A Review of Image Fusion Techniques and Its Applications

[1]Mr. Syed Munawwar, [2]Mr. G. Sudhakar Reddy,

[1]Assistant Professor, Department of ECE, Santhram Engineering College, Nandyal, Andhrapradesh.

[2]Assistant Professor, Department of ECE, CMRIT, Hyderabad, Telangana.

Abstract: Image fusion is process of combining multiple input images into a single output image which contain better description of the scene than the one provided by any of the individual input images. The need of image fusion for high resolution on panchromatic and multispectral images or real world images for better vision. There are various methods of image fusion and some techniques of image fusion such as IHS, PCA, DWT, Laplacian pyramids, DCT and NSCT. Several digital image fusion algorithms have been developed in a number of applications. Image fusion extracts the information from several images of a given scene to obtain a final image which has more information for human visual perception and become more useful for additional vision processing. It also intends to review quality assessment metrics for image fusion algorithms. The gray-scale image fusion techniques are explored at pixel level, feature-level and review the concept, principals, limitations and advantages for each technique.

Keywords—Fused images, PC, HIS, Discrete Wavelet Transform and NSRCxWT.

I. INTRODUCTION: There has been an ever-increasing interest in developing and applying medical imaging technique to problems in clinical diagnosis. The list of possible applications of X-ray, ultrasound, CT, MRI, SPECT, and PET in clinical diagnosis continues to grow and diversify. Although those imaging technologies have given clinicians an unprecedented toolbox to aid in clinical decision-making, advances in image fusion[1] of comprehensive morphological and functional information retrieved from different imaging technologies could enable physicians to identify human anatomy, physiology, and pathology as well as diseases at an even earlier stage. Recently, there has been active research using medical image fusion technology for clinical applications in the academic community.

II. TYPES OF IMAGE FUSION:

Single Sensor*:* Single sensor captures the real world as a sequence of images. The set of images are fused together to generate a new image with optimum information content. For example in illumination[1] variant and noise full environment, a human operators like detector operator may not be able to detect objects of his interest which can be highlighted in the resultant fused image.

The shortcoming of this type of systems lies behind the limitations of the imaging sensor that are being used in other sensing area. Under the conditions in which the system can operate, its dynamic range, resolution, etc. are all restricted by the competency of the sensor. For example, a visible-band sensor such as the digital camera is appropriate for a brightly illuminated environment such as daylight scenes but is not suitable for poorly illuminated situations found during night time, or under not good conditions such as in fog or rain.

Multi Sensor **:** A multi-sensor[2] image fusion scheme overcomes the limitations of a single sensor image fusion by merging the images from several sensors to form a composite image an infrared camera is accompanying the digital camera and their individual images are merged to obtain a fused image. This approach overcomes the issues referred to before. The digital camera is suitable for daylight scenes; the infrared camera is appropriate in poorly illuminated environments. It is used in military area, machine vision like in object detection, robotics, medical imaging[6]. It is used to solve the merge information of the several images.

Multiview Fusion: In this images have multiple or different views at the same time. Multimodal Fusion: Images from different models like panchromatic, multispectral, visible, infrared, remote sensing. Common methods of image fusion [5] are

- Weighted averaging pixel wise
- Fusion in transform domain
- Object level fusion

Multi focus Fusion: images from 3d views with its focal length. The original image can be divided into regions such that every region is in focus in at least one channel of the image.

III.IMAGE FUSION TECHNIQUES:

Image fusion method can be divided into two groups.

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

Spatial domain fusion methods directly deal with pixels of input images. The fusion methods such as simple maximum, simple minimum, averaging, principal component analysis (PCA) and IHS [7]based methods fall under spatial domain approaches.

In transform domain method image is first transferred in to frequency domain. The fusion methods such as DWT fall under transform domain method.

Some of these pixel-level algorithms are described below:

a) Simple Maximum Method: In this method, the resultant fused image is obtained by selecting the maximum intensity of corresponding pixels from both the input image.

b) Simple Minimum Method: In this method, the resultant fused image is obtained by selecting the minimum intensity of corresponding pixels from both the input image.

c) Simple Average Method: In this method the resultant fused image is obtained by taking the average intensity of corresponding pixels from both the input image.

d) Weighted Average Method: in this method the resultant fused image is obtained by taking the weighted average intensity of corresponding pixels from both the input image.

e) Principal Component Analysis (PCA) method: Principal Component Analysis is a sub space method, which reduces the multidimensional data sets into lower dimensions for analysis. This method determines the weights for each source. Image using the eigenvector corresponding to the largest Eigen value of the covariance matrix of each source image.

f) **Discrete Wavelet Transform Method:** Wavelet transforms are multi-resolution image decomposition tool that provide a variety of channels representing the image feature by different frequency sub bands at multi-scale. It is a famous technique in analyzing signals. When decomposition is performed, the approximation and detail component can be separated 2-D Discrete Wavelet Transformation (DWT)[9] converts the image from the spatial domain to frequency domain. The image is divided by vertical and horizontal lines and represents the first-order of DWT, and the image can be separated with four parts those are LL1, LH1, HL1 and HH1.

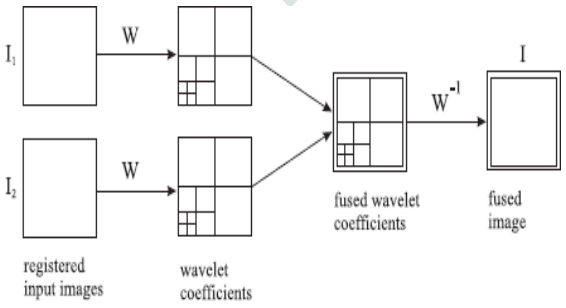


Fig.1**:** Fusion of the wavelet transforms of two images

g) Non-Sub Sampled Rotated Complex Wavelet Transform (NSRCxWT):

Image Fusion involves basic three steps-image modalities, image registration followed by feature based fusion, and the performance evaluation as shown in Fig.2. Two or more modality images are used as the source images. These source images are co-registered using registration algorithm. The image registration is a trivial problem due to non-similarity of the representations in CT[8] and MRI. The acquisition process and devices are different, so the source images vary in orientation, structural presentations, and spatial resolution.

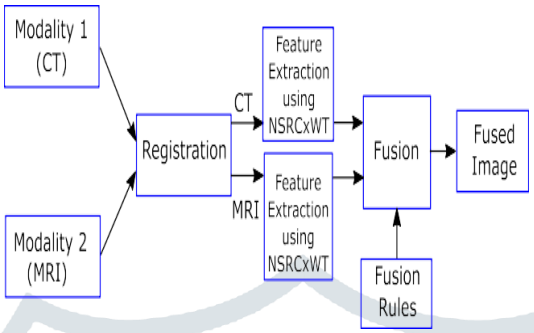
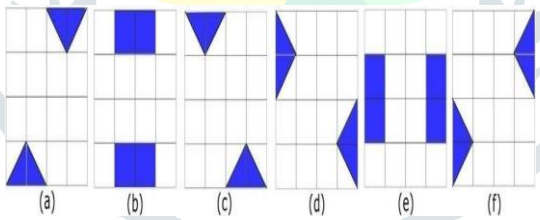


Fig.2: Block Schematic of Multimodality image fusion using NSRCxWT method.

However, these images complement each other regarding anatomical structures. In this method, CT and MRI images are observed by overlapping on each other in all three views(sagittal, axial and coronal) and simple geometric transformation techniques which include scaling, rotation, panning, shifting, etc. are applied to bring them into voxel alignment. The effectiveness of fusion algorithms is very much dependent on the precise image registration. In the feature based fusion, the feature extraction technique is used to separate the salient information from input images, and these features are combined to create a new image. The next few subsections deal with the principle and design of proposed Non-Sub sampled Rotated Complex Wavelet Transform.

Fig.3: Fourier spectrum of 2D NSRCxWT filter kernels presenting orientations in



(a) -30°, (b) 0°, (c) 30°, (d) 60°, (e) 90°, (f) -60°

IV. APPLICATIONS AND USES OF IMAGEFUSION

- Fusion is basically used remote or satellite area for the proper view of satellite vision
- It must use in medical imaging where disease should analyses through imaging vision through spatial resolution and frequency perspectives.
- Image fusion used in military areas where all the perspectives used to detect the threats and other resolution work based performance.
- For machine vision it is effectively used to visualize the two states after the image conclude its perfect for the human vision.
- In robotics field fused images mostly used to analyse the frequency variations in the view of images.
- Image fusion is used in artificial neural networks in 3d where focal length varies according to wavelength transformation.

VI. ADVANTAGES AND DISADVANTAGES OF IMAGE FUSION

Advantages:

- It is easiest to interpret.
- Fused image is true in color.

- It is best for identification and recognition
- It is low in cost
- Image fusion maintains ability to read out signs in all fields.
- Image fusion has so many contrast advantages basically it should enhance the image with all the perspectives of image.
- It increases the situational or conditional awareness.
- Image fusion reduced the data storage and data transmission.

Disadvantages:

- Images have less capability in adverse weather conditions it is commonly occurred when image fusion is done by single sensor fusion technique.
- Not easily visible at night it is mainly due to camera aspects whether it is in day or night.
- More source energy is necessary for the good visualization of mages based on spatial frequency.
- Due to rain or fog visualization is not cleared if one click the two source images in this type of weather conditions it will give the worst output.
- In this process there are huge chances of data loss.
- It needs the proper maintenance.
- Processing of data is very slow when images are fused.

VII. MSE, PSNR and Entropy:

MSE is the cumulative squared error between the blurred image and the original image, whereas PSNR is a measure of the peak error.

$$\text{MSE} = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2$$

The PSNR (in dB) is defined as:

$$\text{PSNR}=10\log_{10}\left(\frac{\text{MAXI2}}{\text{MSE}}\right) \quad =20\log_{10}\left(\frac{\text{MAX}_I}{\sqrt{\text{MSE}}}\right) \quad =20\log_{10}(\text{MAX}_I) - 10\log_{10}(\text{MSE})$$

Where in the MSE,

m = no of rows n = no of columns I (i, j) = input image K (i, j) = fused image

In the PSNR, MAX_1 = maximum possible no of pixels in an image

Peak signal-to-noise ratio, is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. Peak signal to noise ratio (PSNR) value will be high when the fused and reference images are alike and higher value implies better fusion .If the PSNR value is high, then the appearance of image is clear. If the reference image and fused image are alike give the MSE value equal to zero and it will increase when the dissimilarity increases between the reference and fused image.

Mutual Information (MI): Mutual information is a measure of the dependence between two input source images (X, Y). Mutual information is how much information is calculated in the source image and transferred to the fused image.

Method	MSE	PSNR (dB)
Simple	0.05	71.062 [1]
Average	9.91	76.42 [10]
PCA	9.86	76.44 [7]
DCT	0.0791	59.14 [9]
Wavelet	9.18	77.08 [10]

Table 1: Comparison of Parameters of Various Techniques

When the difference between the original and reconstructed image is smaller, the PSNR value is larger. There are some other performance measurement characteristics such as Entropy, Standard deviation, Execution time and Error Image.

VIII. CONCLUSION:

The process of image fusion combines the input images and extracts useful information giving the resultant image. Image fusion applications have increased manifold with the advent of large number of images being captured by different types of sensors. We have discussed a few techniques that are traditional IHS, PCA, Wavelets and advanced techniques like DWT, Curvelets and NSRCxWT.

REFERENCES:

[1] Digital Image Processing 3rd Edition by Rafael C. Gonzalez and Richard E. Woods

[2] Fundamentals of Digital Image Processing by S. Annadurai and R. Shanmuga Lakshmi.

[3] Digital Image Processing and Analysis by B.Chanda and D.Dutta Majumder.

[4] Digital Image Processing Using MATLAB by Rafael C. Gonzalez ,Richard E. Woods, Steven L.Eddins.

[5] "ROBUST BLUR KERNEL ESTIMATION FOR LICENSE PLATE IMAGES" IEEE Transaction by Wengang Zhou and Lu Fang.

[6] S.S. Chavan, S.N. Talbar, Multimodality medical image fusion using M-band wavelet and Daubechies complex wavelet transform for radiation therapy, IGI Global: Int. J. Rough Sets Data Anal. (IJRSDA) under Special Issue on Medical Image Mining for Computer Aided Diagnosis 2 (2015) 1–23.

[7] M. Kokare, P.K. Biswas, B.N. Chatterji, Texture image retrieval using new rotated complex wavelet filters, IEEE Trans. Syst. Man Cybern.-PartB:cybernetics 35 (2005) 1168–1178.

[8] M. Kokare, P.K. Biswas, B.N. Chatterji, Rotation-invariant texture image retrieval using rotated complex wavelet filters, IEEE Trans. Syst. Man Cybern. Part- B:cybernetics 36 (2006) 1273–1282.

[9] Syed Munawwar -Fusion of MRI and PET Images using DWT,IJEIR Sept-2017,Volume 6, Issue 5, ISSN (Online) : 2277 – 5668.

[10] Y. Xiong, Y. Wu, Y. Wang, and Y. Wang, "A medical image fusion method based on SIST and adaptive PCNN," in 2017 29th Chinese Control And Decision Conference (CCDC), pp. 5189–5194, Chongqing, China, May 2017.

[11] Math Works, 2013.

[12] Bhavana V., Krishnappa H.K., Multi-modality medical image fusion using discrete wavelet transform, in: Fourth International Conference on Eco-friendly Computing and Communication Systems, ICECCS-2015, Kururkshetra, Haryana, India, vol. 70, Elsevier, 2015, pp. 625–631.

[13] Yufeng Zheng "Image Fusion and ItsApplications".

[14] Hamid Reza Shahdoosti, Hassan Ghassemian,"Spatial PCA as A New Method for Image Fusion," The 16th CSI International Symposium on Artificial Intelligence and Signal Processing (AISP), 2012.