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PERFORMANCE ANALYSES OF MULTI RESOLUTION TECHNIQUES IN BIO MEDICAL IMAGE PROCESSING

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ABSTRACT

This is the novel approach to develop an assisting tool for cleft patient that will help the physician while performing an efficient and quality treatment. Cleft lip, palate, together are known as discrepancy of clefting congenital deformity sourced by abnormal facial development during gestation. The area of interest in the calculation of cleft lies in the lip bow and nasal part of human face. The lip portion and nose part of the human face is concentrated more for the classification of the cleft portion. To separate the lip and nasal form of the facial image is also tedious process in this automation. Towards this objective, three major transformation techniques are applied to this segmentation. They are Wavelet transform, Curvelet and Contourlet. The theory behind the transformation techniques and the evolution of their performance is discussed. From the performance analysis, the best and optimized transformation is applied for severity measurement.

Keywords: Cleft lip, curvelet , wavelet, contourlet , cephalometry

1.Introduction:

Bio medical image processing using non-invasive approach is necessary in medical field, specially for children that too for a new born. According to statistical analysis, one in 700 children born have a cleft lip and/or a cleft palate. Cleft in lip, palate and together is a common facial deformity. It can occur on the left side or right side (Unilateral) or on both sides (Bilateral) in the upper jaw of human face. The fissure portion occurred in palate portion is named as cleft palate. Cleft in lip and palate are causes of deformity in nasal part of infant face. Evaluation and classification of cleft lip has become important for the lip and palate that are in normal or abnormal cleft and to operate it.

Sheppard (2005)described cleft defect and surgical procedure where virtual surgery brings back smiles. Causes for cleft lip and palate were also discussed. Step by step procedure involved in the repair of the defect was animated in CD-ROMs. It used Computer Tomography and Magnetic Resonance Imaging. It affords a complete reference for surgeon. This animation created a reference model that retained fidelity, smoothing and easier to manipulate. It provided a space for novice surgeon for practicing through virtual reality environment. Kim. D.W et al (2006) published a paper in the topic of statistical Evaluation of the cleft lip and nose deformity image. Depending upon doctor's subjective judgment, the surgical correction and assessment of prognosis was evaluated. But objective assessment tool would helped the surgeon in advanced stage. With this main idea, this paper discussed quantitative assessment method for a cleft lip nose deformity. Photographic image of patient was used for this calculation. The main parameters are angle difference between two nostril axes, center of the nostril and distance and overlapping area and symmetry. Regression model was built up using correlation and factor analysis of parameter. After measuring the angle, the symmetry was measured. The difference between the angles showed the symmetry. With this, the value of the severity was measured. In the above mentioned method, the symmetry of nostril position and symmetry of the nostril area was also calculated. This paper concluded that the computer based assessment method was main for non- invasiveness, easy to use, inexpensive and lesser time. Salazar et al (2006)estimate the position and contour of the lips , teeth and tongue position . This method detected contour under natural condition without any extra requirement in the image capturing. The lip contour, based on red hue field is detected. Then the geometrical features of the lips were extracted from the detected portion. This method first search the face and mouth , Lip contour was detected in the second step and in the last step Geometrical features are computed from the result. The image feature set was developed by multivariate analysis techniques. The Bayesian estimators evaluated the discriminant performance of the selected training

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set. This paper concluded that the proposed method had very low efficiency due the computational requirements in the initial feature set.

De Korte et al (2009)discussed scar formation during the reconstruction of a cleft lip .The restored oral orbicular muscle was assessed due to the quantification of the local contractility of this muscle. For every individual patient, the treatment planning was different. The important aspect is the information about the contraction capability of the oral orbicular muscle. Ultrasound elastography is used to calculate the local deformation of the upper lip. Separating the contracting muscle from passive scar tissue is also done. The local tissue strain was computed by an iterative coarse- to-fine strain estimation method. From the region of reconstruction and the muscle tissue surrounding, the patient deviation values were calculated. This paper concluded that in healthy subjects, the strain profiles in all parts of the muscle are similar. The maximum strain of the muscle is 20 %. It was a preliminary study with the strain values decreasing related to the success for the reconstruction. Adusumilli et al (2013),published a paper under the topic of Interdisciplinary Treatment of an adolescent with unilateral Cleft lip and Palate. They presented case study regarding the importance of interdisciplinary approach. It also included the management of an adolescent with cleft lip and cleft palate problem. The case of cleft and palate was discussed briefly in this paper. Case study was conducted for girl under the age of 14-15. This paper discussed the treatment plan in elaborate.

Ksheerasagara (2012), described cleft lip and palate patient management in the adultant stage. This paper described the channel to manage a boy in the adult stage after surgery. That person suffered postpubertal cleft palate and referred by a plastic surgeon for orthodontic correction of irregular upper teeth and deficiency in maxillary. At the beginning of treatment plan it was for maxillary. In the middle of the treatment plan, patient was reluctant to orthognathic surgery. Therefore extraction of lower first problem proclination upper anteriors was achieved by an alternate treatment plan. That was named as nonsurgical orthodontic Camouflage treatment plan. The author strongly suggested that interdisciplinary approach scored better and also optimum result.

The input cleft lip and palate images are processed using Curvelet transform to extract appropriate portion from the input image, as it may contain smaller curve. In this proposed work, Curvelet transform is used to extract cleft portion and cupid bow part from the noisy free images. Various edge detection techniques based on gradient and Laplacian approach is used to extract the area of interest from the image. For some images, the boundaries of other part in human face may be recognized which lead completely wrong calculation. So the curvelet transform improves to extract more curved portion in the image. Accuracy, sensitivity and specificity are computed to conclude the

In medical field, this problem may be reconstructed by surgery. It is a novel and first step for cleft lip patient to assist them for treatment plan and to ensure the quality for their life. The picture for cleft lip and palate is shown in Figure 1.1 (a to c)

(a) **(b)**

(c)

Figure Error! No text of specified style in document.**.1 Images of cleft children a. Unilateral cleft lip. b. unilateral cleft lip with palate c. Bilateral cleft**

1.1 CURVELET TRANSFORMATION

Curvelet transformation[3] is one of the multi resolution method in signal processing. In analysis part, the first step is to find the Curvelet coefficient. Curvelet coefficient is calculated from the convolution result of curve and image. The convolution part has been easily calculated in the

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frequency domain. In order to obtain the frequency domain, first Fourier transform of the curve and image has been calculated. In the frequency domain convolution is turned as multiplication. So the product of the result is computed and finally inverse Fourier transform of the product is obtained. To obtain maximum value of efficiency, the frequency domain is employed in curvelet transform[5]. The process can be applied as both the curve and image. This statement is represented in the equations1.1 &1.2

Curvelet coefficient = IFFT [FFT (Curvelet) X FFT (image)] (1.1)

In mathematical way, the curvelet transform is defined as

$$F(a,b,\theta) = \langle f_i | \gamma_{ab\theta} \rangle \quad (3.2)$$

Curvelet should obey parabolic square law. i.e

$$l \approx w^2$$

Here l = length curve

W = width of the curve

Where $\gamma_{ab\theta}$ is known as curvelet.

$\gamma_{ab\theta}$should obey certain rapid changing in the curve condition. It should be smooth. The continuous curvelet transform is described on function in space (R) and extends by density on $R^{2.}$ The inner product (f) on to analyzing elements rapidly changes as "a" by$\sqrt{a}$. The interpretation of curvelet coefficients are known by how the curves are aligned in the input image. Coefficient value is high for more accuraltely aligned image. The curvelet named '**c**' in the input image is almost perfectly aligned with the curved edge and therefore has a high coefficient value. A signal localized in frequency domain is spread out in the spatial domain or vice-versa. A notable point regarding curvelets is that, they are better localized in both frequency and spatial domain compared to other transforms.

The Inverse Fourier transform is applied to the output to get the curvelet co-efficient. To keep away from inconsistency, a parallelogram is chosen as a support for the wedge data. The size of the parallelogram is equal to the wedge data. The wrapping process is completed by periodic tilling of the spectrum inside the wedge. After that, the rectangular coefficients are collected at the center. The wedge data cannot be taken directly into a rectangle of size 2^jx $2^{j/2}$. Wrapping ,based on fast discrete curvelet is more effective and to provide better feature extraction. The corresponding curvelet co-efficient in the smooth part of the image is small and an edge part co-efficient have significant value. The curvelet via wedge wrapping technology is applied to preserve the edges.

1.2 WAVELET TRANSFORMS

Transform in image processing is used to analyse the data in different form. From the analysis part wanted and essential details are synthesis for further calculation. The fast wavelet transformation analysis filter bank is shown in the Figure 1.1. As per the diagram, the input image is subjected into low pass filter Equation (1.3)and result is named as I_l. High frequency components are separated from Equation (1.4)the input image and named as I_h. The result is down sampled by 2. This is represented by the down arrow symbol in the diagram. Again the two separated images are subjected into low pass filter and high pass filter.

$$L = (x * h_\psi)[-n] \quad (1.3)$$

$$H = (x * h_\varphi)[-n] \quad (1.4)$$

Divided sub images are named as Low-low, low-high, high-low and high-high. Low –high band shows the variation in the y-axis in mean time high- low indicated the variation is in the x-direction. Low-low sub image again subjected to analysis with respect to the frequency component present in the image. Segregating the unwanted edge from the resultant and synthesis of the result has been taken place and original image is reconstructed. Analysis and synthesis part of the wavelet transform is shown in the Figure 1.2.1 and 1.2.2.

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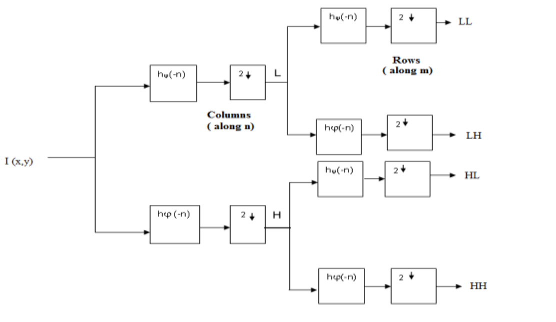

Figure1.2.1 Fast wavelet transform analysis filter bank

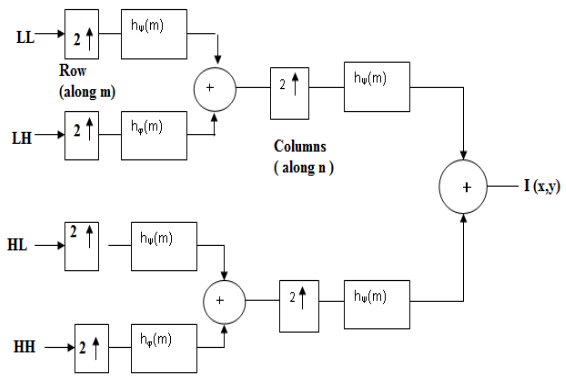

Figure1.2.2 Fast wavelet transform synthesis filter bank

1.3 CONTOURLET TRANSFORM

Contourlet transform is one among the popular the multi resolution techniques in signal processing. In general contour-let transformation is a combination of Laplacian pyramid and directional filter bank (DFB). The framework is shown in Figure 1.3.1

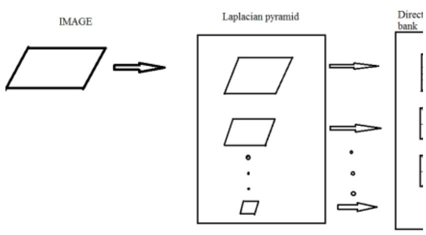

Figure 1.3.1 Block diagram of Contourlet transform

There are two major stages mentioned in the framework of contour-let. First one is Sub band decomposition and the second one is directional transform. The sub band decomposition is achieved by using Laplacian pyramid. Laplacian pyramid decomposition at each level generates a down sampled low pass version of the original and the difference between the original and the prediction, resulting in a band pass images. The coefficient of contourlet transformation is obtained by Equation (1.5), (1.6), (1.7)& (1.8). To each band pass channel directional filter bank is applied for the transform result. The frequency decomposition is shown in Figure1.3.2. From the directional filter bank, frequency is partitioned with the value l=3 and 2^3=8 real wedge shaped frequency bands. In this value 1-4 corresponds to horizontal edges and above 4 mostly corresponds to vertical direction.

$$d_{i,j} = centered\ window\ of\ NXN\ (N{:}\ Size\ of\ the\ window)$$

$$S_{i,j}^2 = \sum_{p=i-\left(\frac{n-1}{2}\right)}^{i+\left(\frac{n-1}{2}\right)} \sum_{q=j-\left(\frac{n-1}{2}\right)}^{j+\left(\frac{n-1}{2}\right)} d_{p,q}^2 \quad (1.5)$$

$$\eta = \sqrt{2\sigma^2 \log n^2} \quad (1.6)$$

Where σ = Standard Deviation

$$I(x) = \{^{x x\geq 0}_{0\ x<0} \quad (1.7)$$

$$\alpha_{i,j} = I\left(1 - \frac{\eta^2}{S_{i,j}^2}\right) \quad (1.8)$$

From the input image, all directional frequency components are computed by the above discussed method. Threshold value is applied to the resultant component to remove the unwanted frequency component present in the input image. Immediately synthesis of the transformation has been computed in order to get the recovered image. From the recovered image, the edge details are analyzed to compute efficiency of the transformation while preserving the wanted information and removing the unwanted information.

2.PERFORMANCE EVALUATION OF TRANSFORM TECHNIQUES

After applying the above mentioned, three transformation techniques to the

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cleft lip input image, the performance is evaluated in this section. The various transforms are analyzed through amount of the preservation of desired information and deleting the unwanted information inthe image details. Three transformation techniques are applied to the face image for preserving the edge information. Edge information is grouped in to two catories. They are wanted edge information and unwanted edge information. For this calculation lip and nose edge portion are considered as wanted edge features. Other edge information is undesired information for this further classification. For the quantitative measurement of the three transformations is based on preserving efficiency of wanted edge and curved information and calculating the removing efficiency of unwanted information. From Equation 1.9 Efficiency for preserving the edge information is calculated.

$$\eta_p = \frac{E_p}{T_w} X100 \quad (1.9)$$

$$\eta_d = \frac{E_d}{T_{uw}} X100 \quad (1.10)$$

η_p = Efficiency of Preserving (%)

η_d= Efficiency of deleting (%)

E_p= Total Number of edges preserved

E_d= Total number of edges deleted

T_w= Total number of edge to be wanted

T_{UW}= Total number edges to be unwanted

Equation 1.10 helps to compute the value for computing efficiency of deleting the edge details. Therefore With the help of above mentioned equations, Efficiency values for three transformation techniques are calculated and the comparison chart is plotted in the Figure 2.1

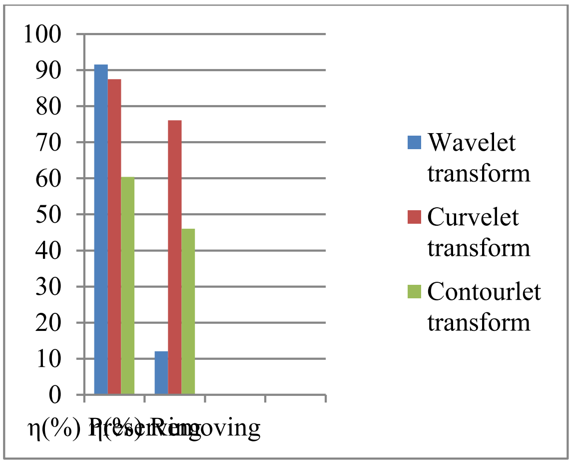

Figure 2.1 Performance analysis of various transformation techniques

From the comparison[1] Figure 2.5, it is clearly shows that after analysis and synthesis part of transformation, to preserve the wanted edge information, wavelet transformation is leading by the value 91.6 %. But this transformation also preserves the unwanted information. The value of removing unwanted information efficiency is just 12.03 %. So purpose of applying transformation is not achieved. The next transformation, contourlet also scores 46.06 % in the removing of unwanted edge information. In the meantime it deleted number edge information which is needed for further calculation. While comparing these two transformations, Curvelet scores optimized value of this two important parameter value. It preserves almost 87.5 % of wanted information. It deleted the 76.11 % of unwanted edge features .

After this comparison, it has been shown and concluded that curvelet transformation is more effective for curve preserving transformation than other transformations.

Before extracting the edge information and applying classification tool, to preserve the only desired edge information is important task. Curvelet transformation is used for this purpose. After analysis, the performance of the important transformation technique. Curvelet is chosen as an optimized one and its output is taken for the feature extraction and classification.

3.RESULT AND DISCUSSION

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In this section, the steps behind the classification is discussed that combination of curvelet transform and edge detection techniques. Experimental results are simulated by MATLAB software tool. The first image is the input image. That is affected by unilateral cleft. From the input image edges are obtained by moving the edge mask. It consists of more edges. The curvelet transformation is applied to the interested image. After applying curvelet transform the image has changed in the spatial domain for different scale. This is the one going to act as a input for feature extraction. That resultant image is considered as a input image for edge detection. In this moment curved edges are extracted from the input image.

Desired curve portion should be retained in the classification process. In facial image, the curved portion are lip curve and eyebrow curve. The curvature of the both are different by scale. Lip portion and nasal portion is most wanted for this classification of severity.

Other than lip and nasal portion, the other curved parts are considered as unwanted curve and removed from the classification feature. In order to obtain the main objective, the input image is subjected to transformation named wavelet transformation, curvelet transformation and contourlet transformation. From the Table . it is very obvious that Retaining the wanted curve[2] and the efficiency of removing the unwanted curve portion are measured and the performance was charted .

(a) (b)

Figure 3.1 Input and output images without curvelet transform.
(a) Input image.b) Canny edge detection without Curvelet transforms

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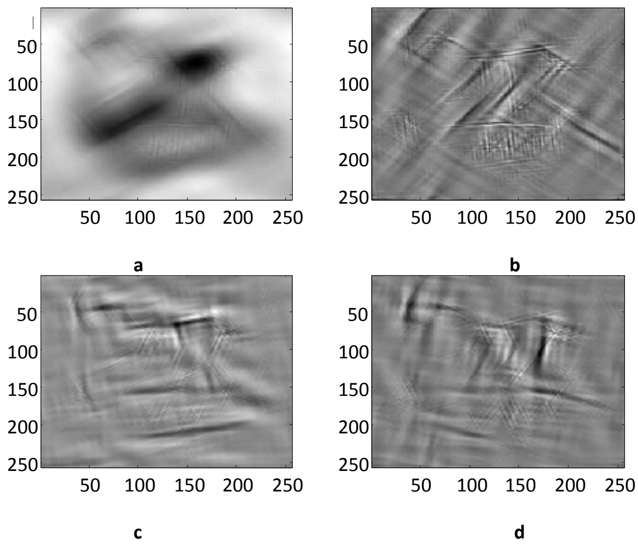

Figure 3.2 Curvelet transform output for various scale

4 .CONCLUSION

It is concluded that curve let transformation deals better with curves with comparison with wavelet transform and contourlet. Even both the techniques have big advantage over the other multi resolution techniques, the curvelet

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works better detailed coefficient and wavelet for high frequency components. It is observed that wavelet transform cannot make out smoothness along separating area and yields fruitless representation. But the curvelet transform analyses the features in terms of scale are taken for calculation. The area of interest curve is retained and other portion is not considered for synthesis. In future this is subjected to edge detection techniques. From the comparison chart most suitable edge detection is selected. Then classification of unilateral cleft lip and bilateral cleft is attained by analytical method and template method.

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