Design and implementation of image fusion algorithm using DCT and LAPLACIAN PYRAMID approach

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Abstract-In this paper introduces a approach to implement image fusion algorithm i.e. LAPLACIAN PYRAMID based on (discrete cosine transform) DCT. This proposed technique implements a pattern selective approach to image fusion. The basic idea is to perform pyramid decomposition on each source image. It is concluded that fusion with higher level of pyramid provides better fusion quality. The execution time is proportional to the number of pyramid levels used in the fusion process. The performance of this technique is measured by root mean square error, peak signal to noise ratio, mea absolute error and signal to noise ratio. From the performance analysis it has been observed that PSNR and SNR is increased, whereas RMSE and MAE is decreased in this technique.

The aim of image fusion, apart from reducing the amount of data, is to create new images that are more suitable for human/machine vision. The proposed algorithm is very simple, easy to implement and could be used for real time applications such as military, remote sensing and medical imaging.

Index Terms—Image fusion, Laplacian Pyramid, DCT, Pyramid level

I. INTRODUCTION

In recent years, image processing technology has been widely used in many fields. The aim of image fusion, apart from reducing the amount of data, is to create new images that are more suitable for the purposes of human/machine perception. For example, visible-band and infrared images may be fused to aid pilots landing aircraft in poor visibility.

In image fusion is the process of combining relevant information from two or more images into a single image. The resulting image will be more enhanced than any of the input images. The merged image includes the more details of information of the original images and improves the details of image. The concept of image fusion has been used in wide variety of applications like medicine, remote sensing, machine vision, automatic change detection, bio metrics etc. With the emergence of various image-capturing devices, it is not possible to obtain an image with all the information. Sometimes, a complete picture may not be always feasible since optical lenses of imaging sensor especially with long focal lengths, only have a limited depth of field. Image fusion helps to obtain an image with all the information. Image fusion is a concept of combining multiple images into composite products, through which more information than that of individual input images can be revealed. Multi-sensor images often have different geometric representations, which have to be transformed to a common representation for fusion. This representation should retain the best resolution of sensor.

II. MULTI-SENSOR IMAGE FUSION SYSTEM

The multi sensor data fusion is found to play a vital role in defense as well as in civilian applications because diversity of sensors available and these working in different spectral bands. Image fusion, where multiple registered images are combined together to increase the information content, is a promising research area.

Fig.1 shows an illustration of a multi-sensor image fusion system. In this case, an infrared camera is being used the digital camera and their individual images are fused to obtain a fused image. This approach overcomes the problems referred to single sensor image fusion system, while the digital camera is appropriate for daylight scenes; the infrared camera is suitable in poorly illuminated ones.

Fig.1: Multi-Sensor Image Fusion System
Merits of multi-sensor image fusion

1. Reliability Increases – the fusion of multiple measurements can reduce noise and improve the reliability of the measured quantity.

2. System performance – redundancy in multiple measurements can help in systems robustness. If one or more sensors fail, the system can depend on the other sensors.

3. Range of operation – multiple sensors that operate under different operating conditions can be deployed to extend the effective range of operation.

4. Reduced uncertainty – joint information from multisensors can reduce the uncertainty associated with the sensing decision process.

III. DUSCRETE COSINE TRANSORM

Discrete cosine transform (DCT) is an important transform in image processing. Large DCT coefficients are concentrated in the low frequency region; hence, it is known to have excellent energy compactness properties. The 2D discrete cosine transform of an image or 2D signal of size MxN is defined as:

\[
Z(u,v) = \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} z(x,y) \cos \left( \frac{\pi}{2M} (2x+1)u \right) \cos \left( \frac{\pi}{2N} (2y+1)v \right)
\]

(1)

where \(u = 0, 1, \ldots, M-1\) and \(v = 0, 1, \ldots, N-1\).

IV. IMPLEMENTATION OF LAPLACIAN PYRAMID

The Laplacian Pyramid implements a "patternselective" approach to image fusion, so that the composite image is constructed not a pixel at a time. Implemented laplacian pyramid fusion first constructs the laplacian pyramid of two input images to be fused. Take the average of the two pyramids corresponding to each level and sum them. The resulting image is a simple average of two low resolution images at each level.

The procedure for Laplacian pyramid construction is illustrated in Fig. 2. The image at the 1st level LP1 of size MxN is reduced to obtain the next level LP2 of size 0.5Mx0.5N, where both spatial density and resolution are reduced. Similarly, LP3 is the reduced version of LP2 and so on.

Fusion performance

The following metrics can be computed to evaluate the fusion performance when the final fused image is available.

Root Mean Square Error (RMSE) [5]: It is computed as the root mean square error of the corresponding pixels of the reference image \(I_r\) and the fused image \(I_f\). It will be zero when the reference and fused images are alike.

\[
RMSE = \sqrt{\frac{1}{2MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (I_r(x,y) - I_f(x,y))^2}
\]

Peak signal to Noise Ration (PSNR) [6]: This value will be high when the fused and reference images are similar.

\[
PSNR = 10 \log_{10} \left( \frac{L^2}{\frac{1}{2MN} \sum_{x=0}^{M-1} \sum_{y=0}^{N-1} (I_r(x,y) - I_f(x,y))^2} \right)
\]

where \(L\) is the number of gray levels in the image. Similarly, SNR and MAE are tabulated in Table 1.

<table>
<thead>
<tr>
<th>Pyramid levels</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSNR</td>
<td>36.8856</td>
<td>35.3197</td>
<td>40.9677</td>
<td>44.3397</td>
<td>45.8986</td>
<td>47.1282</td>
<td>47.3124</td>
<td>47.3210</td>
</tr>
<tr>
<td>SNR</td>
<td>26.2294</td>
<td>25.9355</td>
<td>32.7376</td>
<td>39.6540</td>
<td>44.0419</td>
<td>45.8146</td>
<td>45.8700</td>
<td>45.6493</td>
</tr>
<tr>
<td>RMSE</td>
<td>9.6398</td>
<td>7.7153</td>
<td>5.9315</td>
<td>2.4650</td>
<td>1.4944</td>
<td>1.2394</td>
<td>1.2619</td>
<td>1.2143</td>
</tr>
<tr>
<td>MAE</td>
<td>3.0556</td>
<td>2.8565</td>
<td>2.6988</td>
<td>1.4481</td>
<td>0.9138</td>
<td>0.7911</td>
<td>0.7703</td>
<td>0.7706</td>
</tr>
</tbody>
</table>
V. RESULT

Figure (a) and (b) are the reference images, and (c) is the fused image.

VI. CONCLUSION AND FUTURE WORK

Some image fusion approaches have been studied. All of them were found reliable fusion methods and in conjunction they gave acceptable results in image fusion schemes. It is difficult to conclude which method is the best one. Laplacian pyramid based on DCT has been presented and its performance evaluated. It is concluded that fusion with higher level of pyramid provides high quality image from two source images. There are still enough to be further improved. The proposed algorithm is also extended to fuse the color images and the results are encouraging.

REFERENCES


