Hybrid of Contourlet and Curvelet Transformation with Fuzzy logic for Image Fusion

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Abstract: Image fusion has a wide range of application in satellite images, general photography, medical images etc. Image fusion is the process in which we combine two or more images or some features of images to form a single image which is free from distortion and does not lose its information. Images which are taken from different angles sometimes need to be fused together to form a single image which has all the detail information to create an accurate description of the image. Its application lies in medical imaging, satellite images, general photography etc. Nowadays, medical image fusion plays a vital role for diagnosis. There are many issues related to image fusion that needs to be resolved. None of the single method can work as generalized for image fusion. In the current paper, we are going to hybrid two methods: contourlet transformation and curvelet transformation for better fused images. Fuzzy logic is being implemented to provide a better coefficient extraction.

Keyword: Image Fusion, Contourlet transformation, Curvelet transformation, fuzzy logic.

I. INTRODUCTION

Image fusion is the process by which we combine the relevant information from two or more sources to form a single image. The fused image has more information and clarity than the source images. The fused image has characteristics of spectral information and multispectral data. The main goal of image fusion is the fused image should be free from distortion and it should not lose the vital information.

In general, there are two types of Image fusion techniques [2, 3, and 4]: Spatial Domain Fusion and Transform Domain Fusion. Various types of spatial fusion methods are Average method, Intensity-hue-saturation (HIS), Principle component analysis (PCA), Brovey Transform and Artificial Neural Network. The main disadvantage of spatial fusion method is that the fused image contains spectra distortion. Various types of transform Domain fusion method are pyramid method and wavelet method, which usually use the discrete wavelet transformation. Other methods of image fusion are Laplacian pyramid based, contourlet transformation and curvelet transformation. All these methods are good image fusion methods but they have certain limitations and disadvantages. Average method finds the average of the two images at pixel to pixel level which is easy way but it reduces the contrast of the fused image. IHS, PCA and Brovey transform are easy techniques but they suffer from spectral degradation, the performance of ANN is dependent on the source images i.e. they vary according to images, pyramid method produce blocking effect in the fused images. Curvelet transformation is different from other wavelet transformation as most of them do not deal with the problem of smoothening of curves which Curvelet transformation handles effectively. Curvelet transformation is best to represent the images which are smooth apart from singularity among smooth curves, i.e. where objects image have minimum length scale.

The major drawback of DWT is that it could not capture the directional information. To tackle with this problem Contourlet transformation was developed. It contains directional filter bank (DFB) and two directional multiscale. Contourlet not only has all the properties of discrete transformation and also provide high degree of directionality. Hence different and flexible numbers of direction images could be fused through it. CNT gives multi resolution, local directional images. As we saw different image fusion method has different disadvantages. There is no one method which could
be said to perfect. Hybrid of two or more methods could be used. Fuzzy logic is a multi-valued logic, in binary sets where we have only two values 1 and 0 fuzzy logic may have value that ranges between 0 and 1. It does not deal with discrete values. Fuzzy logic can be used in image fusion as it is a good way to deal with the extraction of coefficients. Fuzzy logic has been widely used in image processing now days.

An interesting method was recently developed by sabri banu Malay kumar kundu in which they combined two different image fusion techniques Contourlet transformation and Activity level Management and it was seen that resultant fused image was more clear and had reduced noise.

So we have hybrid the properties of contourlet and Curvelet transformation and have used the fuzzy logic for the purpose of coefficient extraction and evaluated the result using various parameters. The paper is organized as follows. Section II the proposed algorithm that is hybrid of contourlet and curvelet using fuzzy logic is demonstrated. In the section III implementation results are shown and in the section IV finally conclusion and future work is presented.

II. PROPOSED ALGORITHM

The proposed algorithm is the hybrid of Contourlet transformation and Curvelet transformation with the use of fuzzy logic as feature extraction. Both algorithms have their own features and limitation.

Fig.1. Block Diagram of Curvelet Transformation

Contourlet offer high degree of directionality and anisotropy where as Curvelet transformation is effective in images which have bounded curves as it provides smoothening of curves. Fuzzy logic has been used to extract the coefficient for faster and better results. So hybrid of Contourlet and Curvelet transformation is done. The steps have been explained.

**STEP-1:** In the first step Contourlet transformation is applied on the source image A and B to estimate the coefficients. The coefficients are evaluated using the fuzzy logic. CNT works with two dimensional multi scale and directional filter bank (DFB). In addition CNT also uses iterated filter bank which makes it computationally efficient.

The perfect directional basis for discrete signals is created with the help of DFB which was major drawback of the wavelet transformation. This can be represented as follows:

\[
g[n] = \frac{2\pi}{n_1} \left[ \varphi \left( \frac{n_1(l+1)}{N} + n_2 \right) - \varphi \left( \frac{n_1}{N} + n_2 \right) \right] \quad \text{eq 2}
\]
Where \( N = 2^{n-2} \) and \( \varphi(x) \) is similar to the common \( \sin \) function

\[
\varphi(x) = \frac{1 - \cos(\pi x)}{\pi x}
\]

**Step-2:** In the second step Curvelet transformation is applied to source image A and source image B to estimate the coefficient. These coefficients are also evaluated using fuzzy logic. Curvelet transformation has four stages

1. Sub-band decomposition
2. Smooth Partitioning
3. Renormalization
4. Ridgelet Analysis

**Step-3:** In this step the intermediate results for both the source images A and B for contourlet and Curvelet are masked together as shown

**Step-4:** This is the final step in this the images are fused together to form the final required image

### III. IMPLEMENTATION RESULTS

In this section we will check the effectiveness of the proposed scheme that is hybrid of the Contourlet and Curvelet transformation with the use of fuzzy logics. Various parameters such as Entropy, Structural Content, Maximum difference, Standard deviation, Quality Index are used to evaluate the effectiveness.

**Example 1:** (a) Source image 1, (b) Source image 2 (c) Fuzzy based hybrid

**Example 2:** (a) Source image 1, (b) Source image 2 (c) Fuzzy based hybrid
Example 3: (a) Source image 1, (b) Source image 2 (c) Fuzzy based hybrid

Table 1: Results using contourlet transformation

<table>
<thead>
<tr>
<th>Image Set</th>
<th>Quality Index</th>
<th>Entropy</th>
<th>SD</th>
<th>Max Diff</th>
<th>Structural Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex 1</td>
<td>137.88</td>
<td>30.42</td>
<td>77.92</td>
<td>108.5</td>
<td>0.83</td>
</tr>
<tr>
<td>Ex 2</td>
<td>120.62</td>
<td>30.90</td>
<td>99.47</td>
<td>124</td>
<td>1.098</td>
</tr>
<tr>
<td>Ex 3</td>
<td>135.41</td>
<td>31.27</td>
<td>69.79</td>
<td>101.5</td>
<td>1.452</td>
</tr>
</tbody>
</table>

Table 2: Results using Curvelet transformation

<table>
<thead>
<tr>
<th>Image Set</th>
<th>Quality Index</th>
<th>Entropy</th>
<th>SD</th>
<th>Max Diff</th>
<th>Structural Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex 1</td>
<td>31.04</td>
<td>15.76</td>
<td>80.15</td>
<td>130</td>
<td>0.79</td>
</tr>
<tr>
<td>Ex 2</td>
<td>30.77</td>
<td>14.82</td>
<td>85.72</td>
<td>149</td>
<td>1.11</td>
</tr>
</tbody>
</table>

Table 3: Results using hybrid of contourlet and curvelet transformation

<table>
<thead>
<tr>
<th>Image Set</th>
<th>Quality Index</th>
<th>Entropy</th>
<th>SD</th>
<th>Max Diff</th>
<th>Structural Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex 1</td>
<td>158.36</td>
<td>91.72</td>
<td>92.62</td>
<td>70.05</td>
<td>2.26</td>
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<tr>
<td>Ex 2</td>
<td>140.49</td>
<td>82.92</td>
<td>114.51</td>
<td>115.1</td>
<td>1.901</td>
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<tr>
<td>Ex 3</td>
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<td>60.75</td>
<td>84.45</td>
<td>106.8</td>
<td>1.73</td>
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</tbody>
</table>

Table 4: Results using hybrid of contourlet and curvelet transformation with extraction of coefficient with fuzzy logic

<table>
<thead>
<tr>
<th>Image Set</th>
<th>Quality Index</th>
<th>Entropy</th>
<th>SD</th>
<th>Max Diff</th>
<th>Structural Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ex 1</td>
<td>188.15</td>
<td>171.78</td>
<td>106.3</td>
<td>14</td>
<td>2.90</td>
</tr>
<tr>
<td>Ex 2</td>
<td>163.92</td>
<td>165.83</td>
<td>129.6</td>
<td>56</td>
<td>2.59</td>
</tr>
<tr>
<td>Ex 3</td>
<td>182.28</td>
<td>86.42</td>
<td>98.30</td>
<td>48</td>
<td>2.36</td>
</tr>
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</table>

The values of various parameters have been shown in the form of graphs. From these graphs we can evaluate the performance of all the algorithms and can see the results of the proposed algorithm.
Fig. 4. Graph Showing Entropy Result

Fig. 5. Graph Showing Quality Index

Fig. 6. Graph showing Maximum Difference

Fig. 7. Graph showing Standard Deviation
The results show that the proposed algorithm that is hybrid of contourlet and curvelet transformation with the use of fuzzy logic is better than the Contourlet and Curvelet alone.

IV. CONCLUSION AND FUTURE WORK

Hybrid of Contourlet and Curvelet transformation with fuzzy logics has been presented. The results show that the combination of the two algorithms for image fusion increases the quality of the images; distortions are decreased and provide better results for any kind of images.

In the future the efficiency of the algorithm can be tested using various other parameters as well as Combined activity level measurement (ALM) can be used with proposed algorithm and results can be verified.

REFERENCES


AUTHORS BIOGRAPHIES

Rohit D, male, is a lecturer at Baba Kuma singh ji engineering college, PTU. He is currently working on development of new and efficient algorithms for image fusion. His research includes image processing, image registration and image fusion. His teaching interest includes image processing, object oriented programming and theory of computation.

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