Modified Wavelet Based Sharp Feature Multi-Focus Image Fusion in DCT Domain

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Abstract: ***The Dissertation a multi-focus image fusion approach using a new sharpness criterion that depends on statistics of image's gradient information is proposed in this dissertation. The proposed approach exploits a Discrete Cosine Wavelet criterion to adaptively perform image fusion by selecting most informative (sharp) information from the input images. The proposed Discrete Cosine Wavelet sharpness criterion outperforms over Bacterial conventional sharpness criterions, as verified in our extensive experiments using four sets of test images under two objective metrics, and the comparison takes places in the table and shows that resultant image is better quality than the previous method.***

Keywords: Image Processing, Image Fusion, Wavlets

1. Introduction

Image Processing is a method to enhance raw images received from cameras/sensors placed on satellites, space probes and aircrafts or images taken in normal day-to-day life for many applications. Many methods have been discovered in Image Processing in the last four to five decades. [1] Most of the methods are discovered for enhancing images taking from spacecrafts, space probes and military reconnaissance flights. Image Processing systems are becoming popular due to simply available of powerful personnel computers, large size memory devices, graphics softwares etc. [2].

2. Image Fusion

The word fusion signifies in general an approach to extraction of knowledge acquired in several domains. The goal of image fusion (IF) is to integrate complementary multisensor, multitemporal and/or multi view knowledge into one new image containing knowledge the quality of which cannot be achieved otherwise. The term quality, its meaning and measurement depend on the particular application. [3]

Image fusion is used in many areas. In astronomy and in remote sensing, multisensory fusion is used to obtain high spatial and spectral resolutions by joining images from two sensors, one have high spatial resolution and second have high spectral resolution. Numerous fusion applications have appeared in medical imaging like simultaneous evaluation of CT, MRI images etc. Plenty of uses which use multisensor fusion of visible and infrared images have showed in military, security, and surveillance areas. In multi view fusion, a set of images of the equal scene taken by the same sensor but from dissimilar viewpoints is fused to get an image with higher resolution than the sensor normally provides or to recover the 3D representation of the scene. The multitemporal approach recognizes two dissimilar aims. Images of the equal scene are acquired at dissimilar times either to find and evaluate changes in the scene or to get a less degraded image of the scene. The former aim is common in medical imaging, especially in change detection of tumors and organs, and in remote sensing for monitoring land or forest exploitation. The acquisition period is usually months or years. The latter aim needs the dissimilar measurements to be much closer to each other, typically in the scale of seconds, and possibly under dissimilar conditions. [4]

The list of applications illustrates the diversity of difficulties we face when fusing images. It is impossible to manipulate a universal approach applicable to all image fusion tasks. Every scheme should take into account not only the fusion purpose and the characteristics of individual sensors, but also specific imaging conditions, imaging geometry, noise corruption, required accuracy and application-dependent data properties [5]

2.1 Types of Wavelet Transforms

There are two types of Wavelet transforms:-
1. Discrete Wavelet Transforms
2. Discrete Cosine Transforms

We find sharpness of an image using wavelet transform with modified WASH Metric method.

3. Wash Metric

The Wavelet Based Sharp Features (WASH) metric estimates the perceived quality of an image using the concepts of sharpness and zero-crossing. Sharpness of an image as perceived by humans is determined by the sharpest regions in the image than the number of sharp regions. The sharp region is the highly attentive region in an image and is one in which the fine details are resolvable at multiple levels. [6]

Edge points account for the sharp variations in an image. The distortions affect these sharp points in the image changing its structural data content. The zero crossing is used for obtaining the edge points in the image. The image is analyzed in the wavelet domain which on multi-level decomposition generates the information contained in the different sub-bands. The edge is the local structural data that is characterized by set of pixels showing sharp intensity variations in their neighborhood. The edge data is extracted from an image using gradient or the Laplacian methods. The wavelet based zero crossings come under the Laplacian based edge detection which analyses the second derivative of the image.[7]

3.1 Modified Wash Metric

The conventional WASH metric estimates the perceived quality of an image using the concepts of sharpness and zero-crossing. The image is analyzed in the wavelet domain which on multi-level decomposition generates the information contained in the different sub-bands. The modified WASH method proposed here is based on the conventional WASH metric and estimates the perceptual quality of the image using the sharpness and zero-crossing in the wavelet domain. [8]

The sharpness of an image being one of the important perceived qualities of the image is estimated from the energy in the wavelet sub-bands. The perceived sharpness is estimated from the linear spatial frequency data extracted from the three level separable wavelet decomposition of the image. The log energies of the sub-bands are then calculated and sharpness is estimated.

In conventional WASH the sharpness is estimated based on a weighted geometric mean of the log-energies, providing a greater weight to the finer scales (high frequency bands). But in the modified WASH no weighting scheme is used and instead of geometric mean the modified WASH uses linear superposition of the log-energies with equal weightage to all the subbands, thereby making it simpler. [9]

Then the sharpness value is condensed into a scalar index value and the sharpness of the reference image as well as the distorted image is calculated. The similarity in sharpness of the reference and the distorted images is estimated. The variations in the sharpness of the reference and distorted images. In modified WASH, the wavelet decomposition of the image gives the high frequency sub-bands at ith level as $\{W_{LH}^{I}, W_{HL}^{i}, W_{HH}^{i}\}$. Log energies of each sub-band for level $i \in \{1,2,3\}$ are given as:

$$E_x^i = \left| log2\left(\frac{|D(x)|}{N_x^i}\right) \right|$$

$D(x)$,is the sum of coefficients of the sub-bands x, where x take values$W_{LH}^{i}, W_{HL}^{i}, W_{HH}^{i}$. Unlike $C(x)$ which uses sum of *squared* coefficients in case of conventional WASH, $D(x)$ uses absolute value of the subband coefficients thereby making it simpler and more calculation efficient. N_x^i Is the number of coefficients of sub-band x at level i. The total log-energy at each level of decomposition is computed as:[10]

$$E^i = E_{W_{LH}}^i + E_{W_{HL}}^i + E_{W_{HH}}^i$$

The overall sharpness index of an image given as:

$$\psi = \sum_{i=1}^{3} E^i$$

4. Results

Experiments are conducted to compare the performance of the proposed bilateral sharpness criterion with other using a bilateral gradient-based sharpness criterion, by individually incorporating them as the weighting scheme to perform image fusion. The parameters of the proposed criterion are experimentally set as α=1 and β=0.5. Also, the size of the neighborhood is set to be 5×5. The above parameter settings are experimentally selected. Our setting might not be globally optimal, but this setting yields fairly good performance in our simulations. The first experiment is to conduct image fusion using three sets of images with different focus levels: 256×256 Clock, 256×256 Bottle, and 256×256 Book, as shown in Fig. 1.1-1.9.

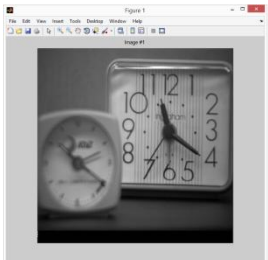

Figure 1.1: Reference clock Image 1

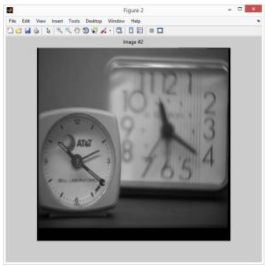

Figure 1.2: Reference clock Image 2

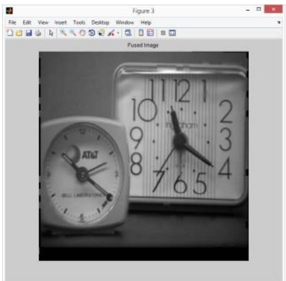

Figure 1.3: Final clock Image After Fusion

The comparison of various fused images are presented in Figs. 1.1 -1.9, respectively. One can see that the fused images obtained using the proposed method yield better image quality than that of conventional approaches.

Figure 1.4: Reference Bottle Image 1

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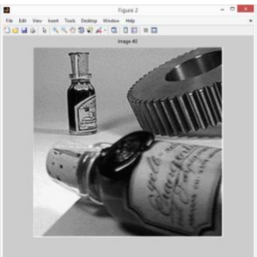

Figure 1.5: Reference Bottle Image 2

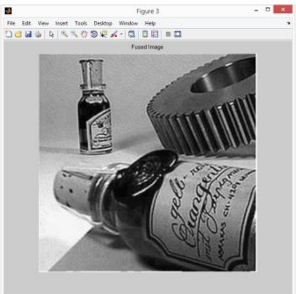

Figure 1.6: Final Bottle Image After Fusion

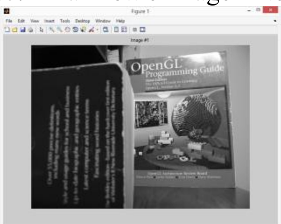

Figure 1.7: Reference Book Image 1

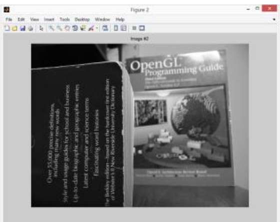

Figure 1.8: Reference Book Image 2

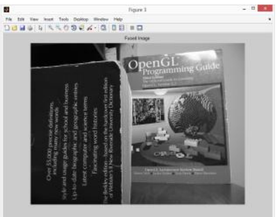

Figure 1.9: Final Book Image after Fusion

Since there is no ground truth image to evaluate the performance of image fusion algorithms. The objective performance comparisons are presented in Tables 1.1, where one can see that the proposed approach always outperforms other using a bilateral gradient-based sharpness criterion by producing the best objective performance.

These image fusion approaches are implemented using the Matlab programming language and run on a PC with a Corei3 2.3GHz CPU and a 2048MB RAM.

The computational complexity of the image fusion approach with the incorporation of the proposed sharpness criterion is comparable to that of using a bilateral gradient-based sharpness criterion.

Table 1.1: Comparison of Mutual Information with bilateral gradient-based sharpness criterion [11]

Test Image	Using Bilateral gradient based sharpness	Using Wash	Using Modified Wash
Clock	8.52	15.99	25.49
Bottle	8.54	21.18	34.97
Book	9.36	20.89	29.19

5. Conclusion

A multi-focus image fusion approach using a new sharpness criterion that depends on statistics of image's gradient information is proposed in this dissertation.

The proposed approach exploits a Discrete Cosine Wavelet criterion to adaptively perform image fusion by selecting most informative (sharp) information from the input images.

The proposed Discrete Cosine Wavelet sharpness criterion outperforms over Bacterial conventional sharpness criterions, as verified in our extensive experiments using four sets of test images under two objective metrics, and the comparison takes places in the table and shows that resultant image is better quality than the previous [12] method.

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