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An Appraisal of Different Image Fusion Techniques Used for Energy Salvation of Wireless Visual Sensor Networks

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Abstract: **This paper presents an appraisal of different image fusion techniques used for energy salvation of wireless visual sensor networks. The *image fusion is going to be the part of* the important techniques in *image* processing. Many *image fusion* methods have been discovered in a number of applications. Image fusion amalgamates the information from the several images of one scene to obtain an enlightened image which is much better for human visual perception or additional vision processing.Image focus is related to the quality of the image. Many *image fusion* methods have been discovered to conserve the energy of wireless visual sensor networks. The main objective of image fusion is to combine the information from multiple images of same scene in order to transfer only the useful information. The discrete cosine transforms (DCT) based methods of image fusion are more suitable for the energy conservation of wireless visual sensor networks and time-saving in real-time systems using the DCT based standards of the image of still scene.**

Keywords: image fusion; discrete cosine transformation; wavelet transformation; principle component analysis; multi-focus images

1. INTRODUCTION

Image fusion is a technique of merging the useful information from two or more images into a single image. Comparatively, the fused image is more useful for computer processing task than any other input images. Image fusion brings information of interest from two or more images of the same scene into a single highly informative image. The objectives of an image fusion extract all the useful information from the source images without introducing artifacts or inconsistencies. Image fusion is useful technique for merging similar sensor and multi-sensor images to enhance the information. The purpose of image fusion is to combine information from multiple images of the same scene in order to transfer only the useful information. The image fusion methods which are based upon the discrete cosine transforms (DCT) are more suitable and time saving in real-time systems using DCT based standards of still image or video.

There are many situations in which a single image cannot be able to represent the scene properly. More than one sensors are used to capture the scenes in such situations, but human and machine dispensation is better suited with a single image, hence fused images are obtained from the different sensors which contain only the relevant information of source images. So we can say that, Image fusion combines all the relevant information contained in the different images into a single composite image. Image fusion can be applied according to signal level, pixel level, feature level, decision and symbol level.

The right blurred image has been shown in fig 1. That means camera has been focused on its left hand side during the capturing of image. Fig. 2 is showing the left blurred image part. That means camera has been focused on its right hand side during the capture of image. Fig 3 is shown the fused image in which the blurred part has been removed by fusing the Fig 1 and Fig.2 It is clearly shown that the fused image contain more information than the normal one.

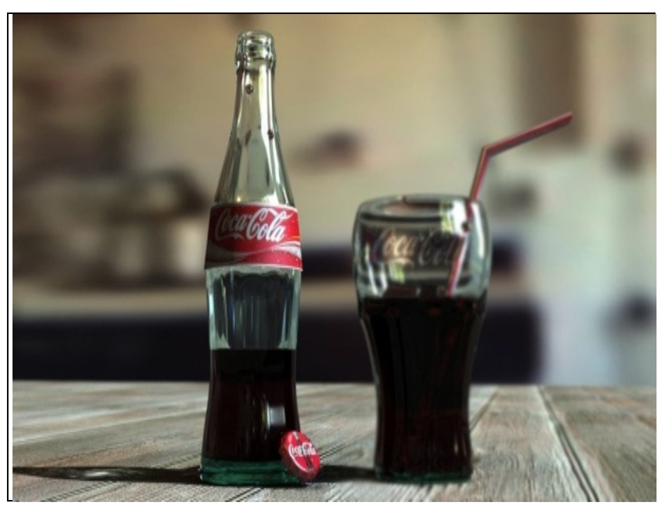

Fig. 1. Right blur image

Fig. 2. Left blur image

Fig. 3. Fused image

The spatial and spectral resolution of the remote sensors has been significantly enhanced with the development of the technology of modern remote sensing which leads to the variety and complexity of data sources. Various image fusion algorithms such as intensity-hue-saturation (IHS) transform, principal component analysis (PCA), discrete wavelet transform (DWT) and discrete cosine transform (DCT), etc had introduced.

2. VISUAL SENSOR NETWORKS (VSN)

VSN is the term used in the literature to refer to the system with a large number of cameras, geographically swell resources and many of the monitoring points. A visual sensor network is a network of spatially distributed smart camera devices capable of the processing and fusing of the images of a same scene from the variety of viewpoints into some form more useful than the individual images. Due to this more local processing is needed to transfer only the useful information represented in a conceptualized level. Visual sensor networks (VSNs) are the most useful in applications involving area surveillance, tracking, and the environmental monitoring. According to the process of the Image fusion, the superior 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.

Fig. 4 has shown the architecture of the VSNs. VSNs contain a sink also called the base station and also different cameras which captures a scene from various parts.

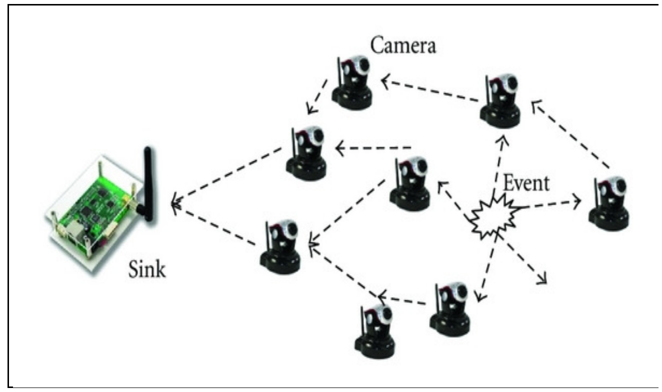

Fig. 4: VSN Architecture

3. IMAGE FUSION TECHNIQUES

In the Image Fusion method is the method in which useful 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 generally classified into two following categories i.e.

- Spatial domain fusion method
- Transform domain fusion

In spatial domain techniques, we directly deal the image with the value of pixels. The pixel values are manipulated to achieve the required result. In frequency domain methods the pixel value is first transferred in to the domain methods by applying the DCT and DFT based fusion methods and the further image is enhanced by altering the frequency constituent of an image. Image Fusion applied in every field where images are allowed to be analyzed. Some other fusion methods are also present such as Laplacian pyramid based, Curvelet conversion based etc.

3.1 Principal Component Analyses (PCA)

PCA is a mathematical tool which is used for the transformation of a number of correlated variables into a number of uncorrelated variables. The PCA involves a mathematical formula that is used for the transformation of a number of correlated variables into a number of uncorrelated variables called principal components. First principal component is taken to be along with the direction with the maximum variance. The second principal component is guarded to lie in the subspace which is perpendicular of the first. Within this Subspace, this constituent points toward the direction of utmost variance. The third principal component is taken in the maximum variance direction in the subspace which is perpendicular to the first two and so on.

3.2 Discrete Wavelet Transform

Wavelet transform is the method in which a signal is totally decomposed into two wavelets, one is higher level and another one is lower level. The coefficients of these two filters are further calculated by the mathematical formula and again this can be decomposed. The depth or decomposition performed is chosen according to the application purpose or use only. If level of decomposition is higher, then there is the chance for the lower band overlapping. The low- frequency component habitually contains most of the contents of the signal or can say the informative part i.e. lower frequency contains most of the valuable information, so it is known as the approximation frequency band. The high frequency component contains only the details of the signal. Further fusion can take place through biorthogonal and orthogonal wavelets.

3.3 Biorthogonol Wavelet Transform

In many filtering applications we need filters with symmetrical coefficient to achieve linear phase. None of the orthogonal wavelet systems, except Haar, have symmetrical coefficients. Biorthogonal wavelet system can be premeditated to achieve symmetry property and exact reconstruction by using two wavelet filters and two scaling filters instead of one. Biorthogonal family contains biorthogonal compactly supported spline wavelets. With these wavelets symmetry and perfect reconstruction is possible using FIR (Finite Impulse Response) filters, which is unfeasible for the orthogonal filters (except for the Haar filters). The biorthogonal family uses separate wavelet and scaling functions for the analysis and synthesis of image. The reverse biorthogonal family uses the synthesis functions for the analysis and vice versa. As exposed below in Fig.5

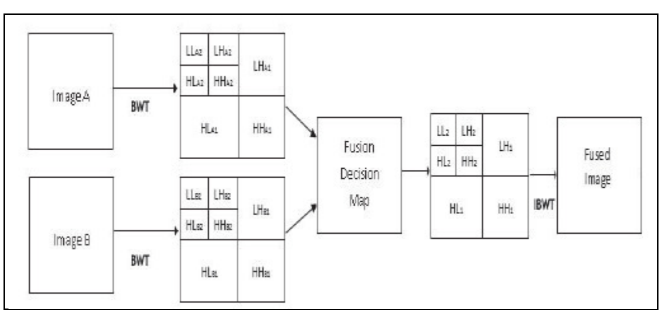

Fig.5 Block diagram of biorthogonal wavelet transform [10]

Suppose I1(x, y) and I2(x, y) are the two images to be fused and their wavelet coefficients are W1(m, n) and W2(m, n) respectively, then Absolute Maximum Selection Fusion Rule is used to combine wavelet coefficients as in (1)

$$W(m, n) = \begin{cases} W_1(m,n), if\ |W_1(m,n)| \geq |W_2(m,n)| \\ W_2(m,n), if |W_2(m,n)| > |W_1(m,n)| \end{cases} \quad (1)$$

3.4 Discrete Cosine Transform

It is most of the spatial domain image fusion methods which are complex and the time consuming which are also difficult to be performed in the real-time applications.To perform the JPEG coding, an image is first subdivided into the blocks of 8x8 pixels. The Discrete Cosine Transform (DCT) is then performed on each of the block. This generates 64 coefficients which are then quantized for the reduction of their magnitude.

The coefficients are then reordered into a one-dimensional array in a zigzag manner before the further entropy encoding. The compression is performed in two parts, the first is during the quantization and the second is during the entropy coding process. Reverse process of coding is known as JPEG decoding and further transmitted to the fusion agent of VSN. For the second technique called DCT + Contrast, fusion criterion or activity level is based on a measure of contrast which is calculated for every 63 AC coefficients of the blocks from the source images. Then the comparison of contrast measures of each coefficient in source images take place. Then the coefficient with the highest contrast rate is selected. The DCT block of the output image is made up of the AC coefficients with the highest contrast in the comparison procedure. This algorithm is also little complexive in calculating the contrast measure for each coefficient. Furthermore, it suffers from the side effects including blocking artifacts due to the manipulation in the diverse selection of the DCT coefficients.

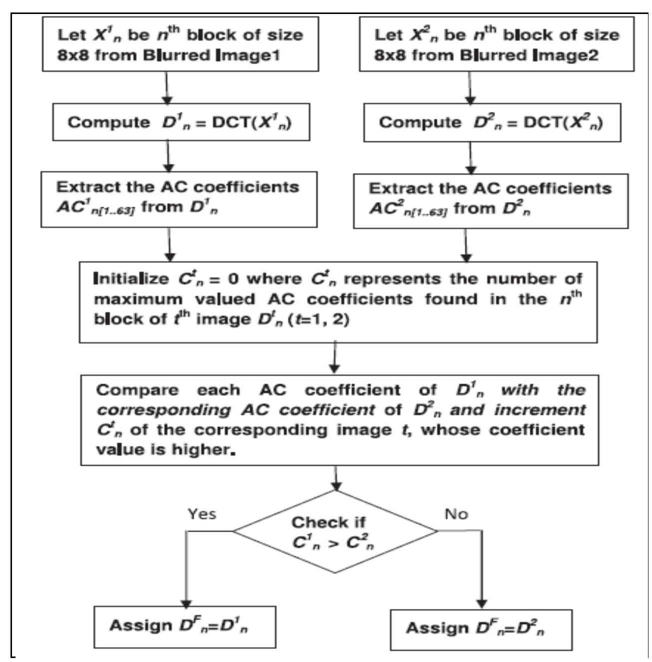

Fig.6. Flowchart for AC_Max Fusion Rule [8]

The variance of 8×8 blocks calculated from DCT coefficients is used as the criteria for contrast for the activity measure. Then, a consistency verification (CV) stage improves the quality of output image. Simulation grades and comparisons show the considerable improvement in the quality of the output image and reduction of computation complexity. As shown below in Fig.6

4. RELATED WORK

Jianfei Cai and Chang Wen Chen in 2000 [1] contributed towards bridging the gap between image transmission and wireless channels. They presented a fixed length Robust Joint Source Channel Coding (RJSCC) scheme for transmitting images over wireless channels. Their experimental results show that the Robust Joint Source Channel Coding (RJSCC) Scheme is able to achieve very good Peak Signal to Noise Ratio (PSNR) performance and perceptual quality with modest complexity. They showed that the Robust Joint Source Channel Coding (RJSCC) Scheme is more robust to channel mismatches.

R.S. Dilmaghani et. al. in 2004 [2] presented an infrastructure for progressive transmission and compression of medical images, which can distil an initial image by increasing the detail information not only in scale-space, but also in coefficient precision. They proposed an application of the Embedded Zero tree Wavelet algorithm in progressive medical image transmission in which it control both the resolution constraint and rate constraint. They used Progressive image transmission (PIT) which is defined as a class of image transmission techniques where the information of the image is transmitted in several successive stages. Their results show that the compression performance obtained by the EZW is superior over JPEG-2000, especially at higher compression ratios.

Catalina Cocianu, Luminita State and Panayiotis Vlamos in 2009, [3] worked on image compression and noise removal. Principal Component Analysis is a well known statistical method for feature extraction. They introduced the algorithms Generalized Multiresolution Noise Removal (GMNR) and Noise Feature Principal Component Analysis (NFPCA). They concluded that there are no significant differences between the proposed algorithms and similar currently used algorithms from the computational complexity point of view and the relative complexity tested against some currently used methods being formulated on experimental basis, mainly on measurements on run time performance. The tests were performed on monochrome images only.

Reeta Charde in July 2012 [4] conducted an analysis of image performance over Additive White Gaussian Noise (AWGN) channel with the help of phase shifting key (PSK) modulation. They compared the performance of normal image and compressed image over Additive White Gaussian Noise (AWGN) channel. They concluded that with increase in signal to noise ratio (SNR) values bit error rate BER & root mean square (RMSE) value decreases and peak signal to noise ratio (PSNR) increases with Additive White Gaussian Noise (AWGN) channel. But root mean square (RMSE) & peak signal to noise ratio (PSNR) values remain constant for without AWGN channel.

Puneeth S. and Dr. Fathima Jabeen in 2012 [5] aimed for the optimized transmission of images over coded Orthogonal Frequency Division Multiplexing (OFDM) over Additive White Gaussian Noise (AWGN) channel using Low Density Parity Check (LDPC) coding. The Discrete Wavelet Transform (DWT) based Set Partitioning in Hierarchical Trees (SPIHT) algorithm is used for source coding of the images to be transmitted. They concluded the improvement in the effectiveness of the system which is investigated through simulations over AWGN channel. Their project can be extended to video coding using 3D Set Partitioning in Hierarchical Trees (SPIHT) coding.

J. Abirami et al. in 2013 [6] conducted the performance analysis of different wavelet function for compression of Images using Wavelet Thresholding. They concluded that local thresholding provides better reconstruction of image than Global thresholding, higher compression ratio can be achieved through high level of decomposition, Biorthogonal transform is more effective, better compression ratio and low peak signal to noise ratio (PSNR) as compared to Haar transform. Mohammad Bagher Akbari Haghighat et al. in 2010 [7] has proposed an efficient approach for fusion of multi-focus images based on variance calculated in DCT domain. They worked on the parameters like DCT Variance, Quality and Complexity. It was more efficient than the other methods when the source images are in JPEG format or the fused image is saved or transmitted in JPEG format, principally in visual sensor networks.

R. Amutha et al in 2013 [8] presented a simple and efficient multi-focus image fusion scheme explicitly designed for wireless visual sensor systems equipped with resource constrained, battery powered image sensors employed in various fields. The fusion of multi-focus images is based on higher valued Alternating Current (AC) coefficients calculated in Discrete Cosine Transform (DCT) domain. They worked on parameters like image quality and energy conservation. The experimental results verified the significant efficiency improvement of the proposed method in output quality and energy consumption, when compared with other fusion techniques in DCT domain.

Dr. V.Vaidehi et al. in 2013 [9] presented a novel method for adaptive fusion of multimodal surveillance images based on Non-Subsampled Countourlet Transform (NSCT).In order to reduce the energy and bandwidth used in transmission, the proposed method used Compressive sensing (CS) which could compress the input data in the sampling process efficiently. The reconstructed input images are fused using an adaptive algorithm based on NSCT in a centralized server. Mutual information is more through the proposed technique. Value of Petrovic Metric is improved through the proposed technique. Bandwidth conservation is good through the proposed method. Prakash et al. in 2013 [10] proposed a pixel-level image fusion scheme using multi-resolution Biorthogonal wavelet transform (BWT).Wavelet coefficients at different decomposition levels are fused using absolute maximum fusion rule. The results have been extensively tested on several pairs of multifocus and multimodal images both free from any noise and in presence of AWGN. Experimental results have shown that the proposed method has improved fusion quality by reducing loss of significant information available in entity images. Fusion factor, entropy and standard deviation are used as quantitative quality measures of the fused image.

5. GAPS IN EARLIER WORK

By conducting the review it has found that the existing literature has neglected at least one of the following:

1) As most of the existing methods are based upon therefore it may results in some colour artefacts which may reduce the performance of the transform based image fusion methods and conserve more energy of the wireless visual sensor networks.
2) It is also found that the problem of the uneven illuminate has also been neglected in the most of existing literature on fusion.
3) The use of the Energy salvation has also been neglected to reduce the noise which may be in the output image due to transform domain methods or during capturing time.

6. POSSIBLE SOLUTION

Image fusion integrates the useful information from the number of images of the same scene to attain an informative image which is more suitable for vision processing applications.Image efficiency or image quality is closely associated to image focus and the noise present is closely related to the energy conservation.The image fusion is becoming one of the major pre-processing techniques in the field of image processing in visual sensor networks. Many image fusion methods have been developed in the various vision methods. The discrete cosine transforms (DCT) based approaches are more appropriate for the image fusion and time saving in actual real time systems. So in order to overcome this problem one integration of well-known fog removal technique “dark channel prior method” to enhance the results further and also to remove the colour artefacts.

7. CONCLUSION

This paper has presented a related work of the different image fusion techniques used for the energy salvation of visual sensor networks. The main aim of image fusion process is to do fusion in the images of multi-focus cameras to integrate the information from several pictures of the identical scene in order to transfer only the multi focused image. The Discrete Cosine Transform (DCT) domain based methods of image fusion are proved to be more suitable and time-saving in real-time systems for still images or videos. In this paper an proficient approach for the fusion of multi-focus images based on variance calculated in DCT domain has been also studied. We have found that in the existing literature has the problem of noise has been neglected which will be presented in fused image due to integration of two images.

So in near future we will propose a new technique which will integrate modified DCT to enhance the fusion superiority further. No implementation has been done in this work till now, so in near future to validate the proposed work MATLAB tool will also be used for experimental purpose.

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