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SYNTHETIC APERTURE RADARIMAGE FUSION USING DCT AND DWT

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Abstract
In this paper presents a novel method of image fusion of synthetic aperture radar (SAR) images using DCT and DWT. Image fusion is the process in which two or more images are combined into single image which can retain all important features of all original images. The result of image fusion is a new image that retains the most desirable information and characteristics of each input image. The proposed approach is applied to generate the fused images by using DCT and DWT. Experiments on real SAR images confirm that the proposed approach using Discrete Wavelet Transform (DWT) does better than the Discrete Cosine Waveform (DCT).

Introduction
Fusion is a process which can be used to improve quality of information from two or more images of a same scene into a single image whose quality is superior to any of input images. Fused image is more informative and is more suitable for visual perception or computer processing. The objective in image fusion is to reduce uncertainty and minimize redundancy in the output while maximizing relevant information particular to an application or task. Given the same set of input images, different fused images may be created depending on the specific application and what is considered relevant information.
In the field of remote sensing, medical imaging and machine vision the multi-sensor data may have multiple images of the same scene proving different information.
Image fusion takes place at three different levels i.e. pixel, feature and decision. Pixel level is a low level of fusion which is used to analyse and combine data from different sources before original information is estimated and recognised. Feature level is a middle level of fusion which extracts important features from an image like shape, length, edges, segments and direction. Decision level is a high level of fusion which points to actual target.
Its methods can be broadly classified into two that is special domain fusion and transform domain fusion. Averaging, Principal Component Analysis (PCA), based methods are special domain methods. But special domain methods produce special distortion in the fused image .This problem can be solved by transform domain approach. The DCT and DWT are the transform domain methods.
Here synthetic aperture radar image fusion is carried out using DCT and DWT.

What is Synthetic Aperture Radar (SAR)?
Synthetic Aperture Radar (SAR) providesbroad-area imaging at high resolutions for the applications such as Environmental monitoring, earth-resource mapping, and military systems. Often, this imagery must be acquired at night or during inclement weather. Synthetic Aperture Radar (SAR) provides such a capability. Synthetic Aperture Radar (SAR) systems take advantage of the long-range propagation characteristics of radar signals and the complex information processing capability of modern digital electronics to provide high resolution imagery. Synthetic Aperture Radar (SAR) complements photographic and other optical imaging capabilities because it is not limited by the time of day or atmospheric conditions and because of the unique responses of terrain and cultural targets to radar frequencies.
Synthetic Aperture Radar (SAR) technology has provided terrain structural information to geologists for mineral exploration, oil spill boundaries on water to environmentalists, sea state and ice hazard maps to navigators, and reconnaissance and targeting information to military operations. There are many other applications for this technology. Some of these, particularly civilian, have not yet been adequately explored because lower cost electronics are just beginning to make Synthetic Aperture Radar (SAR) technology economical for smaller scale uses.
SAR (Synthetic Aperture Radar) sensors are active sensors and can collect images during day and night without being affected by weather conditions. SAR sensors are capable of sensing the geometry and structure of the features such as terrain topography, thickness and roughness of surface cover. They also sense the moisture content and presence of vegetation.

Methods
Discrete cosine transform

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This experiment tries the method of 2-D Discrete Cosine Transformation (DCT) at first. The image should be gray scale before the DCT starts, After the gray scale transformation is completed, just start the process of 2 dimension Discrete Cosine Transformation (DCT) for each 8*8 blocks. The process of the RGB image transformed to gray scale image is shown in Fig. 1 and Fig. 2.

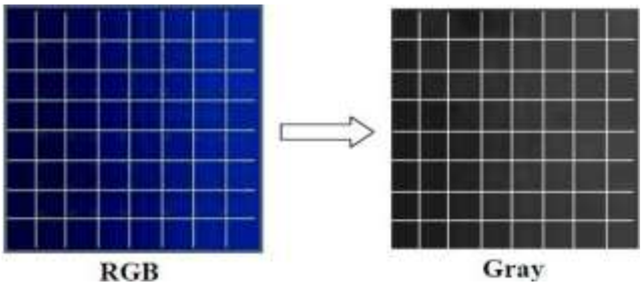

Figure 1: Colour images type to gray scale image type

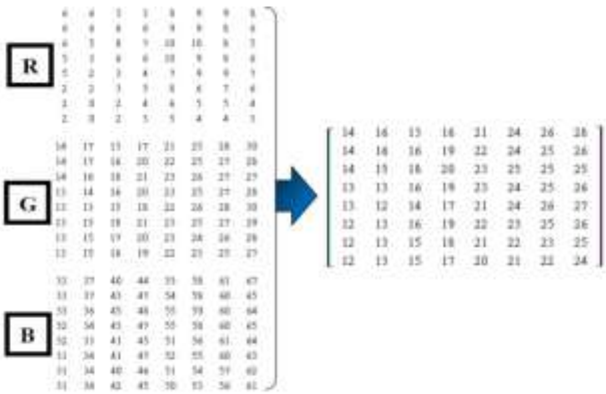

Figure 2: Colour images type to gray scale image type

According to the Fig.1, the RGB image is divided into blocks with size of 8*8 pixel with blue colour in gradient, the gradient scalar field is show the direction from left (deep blue) to right (light blue). After gray scale, the RGB image should be in gray colour, the gradient scalar field is show the direction from left (black) to right (gray). Fig.2 showed the processing of gray scale, the image is grouped by matrices of red, green and blue, and it converts to one grey matrix. This matrix will be used in next DWT transformation.
After the matrix of gray scale will process the two dimensional Discrete Cosine Transformation (DCT2), the definition two dimensional of Discrete Cosine Transformation (DCT2) is:

$$c(u,v) = \propto(u) \propto(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \left\{ cos\left[\frac{\pi(2x+1)u}{2N}\right] cos\left[\frac{\pi(2x+1)u}{2N}\right] \right\}$$

The two dimensional Discrete Cosine Transformation (DCT2) is defined that frequency of gray scale blocks convert from spatial domain to frequency domain and gain the result of frequency matrix. Discrete Cosine Transformation (DCT) has the characteristic of energy compact. In the following steps, we will observe the distribution of AC values by STD calculation.

Discrete wavelet transform
Before process of Discrete Wavelet Transformation (DWT), the original image should be converted into the gray scale first similarly. After Discrete Wavelet Transform (DWT) transformation we get four sub bands, which are LL, LH, HL and HH. From the fig.3, the original image shows in 4*4 blocks and the processing and converting are shown in Fig.4.
After the DWT, the standard deviation of frequencies in LH, HL and HH Will be calculated in the following steps

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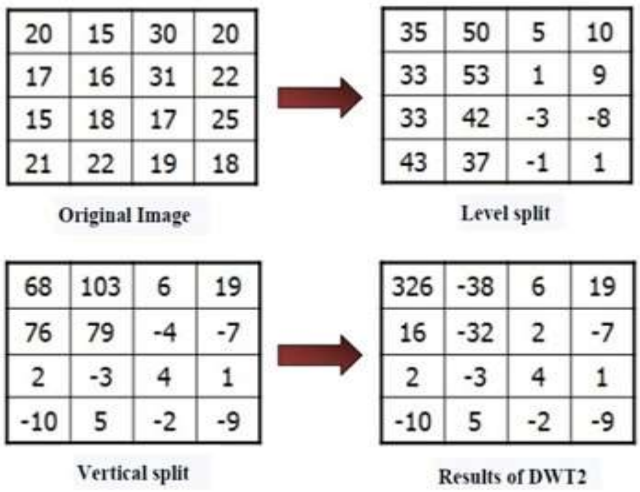

Figure 3:Result of DWT

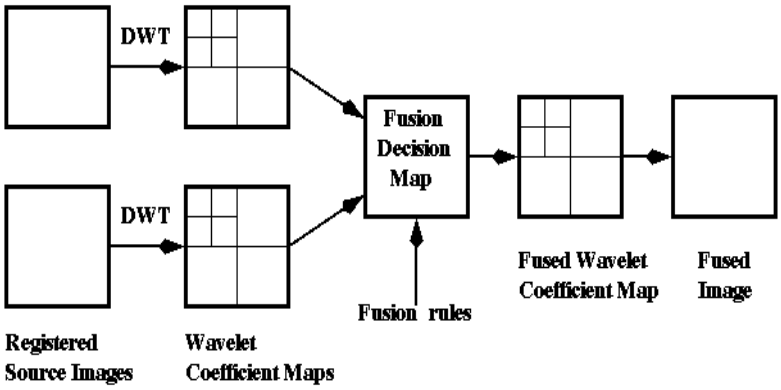

Figure 4:wavelet transform domain

Image fusion

Fig.5 shows the processing of image fusion. For each block of the same position, DCT or DWT is used to select the suit blocks. The block with larger DCT (or DWT) value is selected to constitute the new image.

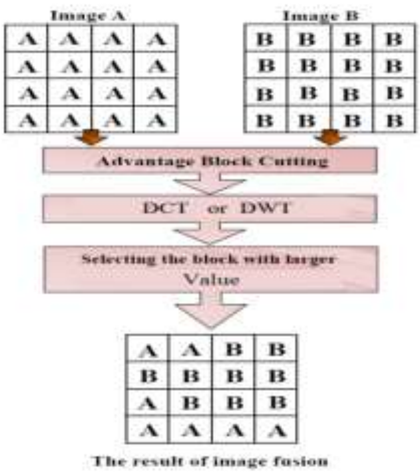

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Figure 5: Result of image fusion

Material

There are two radar images of Kolkata, India, illustrates different urban land use patterns. Kolkata, the largest city in India, is located on the banks of the Hugli River, shown as the thick, dark line in the upper portion of the image. The surrounding area is a flat swampy region with a subtropical climate. As a result of this marshy environment, Kolkata is a compact city, concentrated along the fringes of the river. The average elevation is approximately 9 meters (30 feet) above sea level. Kolkata is located 154 kilometers (96 miles) upstream from the Bay of Bengal. Central Kolkata is the light blue and orange area below the river in the center of the image. The bridge spanning the river at the city center is the Howrah Bridge which links central Kolkata to Howrah. The dark region just below the river and to the left of the city center is Maidan, a large city park housing numerous cultural and recreational facilities. The international airport is in the lower right of the image. The bridge in the upper right is the Bally Bridge which links the suburbs of Bally and Baranagar. These images are 30 kilometers by 10 kilometers (19 miles by 6 miles) and centered at 22.3 degrees north latitude, 88.2 degrees east longitude. North is toward the upper right. The colors are assigned to different radar frequencies and polarizations as follows: red is L-band, horizontally transmitted and received; green is L-band, horizontally transmitted and vertically received; and blue is C-band, horizontally transmitted and vertically received. The image was acquired by the Space borne Imaging Radar-C/X-band Synthetic Aperture Radar (SIR-C/X-SAR) onboard the Space Shuttle Endeavour

Results and discussion

1. Mean square error:

$$\text{MSE} = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}(Aij - bij)^2$$

2. Peak Signal to Noise Ratio :

$$\text{PSNR} = 10\log_{10}\left(\frac{peak2}{MSE}\right)$$

Table: 1 Fusion techniques and their quality measures

Fusion Method	Quality Measurements	
	Peak Signal to noise ratio	Mean Square error
DCT	18.3991	940.0878
DWT	31.1174	50.2736

The results of these experiments are shown in fig. 6. There are two original images. The fusion of two original images is proposed by DCT and DWT. Original image1 is distorted on the right hand side while Original image2 is distorted on the left hand side as shown in fig. 6 (a) and 6 (b). The fused images using DCT and DWT are shown in fig. 6 (c) and 6 (d) respectively.

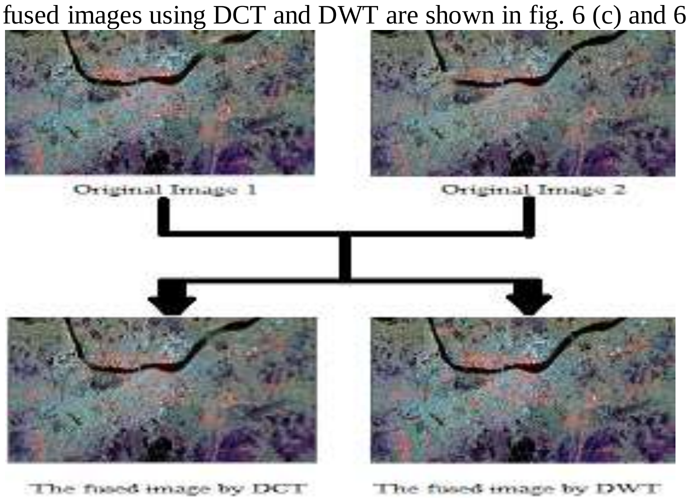

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Figure 6: Result of image fusion

Conclusions

From the above output images and the values of quality measures presented in the table 1, it can be concluded that DWT based image fusion techniques provide us good quality fused images than DCT based techniques.

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