Multifocus Images Fusion Based On Homogenity and Edges Measures

Heba K.Abbas*   *Ali A. Al-Zuky***   *Anwar H.Mahdy****

Abstract:

Image fusion is one of the most important techniques in digital image processing, includes the development of software to make the integration of multiple sets of data for the same location; It is one of the new fields adopted in solve the problems of the digital image, and produce high-quality images contains on more information for the purposes of interpretation, classification, segmentation and compression, etc. In this research, there is a solution of problems faced by different digital images such as multi focus images through a simulation process using the camera to the work of the fuse of various digital images based on previously adopted fusion techniques such as arithmetic techniques (BT, CNT and MLT), statistical techniques (LMM, RVS and WT) and spatial techniques (HPFA, HFA and HFM). As these techniques have been developed and build programs using the language MATLAB (b 2010). In this work homogeneity criteria have been suggested for evaluation fused digital image's quality, especially fine details. This criterion is correlation criteria to guess homogeneity in different regions within the image by taking a number of blocks of different regions in the image and different sizes and work shifted blocks per pixel. As dependence was on traditional statistical criteria such as (mean, standard deviation, and signal to noise ratio, mutual information and spatial frequency) and compared with the suggested criteria to the work. The results showed that the evaluation process was effective and well because it took into measure the quality of the homogenous regions.

Keywords: Image fusion techniques; Quality evaluation measurements

Introduction:

Many algorithms and image fusion software's are developed in recent years using various approaches for various applications. The actual fusion process can takeplace at different levels of information representation; a generic categorization is to consider the different levels as, sorted in ascending order of abstraction: signal, pixel, feature and symbolic level. The lowest possible technique in image fusion is the pixel level, is called as nonlinear method, in which the intensity values of pixels of the source images are used for merging the images. The next level is the feature level, which operates on characteristics such as size, shape, edge etc. The next highest level called decision level fusion deals with symbolic representations of the images [1]. Currently, most of the image fusion has been performed using pixel based methods [2,3]. A new multi-focus image fusion algorithm, which is on the basis of the Ratio of Blurred and Original Image Intensities, was proposed see [4]. A multi-focus image fusion method using spatial frequency was proposed see [5].The advantage of the pixel level image fusion is that images contain original information. Furthermore it is easy to implement. Image fusion methods based on

*Lucture, Dept. of Physics, College of Science for women, Baghdad Un.
**Professor, Dept. of Physics, College of Science Dept. Al-Mustansiriyah Un.
***Assesent Lucture, Dept. of Computer, College of Science Dept. Al-Mustansiriyah University.

wavelet transform have been widely used in recent years. A simple image fusion Algorithm based on wavelet transform is proposed in reference [6].This paper discusses the different image fusion of multi focus images using the different fusion techniques like BT ,CNT,MLT,HFA,HFM,HPFA,RVS,LMM and WT. Section 2 gives a review of the some excite quality measurements. The experimental results are discussed in section 3. At the end of the section 3 performance assessment is discussed.

Depth of Field

Depth of field refers to the region of proper focus that is available in any photographic image. When the camera is focused, it is not possible to get a paper-thin region of proper focus in an image; instead, there's some distance in front and behind the subject that will also be in focus. This entire region of sharp focus is called the depth of field, or sometimes the depth of focus. The region that is out of depth of field will be blurry. There are three factors determining the depth of field [7]:

- **Aperture** which means the size of the lens opening that determines how much light
Reaches camera's imaging sensor.

- **Focal length** is the second factor which means a measure of the lens's ability to magnify a scene.

- **Subject distance** is the distance from the subject determines how much depth of field can be
Obtained in the scene. These three factors work together in any shooting situation. Hence, depth
of field is an extremely important element in the overall composition of photographs. Using depth of field, a subject can be isolated by making sure it is the only sharply focused

person or object in the frame. Alternately, depth of field can be increased to make the entire image. From foreground to background as sharp as possible [7].

Image Fusion Techniques:

Information fusion has long been studied in various areas of computer science and engineering,
and the number of applications for this class of techniques has been steadily growing. Image fusion is the process of combining images from two or more sources into highly informative fused image. The objective of image fusion is to increase information for later processing or applications of these images. Image fusion techniques can be divided into three levels, namely: pixel level, feature level and decision level of representation [8]. The image fusion techniques based on pixel can be grouped into several techniques depending on the tools or the processing methods for image fusion procedure. The technology of image fusion was developed at the same time with the computers development. In recent years there has been a growing interest in image fusion processing to increase the capability of the intelligent machines and systems. In this work proposed categorization scheme of image fusion techniques Pixel based image fusion methods summarized as the fallowing:

 a. Arithmetic Combination techniques: such as Bovey Transform (BT) [9]; Color Normalized Transformation (CN) [10]; Multiplicative Method (MLT) [11].

b. Frequency Filtering Methods :see [12]such as High-Pass Filter Additive Method (HPFA) , High –Frequency-Addition Method (HFA) , High Frequency Modulation Method (HFM)

and The Wavelet transform-based fusion method (WT).

c. Statistical Methods: see [13] such as Local Mean Matching (LMM), Local Mean and Matching (LMVM), Regression variable substitution (RVS), and Local Correlation Modeling (LCM). Therefore, the best method for each group selected in this study as the fallowing:

a. Arithmetic and Frequency Filtering techniques are Bovey Transform (BT) , Color Normalized Transformation (CNT) , Multiplicative Method (MLT) , High-Pass Filter Additive Method (HPFA) , High –Frequency- Addition Method (HFA) , High Frequency Modulation Method (HFM) and The Wavelet transform-based fusion method (WT). [12].

b. The Statistical Methods it was with Local Mean Matching (LMM) and Regression variable substitution (RVS)[13].

Quality Evaluation Of The Fused Images:
1. Mean (µ):
The mean of a data set is simply the arithmetic average of the values in the set, obtained by summing the values and dividing by the number of values. recall that When we summarize a data set in a frequency distribution, we are approximating the data set by "rounding " each value in a given class to the class mark .With this in mind, it is natural to define the mean of frequency distribution by [13]:

$$\mu = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N} BV(i,j), \ldots\ldots (1)$$

Where N,M length and width image..Respectively, the product

between them equal number of image elements, BV numbers of pixels

2. Standard Deviation (SD):
The standard deviation (SD), which is the square root of variance, reflects the spread in the data. Thus, a high contrast image will have a larger variance, and a low contrast image will have a low variance .It indicates the closeness of the fused image to the original image at a pixel level. The ideal value is zero [13].

$$\sigma = \sqrt{\frac{\sum_{i=1}^{M}\sum_{j=1}^{N}(BV(i,j)-\mu)^2}{M\times N}} ,\ldots(2)$$

3. Signal - to noise ratio(SNR)
The signal is the information content of the data of original MS image M_K, while the merging F_K can cause the noise, as error that is added to the signal. The RMS_K of the signal – to noise ratio can be used to calculate the signal to noise ratio SNR_K, given by [12]:

$$SNR_K = \sqrt{\frac{\sum_i^M\sum_j^N(F_K(i,j))^2}{\sum_i^M\sum_j^N(F_K(i,j)-M_K(i,j))^2}} ,\ldots(3)$$

where F_K is the fused pixel ,M_K is the original pixel.

4. Correlation coefficient (CC)
The correlation coefficient measures the closeness or similarity between two images. It can vary between(-1 to +1). A value close to +1 indicates that the two images are very similar , While a value close to -1 indicates that they are highly dissimilar . The formula to compute the correlation between F_k ,M_k [12] :

$$CC = \frac{\sum_i^M\sum_j^N(F_k(i,j)-\overline{F_K})(M_k(i,j)-\overline{M}_k)}{\sqrt{\sum_i^M\sum_j^N(F_k(i,j)-\overline{F_K})(M_k(i,j)-\overline{M}_k)^2}\sqrt{\sum_i^M\sum_i^N(M_k(i,j)-\overline{M}_k)^2}} ,\ldots(4)$$

where F_K is the fused pixel ,M_K is the original pixel. The local mean matching filtering techniques was applied by using a sliding window of dimensions 3x3 pixel.

5. Spatial frequency (*SF*):

The spatial frequency, which originated from the human visual system, indicates the overall active level in an image. The human visual system is too complex to be fully understood with present physiological means, but the use of spatial frequency has led to an effective objective quality index for image fusion .The spatial frequency of an image is define as follows[12] :

Consider an image of size M×N, where M equal the number of rows and N the number of columns. The row (RF) and column (CF) frequencies of the image are given by [12]:

$$RF = \sqrt{\frac{1}{MN} \sum_{m=0}^{M-1} \sum_{n=1}^{N-1} [F(m,n) - F(m,n-1)]^2}$$
,…….(5)

$$CF = \sqrt{\frac{1}{MN} \sum_{n=0}^{N-1} \sum_{m=1}^{M-1} [F(m,n) - F(m-1,n)]^2}$$
,….(6)

Where F(m,n) is the gray value of pixel a position (m,n) of image F. The total spatial frequency of the image is then[12]

$$SF = \sqrt{(RF)^2 + (CF)^2} ,….(7)$$

6. Mutual information (*MI*):

MI measures the degree of dependency between two variables A and B ,by measuring the distance between the joint distribution $P_{AB}(a,b)$ and the distribution associated with the case of complete independence $P_A(a),P_B(b)$, by means of the relative entropy [12].

$$I_{AB}(a;b) = \sum_{a,b} P_{AB}(a,b) \log_2 \frac{P_{AB}(a,b)}{P_A(a). P_B(b)}$$
,… (8)

MI is a basic concept of information theory measuring the amount of information that one variable contains about another. This is the motivation to employ the MI as a measure of image fusion performance. However, in order to MI, you need to have the joint probability distribution function. In [12], the joint and marginal distribution, $P_{AB}(a,b),P_A(a)$and $P_B(b)$, are simply obtained by normalized of the joint and marginal histograms of both images . The joint histogram of images A and B, is defined as[12]:

$$h_{AB}(a,b) = \sum_{m=1}^{M} \sum_{n=1}^{N} h_{AB}(I_A(m,n), I_B(m,n))$$
,…(9)

a=0,1,… ,I   b=0,1,…,J

Where MXN is the size of the images, *$I_A(m,n)$ and $I_B(m,n)$* are intensity values of pixel (m,n) of the images A and B, so that *$I_A(m,n)$* $\in$ [0,I] and *$I_B(m,n)$* $\in$ [0,J].Considering two source images A and B ,and the fused image F, the amount of information that F contains about A and B is calculated as[12] :

$$I_{FA}(f;a) = \sum_{f,a} p_{FA}(f,a) \log_2 \frac{p_{FA}(f,a)}{p_F(f) . p_A(a)}$$
,…..(10)

$$I_{FB}(f;b) = \sum_{f,a} p_{FB}(f,b) \log_2 \frac{p_{FB}(f,b)}{p_F(f) . p_B(b)}$$
,….(11)

Consequently, the image fusion performance measure can be defined as[12]:

$$MI_F^{AB} = I_{FA}(f;a) + I_{FB}(f;b)$$
,…..(12)

Studying cases

• Of the National Aerospace Laboratories, the indigenous aircraft SARAS, use a pair of multi-focus aircraft was the first where blurring of the top half and the second vagueness in the bottom half; both size (512 × 512) pixels and bit depth (8bits) and gray level ranged between (0-255), these images are shown as figure (1a,b).

(a) First source image I $_1$ **(b) Second source image I$_2$**
Fig.(1a,b): The Source Image

- Camera with high focal lengths that suffer from the problem of limited depth of field is a result be difficult to get the good focus for all components in the image where solve the problem of multi focus by taking two images of the same scene, but with different concentrations of the components of these images where appears in each image one component is explained from the rest of components as shown in Figure(4-3)

and then merged these images with each style combine images were obtained single image where all the ingredients just as clearly as technique's merger by arithmetical methods such as (BT, CNT and MLT), statistical methods such as (LMM, RVS and WT) and spatial methods such as(HPFA, HFA and HFM) were obtained from which the best results as shown in Figure(2).

(a):BT   **(b):CNT**   **(c):MLT**

(d):HFA   **(e):HFM**   **(f):HPFA**

(g):LMM   **(h):RVS**   **(i):Wavelet transformation**

**Fig. (2) :I$_F$ fused images for different image techniques**

• Shown from figures (1 and 2) where criteria of multi focus images were calculated for each image and different merge techniques where the figure (3) shows the relationship between the criteria for each image due to the merge technique's arithmetic methods (BT,CNT and MLT), statistical methods (LMM ,RVS and WT) and spatial methods (HPFA,HFA and HFM).

Compute Evaluation criteria in this work, five evaluation criteria are used. These criteria can be used to measure the quality homogenous regions in images such as (mean, standard deviation and signal to noise ratio) and then study quality edges by used two criteria such as (mutual information and spatial frequency). It can be seen that from fig.(3a) the µ results of the fused image with remains constant except BT, HFM, HFA , HPFA to be high but note the decreased in BT . Too, It can be seen that from fig.(3 b),

the SD results of the fused images remain constant for all methods except BT and LMM for green and blue bands, but the red band except in BT and HPFA are decreased but note high in HFA. Results of the SNR appear changing significantly. It can be observed from fig.(3c) for results SNR of the fused image the HFA and HFM gives the best results with respect to the other methods . Means that this method maintains most of the information contacts reference data set, which get the same values, presented the lowest value of other methods. Results of the MI appear changing except HFA and HFM but SF appears changing significantly in all the methods. It can be observed from fig. (3 d) for result MI and SF of the fused image.
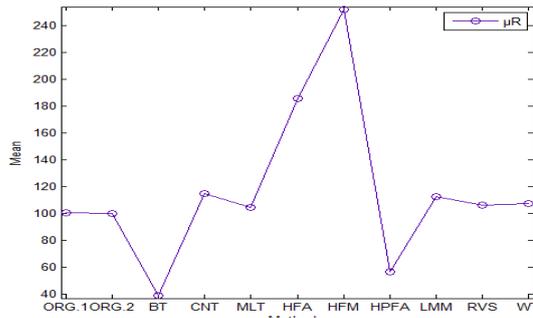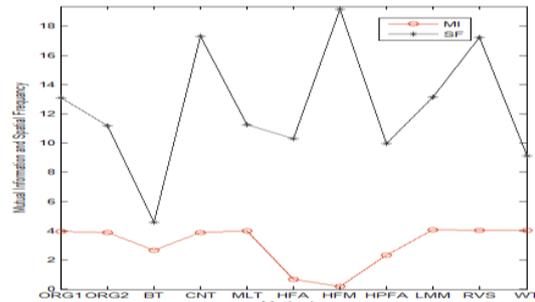
(a): Representation of µ of Fused Image
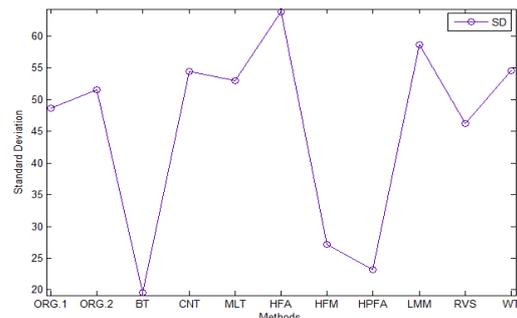
(b): Representation of SD of Fused Image
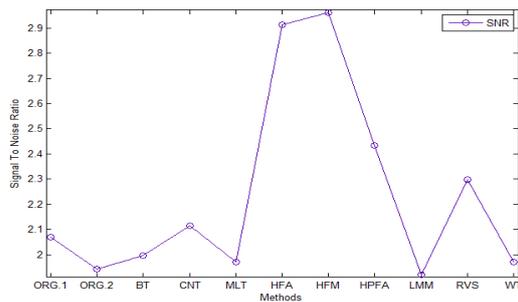
(c): Representation of SNR of Fused Image

(d): Representation of MI&SF of Fused Image

Fig.(3): The Results Shows of Some Traditional Criteria (µ,SD,SNR ,MI and SF of Original and Fused Multi Focus images

- This result in Table (1a) but the spatial frequency (SF) and mutual information (MI)are showing results in Table (1b) visibility is calculated which is used in the fusion approach and are tabulated.

Algorithm Correlation and Evaluations µ, σ, SNR,MI, and SF :

Input: The input of the algorithm is the gray image Img (x, y), where the values of Img are between 0 and

255, of size M×N.

Output: The outputs of the algorithm are the µ, σ, SNR,MI, and SF for the input image.

Step 1: Extract 5 blocks from the input image; the size of each block is equal to 5×5 pixels.

Step2: Categorize each block and find out Correlation Coefficient R using:

$$R = \frac{\sum_{i=1}^{5}\sum_{j=1}^{5}(imBA(i,j) - \overline{imBA})(imBB(i,j) - \overline{imBB})}{\sqrt{(\sum_{i=1}^{5}\sum_{j=1}^{5}(imBA(i,j) - \overline{imBA})^2)(\sum_{i=1}^{5}\sum_{j=1}^{5}(imBB(i,j) - \overline{imBB})^2}}$$

Where imBA imBBrepresent the value of block image A and B respectively, and $\overline{imAB}, \overline{imBB}$ represent the value of the block's mean A and B.

Step 3: calculate µ, σ and SNR as follow:-

count =5×5=25 (compute number of count in each extracted block)

$$sum = sum + Img(i,j)$$
$$\mu = sum / \ count$$
$$\sigma = \sqrt{(Im\,g(x,y) - \mu)^{\wedge}2} / count$$

$$SNR = \frac{\mu}{\sigma}$$

Step 4: Calculate SF and MI creation of the image

$$SF = \sqrt{(RF)^2 + (CF)^2}$$
$$MI_F^{AB} = I_{FA}(f;a) + I_{FB}(f;b)$$

Step 5: End

Table1 a ,b: Quantitative analysis of original images and fused image results through the different methods

Table (1a)

Methods	Bands	μ	SD	SNR
Original 1	R,G,B	101	49	2.07
Original 2	R,G,B	100	52	1.94
BT	R,G,B	39	20	1.99
CNT	R,G,B	115	54	2.11
MLT	R,G,B	104	53	1.97
HFA	R,G,B	186	64	2.91
HFM	R,G,B	252	27	2.96
HPFA	R,G,B	56	23	2.43
LMM	R,G,B	113	59	1.92
RVS	R,G,B	106	46	2.29
WT	R,G,B	107	55	1.9696

Table (1b)

| Methods	MI	SF
Original 1	3.9687	13.1046
Original 2	3.8972	11.1840
BT	2.6686	4.6031
CNT	3.8748	17.3027
MLT	3.9912	11.2483
HFA	0.6669	10.3147
HFM	0.1841	19.1671
HPFA	2.3530	9.9540
LMM	4.0602	13.1288
RVS	4.0275	17.2323
WT	4.0338	9.1280

Results and Dissections:

- We calculated criterion correlation between first image combine with second image and by techniques fusion as in figures (1 and 2).It was observed using this criterion after taking five blocks from different regions in the image size (10×10) and that the work relationship between correlation and shifted of these blocks by ten pixels, figure (4) represents the relationship between the correlation criteria and shifted of block per pixel of the original images before the fusion, while figure(5) represents the relationship between the correlation criteria and shifted of block per pixel of the fused images by merger arithmetic techniques of (BT,CNT and MLT), statistical techniques (LMM RVS and WT) and spatial techniques (HPFA,HFA and HFM).
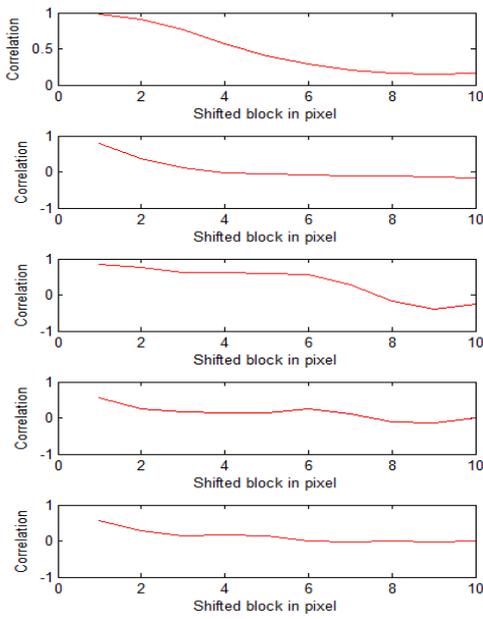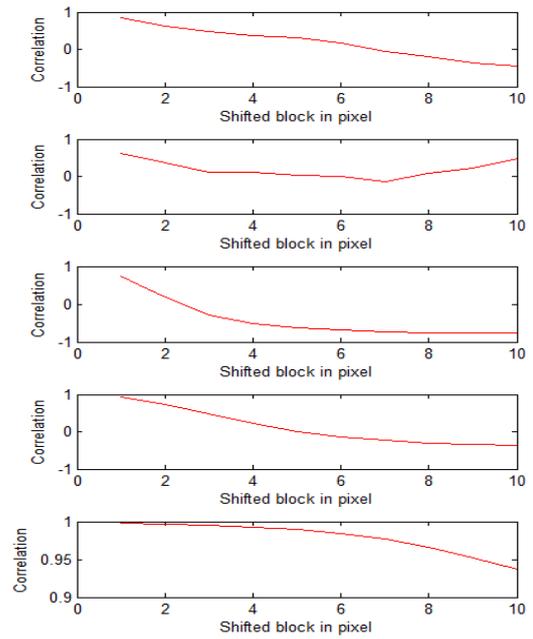
(a): chart representation of correlation of first original image
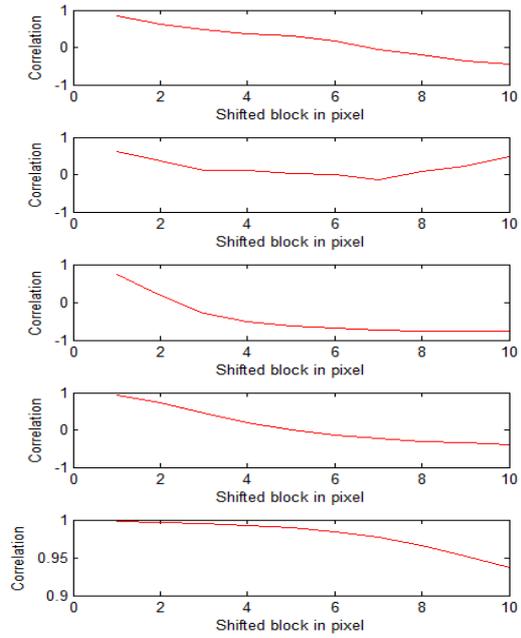
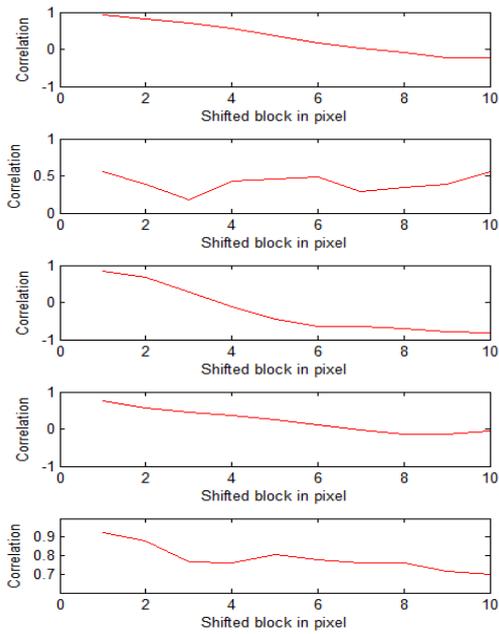(b): chart representation of correlation of second original image
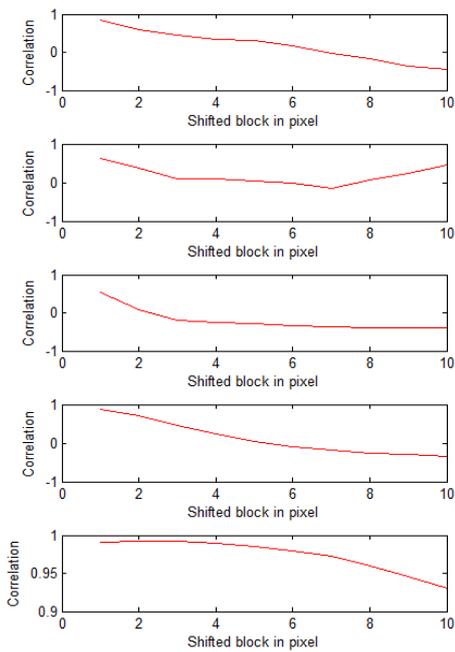
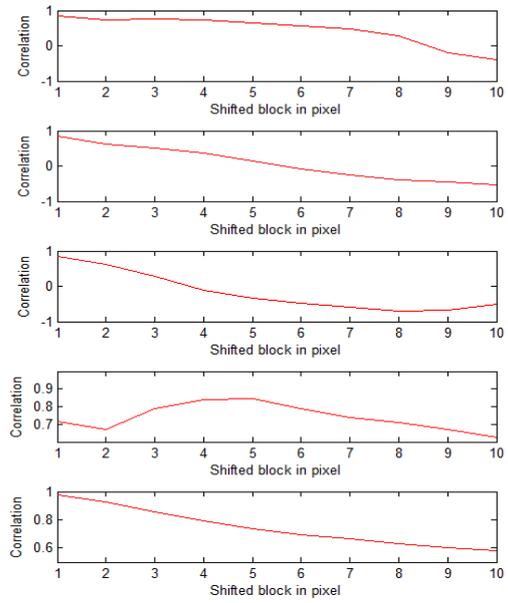(c): chart representation of correlation of BT
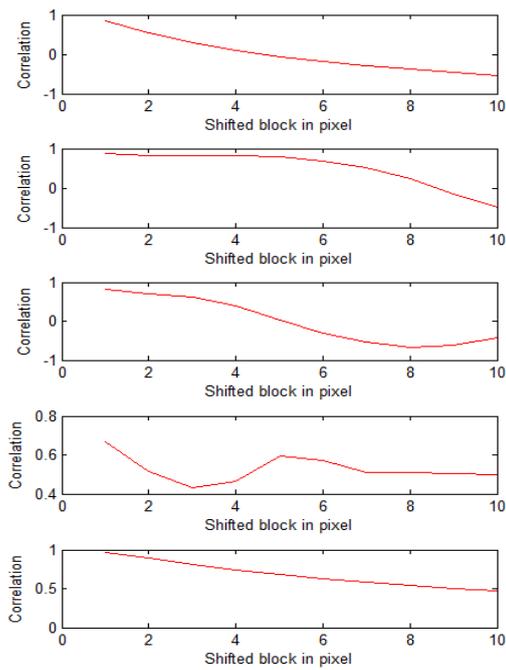
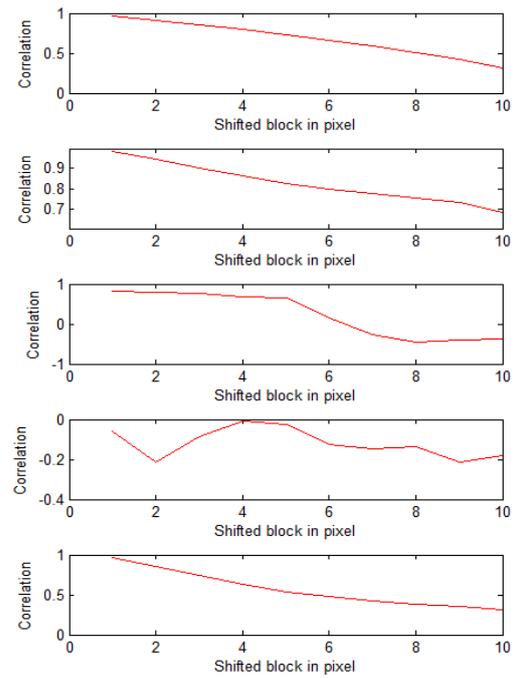(d): chart representation of correlation of CNT

Continue Figure (4)

(e): chart representation of correlation of MLT

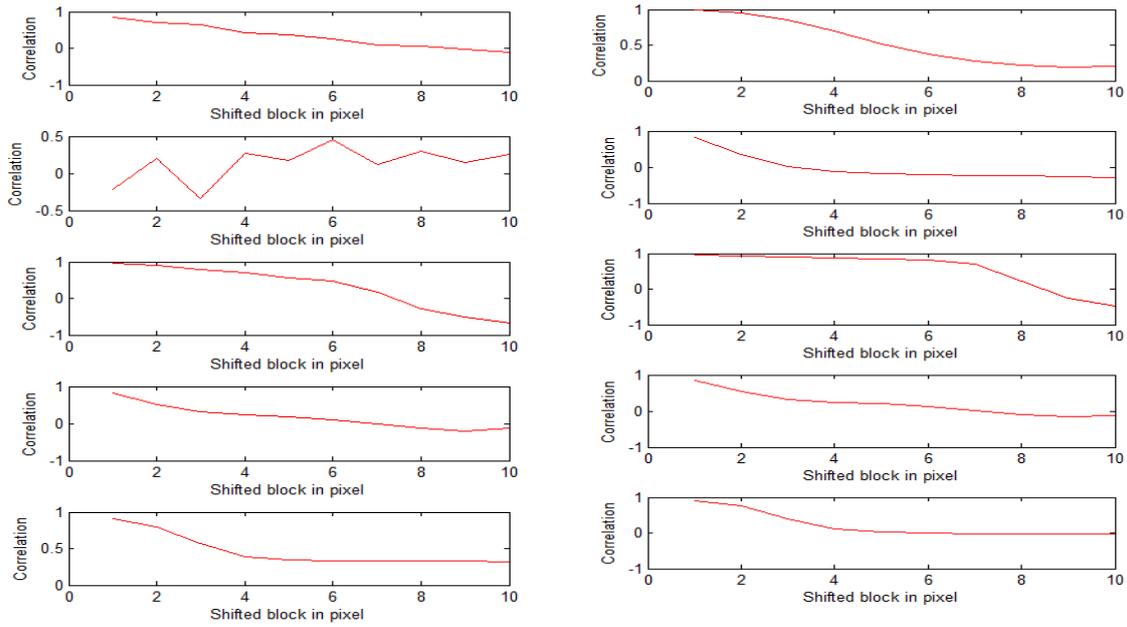(f): chart representation of correlation of HPFA
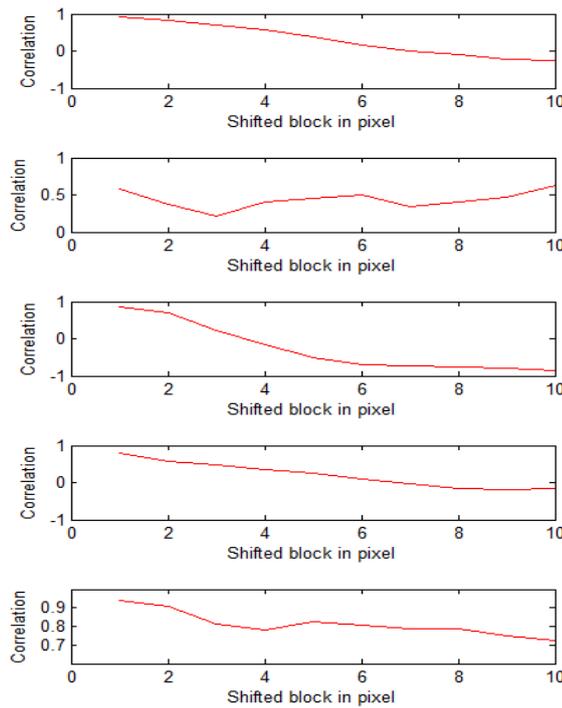

(g): chart representation of correlation of HFA

(h): chart representation of correlation of HFM

Continue Figure (4)

(i): chart representation of correlation of
LMM

(j): chart representation of correlation of
RVS

(k): chart representation of correlation of
WT

**Fig. (4): Chart representation of correlation of original image and fused image by
different techniques**

Conclusions :

From the results, we can conclude after apply two criteria quality image particular homogeneity and edges to be results observed to assume the following figures and tables. Nine different types of image fusion algorithms based on BT,CNT,MLT,HFA,HFM,HPFA,LMM,RVS and WT and fused image quality was evaluated using performance evaluation metrics.

- We found that the best way is to integrate MLT, HPFA and WT. because they show the quality and accentuation of the merged images.

- We noticed the correlation factor interdependence guess uniformity in how to determine homogeneity in different regions of the image.

- We found the importance of quality measurements or evaluation of its importance in determining the quality of the details of the image and especially the accurate details and edges.

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دمج الصور ذات التركيز المتعدد بالاعتماد على مقياسي التجانس والحافات

هبة خضير عباس   *علي عبد داود الزكي***   *انوار حسن مهدي****

*جامعة بغداد ،كلية العلوم للبنات ، قسم الفيزياء

**الجامعة المستنصرية ،كلية العلوم ،قسم الفيزياء

***الجامعة المستنصرية ،كلية العلوم ،قسم الحاسوب

الخلاصـة:

عملية دمج الصور تتضمن وضع برمجيات لإجراء التكامل لمجموعات متعددة من البيانات لنفس الموقع في ازمان مختلفة،لمعرفة التغيرات التي تطرأ على ذلك الموقع بمرور الزمن، وتعد تقنيات دمج الصور الرقمية احد المجالات الجديدة المعتمدة في حل المشكلات التي تواجه الصور الرقمية ،وتهدف الى انتاج صور اكثر معلوماتية لأغراض التفسير، والتصنيف، والتجزئة والضغط ...الخ. وفي هذا البحث تم اقتراح مجموعة من الحلول للمشكلات التي تواجه عملية دمج الصور الرقمية المختلفة. كانت هذه الحلول عن طريق اجراء عملية محاكاة بأستخدام الكاميرا لعمل دمج للصور الرقمية المختلفة (الصور المتعددة التركيز) بالاعتماد على تقنيات الدمج المعتمدة سابقاً والتي تشمل التقنيات الرياضية، والإحصائية والمكانية. ولدينا مقترحات في عملنا بأستخدام معيارالترابط لغرض تقييم جودة تفاصيل الصور الرقمية وخصوصاً التفاصيل الدقيقة جداً وهذا المعيار يستخدم لتخمين التجانس لتحديد مناطق الصورة المختلفة بأستخدام عامل الارتباط وذلك عن طريق اخذ بلوكات من مناطق مختلفة من الصورة وبأحجام مختلفة وتزحيف البلوك عشر مرات ثم حساب الارتباط في كل مرة. كما واعتمد البحث على المعايير الاحصائية التقليدية(كالمعدل، والانحراف المعياري نسبة الاشارة الى الضوضاء، والمعلومات الافتراضية والتردد المكاني)، ومقارنتها بالمعايير المعتمدة. وبينت النتائج ان عملية التقييم فعالة وجيدة لأنها اخذت في الحسبان قياس جودة المناطق المتجانسه.