Secret Image Protection through Image Fusion Technique

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Abstract: ***The fast development of digital image processing leads to the growth of feature extraction of images which leads to the development of Image fusion. Image fusion is defined as the process of combining two or more different images into a new single image retaining important features from each image with extended information content. An algorithm for protecting the secret image whose confidentiality needs to be maintained, and also to authenticate the distributor who distributes that secret image to multiple users is proposed. This paper evaluates the performance of multi focused image fusion of using Stationary Wavelet Transform, Lifting Wavelet Transform in terms of various performance measures like MSE, RMSE, PSNR, SNR and Correlation***

Keywords: Dealer, Image Fusion, Secret Sharing, Stationary Wavelet Transform, Lifting Wavelet Transform

1. Introduction

The authenticity of the user becomes major issue in today's internet applications as per increasing concerns over the personal information has increased the interest in computer security. In the field of medicine, military, geographical fields etc, lots of images need to be processed to obtain the clear information about the problem a patient has in the case of medical field, to obtain the information about the attackers or terrorists in the field of military, to obtain the information about the fields which provide good crop or mining facility etc in the field of geography. All these applications use the different kinds of images taken from different sources and processed based on the requirements by using various image processing tools. The images can be the general ones which can be accessed by any user or the important once which can be accessed only by the authorized users.

Image fusion is defined as the process of combining two or more different images into a new single image accommodating important features from each image with extended information content. Transform fusion uses transform for illustrate the source images at multi scale. The most common extensively used transform for image fusion at multi scale is Wavelet Transform since it minimizes structural distortions. But, wavelet transform suffers from lack of shift invariance & poor directionality and these disadvantages are overcome by Stationary Wavelet Transform. The conventional convolution-based implementation of the discrete wavelet transform has high computational and memory requirements. Lifting Wavelets has been developed to overcome these drawbacks. There are three levels of image fusion namely Pixel level, Area level and region level. This paper evaluates the performance of all levels of multi focused image fusion of using Stationary Wavelet Transform, Lifting Wavelet Transform in terms of various performance measures.

2. Related work

VPS Naidu [1] use Six different types of image fusion algorithms based on discrete cosine transform (DCT) were developed and their performance was evaluated. Fusion performance is not good while using the algorithms with block size less than 8x8 and also the block size equivalent to the image size itself. DCTe and DCTmx based image fusion algorithms performed well. These algorithms are very simple and might be suitable for real time applications. Different image fusion algorithms have been developed to merge the multiple images into a single image that contain all useful information. To overcome this side effects many researchers have developed multi resolution, multi scale and statistical signal processing based image fusion techniques.

Kanisetty Venkata Swathi and CH. Hima Bindu [2] presented the multimodal medical image fusion is an important application in many medical applications. This is used for the retrieval of complementary information from medical images. The MRI and CT image provides high resolution images with structural and anatomical information. In this paper, a new approach of multimodal medical image fusion on Daubechies wavelet transform coefficients. Here the standard deviation can be used to characterize the local variations within the block. The performance of proposed image fusion method is compared with existing algorithms and evaluated with mutual information between input and output images, entropy, standard deviation, fusion factor metrics.

Poonam Bidgar and Neha Shahare [3] Presented a rapidly growing network, Internet has become a primary source of transmitting confidential or secret data such as military information, financial documents, etc. Visual Cryptography is also one of them which is used to hide secret visual information (such as image, text, etc) in which secret sharing scheme is used. Secret sharing is used to encrypt a secret image into customized versions of the original image. There are many secret sharing algorithms in literature including

Shamir, Blakley, and Asmuth-Bloom to divide the image into no. of shares. A new method in which a symmetric secret key is used to encrypt the image and then secret shares are generated from this image using Novel secret sharing technique with steganography. So, finally this method will produce meaningful shares and use of secret key will ensure the security of scheme. This scheme can become a reliable solution suitable for today's authentication challenges. Objective of proposed scheme is to design an encryption/ decryption algorithm that efficiently provides high level security for visual information from illicit attacks. P. Devaki and Dr G Raghavendra Rao [4] In the field of medicine, military, geographical fields etc, lots of images need to be processed to obtain the clear information about the problem a patient has in the case of medical field, to obtain the information about the attackers or terrorists in the field of military, to obtain the information about the fields which provide good crop or mining facility etc in the field of geography. In both the cases the image must be protected from the unauthorized users especially in a public network like internet. An algorithm for protecting the secret image whose confidentiality needs to be maintained, and also to authenticate the distributor who distributes that secret image to multiple users is proposed. The secret image will be fused with the fingerprint of the dealer for authentication purpose.

3. Proposed Algorithm

The proposed method is used in this thesis their block diagram and the proposed method is used brief description are given below:

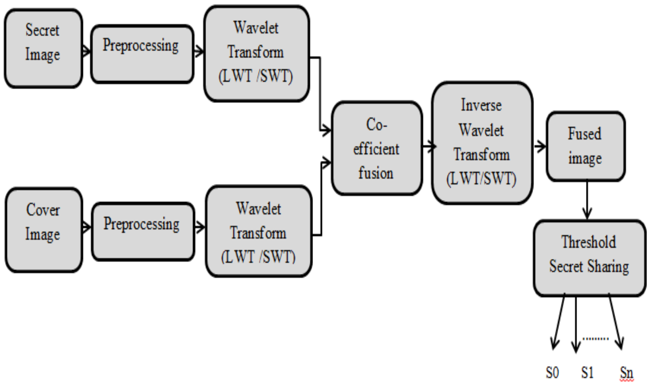

Figure 1: Sender Side

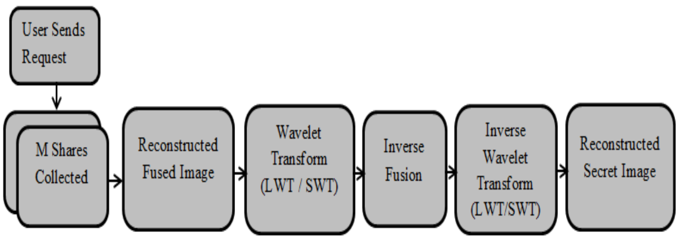

Figure 2: Recevier side

The brief description of the sender side and receiver side of the Image fusion technique based on wavelet is given below:

3.1 Input Image

Secret image as well as cover image is taken as input. Secret image is the one which needs to be protected and the cover image is known both during distributer as well as dealer process.

3.2 Pre-processing of input Image

One of the main issues in image fusion is image alignment or resize. For the resultant output image to be distinct and have a better visual interpretation. It is necessary to have both the Secret & Cover images of same size. Same size of images becomes a basic requirement for point to point correspondence between two pixel values.

3.3 Wavelet Transform:

Wavelet theory was introduced as a mathematical tool in 1980s, it has been extensively used in image processing that provides a multi-resolution decomposition of an image in a bio-rthogonal basis and results in a non-redundant image representation. The basis are called wavelets and these are functions generated by translation and dilation of mother wavelet. In Fourier analysis the signal is decomposed into sine waves of different frequencies. In wavelet analysis the signal is decomposed into scaled (dilated or expanded) and shifted (translated) versions of the chosen mother wavelet or function. A wavelet as its name implies is a small wave that grows and decays essentially in a limited time period.
Image fusion is basically a technique to combine the set of same type of images taken at different sources or angles to obtain the complete image. After taking two images, apply wavelet transform to that images. The two different types of wavelet transform are as follows:

Lifting Wavelet Transform:

The Wim Sweldens developed the lifting scheme for the construction of bi-orthogonal wavelets. The main feature of the lifting scheme is that all constructions are derived in the spatial domain. It does not require complex mathematical calculations that are required in traditional methods. Lifting scheme is simplest and efficient algorithm to calculate wavelet transforms. It does not depend on Fourier transforms. Lifting scheme is used to generate second-generation wavelets, which are not necessarily translation and dilation of one particular function.

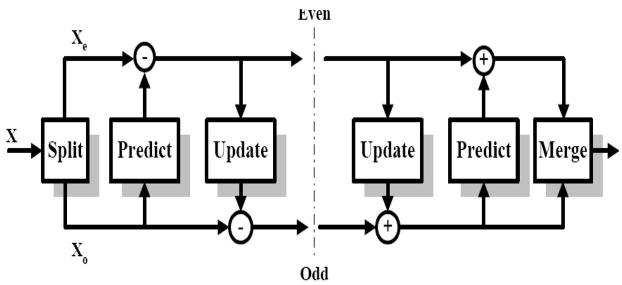

Figure 3: Lifting-based Wavelet Transform

the lifting scheme became a method to implement reversible integer wavelet transforms. Constructing wavelets using lifting scheme consists of three steps: The first step is split phase that split data into odd and even sets. The second step is predict step, in which odd set is predicted from even set. Predict phase ensures polynomial cancellation in high pass.

The third step is update phase that will update even set using wavelet coefficient to calculate scaling function. Update stage ensures preservation of moments in low pass. The reconstruction operation does exactly the same, but using the reverse process. The data is first predicted, then updated and finally merged.

Stationary Wavelet Transform:
The Discrete Wavelet Transform is not a time invariant transform. The way to restore the translation invariance is to average some slightly different DWT, called un-decimated DWT, to define the stationary wavelet transform (SWT). It does so by suppressing the down-sampling step of the decimated algorithm and instead up-sampling the filters by inserting zeros between the filter coefficients. Algorithms in which the filter is upsampled are called “à trous”, meaning “with holes”. As with the decimated algorithm, the filters are applied first to the rows and then to the columns. In this case, however, although the four images produced (one approximation and three detail images) are at half the resolution of the original; they are the same size as the original image. The approximation images from the undecimated algorithm are therefore represented as levels in a parallelepiped, with the spatial resolution becoming coarser at each higher level and the size remaining the same. Stationary Wavelet Transform (SWT) is similar to Discrete Wavelet Transform (DWT) but the only process of down-sampling is suppressed that means the SWT is translation-invariant. The 2-D SWT decomposition scheme is illustrated in Figure 4.

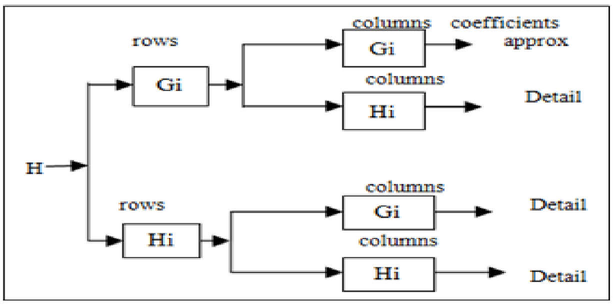

Figure 5: SWT decomposition scheme

The 2D Stationary Wavelet Transform (SWT) is based on the idea of no decimation. It applies the Discrete Wavelet Transform (DWT) and omits both down-sampling in the forward and up-sampling in the inverse transform. More precisely, it applies the transform at each point of the image and saves the detail coefficients and uses the low frequency information at each level. The Stationary Wavelet Transform decomposition scheme is illustrated in Figure 4 where Gi and Hi are a source image, low pass filter and high-pass filter, respectively. Figure 4 shows the detail results after applying SWT to an image using SWT at 1 to 4 levels[7].

3.4 Image fusion Based wavelet transform and its inverse:

Wavelet transform is first performed on each source images, then a fusion decision map is generated based on a set of fusion rules. The fused wavelet coefficient map can be constructed from the wavelet coefficients of the source images according to the fusion decision map. Finally the fused image is obtained by performing the inverse wavelet transform.

The block diagram of a wavelet based image fusion scheme is shown in the following figure:

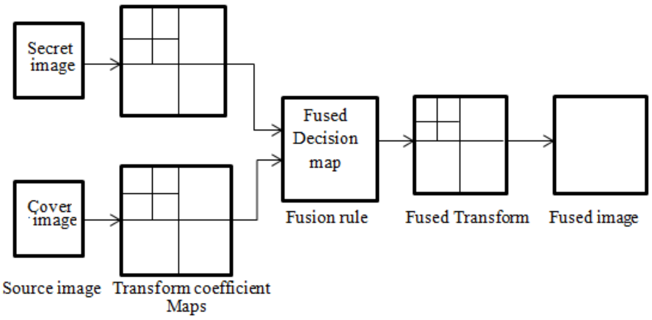

Figure 4: Wavelet based image fusion

Decomposition Process:
The image is high and low-pass filtered along the rows and the results of each filter are down- sampled by two. Those two sub-signals correspond to the high and low frequency components along the rows and are each of size N by N/2. Each of those sub-signals is then again high and low-pass filtered, but this time along the column data. The results are again down-sampled by two.

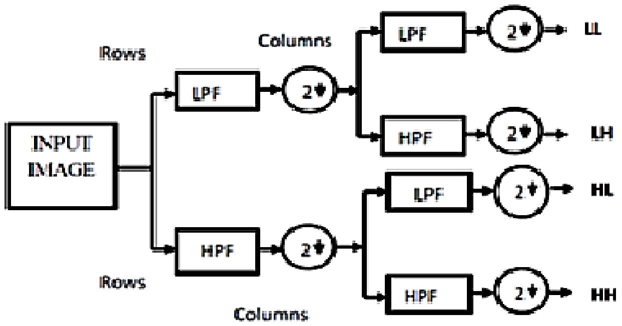

Figure 6: Decomposition of an image using LWT /SWT

The source images such as fingerprint and secret image are decomposed in rows and columns by low-pass (L) and high-pass (H) filtering and subsequent down sampling at each level to get approximation (LL) and detail (LH, HL and HH) coefficient. The LL Coefficient is the result of low-pass filtering both the rows and columns and contains a rough description of the image. Therefore the LL Coefficient is also called the approximation Coefficient. All three Coefficient HL, LH and HH are called the detail Coefficient, because they add the high-frequency detail to the approximation image. Scaling function is associated with smooth filters or low pass filters and wavelet function with high-pass filtering. Wavelet transforms provide a framework in which an image is decomposed, with each level corresponding to a coarser resolution band.

From the above diagram, we can see that the fusion rules are playing a very important role during the fusion process. Here are some frequently used fusion rules in the previous work:

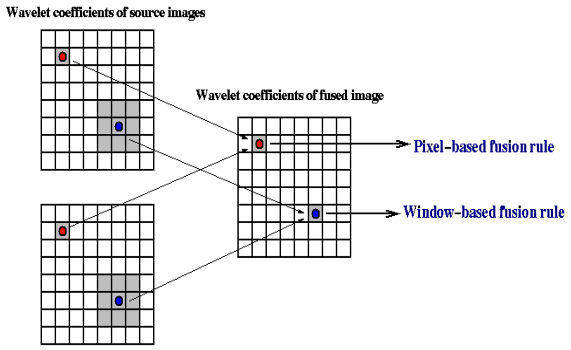

Figure 7: Frequently used fusion rules

When constructing each wavelet coefficient for the fused image. We will have to determine which source image describes this coefficient better. This information will be kept in the fusion decision map. The fusion decision map has the same size as the original image. Each value is the index of the source image which may be more informative on the corresponding wavelet coefficient.

3.5 Threshold secret sharing:

Shamir's Secret Sharing is an algorithm in cryptography created by Adi Shamir. It is a form of secret sharing, where a secret is divided into parts, giving each participant its own unique part, where some of the parts or all of them are needed in order to reconstruct the secret. Counting on all participants to combine the secret might be impractical, and therefore sometimes the threshold scheme is used where K any of the parts are sufficient to reconstruct the original secret.

Reconstruction of Secret image:
When gets minimum number of shares the reconstruction of the fused image can take place. After Reconstruction the two level decomposition which separate the high and low frequency information. which gives two components as approximation and Detail. This bands or coefficients are performed with inverse fusion rule Final step is Inverse decomposition is applied on fused coefficient which gives fused image without loss of information.

4. Result and Discussion

Proposed research work has been developed by using MATLAB R2013a for simulation of image fusion algorithms. The Sender side and Receiver side process and also evaluation of the quality of image in the MATLAB. Code is developed for opening GUI for this implementation. After the developed a code for the loading the input image in the MATLAB. Then developed code and resize secret image and cover image then applies lifting and stationary wavelet transform of of the secret and cover image, for the two level decomposition which separate the high and low frequency information This bands or coefficients are performed with fusion rules. Then apply the Inverse decomposition is applied on fused coefficient which gives fused image. The threshold secret sharing is used a fused image obtained is divided the four different image share and distributed to authorized users. Code is developed reconstruction of the fused image, After Reconstruction the two level decomposition which separate the high and low frequency information. This bands or coefficients are performed with inverse fusion rule Final step is Inverse decomposition is applied on fused coefficient which gives fused image without loss of information.

The code developed for opening GUI in the MATLAB for this implementation. There are two push button for input of the load cover and secret image. There are used two panels. One is sender panel include in LWT/SWT wavelet decomposition, fusion rule, inverse wavelet Decomposition, Fused image and threshold secret sharing. Second is receiver panel including in load secret share, Reconstruction, LWT/SWT wavelet decomposition, inverse fusion rule and inverse wavelet Decomposition. Then secret and recovered secret image analysed performance parameter is MSE, RMSE, SNR, PSNR and correlation. Finally close button is used close the program.

4.1 Evaluation Criteria

Objective image quality measures play an important role in various image processing applications. The fused images are evaluated, taking the following parameters into consideration.

4.2 Mean-Squared Error

The mean-squared errors (MSE) between two images are I1 (m, n) and I2 (m, n) is:

$$MSE = \frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M*N}$$

In the above formula M and N are the number of rows and columns in a input images, respectively.

4.3 Root Mean-Square-Error:

The Root Mean Square Error (RMSE) firstly calculated MSE then square root of the MSE.

$$RMSE = \sqrt{\frac{\sum_{M,N} [I_1(m,n) - I_2(m,n)]^2}{M*N}}$$

4.4 Signal –To-Noise Ratio:

Signal-to-noise ratio is defined as the ratio of the power of a signal in decibel (meaningful information) and the power background noise in decibel (unwanted signal):

$$\mathrm{SNR_{dB}} = 10 \log_{10} \left(\frac{P_{\mathrm{signal}}}{P_{\mathrm{noise}}} \right)$$

Where P is average power, both signal and noise must be measured at the same or equivalent point in a system.

4.5 Peak Signal-To-Noise Ratio:

Peak Signal-to-Noise Ratio (PSNR) will help to avoid this problem by scaling the MSE according to the given image range:

$$PSNR = 10 \log_{10} \left(\frac{R^2}{MSE} \right)$$

PSNR is measured in decibels (dB) and it is a good measure for comparing restoration results for the same image. R is the maximum fluctuation in the input image data type.

4.6 Correlation

If we have a series of n measurements of X and Y written as xi and yi where i = 1, 2… n, then the sample correlation coefficient can be used to estimate the population Pearson correlation r between X and Y. The sample correlation coefficient is written:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}},$$

Where, $\bar{x}$ and $\bar{y}$ are the sample means of X and Y, and sx and sy are the sample standard deviations of X and Y.

4.7 Performance Parameter Table

The various images evaluate the parameter values in the MATLAB code. The separate parameter performance table for lifting and stationary wavelet transform is given below:

Input Images	MSE	RMSE	PSNR	Correlation	SNR
 Alarmclock	6.9794	1.6254	39.6926	0.9924	11.3855
 Airplane	1.7163	1.1446	45.7848	0.9985	19.3214
 Light house	1.3266	1.0732	48.9035	0.9988	20.6798

Table 1: Performance of various parameter for image fusion based lifting wavelet transform

Input Images	MSE	RMSE	PSNR	Correlation	SNR
 Alarmclock	31.7330	2.3734	33.1157	0.9792	9.0026
 Airplane	7.0705	1.6307	396363	0.9958	15.5783
 Light house	5.6945	1.5448	40.5762	0.9962	16.5191

Table 2: Performance of various parameter for image fusion based stationary wavelet transform

Input Images	MSE		RMSE		PSNR		CORRILATION		SNR	
	LWT	SWT	LWT	SWT	LWT	SWT	LWT	SWT	LWT	SWT
 Alarmclock	6.9794	31.7330	1.6254	2.3734	39.6926	33.1157	0.9924	0.9792	11.3855	9.0026
 Airplane	1.7163	7.0705	1.1446	1.6307	45.7848	39.6363	0.9985	0.9958	19.3214	15.5783
 Light house	1.3266	5.6945	1.0732	1.5448	48.9035	40.5762	0.9988	0.9962	20.6769	16.5191

Table 3: Compare lifting wavelet transform and Stationary wavelet transform using Performance of various parameter

5. Conclusion and Future Scope

In this project we will going to propose a secret image protection technique through image fusion technique. In image fusion we have use to transformation image fusion method. We can protect secret image efficiently with less computational Complexity. In this research work, attention was drawn towards the current trend of the use of multi resolution image fusion techniques such as lifting wavelet transform and stationary wavelet transform. An efficient image fusion technique has been proposed here which is formed by combining the features of both lifting wavelet transform and stationary wavelet transform image fusion algorithms. In our proposed technique of image fusion we get more enhanced image and work well for edges, corners and helps in minimization of the localized errors. LWT provides computationally efficient and better qualitative and quantitative result in region level fusion among SWT.

Then evaluated the performance parameter is observed through various self-developed image processing algorithms in Matlab. The implement and perform comparative analysis on secret image and Reconstruct secret image. The parameter like MSE, RMSE, PSNR, correlation coefficient and SNR on the different images and the results are evaluated to check best quality of Images having high PSNR ratio, less MSE, The root mean square error also gets reduced and correlation is 1. Future work performed does hold scope for further advancements as a lot of research is happening in the field.

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