ENGINEERING IN ADVANCED RESEARCHSCIENCE AND TECHNOLOGY

ISSN 2352-8648
Vol.03, Issue.01
June-2022
Pages: -273-280

DISCRETE WAVELET TRANSFORM BASED IMAGE FUSION USING UNSHARP MASKING

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Abstract : Nowadays the result of infrared and visible image fusion has been utilized in significant applications like military, surveillance, remote sensing and medical imaging applications. Discrete wavelet transform based image fusion using unsharp masking is presented. DWT is used for decomposing input images (infrared, visible). Approximation and detailed coefficients are generated. For improving contrast unsharp masking has been applied on approximation coefficients. Then for merging approximation coefficients produced after unsharp masking average fusion rule is used. The rule that is used for merging detailed coefficients is max fusion rule. Finally, IDWT is used for generating a fused image. The result produced using the proposed fusion method is providing good contrast and also giving better performance results in reference to mean, entropy and standard deviation when compared with existingtechniques.

Keywords : infrared image, visible image, image fusion, DWT, unsharp masking.

Related works : Li et al. [14] have introduced a multi-sensor fusion technique based on DWT. For merging approximation and detailed coefficients of input images the max fusion rule has been used. Feature selection has been done by using maximum area selection based rule and through consistency verifying step. The proposed technique fused image has been giving better performance compared to laplacian pyramid techniques because of directional selectivity, compactness, and orthogonality of DWT.

Fan et al. [15] have presented an improved fusion method based on DWT. For merging approximation coefficients, the human visual system (HVS) based fusion rule is used. For merging detailed coefficientsabsolute value fusion rule has been used. IDWT has been used for reconstructing the fused image. Theresultant image obtained using this method is preserving edge details of the target better than the mean method, min method, and mean max method. Godse and Bormane [16] have presented a fusion technique based on DWT. The fusion rule that has been used in this technique is the maximum selectionrule. The fused image is providing better performance but producing a blurred result.

Xu and Su [17] have introduced the fusion algorithm based on discrete wavelet decomposition. The low-frequency coefficient of the infrared image is improved in terms of contrast and gradient by using the enhanced method using DWT and DT-CWT. Fused image produced using this method has improved contrast when compared with basic DWT and DTCWT methods.
Zhou and Tan [18] have introduced the fusion technique for multimodal images(infrared, visible) that is based on the wavelet transform. Fusion strategies that have been used are developed using a comparison of different fusion rules. The Fused image is providing a better overall under- standing of the scene information but unable to produce good texture information.

Vijayarajan and Muttan [19] have presented a fusion scheme based on DWT. Principle component analysis has been utilized for merging approximation and detail coefficients. PCA fusion is based on the average of principal components of coefficients of source images. This fusion scheme is clearly removing spatial distortions.
Han et al. [20] have presented a fusion scheme for complementary images(infrared, visible) based on DWT. The wavelet decomposition technique is applied to input images to produce approximation and detail coefficients. Approximation coefficients have been merged using absolute value selection fusion rule and detailed coefficients have been merged using weighted average fusion rule. IDWT has been used for reconstructing the fused image.

Compared to traditional methods fused image achieved with the above scheme has given good performance regarding entropy, spatial frequency, average gradient, and standard deviation but it lacks in achieving good contrast.

Zhan et al. [10] have presented a fusion method for multi-sensor images (infrared, visible) based on DWT. Regional energy fusion strategy has been used for merging approximation coefficients. The fused image achieved using the above method has given better target information but lacks in providing goodtexture information.

Habeeb et al. [21] have presented an enhanced fusion method based on weighted averaging or a discrete wavelet transform. Input images (infrared, visible) that have fused in the spatial domain using a weighted average fusion rule produce a blurred image. And input images that have fused in transform domain basing on DWT produce a better result but it reduces spatial domain details. Applying a sharpening filter on input images in the spatial domain and fusing using weighted averaging or discrete wavelet transform improves the contrast details of the resultant fused image.

Habeeb et al. [22] have presented a multi-modal fusion algorithm. The main techniques used for enhancement are PCA, Histogram equalization and sharpen filter. The fusion rule used is weighted average rule. Proposed algorithm got better results than the existing methods.

The method proposed here is a discrete wavelet transform based image fusion using unsharp masking. This method is aimed to give better performance com- pared to multi-scale transform techniques. Unsharp masking has been used for improving contrast. The proposed method has been developed for improving contrast and also preserving edge information.

Introduction : Nowadays sensor technology is rapidly growing. The same scene information is captured using infrared and visible image cameras. Infrared cameras capture the thermal radiation of light. Infrared image main advantage is, it pro- vides good target details even in poor weather conditions such as low light condition, snow, and fog. But the problem is, it is having low spatial resolution and poor texture [1].

Background information is not clearly seen in infra- red images. On the other side, the visible camera captures the reflection of light. It is having high spatial resolution [2]. The visible image'smain advantage is, it provides good back- ground information so that humans can easily understand scene information. But the problem is, it cannot capture tar-get details in poor weather conditions. By considering infra- red and visible images advantages. Fusing them provides better scene information in a single image [3]. The result of fusion has been utilized in most significant applications such as the military [4], surveillance [5], remote sensing [6], and medical imaging applications [7].

Traditionally fusion can be performed mainly using two methods.

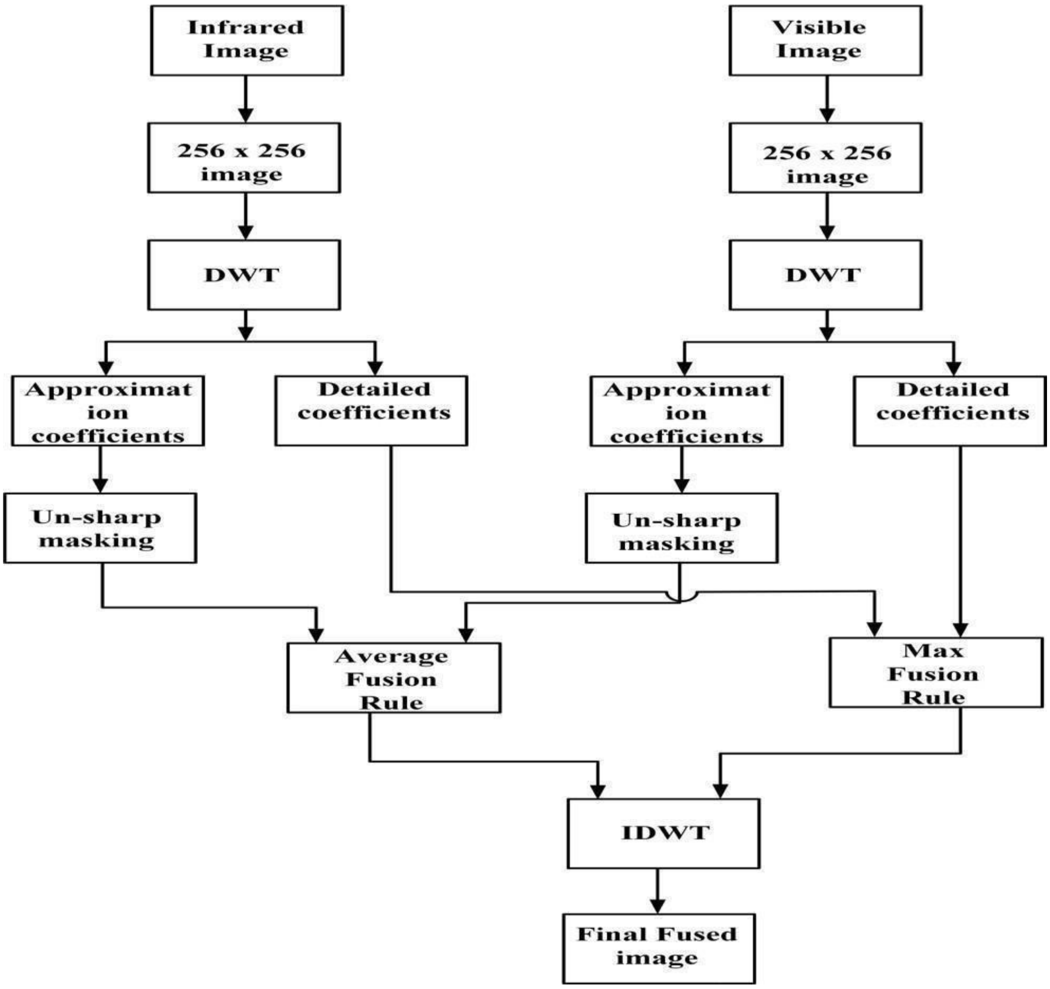
1. Spatial domain fusion method.
2. Transform domain fusion method.

In the spatial domain method, two source images (infra- red, visible) are combined based on fusion rule. Here no transforms are used in this method. Fusion rule is applied directly to pixels of the images. Generally, fusion rules used in this method are the average and max fusion rules. The fused image result that has been produced based on the spatial domain based method has low contrast, reduction in sharpness and blurred edges [8]. Later transform domain fusion based method has been developed for improving the performance of the fusion result. The problems that occur in the spatial domain fusion method have been rectified by using the transform domain fusion method [9].

Mainly transform domain fusion based method involves three steps.

1. In the first step, a multi-scale transform has been used for decomposing two source images (infra- red, visible) into multi-scale components. (High- frequency and low- frequency components).
2. Different fusion rules have been used for combining multi-scale components.
3. The final fused image has been reconstructed with an inverse multi-scale transform.

BLOCK DIAGRAM :



Proposed method :

Discrete wavelet transform based image fusion using unsharp masking is presented. Mainly in this method, the first two source images (infrared, visible) are scaled down to 256 × 256 images. DWT has been used for decomposing. After decomposition approximation and detailed coefficients are produced. For improving contrast unsharp masking has been applied especially on approximation coefficients. For combining approximation coefficients that are produced after unsharp masking the aver- age fusion rule is used. For merging detailed coefficients max fusion rule isused. IDWT has been used for recon- structing the final fused image

Discrete wavelet transform :

DWT has been one of the significant multi-scale and multi-resolution transform. Generally, spatial domain fusion produces spatial distortions and spectral degradations. The main advantage of DWT usage in image fusion is it reduces spectral degradations and spatial distortions produced in the fused image. Here DWT is used for decomposing two input source images (infrared, visible). Approximation coefficients and detailed coefficients are produced. Mainly approximation coefficients give average image information and detailed coefficients. give edge details information. For merging approximation coefficients and detailed coefficients different fusion rules have been introduced. IDWT has been used for recon- structing the fused image.

Unsharp masking :

Unsharp masking is an enhancement technique that will improve the appearance details of an image by increasing the contrast of edges. The blurred image is subtracted from its original image could produce a sharpened image. Let $f(l,k)$ is a image, $fs(l,k)$ is a sharpen image and $f^\wedge(l,k)$ is a blurred imageof $f(l,k)$.

Therefore unsharp masking is obtained by

$$fs(l,k) = f(l,k) - f^\wedge(l,k).$$

Fusion rule that has been applied for approximation coefficients :

Unsharp masking is applied to approximation coefficients. Its main aim is to improve the contrast of edges and texture. Coefficients produced after un-sharp masking are fused by using average fusion rule. The main advantage of the average fusion rule is it considers all regions of both the images. The output of average fusion rule is calculated simply by adding corresponding coefficients of two images and dividing the result by two.

Let $ILf(v,w)$ is approximation fused coefficients, $IL1(v,w)$ is approximation coefficients produced after unsharp masking for infrared image and $IL2(v,w)$ is approximation coefficients produced after unsharp masking for the visi- ble image. Average fusion rule is obtained by $ILf(v,w)=IL1(V,W)+IL2(V,W)\ /\ 2$

Fusion rule that has been applied for detailed coefficients :

Generally, detailed coefficients contain edge information. For improving the focus of edge information max fusion rule has been introduced for merging detailed coefficients.Let $IHf(v,w)$ is detailed fused coefficients, $IH1(v,w)$ is detailed coefficients of infrared image, and $IH2(v,w)$ is detailedcoefficients of the visible image. Max fusion rule is obtained by $IHF(V,W)=MAX[IH1(V,W),IH2(V,W)]$

RESULTS:

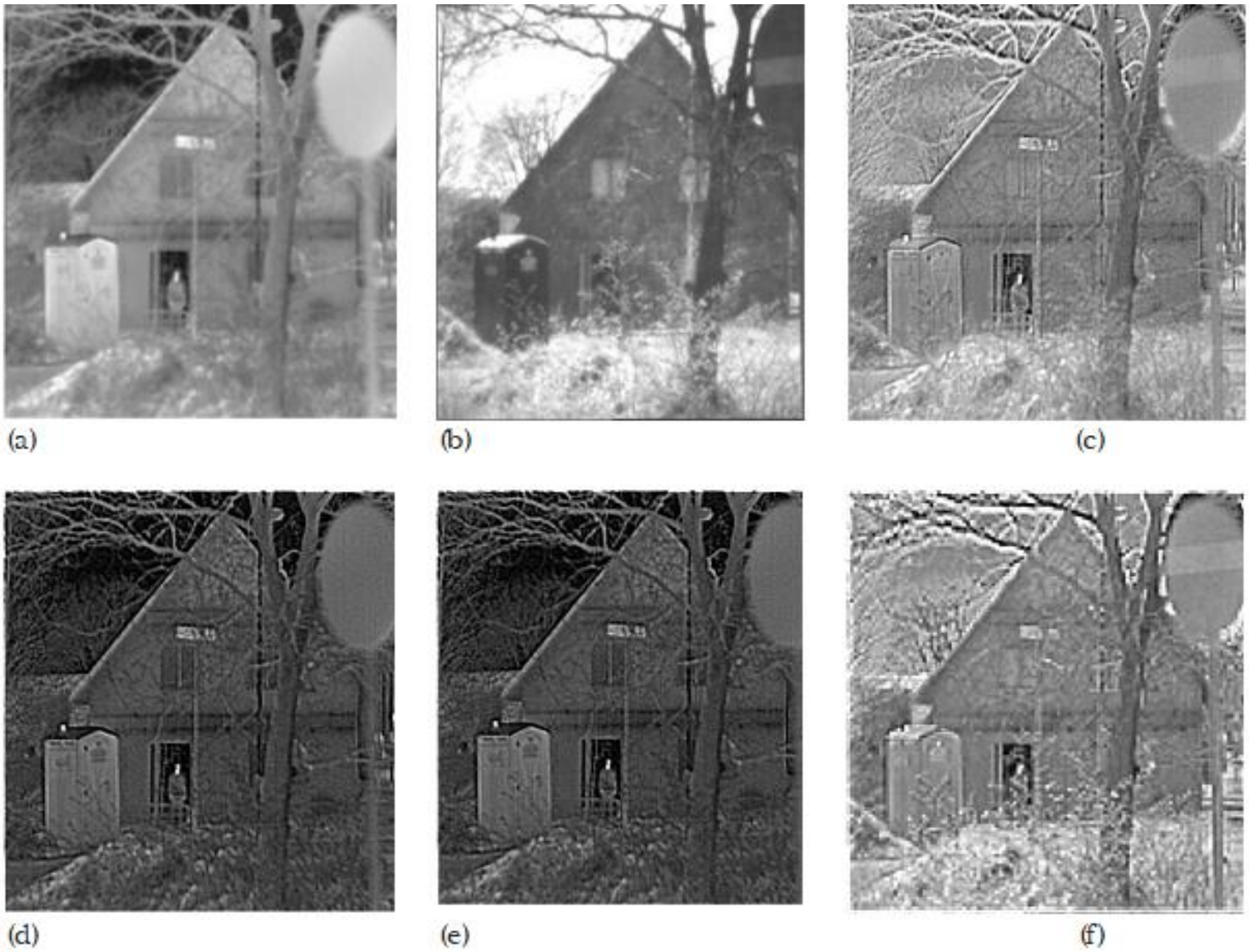


Fig. 1.1 The fused resultsof "Single person image"
(a) Infrared image (b) Visible image (c) Sharpen fused-image (d) PCA1fused-image (e) PCA2 fused-image
(f) Proposed fused-image

Fig.1.1 shows the fused results of "Single person image", where Fig. 1.1 (a) shows an Infrared image, Fig. 1.2 (b) shows a visible image, Fig. 1.1 (c) shows sharpen fused-image which is obtained after Implementation of DWT based fusion algorithm using sharpen filter, Fig. 1.1 (d) shows PCA1 fused- image which is obtained after Implementation of fusion algorithm in spatial domain using PCA, Histogram Equalization, Sharpen filter and Weighted average fusion rule, Fig. 1.1 (e) shows PCA2 fused-image which is obtained after Implementation of fusion algorithm in spatial domain using Histogram Equalization, Sharpen filter, PCA and Weighted average fusion rule and Fig. 1.1 (f) shows the proposed fused- image of "Single person image". It can be observed that the proposed fused-image is having high contrast. Person, house, board and tree details are clearly seen in the proposed method as shown in Fig. 1.1 (f). But the above details are not properly seen in sharpen fused- image as shown in Fig. 1.1(c) because in this method sharpen filter is only applied on infrared image, due to that visible source image features are less seen after fusion process. And also above details are not clearly seen in PCA1 fused-image and PCA2 fused-image as shown in Fig. 1.1 (d) and Fig. 1.1 (e) because weighted average fusion rule is applied in spatial domain due to that low brightness, low contrast and less quality fused images are produced.

CONCLUSION : Discrete wavelet transform based image fusion using unsharp masking has been proposed. First input images are scaled to 256 × 256 images. DWT decomposition has been used. Approximation and detailed coefficients have been produced. Here for improving contrast unsharp masking has been applied on approximation coefficients. For combining approximation (low-frequency) coefficients produced after unsharp masking fusion rule especially used is average fusion rule. Max fusion rule has been introduced for merging detailed coefficients. IDWT is used for reconstructing the fused image. The proposed method fused image is having higher contrast when compared with fused images obtained using existing techniques. And it is also giving better results with reference to mean, entropy and standard deviation when compared to existing techniques. The proposed method is providing good texture and edge information so that scene information can easily be understood by humans

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