DSP PROJECT REPORT

IMAGE FUSION USING DCT

THEORY:-

Image Fusion:-

The main purpose of image fusion is to combine information from two or more images in such a way that the target image is more suitable for human visual perception and computer based algorithms and also to retain the most desirable characteristics of each image.

Images to be fused

Fused Image

METHOD:

Discrete Cosine Transform:-

A digital image generally consists of two different domains spatial domain or frequency domain. In spatial domain image can be realized through our human eyes, but frequency domain is used to analyse spatial domain

Discrete cosine transform (DCT) is a very important transform in image processing. It is always used to express a sequence of finite data points in terms of a sum of cosine functions oscillating at different frequencies. Large DCT coefficients are concentrated in the low frequency region. Hence, it is known to have excellent energy compactness properties and edges may contribute high frequency coefficients. The signal energy due to smooth regions is compacted mostly into DC coefficients; hence edges in the spatial domain can only contribute energy to a small number of AC coefficients

Formulation of DCT:

The 2D discrete cosine transform of an image is defined as:

$$Z(u,v) = \alpha(u)\alpha(v)\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} z(x,y)\cos\left(\frac{\pi(2x+1)u}{2M}\right)\cos\left(\frac{\pi(2y+1)v}{2N}\right), \quad \begin{matrix} 0 \le u \le M-1 \\ 0 \le v \le N-1 \end{matrix}$$

$$\text{Where } \alpha(u) = \begin{cases} \dfrac{1}{\sqrt{M}}, & u = 0 \\ \sqrt{\dfrac{2}{M}}, & 1 \le u \le M-1 \end{cases} \quad \text{and} \quad \alpha(v) = \begin{cases} \dfrac{1}{\sqrt{N}}, & v = 0 \\ \sqrt{\dfrac{2}{N}}, & 1 \le v \le N-1 \end{cases}$$

u & v are discrete frequency variables (x, y) pixel index

Similarly, the 2D inverse discrete cosine transform is defined as [10]:

$$z(x,y) = \sum_{u=0}^{M-1}\sum_{v=0}^{N-1} \alpha(u)\alpha(v)Z(u,v)\cos\left(\frac{\pi(2x+1)u}{2M}\right)\cos\left(\frac{\pi(2y+1)v}{2N}\right), \quad \begin{matrix} 0 \le x \le M-1 \\ 0 \le y \le N-1 \end{matrix}$$

Process flow:-

Images to be fused are divided into non-overlapping blocks of size NxN as shown. DCT coefficients are computed for each block and fusion rules are applied to get fused DCT coefficients. IDCT is then applied on the fused coefficients to produce the fused image/block. The procedure is repeated for each block.

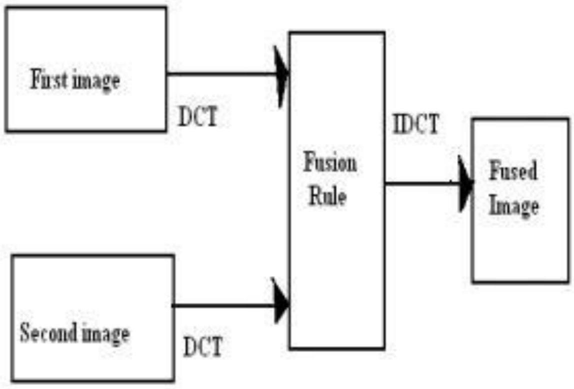

IMAGE FUSION TECHNIQUES:

The following fusion rules are used in image fusion process

DCTav Method:

Let the X1 be the DCT coefficients of image block from image 1 and similarly let X2 be the DCT coefficients of image block from image 2. Assume the image block is of size N x N and X_f be the fused DCT coefficients. Here, all DCT coefficients from both image blocks are averaged to get fused DCT coefficients. It is very simple and basic image fusion technique in DCT domain

$$X_f(k_1,k_2) = 0.5\ X_1(k_1,k_2) + X_2(k_1,k_2)$$

Where k_1, k_2 = 0, 1, 2 ……, N-1

DCTah Method: The lowest AC components including DC coefficients are averaged and the remaining AC coefficients are chosen based on largest magnitude.

$$X_f(k_1,k_2) = 0.5 \;\; X_1(k_1,k_2) + X_2(k_1,k_2)$$

Where $k_1, k_2 = 0,1,2,\ldots,0.5N-1$

$$X_f(k_1,k_2) = \begin{cases} X_1(k_1,k_2) & |X_1(k_1,k_2)| \geq |X_2(k_1,k_2)| \\ X_2(k_1,k_2) & |X_1(k_1,k_2)| < |X_2(k_1,k_2)| \end{cases}$$

Where $k_1, k_2 = 0.5N, 0.5+1, 0.5N+2,\ldots,N-1$

DCTma Method: The DC components from both image blocks are averaged. The largest magnitude AC coefficients are chosen, since the detailed coefficients correspond to sharper brightness changes in the images such as edges and object boundaries etc. These coefficients are fluctuating around zero.

$$X_f(0,0) = 0.5 \;\; X_1(0,0) + X_2(0,0)$$

$$X_f(k_1,k_2) = \begin{cases} X_1(k_1,k_2) & |X_1(k_1,k_2)| \geq |X_2(k_1,k_2)| \\ X_2(k_1,k_2) & |X_1(k_1,k_2)| < |X_2(k_1,k_2)| \end{cases}$$

Where $k_1, k_2 = 1,2,3,\ldots,N-1$

We can also use DCTch, DCTcm and DCTte methods to find the fused image DCT coefficients. Later by applying the IDCT fused image can be obtained by retaining the most desirable characteristics.

FUSION EVALUATION METRICS:

The fusion evaluation metrics are used to evaluate the performance of the image fusion algorithms.

Spatial Frequency:

The frequency in spatial domain indicates the overall activity level in the fused image and it is computed as

Row frequency:

$$RF = \sqrt{\frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=1}^{N-1} I_f(i,j) - I_f(i,j-1)^{\,2}}$$

Column frequency:

$$CF = \sqrt{\frac{1}{MN}\sum_{j=0}^{N-1}\sum_{i=1}^{M-1} I_f(i,j) - I_f(i-1,j)^{\,2}}$$

Spatial frequency: $SF = \sqrt{RF^2 + CF^2}$

The fused image with high SF would be considered.

High spatial frequency indicates that the fused image contains all the information from the source images

RESULTS AND OBSERVATIONS:-

Two complementary source images I1 and I2 (images to be fused) are generated by blurring the source image. The fused and error images using the averaging image fusion technique is shown. The error image is the difference of source image and the fused image.

Image I1

Image I2

Fused Image

Error Image

Spatial frequency:

	DCTav	DCTah	DCTma
2x2	5.5511e-17	0	0
4x4	5.5511e-17	0	0
8x8	5.5511e-17	0	0
16x16	5.5511e-17	0	0
32x32	5.5511e-17	0	0
64x64	5.5511e-17	0	0
128x128	5.5511e-17	0	0
256x256	5.5511e-17	0	0
512x512	5.5511e-17	0	0

Images to be fused   Fused Image

CONCLUSION:-

3 different types of image fusion algorithms based on Discrete Cosine Transform (DCT) are presented and fused image quality was evaluated using performance evaluation metrics (Spatial Frequency). Fusion performance is not good while using the algorithms with block size less than 8x8. One way to obtain best fused image is, compute the performance of the fusion for different block sizes and then select the fused image corresponding to best performance metrics. Since very high computational facility is available, it could be possible to implement this idea for real time applications.

REFERENCES:-

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