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Evaluated the performance of Integrated PCA & DCT Based Fusion Using Consistency Verification & Non-Linear Enhancement

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Abstract

The image fusion is becoming one of the hottest techniques in image processing. Many image fusion methods have been developed in a number of applications. The main objective of image fusion is to combine information from multiple images of the same scene in order to deliver only the useful information. The discrete cosine transforms (DCT) based methods of image fusion are more suitable and time-saving in real-time systems using DCT based standards of still image or video. DCT based image fusion produced results but with lesser clarity, less PSNR value and more Mean square error. Therefore the overall objective is to improve the results by combining DCT with PCA and non-linear enhancement. The proposed algorithm is designed and implemented in MATLAB using image processing toolbox. The comparison has shown that the proposed algorithm provides a significant improvement over the existing fusion techniques.

Keywords: Image fusion, Multi-focus, Visual Sensor, DCT, and PCA.

Introduction

Image fusion is the process of to combine relevant information from two or more images into a single image. The resulting image will contain all the important information as compare to input images. The new image will extracts all the information from source images.Image fusion is a useful technique for merging single sensor and multi-sensor images to enhance the information. The objective of image fusion is to combine information from multiple images in order to produce an image that deliver only the useful information. The discrete cosine transformation (DCT) based methods of image fusion are more suitable and time-saving in real-time systems. In this paper an efficient approach for fusion of multifocus images is presented which is based on variance calculated in dct domain.

In all sensor networks, every sensor can receive, produce and transfer data. Visual Sensor Networks (VSN) refers to a system with a large number of cameras that are used to geographically spread resources and monitoring of many points. In VSN, sensors are cameras which can record either video sequences or still images. Therefore, the processing of output information is related to machine vision subjects and image processing.

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 extract 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, Brovery method, 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 based method will be more efficient for fusion.

Literature Survey

Image Fusion is used extensively in image processing systems. Various Image Fusion methods have been proposed in the literature to reduce blurring effects. Many of these methods are based on the post-processing idea. In other words, Image fusion enhances the quality of image by removing the noise and the blurriness of the image.

Aribi, W et al. [2] explained that the quality of the medical image can be evaluated by several subjective techniques. Authors have developed new techniques based on the multi resolution fusion. MRI and PET images have been fused with eight multi

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resolution techniques. For the evaluation of fusion images obtained, authors opted by objective techniques. The results proved that the fusion with RATIO and contrast techniques to offer the best results. Evaluation by objective technical quality of medical images fused is feasible and successful.

Haozheng, R et al. [5] has proposed multi focus image fusion method based on M-band Multi-Wavelet Transformation. For the purpose, authors initially considered the multi focus image fusion method based on single wavelet followed by multi wavelet, multi-band multi-wavelet along with arithmetic of decomposition and reconstruction. For selecting fusion arithmetic operators, paper compares the method based on pictures, windows and regions. Moreover, images have been compared based on different fusion norms and different wavelets in the aspects of entropy, peak SNR, square root error and standard error. Experimentally, it has been concluded that multiband multiwavelet is an effective image fusion technique and provides better performance than other techniques.

Gintautas, P et al. [3] has presented the Multi-resolution, multi-sensor image fusion framework which provides the multi resolution image fusion while preserving spectral properties of low resolution images. A general framework for image fusion suitable for fusion of multi sensor data such as optical-optical, optical-radar imagery has been proposed. The proposed general framework proceeds as interpolation, fusion and histogram matching. It has been deduced that this approach allows to systematically analyzing most of the known multi resolution fusion methods.

Kiran , P et al.[6]has presented a Comparative Analysis of Multimodality Medical Image Fusion Methods to improve the image content by fusing images like computed tomography and magnetic resonance imaging as magnetic resonance imaging provides better information of soft tissues where as computed tomography is better for denser tissue. In this paper, Fast Discrete Curvelet Transform using Wrapper algorithm based image fusion technique has been applied, examined and compared with Wavelet based Fusion Technique. The fusion performance is evaluated on the basis of the root mean square error (RMSE) and peak signal to noise ratio (PSNR). It has been concluded that edge representation in Curvelet is better and Curvelet Based image fusion is best suited for medical images. Further, images with their true colors can also be fusing using same method.

Xing ,S et al.**[8**] has presented an Image Fusion Method Based on NSCT and Robustness Analysis which focus on the fusion of infrared and visible images for better contrast, clarity and night vision. A regional standard deviation-weighted image fusion method based on non-sub sampled Contourlet transform is proposed. For the purpose, firstly the reiterated infrared and visible images from the same scene transformed by non-sub sampled contourlet transform (NSCT), followed the approximate weight averaged, high- frequency detail components concordant with the weighted of the regional standard deviation proportion then the fusion image is obtained by inverse non-sub sampled contourlet transform. Conclusively, the fused images were compared with the results obtained by wavelet transform, Laplace transform and contourlet transform through a large number of experiments. It has been concluded that NSCT fusion method can achieve better fusion performance and in presence of noise robustness of this method is superior in comparison to other fusion techniques.

Haghighat, M et al. [4] has proposed a new DCT based fusion technique for multi-focus images. This fusion method was based on variance definition in DCT domain. Variance value is calculated from all DCT coefficients which is used as a contrast criterion in image processing applications. The proposed method performs the better result as compare to previous DCT based methods both in quality and complexity reduction.

A.SomaSekhar et al. [1] has proposed a Novel multi-resolution fusion algorithm for medical diagnosis using integrated PCA and wavelet transforms .A multi-resolution based fusion is obtained by combining the aspects of region and pixel-based fusion. For medical diagnosis, this paper addresses the CT and MRI images. Computed Tomography (CT) provides the best information on denser tissue with less distortion. Magnetic Resonance Image (MRI) provides better information on soft tissue with more distortion. So that combination of both Images gives special sophisticated characteristics of the organ to be imaged. Here three different wavelets used in fusion have been discussed such as Orthogonal, Bi-orthogonal and trous wavelet. The performance of DWT's has been compared with the integrated PCA and DWT based fusion methods. The comparison has been done based on five parameters named as Mean, Standard deviation, Entropy, Covariance, Correlation Coefficient. The results depicts that the performance of Integrated DWT and

PCA based fusion techniques is significantly better as compare to simple DWT based fusion method.

Y-T, K et al. [10] has proposed a brightness preserving bi-histogram equalization(BBHE) algorithm for contrast enhancement in an images. The BBHE algorithm firstly decomposes an input image into two sub images based on the mean of the input image. Then the histogram equalization is applied independently to the sub images to preserve the mean brightness of a given image while the contrast is enhanced. Experimental results demonstrate the brightness-preserving function of the BBHE while enhancing contrasts. Hence, many applications can be made possible by utilizing the proposed algorithm in the field of consumer electronics such as TV and VTR.

Om,p et al.[7] has proposed a Biorthogonal wavelet transform (BWT) based image fusion method using absolute maximum fusion rule. Authors have suggested the adoption of this method because Biorthogonal wavelet transform contains spline wavelets. With these spline wavelets symmetry and perfect reconstruction is possible using FIR (Finite Impulse Response) filters. The symmetry means that the filters have linear phase so that BWT is capable to preserve edge information and hence reducing the distortions in the fused image. The experimental results shows that BWT based fusion method gives better result and more applicable because it can retain information of individual image like edges, lines, curves, boundaries in the fused image in better way as compare to traditional spatial domain based image fusion methods like Linear fusion , Principal Component Analysis based fusion and Sharpness criteria based image fusion .

Y. Asnathet al. [9] has proposed a simple and efficient DCT based image fusion technique. Authors have suggested the adoption of this method because DCT based fusion overcomes the computation and energy limitation of low power device. In this fusion method, the image blocks with higher value of AC coefficients is absorbed into the fused image. It is extremely fast as it does not involve any complex floating point arithmetic operations like mean or variance calculation. The proposed fusion technique considerably reduces the computational complexity without compromising image quality and for energy consumption analysis, it uses the ATmega128 processor of Mica 2 mote at 8MHz with an active power consumption of 22mW as the target platform. The experimental results show that the significant efficiency improvement of the proposed method in output quality and energy consumption, when compared with existing fusion techniques in DCT domain.

Gaps in Literature Survey

1. As most of the existing methods are based upon transformation, therefore it may results in some color artifacts which may reduce the performance of the transform based vision fusion methods.
2. It is also found that the problem of the uneven illuminate has also been neglected in the most of existing work on fusion.
3. Image with complex background may not be correctly fused because difficult to extract the useful objects or regions.

Proposed Algorithm

We develop an integrated DCT and PCA based fusion using nonlinear enhancement approach for image fusion. As we know that the image fusion is a process to combine information from multiple images of the same scene in order to deliver only the useful information **.**It is found that the discrete cosine transforms (DCT) based methods of image fusion are more suitable and time-saving in real-time systems using DCT based standards of still image or video. DCT based image fusion produced results but with lesser clarity, less PSNR value and more Mean square error. Therefore the overall objective is to improve the results by combining DCT with PCA and non-linear enhancement. The proposed algorithm is designed and implemented in MATLAB using image processing toolbox.

Steps of proposed approach:

The detailed algorithm for the proposed approach is given below:

Step1: First of all two images which are partially blurred are passed to the system. Then we find the size of an image using equation

$[M, N, D] = size(I(x, y))$ ……. (1)

Where M represent rows, N represent columns and D represent dimensions. I(x,y) is an input image.

Step 2: Apply RGB2PCA to convert given image in PCA plane.

(a) To convert RGB image to PCA, first each component of an RGB image should be converted into vector. Then all these vectors are concatenated by using following equation

$IIV = cat(2, R, G, B)$…….. (2)

Where IIV represent the Input Image Vector and cat represent the concatenate function.

(b) Then Eigen values are computed by using principal component function which is given by following equation

$VV = princomp(IIV)$……. (3)
Where VV represent the vector values and princomp is inbuilt function in MATLAB.
(c) PCA vector is obtained from vector values by using following equation
$Vector = VV/(\sum(VV)$…….. (4)
(d) Finally PCA image is obtained from vector representation by using following function
$OVI = IIV * Vector$……… (5)
Where OVI represent the output vector image and IIV represent the Input Image Vector

Step 3: Now differentiate PCA of image1 and image2 into their 3 planes as PCA1, PCA2 and PCA3 of Image1 and Image2 as image is assumed to be in RGB by using the following equations:
$impca1 = pcaim(:,:,1)$....... (6)
$impca2 = pcaim(:,:,2)$......... (7)
$impca3 = pcaim(:,:,3)$....... (8)
Where Impca1, Impca2, Impca3 represents the pca1, pca2, pca3 of image1 and image2 respectively. Pca1 represent r component, pca2 represent g component and pca3 represent b component.
Step 4: For PCA (:,:, 1) of image 1 and image 2 will be passed for fusion using DCT. And also PCA (:,:,2) & PCA(:.:.3) of image 1 and image 2 will determine new components by taking their averages respectively also called fusion of chrominance.
(a) The two Chrominance components represent color information and it is assumed that the images to be fused are having similar hue and saturation , hence chrominance components can be averaged by using following equation:
$cf2 = (im1pca2 + im2pca2)/2$………… (9)
$cf3 = (im1pca3 + im2pca3)/2$………… (10)
Where cf represents chrominance fusion.
(b) DCT based fusion will be done using expand and reduced function.
Reduced function is used to reduce the size of an image. Image reduction is done by taking dct and applying the idcton an input image. Image reduction will be done by using following equations:
(i) First, we will evaluate the size of an image by using the following equation:
$imsize = size(pca1im)/2$……. (11)
Where imsize function is used to find the size of an image and pca1im indicates the pca1 of image1 and image2 respectively.
(ii) Now apply dct by using following equation:

$$im = dct2(pca1im) \ldots..(12)$$

Where im is the 2d discrete cosine transform of an image and dct is Discrete Cosine Transformation function which transforms an image into discrete frequency variables.
(iii) Now apply idct by using following equation:

$$opr = round\left(idct2\left(im, (size(im1)), (size(im2))\right)\right) \ldots..(13)$$

Where opr represents an output image of reduced function, round represents quantized function in which approximate coefficients are quantized to zero.

An Expand function is the reverse of the reduced function. An expand function is used to expand the size of an image from m*n to the 2m*2n by applying dct and idct function. An expand function will be done by using following equations:
(i) First,we will evaluate the size of an image by using the following equation:

$$imsize = size(pca1im) * 2 \ldots\ldots(14)$$

Where imsize function is used to find the size of an image and pca1im indicates the pca1 of image1 and image2 respectively.
(ii) Now apply dct by using following equation:

$$im = dct2(pca1im) \ldots..(15)$$

Where im is the 2d discrete cosine transform of an image and dct is Discrete Cosine Transformation function which transforms an image into discrete frequency variables.
(iii) Now apply idct by using following equation:

$$ope = \left(idct2\left(im, (size(im1)), (size(im2))\right)\right) \ldots..(16)$$

Where op represents an output image of expand function and idct2 represents an inverse discrete cosine transformation function.
After calculating the expand and reduced function, finally the output of pca1 of image 1 and image2 is obtained by following equation:

$$im1id = im1R - E(im1R) \ldots..(17)$$

$$im2id = im2R - E(im2R) \ldots..(18)$$

Where im1id, im2id represents image identities of image1 and image2 respectively. R indicates reduced function and E indicates the expand function.
Now aggregation function is applied to take the decision which image has more variations in pixels by using following equation:

$$ag = abs(im1id) - abs(im2id) \geq 0 \ldots\ldots\ldots..(19)$$

Where ag represents aggregate function, abs return an absolute value for each element of an image.
Then fusion effect is calculated by using following equation:

$$fe = ag * im1id + (\sim ag) * im2id \ldots\ldots(20)$$

Where fe represents fusion effect, ag represent aggregate function in which image has more variation in pixels and (~ag) indicate not aggregate function.
And finally the output image is obtained by following equations:

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$$op = \frac{im1r + im2r}{2} \ldots..(21)$$

$opf = fe + E(op)$...... (22)

Where opf represents final output image, Fe represents fusion effect, E indicated expand function and op is an output image of reduced function.

Step5: Now concatenation of each output of step IV will be done by using following equation:

$$a = cat(3, opf, cf2, cf3) \ldots \ldots \ldots \ldots (23)$$

Where cat represents concatenate function, opf represents final output image of dct based fusion of the first component of image1and image2. cf2, cf3 represents chrominance fusion of second and third component of image1 and image2 respectively.

Step6: Now PCA2RGB will be applied to get original fused image. PCA2RGB conversion will be done by using following equation:

$$imf = pca2rgb(a) \ldots..(24)$$

Step7: Now non linear colour enhancement will be applied to get clearer image. Image enhancement refers to sharpening, of image features such as boundaries, or contrast to make a graphic display more useful for display & analysis. Colour enhancement is done by following equation:

$$ef = stretchlim(imf) \ldots.(25)$$

Where ef represents equalization factor, stretchlim function is used to change the contrast or brightness value and imf represents fused image.

And finally an output fused image is obtained by following equation:

$$ffi = imadjust(imf, ef) \ldots \ldots (26)$$

Where ffi represents final fused image, ef represents equailization factor and imadjust function is used to adjust the intensity values in an image to enhance the contrast or brightness value of a final output fused image.

Step8: End

Performance Metrics

The quality of an image is examined by objective evaluation as well as subjective evaluation. For subjective evaluation, the image has to be observed by a human expert. The human visual system (HVS) is so complicated that it is not yet modelled properly. Therefore, in addition to objective evaluation, the image must be observed by a human expert to judge its quality. There are various metrics used for objective evaluation of an image. Some of them are Mean squared error (MSE), peak signal to noise ratio (PSNR), Normalized Cross-Correlation (NCC), Average Difference (AD), Structural Content (SC), Maximum Difference (MD) , Normalized Absolute Error (NAE), Detailed Variance(DV) and Background Variance(BV).

Mean Square Error (MSE):

Mean square error is a measure of image quality index. The large value of mean square means that image is a poor quality. Mean square error between the reference image and the fused image is

$$MSE = \frac{1}{mn}\sum_{i=1}^{m}\sum_{j=1}^{n}(A_{ij} - B_{ij})^2$$

Where Ai, j and Bi, j are the image pixel value of reference image

.

Peak Signal to Noise Ratio (PSNR):

The PSNR block computes the peak signal-to-noise ratio, between two images. This ratio is often used as a quality measurement between the original and a fused image. The higher the PSNR, the better the quality of the fused or reconstructed image. PSNR value is computed by following equation:

$$PSNR = 10\log_{10}(\frac{255^2}{MSE})$$

Normalized Cross Correlation (NCC):

Normalized cross correlation is used to find out similarities between fused image and registered image is given by the following equation:

$$\mathbf{NCC} = \sum\nolimits_{\mathbf{i=1}}^{\mathbf{m}}\sum\nolimits_{\mathbf{j=1}}^{\mathbf{n}}(\mathbf{A_{ij}} * \mathbf{B_{ij}})$$

Structural Content (SC):

The structural content measure is used to evaluate two images in a number of small image patches the images include in familiar. The patches to be compared are selected using 2D continuous wavelet which acts as a low level corner detector. The large value of structural content SC means that image is poor quality

$$SC = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(A_{ij})^2}{\sum_{i=1}^{m}\sum_{j=1}^{n}(B_{ij}{}^2)}$$

Maximum Difference (MD):

MD measure difference between any two pixels such that the larger pixel appears after the smallest pixel. The large value of maximum difference means that image is poor in quality.

$$MD = Max(|A_{ij} - B_{ij}|)$$

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Normalized Absolute Error (NAE):

The large value of normalized absolute error means that image is poor quality. NAE is defined as follows

$$NAE = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(|A_{ij} - B_{ij}|)}{\sum_{i=1}^{m}\sum_{j=1}^{n}(A_{ij})}$$

As shown in the below given figures, we are comparing the results of various images. As results show that our proposed approach results are much better than exiting approaches. The developed approach is compared against some well-known methods available in literature. After the results, we are comparing the proposed approach against the existing methods like Discrete Cosine Transformation (DCT), Principal Component analysis (PCA), Discrete Wavelet Transform (DWT).

Experimental Set-up

In order to implement the proposed algorithm, design and implementation has been done in MATLAB using image processing toolbox. In order to do cross validation we have also implemented the enhanced DCT and PCA based image fusion using nonlinear enhancement. The developed approach is compared against some well-known image fusion techniques available in literature. After these comparisons, we are comparing proposed approach against DCT, PCA and DWT using some performance metrics. Result shows that our proposed approach gives better results than the existing techniques. Table 5.1 is showing the various images which are used in this research work. Images are given along with their formats. All the images are of same kind and passed to proposed algorithm.

Table 5.1 Images taken for experimental analysis

Image name	Format	Size in K.Bs (Partially blurred 1)	Size in K.Bs (Partially blurred 2)
image1	.jpg	594	580
image2	.jpg	133	134
image3	.jpg	79.4	79.2
image4	.jpg	265	270
image5	.jpg	96.3	98.8
image6	.jpg	31.7	33.1
image7	.jpg	762	780
image8	.jpg	148	164
image9	.jpg	103	101
image10	.jpg	226	228

Experimental results

Figure 5.1 has shown the input images for experimental analysis. Fig.5.1 (a) is showing the left blurred image and fig.5.1 (b) is showing the right blurred image. The overall objective is to combine relevant information from multiple images into a single image that is more informative and suitable for both visual perception and further computer processing.

Figure 5.1(a): Left blurred image

Figure 5.1(b): Right blurred image

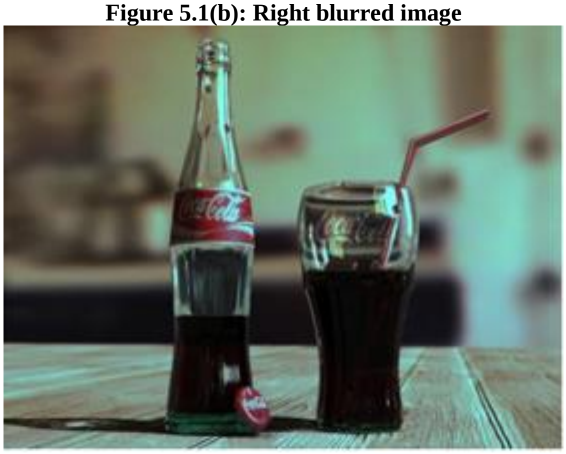

Figure 5.2: DWT based image fusion

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Figure 5.2 has shown the output image taken by wavelet based fusion (DWT). The output image preserves the brightness of original blurred images to be fused but color is imbalanced which have degraded the quality of the image.

Figure 5.3: DCT based image fusion

Figure 5.3 has shown the output image taken by DCT. The output image has contained too much brightness and color imbalance as compare to original blurred images to be fused.

Figure 5.4: PCA based image fusion

Figure 5.4 has shown the output image taken by PCA. The output image has contained low brightness and low contrast as compare to original blurred images to be fused which have degraded the quality of the image.

Figure 5.5: Final proposed image

Figure 5.5 has shown the output image taken by the integrating DCT and PCA based image fusion with nonlinear enhancement. The image has contained the balanced color and brightness as the original images to be fused. The quality of output image is quite good with our proposed method with respect to all the techniques discussed.

Performance Analysis

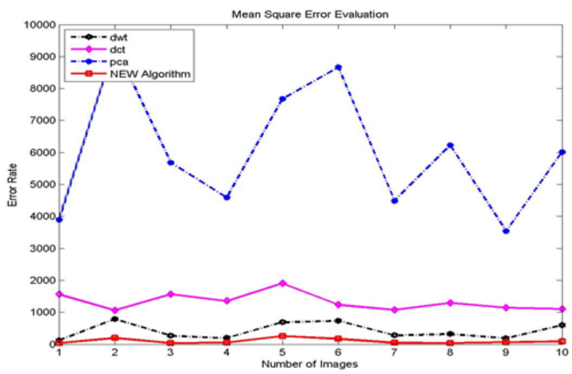
This section contains the cross validation between existing and proposed techniques. Some well-known image performance parameters for digital images have been selected to prove that the performance of the proposed algorithm is quite better than the existing methods.

Mean Square Error Evaluation

Table 6.1 is showing the quantized analysis of the mean square error. As mean square error need to be reduced therefore the proposed algorithm is showing the better results than the available methods as mean square error is less in every case.

Image name	DWT	DCT	PCA	Proposed algorithm
image1	121	1561	3892	39
image2	787	1062	9351	192
image3	265	1566	5683	38
image4	191	1351	4588	50
image5	685	1903	7679	257
image6	732	1234	8667	165
image7	274	1077	4488	44
image8	320	1290	6224	39
image9	188	1141	3535	63
image10	588	1105	6016	85

Table 6.1 Mean Square Error Evaluation



Graph 6.1 MSE of DWT, DCT, PCA& Proposed Approach for different images

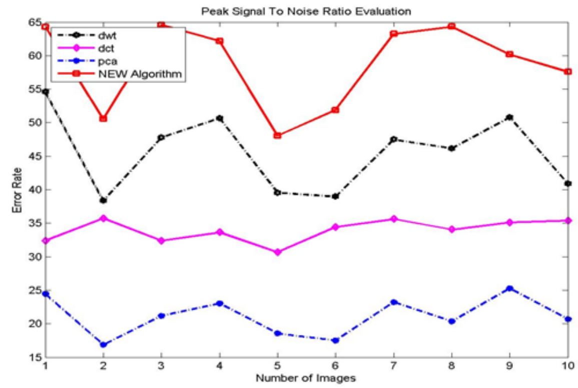
Figure 6.1 has shown the quantized analysis of the mean square error of different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color). It is very clear from the plot that there is decrease in MSE value of images with the use of proposed method over other methods. This decrease represents improvement in the objective quality of the image.

Peak Signal to Noise Ratio Evaluation

Table 6.2 is showing the comparative analysis of the Peak Signal to Noise Ratio (PSNR). As PSNR need to be maximized; so the main goal is to increase the PSNR as much as possible. Table 6.2 has clearly shown that the PSNR is maximum in the case of the proposed algorithm therefore proposed algorithm is providing better results than the available methods.

Image name	DWT	DCT	PCA	Proposed algo
image1	54.573	32.393	24.457	64.2853
image2	38.339	35.734	16.843	50.5532
image3	47.783	32.364	21.169	64.5547
image4	50.634	33.645	23.027	62.1757
image5	39.539	30.618	18.555	48.0478
image6	38.960	34.432	17.503	51.8916
image7	47.501	35.613	23.219	63.2283
image8	46.153	34.048	20.379	64.3267
image9	50.768	35.113	25.293	60.1651
image10	40.871	35.388	20.675	57.5898

Table 6.2 Peak Signal to Noise Ratio Evaluation



Graph 6.2 PSNR of DWT, DCT, PCA& Proposed Approach for different images

Figure 6.2 has shown the quantized analysis of the peak signal to noise ratio of different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color).

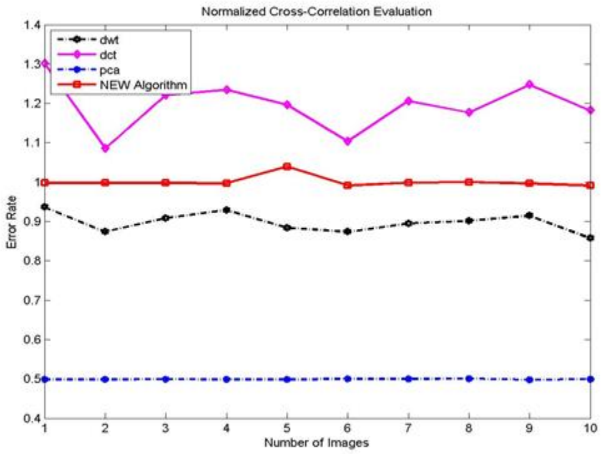
It is very clear from the plot that there is increase in PSNR value of images with the use of proposed method over other methods. This increase represents improvement in the objective quality of the image.

Normalized Cross-Correlation Evaluation

Table 6.3 is showing the comparative analysis of the Normalized Cross-Correlation (NCC). As NCC needs to be close to 1, therefore proposed algorithm is showing better results than the available methods as NCC is close to 1 in every case.

Image name	DWT	DCT	PCA	Proposed algorithm
image1	0.936	1.3012	0.4989	0.9980
image2	0.873	1.0856	0.4985	0.9979
image3	0.908	1.2209	0.4990	0.9980
image4	0.929	1.2347	0.4986	0.9964
image5	0.883	1.1964	0.4987	1.0389
image6	0.874	1.1035	0.4998	0.9914
image7	0.895	1.2059	0.4996	0.9985
image8	0.901	1.1763	0.5004	0.9998
image9	0.914	1.2476	0.4981	0.9967
image1 0	0.857	1.1821	0.4992	0.9910

Table 6.3 Normalized Cross-Correlation Evaluations



Graph 6.3 NCC of DWT, DCT, and PCA & Proposed Approach for different images

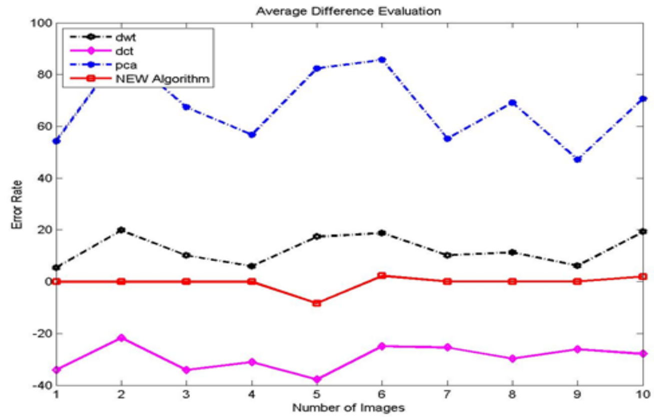
Figure 6.3 has shown the quantized analysis of the Normalized Cross-Correlation of different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color). It is very clear from the plot that there is value of NCC is close to1in every case with the use of proposed method over other methods. This represents improvement in the objective quality of the image.

Average Difference Evaluation

Table 6.4 is showing the comparative analysis of the Average Difference. As Average Difference needs to be minimized; so the main objective is to reduce the Average Difference as much as possible. Table 6.4 has clearly shown that Average Difference is less in our case therefore the proposed algorithm has shown significant results over the available algorithm.

Image name	DWT	DCT	PCA	Proposed algorithm
image1	5.4463	-34.160	54.307	-0.0089
image2	19.8204	-21.678	88.719	-0.0189
image3	10.1252	-34.100	67.352	-0.0139
image4	5.9595	-31.078	56.755	-0.0308
image5	17.3406	-37.762	82.370	-8.3237
image6	18.8087	-24.980	85.717	2.2422
image7	10.1564	-25.465	55.298	0.0288
image8	11.3062	-29.754	69.199	0.0618
image9	6.1149	-26.071	47.172	0.0156
image10	19.2185	-27.896	70.615	2.0004

Table 6.4 Average Difference Evaluation



Graph 6.4 AD of DWT, DCT, PCA & Proposed Approach for different images

Figure 6.4 has shown the quantized analysis of the Average Difference of different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color).

It is very clear from the plot that there is decrease in AD value of images with the use of proposed method over other methods. This decrease represents improvement in the objective quality of the image.

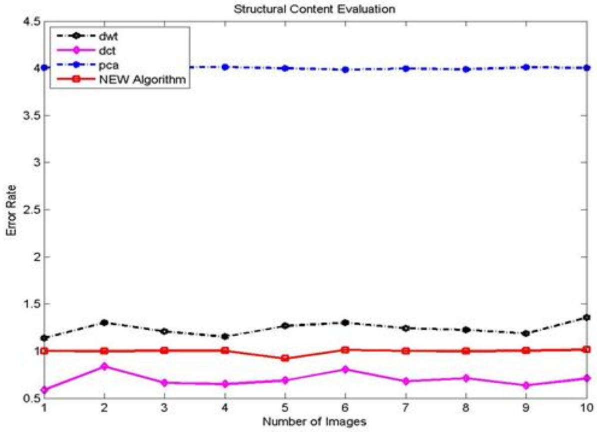
Structural Content Evaluation

Table 6.5 is showing the comparative analysis of the Structural Content. As SC needs to be close to 1, therefore proposed algorithm is showing better results than the available methods as SC is close to 1 in every case.

Image name	DWT	DCT	PCA	Proposed algorithm
image1	1.1357	0.5871	4.0069	1.0015
image2	1.3020	0.8334	4.0060	0.9990
image3	1.2071	0.6618	4.0103	1.0023
image4	1.1514	0.6478	4.0128	1.0045
image5	1.2660	0.6871	3.9997	0.9206
image6	1.3001	0.8046	3.9861	1.0126
image7	1.2415	0.6793	3.9960	1.0004
image8	1.2249	0.7120	3.9887	0.9987
image9	1.1871	0.6342	4.0102	1.0021

image10	1.3528	0.709 1	4.0035	1.0147

Table 6.5 Structural Content Evaluation



Graph 6.5 SC of DWT, DCT, PCA& Proposed Approach for different images

Figure 6.5 has shown the quantized analysis of the Structural Contentof different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color).

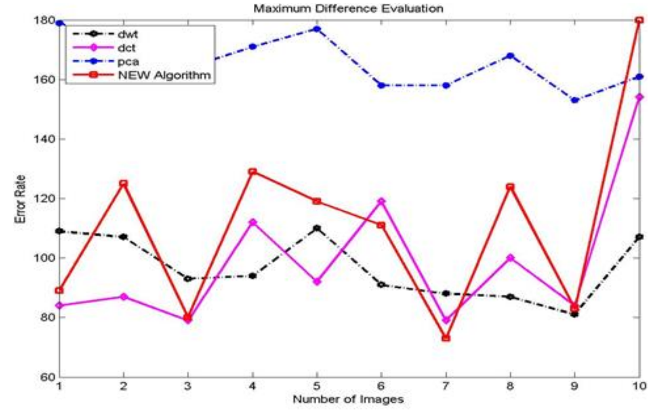
It is very clear from the plot that there is value of SC is close to1in every case by using proposed method over other methods. This represents improvement in the objective quality of the image.

Maximum Difference Evaluation

Table 6.6 is showing the comparative analysis of the Maximum Difference. As Maximum Difference needs to be minimized; so the main objective is to reduce them Maximum Difference as much as possible. Table 6.6 has clearly shown that Maximum Difference is less in most of the cases therefore the proposed algorithm has shown significant results over the available algorithm.

Image name	DWT	DCT	PCA	Proposed algorithm
image1	109	84	179	89
image2	107	87	171	125
image3	93	79	164	80
image4	94	112	171	129
image5	110	92	177	119
image6	91	119	158	111
image7	88	79	158	73
image8	87	100	168	124
image9	81	84	153	83
image10	107	154	161	180

Table 6.6 Maximum Difference Evaluation



Graph 6.6 MD of DWT, DCT, PCA& Proposed Approach for different images

Figure 6.6 has shown the quantized analysis of the Maximum Difference of different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color).

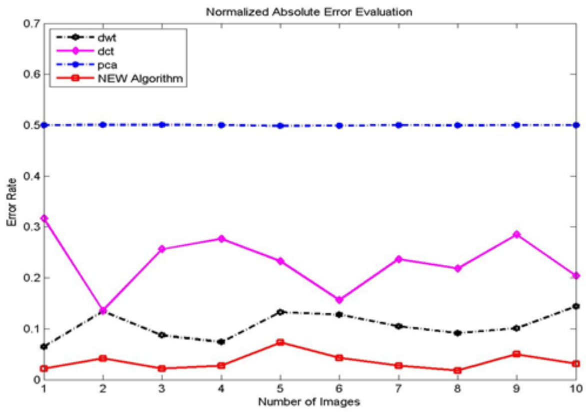
It is very clear from the plot that there is decrease in MD value in some of images with the use of proposed method over other methods. This decrease represents improvement in the objective quality of the image.

Normalized Absolute Error Evaluation

Table 6.7 has shown the quantized analysis of the Normalized Absolute Error. As Normalized Absolute Error needs to be reduced therefore the proposed algorithm is showing the better results than the available methods as Normalized Absolute Error is less in every case.

Image name	DWT	DCT	PCA	Proposed algorithm
image1	0.0647	0.3168	0.5001	0.0214
image2	0.1343	0.1356	0.5008	0.0417
image3	0.0871	0.2563	0.5007	0.0218
image4	0.0738	0.2766	0.5001	0.0274
image5	0.1326	0.2327	0.4988	0.0728
image6	0.1278	0.1565	0.4994	0.0426
image7	0.1050	0.2368	0.5001	0.0275
image8	0.0915	0.2185	0.4999	0.0177
image9	0.1009	0.2848	0.5004	0.0501
image10	0.1442	0.2038	0.5003	0.0312

Table 6.7 Normalized Absolute Error Evaluation



Graph 6.7 NAE of DWT, DCT, and PCA & Proposed Approach for different images

Figure 6.7 has shown the quantized analysis of the Normalized Absolute Error of different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color).

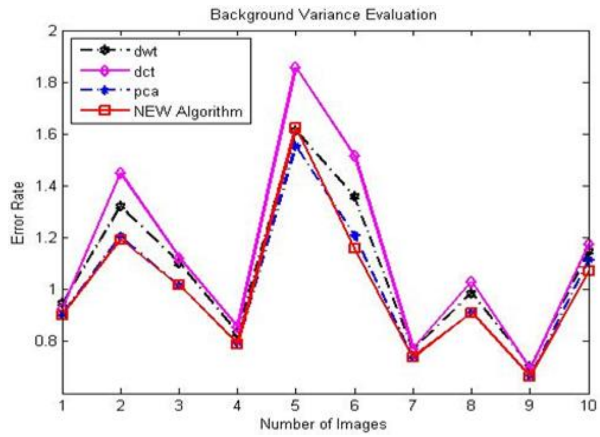
It is very clear from the plot that there is decrease in NAE value of images with the use of proposed method over other methods. This decrease represents improvement in the objective quality of the image.

Background Variance Evaluation

Table 6.8 has shown the quantized analysis of the Background variance. As Background variance needs to be reduced therefore the proposed algorithm is showing the better results than the available methods as Background variance is less in every case.

Image name	DWT	DCT	PCA	Proposed algorithm
image1	0.9474	0.9258	0.9023	0.9010
image2	1.3214	1.4482	1.2060	1.1936
image3	1.1007	1.1224	1.0161	1.0156
image4	0.8318	0.8574	0.7929	0.7902
image5	1.6122	1.8564	1.5527	1.6231
image6	1.3588	1.5173	1.2099	1.1573
image7	0.7675	0.7722	0.7392	0.7381
image8	0.9855	1.0292	0.9108	0.9102
image9	0.7008	0.6953	0.6677	0.6657
image10	1.1475	1.1750	1.1139	1.0706

Table 6.8 Background Variance Evaluation



Graph 6.8 BVE of DWT, DCT, and PCA & Proposed Approach for different images

Figure 6.8 has shown the quantized analysis of the Background Variance of different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color). It is very clear from the plot that there is decrease in BV value of images with the use of proposed method over other methods. This decrease represents improvement in the objective quality of the image.

Detailed Variance Evaluation

Table 6.9 has shown the quantized analysis of the detailed variance. As detailed variance needs to be maximize therefore the proposed algorithm is showing the better results than the available methods as detailed variance is maximum in every case.

Image name	DWT	DCT	PCA	Proposed algorithm
image1	21.1107	21.6034	22.1660	22.1965
image2	15.1351	13.8106	16.5839	16.7561
image3	18.1700	17.8189	19.6822	19.6919
image4	24.0435	23.3255	25.2231	25.3086
image5	12.4053	10.7736	12.8812	12.3218
image6	14.7191	13.1810	16.5303	17.2815
image7	26.0578	25.9014	27.0555	27.0981
image8	20.2933	19.4330	21.9593	21.9730
image9	28.5405	28.7646	29.9516	30.0429

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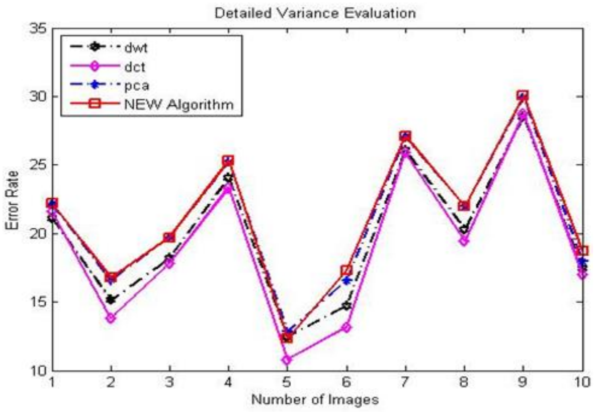
image10	17.4287	17.0219	17.954 5	18.6808

Table 6.9 Detailed Variance Evaluation



Graph 6.9 DVE of DWT, DCT, and PCA & Proposed Approach for different images

Figure 6.9 has shown the quantized analysis of the Detailed Variance of different images using fusion by DWT transform (Black Color), fusion by DCT transform (Magenta Color), fusion by PCA transform (Blue Color), fusion by Proposed Approach (Red Color).

It is very clear from the plot that there is increase in DV value of images with the use of proposed method over other methods. This increase represents improvement in the objective quality of the image.

Conclusion

The image fusion methods using discrete cosine transform (DCT) are considered to be more appropriate and time-saving in real-time systems using still image or video standards based on DCT. But it is found that most of the existing researchers have neglected some of the popular issues of vision processing like image de-noising, image enhancement, and image restoration. So to overcome these problems a new algorithm is proposed in this paper. The proposed work integrates non-linear enhancement, PCA with consistency verification based DCT based fusion technique to give better results than the older techniques. The integrated technique has successfully reduced the limitations of the existing fusion technique. Comparative analysis has shown the significant improvement of the proposed algorithm over the available algorithms.

In near future we will extend this work to use guided filters to enhance the DCT base fusion in more efficient manner. Also to take the full benefits of the proposed algorithm we will extend this work to use it in smart cameras by using the embedded systems. Maximum difference of error has not shown significant results so will modify the proposed algorithm further for enhancing this parameter.

References

[1] *A. Soma Sekhar, Dr.M.N.Giri Prasad. "A Novel Approach Of Image Fusion On MR And CT Images Using Wavelet Transforms." IEEE Trans. on Image Proc., pp. 172-176. IEEE, 2011.*

[2] *Aribi, Walid, Ali Khalfallah, Med Salami Bouhlel, and NoomeneElkadri. "Evaluation of image fusion techniques in nuclear medicine." In Sciences of Electronics, Technologies of Information and Telecommunications (SETIT), 2012 6th International Conference on, pp. 875-880. IEEE, 2012.*

[3] *GintautasPalubinskas and Peter Reinartz. "Multi-resolution, multi-sensor image fusion:general fusion framework." In Joint Urban Remote Sensing Event, 2011 International Conference on, pp. 313-316.IEEE, 2011.*

[4] *Haghighat, Mohammad BagherAkbari, Ali Aghagolzadeh, and HadiSeyedarabi. "Real-time fusion of multi-focus images for visual sensor networks."In Machine Vision and Image Processing (MVIP), 2010 6th Iranian, pp. 1-6.IEEE, 2010.*

[5] *HaozhengRen, YihuaLan, and Yong Zhang. " Research of Multi-Focus Image Fusion based on M- band Multi-Wavelet Transformation." In Fourth International Workshop on Advanced Computational Intelligence,2011International Conference on, pp. 395-398. IEEE,2011.*

[6] *KiranParmar, Rahul Kher. "A Comparative Analysis of Multimodality Medical Image Fusion Methods." In Sixth Asia Modelling Symposium, 2012International Conference on, pp. 93-97. IEEE, 2012.*

[7] *Om Prakash, RichaSrivastava, AshishKhare. "Biorthogonal Wavelet Transform Based Image Fusion Using Absolute Maximum Fusion Rule." In Image processing, 2013 International Conference on Information and Communication Technologies, pp. 577-582.IEEE, 2013.*

[8] *Xing Su-xia□Lian Xiao-feng□Chen Tian-hua, Xiao Hongbing."Image Fusion Method Based on NSCT and Robustness Analysis." In International Conference on Computer Distributed Control and Intelligent*

ISSN: 2277-9655
Impact Factor: 1.852

Environmental Monitoring, 2011,pp. 346-349. IEEE,2011.

[9] *Y.AsnathVictyPhamila, R.Amutha. "Discrete Cosine Transform based fusion of multi-focus images for visual sensor networks." In Signal Processing, 2013 International Conference on, pp.161-170.IEEE, 2013.*

[10] *Y-T. Kim. "Contrast enhancement using brightness preserving bihistogram equalisation." In Consumer Electronics, 1997 International Conference on, vol. 43, pp. 1-8. IEEE, 1997.*