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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. 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 an significant improvement over the existing fusion techniques.

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

1 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 analyze 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.

The discrete wavelet transform has become a very useful tool for fusion. The images used in image fusion should already be registered. Pixel level fusion technique is used to increase the special resolution of the multi-spectral image. 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.

2 Image fusion techniques

In the Image Fusion method the good information from each of the given images is fused together to form a resultant image whose quality is superior to any of the input images. Image fusion method can be broadly classified into two groups i.e

- Spatial domain fusion method
- Transform domain fusion

In spatial domain techniques, we directly deal with the pixel value of an image. The pixel values are manipulated to achieve desired result. In frequency domain methods the pixel value is first transferred in to domain methods by applying dct and dft based fusion methods and further image is enhanced by altering frequency component of an image. Image Fusion applied in every field where images are ought to be analyzed. For example, medical image analysis, microscopic imaging, analysis of images from satellite, remote sensing application, computer vision and battlefield monitoring. The fusion methods such as averaging, Brovey method, principal component analysis (PCA) and IHS based methods fall under spatial domain approaches. Another important spatial domain fusion method is the high pass filtering based technique.

The multi resolution analysis has become a very useful tool for analyzing remote sensing images. The discrete wavelet transform has become a very useful tool for fusion. Some other fusion methods are also there such as Laplacian pyramid based, Curvelet transform based etc. These methods show a better performance in spatial and spectral quality of the fused image compared to other spatial methods of fusion of fusion.

3 Principal Component Analyses (PCA)

PCA is a mathematical tool which transforms a number of correlated variables into a number of uncorrelated variables. The PCA is used extensively in image classification and image compression. The PCA involves a mathematical formula that transforms a number of correlated variables into a number of uncorrelated variables called principal components. It computes a compact and optimal description of the data set. The first principal component accounts for as much of the variance in the data as possible and each succeeding component accounts for as much of the remaining variance as possible. First principal component is taken to be along the direction with the maximum variance. The second principal component is constrained to lie in the subspace perpendicular of the first. Within this Subspace, this component points the direction of maximum variance. The third principal component is taken in the maximum variance direction in the subspace perpendicular to the first two and so on.

4 Discrete Cosine Transform

It is most of the spatial domain image fusion methods are complex and time consuming which are hard to be performed on real-time applications. Moreover, when the source images are coded in Joint Photographic Experts Group (JPEG) standard or when the fused image will be saved or transmitted in JPEG format, the fusion approaches which are applied in DCT domain will be very efficient. To perform the JPEG coding, an image (in color or grey scales) is first subdivided into blocks of 8x8 pixels. The Discrete Cosine Transform (DCT) is then performed on each block. This generates 64 coefficients which are then quantized to reduce their magnitude.

The coefficients are then reordered into a one-dimensional array in a zigzag manner before further entropy encoding. The compression is achieved in two stages; the first is during quantization and the second during the entropy coding process. JPEG decoding is the reverse process of coding. We denote A and B as the output images of two cameras that have been compressed in JPEG coding standard in the sensor agent and further transmitted to fusion agent of VSN. In the case of using spatial domain method these images must be decoded and transferred to spatial domain. Then after applying fusion procedure, the fused image must be coded again in order to be stored or transmitted to an upper node. Tang[4] has considered the above mention issue of complexity reduction and proposed two image fusion techniques in DCT domain, namely, DCT + Average and DCT+ Contrast. DCT +Average is calculated by simply taking the average of all the DCT coefficients of all the input images. This simple method of averaging leads to undesirable side effects including blurring.

In order to reduce the complication for the real-time applications and also enhance the quality of the output image, an image fusion technique in DCT domain. Here, the variance of 8×8 blocks calculated from DCT coefficients is used as a contrast criterion for the activity measure. Then, a consistency verification (CV) stage increases the quality of output image. Simulation results and comparisons show the considerable improvement in the quality of the output image and reduction of computation complexity.

5. 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. Image fusion takes place at three different levels i.e. pixel, feature and decision. 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 multi-resolution analysis has become a very useful tool for analyzing images. A brief summary of the literature is given below:

Patil, U et al. (2011) [9] has focused on image fusion algorithm using hierarchical PCA. Authors described that the Image fusion is a process of combining two or more images (which are registered) of the same scene to get the more informative image. Hierarchical multiscale and multiresolution image processing techniques, pyramid decomposition are the basis for the majority of image fusion algorithms. Principal component analysis (PCA) is a well-known scheme for feature extraction and dimension reduction and is used for image fusion. We propose image fusion algorithm by combining pyramid and PCA techniques and carryout the quality analysis of proposed fusion algorithm without reference image.

We Qiang Wang et al. (2004) [14] has discussed that 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. They mainly discuss the structures of image fusion process, which is classified as hierarchical fusion structure, over-all fusion structure, and arbitrary fusion structure. And the effects of such image fusion structures on the perfo-rmances of image fusion are analyzed. In the experiment, authors explained the typical hyper spectral image data set is fused using the same wavelet transform based image fusion technique, but applying differ-rent fusion structures. The differences among their fused images are analyzed. The experimental results testify the theoretical analysis that the performances of image fusion techniques are related not only to the fusion algorithm, but also to the fusion structures, and different image fusion structures that produces different fusion performance even using the same image fusion method.

Desale, R.P et al. (2013) [2] explained that the Image Fusion is a process of combining the relevant information from a set of images, into a single image, wherein the resultant fused image will be more informative and complete than any of the input images. This paper discusses the Formulation, Process Flow Diagrams and algorithms of PCA (principal Component Analysis), DCT (Discrete Cosine Transform) and DWT based image fusion techniques. The results are also presented in table & picture format for comparative analysis of above techniques. The PCA & DCT are conventional fusion techniques with many drawbacks, whereas DWT based techniques are more favorable as they provides better results for image fusion. In this paper, two algorithms based on DWT are proposed, these are, pixel averaging & maximum pixel replacement approach.

Prakash, C et al. (2012) [11] explained that the Image fusion is basically a process where multiple images (more than one) are combined to form a single resultant fused image. This fused image is more productive as compared to its original input images. The fusion technique in medical images is useful for resourceful disease diagnosis purpose. This paper illustrates different multimodality medical image fusion techniques and their results assessed with various quantitative metrics. Firstly two registered images CT (anatomical information) and MRI-T2 (functional information) are taken as input. Then the fusion techniques are applied onto the input images such as Mamdani type minimum-sum-mean of maximum(MIN-SUM-MOM) and Redundancy Discrete Wavelet Transform (RDWT) and the resultant fused image is analyzed with quantitative metrics namely Over all Cross Entropy(OCE),Peak Signal –to- Noise Ratio (PSNR), Signal to Noise Ratio(SNR), Structural Similarity Index(SSIM), Mutual Information(MI). From the derived results it is inferred that Mamdani type MIN-SUM-MOM is more productive than RDWT and also the proposed fusion techniques provide more information compared to the input images as justified by all the metrics.

Aribi, W et al. (2012) [1] explained that the quality of the medical image can be evaluated by several subjective techniques. However, the objective technical assessments of the quality of medical imaging have been recently proposed. The fusion of information from different imaging modalities allows a more accurate analysis. We have developed new techniques based on the multi resolution fusion. MRI and PET images have been fused with eight multi 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.

Mohamed, M et al. (2011) [7] has define the Image fusion is a process which combines the data from two or more source images from the same scene to generate one single image containing more precise details of the scene than any of the source images. Among many image fusion methods like averaging, principle component analysis and various types of Pyramid Transforms, Discrete cosine transform, Discrete Wavelet Transform special frequency and ANN and they are the most common approaches. In this paper multi-focus image is used as a case study. This paper addresses these issues in image fusion: Fused two images by different techniques which present in this research, Quality assessment of fused images with above methods, Comparison of different techniques to determine the best approach and Implement the best technique by using Field Programmable Gate Arrays (FPGA). First a brief review of these techniques is presented and then each fusion method is performed on various images. In addition experimental results are quantitatively evaluated by calculation of root mean square error, entropy; mutual information, standard deviation and peak signal to noise ratio measures for fused images and a comparison is accomplished between these methods. Then we chose the best techniques to implement them by FPGA.

Haghighat, M et al. (2010) [4] has explained that the image fusion is a technique to combine information from multiple images of the same scene in order to deliver only the useful information. The discrete cosine transformation (DCT) based methods of image fusion are more suitable and time-saving in real time system. In this paper an efficient approach for fusion of multi-focus images based on variance calculated in DCT domain is presented. The experimental results shows the efficiency improvement of our method both in quality and complexity reduction in comparison with several recent proposed techniques.

Pei, Y et al. (2010) [10] explained that this paper proposes an improved discrete wavelet framework based image fusion algorithm, after studying the principles and characteristics of the discrete wavelet framework. The improvement is the careful consideration of the high frequency subband image region characteristic. The algorithms can efficiently synthesis the useful information of the each source image retrieved from the multi sensor. The multi focus image fusion experiment and medical image fusion experiment can verify that our proposed algorithm has the effectiveness in the image fusion. On the other side, this paper studies the quality assessment of the image fusion, and summarize and quantitatively analysis the performance of algorithms proposed in the paper.

Li, H et al. (1995) [6] has discussed that in this paper, the wavelet transforms of the input images are appropriately combined, and the new image is obtained by taking the inverse wavelet transform of the fused wavelet coefficients. An area-based maximum selection rule and a consistency verification step are used for feature selection. A performance measure using specially generated test images is also suggested.

He, D et al. (2004) [5] explained that the The main objective of image fusion is to create a new image regrouping the complementary information of the original images. The challenge is thus to fuse these two types of images by forming new images integrating both the spectral aspects of the low resolution images and the spatial aspects of the high resolution images. The most commonly used image fusion techniques are: Principal Components Analysis (PCA), Intensity-Hue-Saturation Transformation (IHS), High Pass Filter (HPF) and Wavelet Transformation (WT). The PCA and IHS, are simple to use but they are highly criticized because the resulting image does not preserve faithfully the colors found in the original images. The HPF method is sensitive to the filtering used (filtering type, filter window size, etc.) and the mathematical operations used. The WT approach is very often reported in the literature, but it's procedure is based on a complex and sophisticated pyramidal transformation where the result also depends on the level of decomposition and the filtering technique used to construct the wavelet coefficients.

Y-T, K et al. (1997) [15] has discussed in this paper the Histogram equalization is widely used for contrast enhancement in a variety of applications due to its simple function and effectiveness. Examples include medical image processing and radar signal processing. One drawback of the histogram equalization can be found on the fact that the brightness of an image can be changed after the histogram equalization, which is mainly due to the flattening property of the histogram equalization.

T.Zaveri, M et al. (2009) [13] explained that the Image fusion is a process of combining multiple input images of the same scene into a single fused image, which preserves relevant information and also retains the important features from each of the original images and makes it more suitable for human and machine perception. In this paper, a novel region based image fusion method is proposed. In literature shows that region based image fusion algorithm performs better than pixel based fusion method. Proposed algorithm is applied on large number of registered images and results are compared using standard reference and no reference based fusion parameters.

O, R et al. (1997) [8] has discussed a novel approach for the fusion of spatially registered images and image sequences. The fusion method incorporates a shift invariant extension of the discrete wavelet transform, which yields an overcomplete signal representation. The advantage of the proposed method is the improved temporal stability and consistency of the fused sequence compared to other existing fusion methods. We further introduce an information theoretic quality measure based on mutual information to quantify the stability and consistency of the fused image sequence.

Ghimire, D et al. (2011) [3] has discussed that the main objective of image enhancement is to improve some characteristic of an image to make it visually better one. This paper proposes a method for enhancing the color images based on nonlinear transfer function and pixel neighborhood by preserving details. In the proposed method, the image enhancement is applied only on the V (luminance value) component of the HSV color image and H and S component are kept unchanged to prevent the degradation of color balance between HSV components. The V channel is enhanced in two steps. First the V component image is divided into smaller overlapping blocks and for each pixel inside the block the luminance enhancement is carried out using nonlinear transfer function. In the second step, each pixel is further enhanced for the adjustment of the image contrast depending upon the center pixel value and its neighbourhood pixel values. Finally, original H and S component image and enhanced V component image are converted back to RGB image.

Sruthy, S et al. (2013) [12] has focused on the development of an image fusion method using Dual Tree Complex Wavelet Transform. The results show the proposed algorithm has a better visual quality than the base methods. Also the quality of the fused image has been evaluated using a set of quality metrics.

6. Experimental set-up & Results

A. Research methodology

To attain the objective, step-by-step methodology is used in this paper. Subsequent are the different steps which are used to accomplish this work. As mentioned earlier the main focus is on integrating the Consistency Verification (CV) based DCT fusion using the PCA and non-linear enhancement. Following are the various steps used to accomplish the objectives of the dissertation.

The steps are as follows:

Step 1: Input images: Input 2 images image 1 and image 2 in which image1 is left blurred and image 2 is right blurred.

Step 2: RGB2PCA: Now RGB to PCA conversion will be done based upon the certain vector values. Also division of each PCA image will also be done into PCA1, PCA2 and PCA3.

Step3: Apply CV-DCT based fusion: The next step is to apply CV-DCT based fusion on first PCA as highest variations found on the first PCA plane. And chrominance fusion will come in action for other PCA planes i.e. PCA2 and PCA3.

Step4: Concatenation: Now concatenate the result of each plane and get the fused image.

Step5: Non-linear enhancement: Now non-linear enhancement will come in action to preserve the brightness of the fused image.

B. 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. Table 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 1 Images taken for experimental analysis

Image name	Format	Size: Partially blurred 1	Size : 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

For the purpose of cross validation we have taken 10 different images and passed to proposed algorithm. Subsequent section contains a result of one of the 10 selected images to show the improvement of the proposed algorithm over the other technique.

C. Experimental Results

Figure 1 has shown the input images for experimental analysis. Fig.1 (a) is showing the left blurred image and fig.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 1(a) Left blurred image

Figure 1(b). Right blurred image

Figure 2. DWT based image fusion

Figure 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.

Figure3. DCT based image fusion

Figure 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 4. PCA based image fusion

Figure 5. Final proposed image

Figure 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 has shown the output image taken by the 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.

7. 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.

Table 2 has shown 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.

Table 2 Mean Square Error Evaluation

Image	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 3 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 3 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.

Table 3 Peak Signal To Noise Ratio Evaluation

Image	DWT	DCT	PCA	Proposed algorithm
image1	54.5734	32.3934	24.4570	64.2853
image2	38.3393	35.7343	16.8438	50.5532
image3	47.7830	32.3645	21.1696	64.5547
image4	50.6345	33.6457	23.0273	62.1757
image5	39.5392	30.6718	18.5553	48.0478
image6	38.9604	34.4325	17.5033	51.8916
image7	47.5015	35.6134	23.2192	63.2283
image8	46.1536	34.0485	20.3794	64.3267
image9	50.7683	35.1137	25.2934	60.1651
image10	40.8714	35.3883	20.6752	57.5898

Table 4 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.

Table 4 Normalized Cross-Correlation Evaluation

Image	DWT	DCT	PCA	Proposed algorithm
image1	0.9363	1.3012	0.4989	0.9980
image2	0.8734	1.0856	0.4985	0.9979
image3	0.9084	1.2209	0.4990	0.9980
image4	0.9290	1.2347	0.4986	0.9964
image5	0.8837	1.1964	0.4987	1.0389
image6	0.8740	1.1035	0.4998	0.9914
image7	0.8951	1.2059	0.4996	0.9985
image8	0.9018	1.1763	0.5004	0.9998
image9	0.9145	1.2476	0.4981	0.9967
image10	0.8573	1.1821	0.4992	0.9910

Table 5 is showing the comparative analysis of the Structural Content. As SC need 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.

Table 5 Structural Content Evaluation

Image	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	0.7091	4.0035	1.0147

Table 6 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.

Table 6: Normalized Absolute Error Evaluation

Image	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 7 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 7 has clearly shown that Average Difference is less in our case therefore the proposed algorithm has shown significant results over the available algorithm.

Table 7 Average Difference Evaluation

Image	DWT	DCT	PCA	Proposed algorithm
image1	5.4463	-34.1605	54.3077	-0.0089
image2	19.8204	-21.6783	88.7193	-0.0189
image3	10.1252	-34.1009	67.3523	-0.0139
image4	5.9595	-31.0789	56.7556	-0.0308
image5	17.3406	-37.7623	82.3709	-8.3237
image6	18.8087	-24.9806	85.7172	2.2422
image7	10.1564	-25.4655	55.2988	0.0288
image8	11.3062	-29.7548	69.1999	0.0618
image9	6.1149	-26.0716	47.1729	0.0156
image10	19.2185	-27.8964	70.6153	2.0004

Table 8 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 8 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.

Table 8 Maximum Difference Evaluation

Image	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

Figure 6 has shown 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.

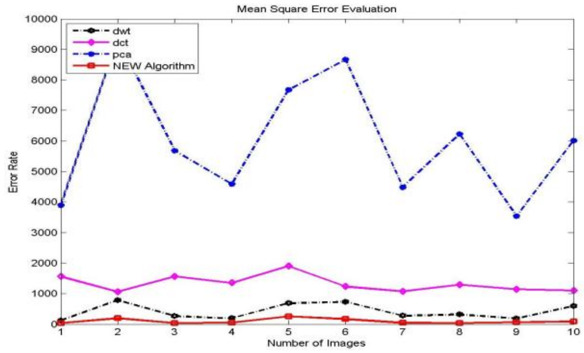

Figure 6. Mean Square Error

Figure 7 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 3 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.

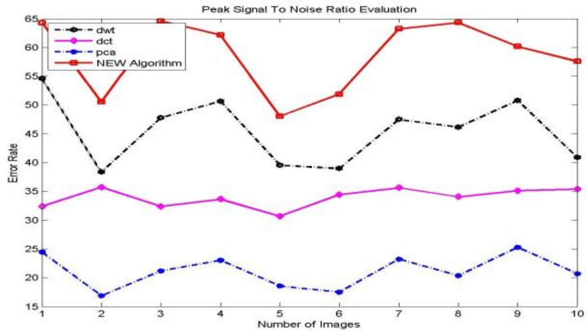

Figure 7. Peak signal to noise ratio

Figure 8 is showing the comparative analysis of the Normalized Cross-Correlation (NCC). As NCC need 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.

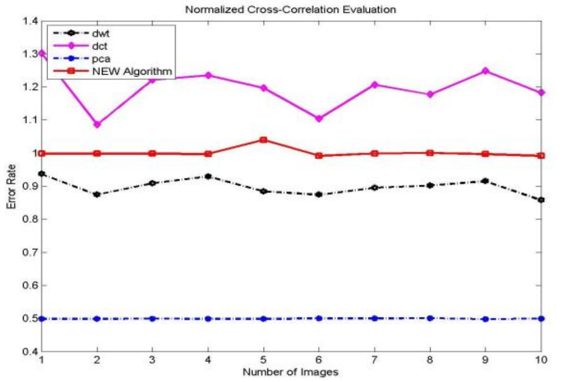

Figure8. Normalized Cross-Correlation

Figure 9 is showing the comparative analysis of the Structural Content. As SC need 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.

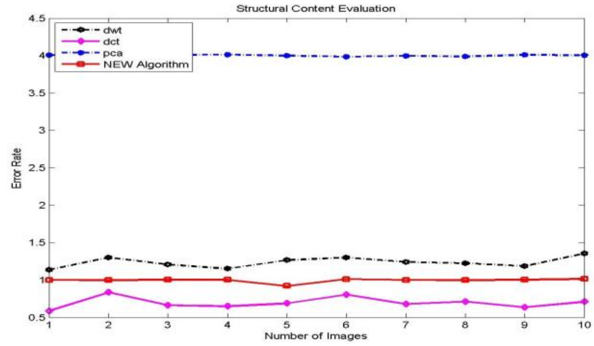

Figure 9. Structural Content

Figure 10 has shown the quantized analysis of the Normalized Absolute Error . As Normalized Absolute Error need 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.

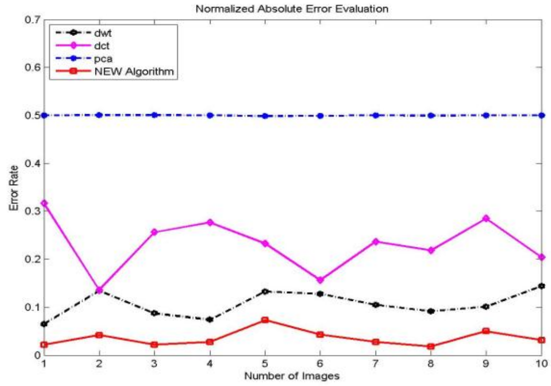

Figure 10. Normalized Absolute Error

Figure 11 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 7 has clearly shown that Average Difference is less in our case therefore the proposed algorithm has shown significant results over the available algorithm.

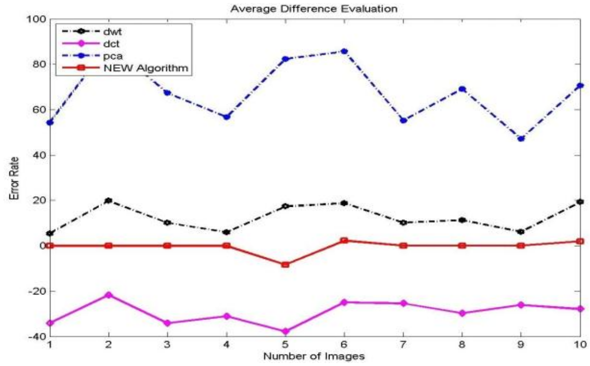

Figure 11 Average difference

Figure 12 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 8 has clearly shown that Maximum Difference is less in the most of the cases therefore the proposed algorithm has shown significant results over the available algorithm.

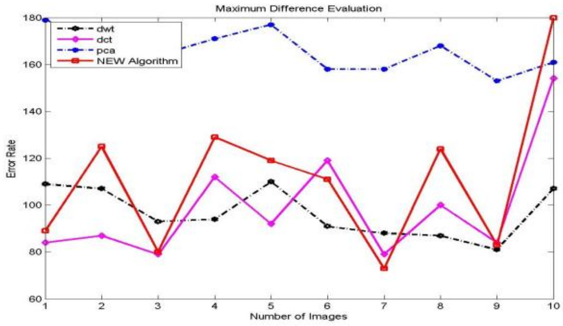

Figure 12.Maximum difference

7. 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.

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