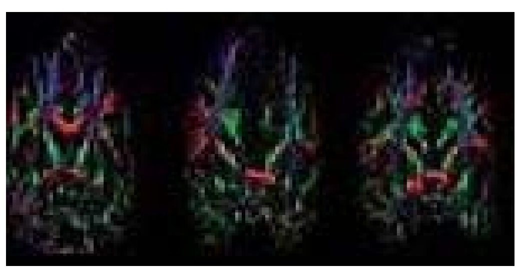
5. RESULTS AND DISCUSSION

The Proposed algorithm Fast Discrete Curvelet transforms with above mentioned fusion rules are applied on Magnetic Resonance Imaging (MRI) medical images. In magnetic resonance imaging (MRI), there are three bands of images ("MRI triplet") available, which are T1-, T2- and PD-weighted images are fused with CoronalDT MRI. The three images of a MRI triplet provide complementary structure information and therefore it is useful for diagnosis and subsequent analysis to combine three-band images into one. The fusion of two images is done by considering one with lesser details as base image and the other base image pair with more details (MRI image - Figure 4 & 5).

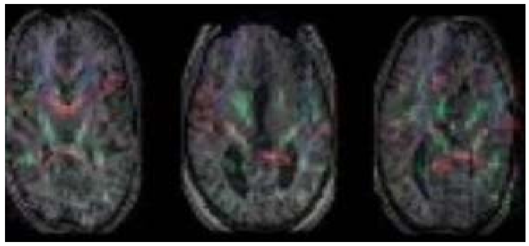
For comparison of outputs of Curvelet fusion, wavelet fusion of images is done with two dimensional discrete wavelet transform using 'db4' wavelet. The fusion rules (Maximum Absolute and Averaging rule) are the same as that for Curvelet transform. Maximum absolute value of wavelet coefficients from three bands MRI are selected for decision map and inverse is taken to yield the fused image.

Curvelet transform is applied on the two base images and the fusion rules – Maximum of absolute value of ridgelet coefficients are used on the resulting coefficients. Taking the inverse transform following the steps 7 to 10 in the previous section gives the fused result as result of rule 1 as shown in figure 3. The figure 4 shows the fusion using Wavelet Transform using Maximum of absolute value of Wavelet Coefficients.

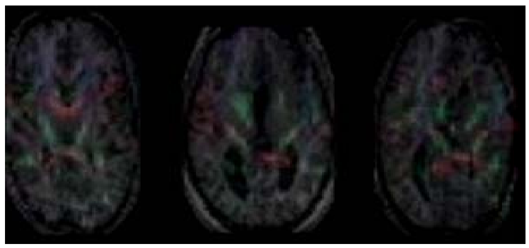
(4)Axial T1W, T2W, PD MRI



(5) CoronalDT MRI



(6) Fused Image using Curvelet Transform using Fusion rule- Maximum of absolute value of ridgelet coefficients



(7) Fused Image using Wavelet Transform using Maximum of absolute value of Wavelet Coefficients.

For the visual evaluation, the following criterion is considered: natural appearance, brilliance contrast, presence of complementary features, enhancement of common features etc.

In order to compare the wavelet and Curvelet based approaches; apart from visual appearance quantitative analysis is done over the fused images. The quantitative criterion includes following parameters namely Entropy, Difference Entropy, Standard Deviation, Quality Measure, and Root Mean Square Error (RMSE). Each has its importance in evaluating the image quality.

Quantitative analysis:

.The quantitative criterion includes three parameters namely Entropy, Difference Entropy and Standard deviation. Each has its importance in evaluating the image quality.

1. Entropy: The entropy of an image is a measure of information content .The estimate assumes a statistically independent source characterized by the relative frequency of occurrence of the elements in X, which is its histogram. For a better fused image, the entropy should have a larger value.

2. Difference Entropy: It is calculated from taking the entropy of the image obtained from subtracting a source image from the fused image and the input source image.

Example: Fused image –CT Image=MRI Image

Entropy [obtained MRI Image –Input MRI] gives Difference Entropy. The difference entropy between two images reflects the difference between the average amounts of information they contained. Minimum difference is expected for a better fusion.

3. Standard deviation: The standard deviation (SD), which is the square root of variance, reflects the spread in the data. Thus, a high contrast image will have a larger variance, and a low contrast image will have a low variance.

These Quantitative measures are computed for the fused images (Three Band MRI Images) as well as CT with Fused Images (Three Band MRI Images) and the result is given in Table2.

Comparing the results in Table 1 and entropy of the fused images in Table 2, entropy of fused images shows an increase in the amount of information in both the transform approaches without any loss.

Quantitative analysis of the fused images indicates better results for curvelet transform based fusion with greater entropy, larger standard deviation and lower difference entropy than their wavelet equivalents. And among the curvelets, addition gives a better result.

	Image set 1		
	T1	T2	PD
Entropy	3.212	3.786	3.567

Table 1: Entropy of source images

6 CONCLUSIONS:

This presented novel approach is a promising step owards the design of challenging eye clinical tools for retinopathy diagnosis and eye treatment, which serves as a substantive basis for further development. The new algorithm can be easily expanded to human or animals' 3D eye, brain, or body image registration and fusion

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Transform	Fusion rule	Entropy	Difference entropy	Standard deviation	Quality Measure Q	RMSE
Fast Discrete C**urvelet**	Maximum absolute	5.832	5.361	69.29	0.900	1.530
	Addition	6.425	4.520	88.81	0.890	2.341
Wavelet	Maximum absolute	5.05	5.40	62.03	0.891	2.392
	Addition	5.79	4.76	87.34	0.879	2.413

Table 2: Quantitative analysis – Comparison of Curvelet and Wavelet

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