INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE

ISSN: 2057-5688

MEDICAL IMAGE FUSION USING COHESIVE PRINCIPAL COMPONENT

Pundru Prasanth Kumar, Research Scholar, Department of Electronics and communication Engineering, Monad University, Hapur, U.P.

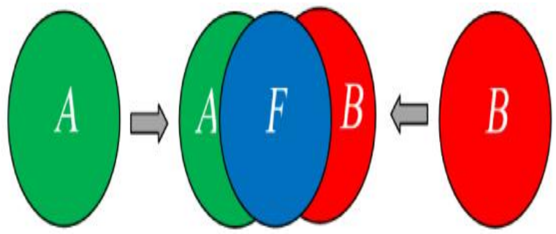
Dr.Jaidev Sharma, Associate Professor, Supervisor, Department of Electronics and communication Engineering, Monad University, Hapur, U.P.

Abstract: Image fusion is becoming more important in image processing applications because there are so many different ways to get data. Fusion of images is when important information from different sensors is aligned together using different mathematical models to make a single composite image. Multiple images are combined to make a single image that has better quality and keeps important features. This is done by combining information from a different time, views, and sensor sources into one image. Robot vision, aerial, satellite imaging, and medical imaging are just a few of the many applications where this is important. In this paper, a variety of state-of-the-art image fusion methods, as well as their advantages and disadvantages, as well as their applications in different fields have been discussed. Finally, this review has come up with a lot of ideas for how image fusion can be used in different ways in the future.

Keywords: Image Fusion, Robot vision, satellite imaging.

1. INTRODUCTION

Image fusion is defined in the photography business as a technique in which more than two pictures from diverse forms of photography are fused into a single image with crucial features. [4] A growing number of high-resolution photos are becoming available as sensor technology progresses. Fusion is an important and commonly used approach to comprehending image data in order to create a more complete representation for each individual image. The following characteristics are included in an effective picture fusion approach. In the first place, it is possible to save the most important information from various photos. First and foremost, there are no artifacts in the image that could divert or confuse a human observation device, nor are there any additional giving out stages in the image. The third need is dependability and toughness. The final point to make is that no critical data from any of the input photos should be ignored. Data fusion is a multi-source technique for handling data and information for decision-making that is enhanced and improved. It is also known as information fusion. When two or more images with different definitions are combined, certain algorithms are used to create a new image with the combination of the two or more images. [12]The primary goal of image fusion is to combine different types of data in order to gain more information than can be collected from each individual sensor database. Image fusion is used to obtain more information than can be obtained from each



individual

Fig 1.1: Graphical representation of the image fusion process

ISSN: 2057-5688

sensor database. During the fusion process, the images A and B of the entry are combined to make a new picture F, which is ideally achieved by transferring all of the information from A to B to F to F.

A basic Venn diagram is used to explain this point graphically. The combination of images from different imaging modalities has the tendency to provide additional clinical information that was not visible in the individual imaging modalities. In order to accomplish this, radiologists have chosen to obtain additional data through the use of multiple imaging modalities. Image fusion is performed in order to acquire and merge all of the useful data from each unique modality into a single picture. In particular, a viable fusion should be able to retrieve precise data from the original photographs and transfer it into the consequence without introducing artifacts or contradictions. [12].

As stated previously, the purpose of IF is to create a merged image from many images. Figure 1.4 depicts the major IF stages. Wide-ranging registration is used to both exploit similarities and reduce cost. Image registration aligns the subsequent features of several photos with a reference image. Using numerous source images, the original image is recognized as a reference image, and the original images are aligned using the reference image. Feature extraction extracts significant features from registered photos to create feature maps. A set of decision maps is created by using a decision operator to label the registered images with pixel or feature maps. The decision or feature mappings derived from semantic equivalence may not be transferable. It connects these maps to a common object for fusion.This step is redundant for sources derived from similar sensors. On spatially aligned images, radiometric calibration follows. Then the feature maps are transformed on a regular scale to produce a similar representation format. Finally, IF combine the consequential photographs into a single image with an enhanced explanation. The purpose of fusion is to get more informative images.

2. STEPS OF IMAGE FUSION PROCESS

A. Image registration:

As a general rule, the process of image registration involves. Horns, lines, ripples, contour, and closed boundary regions are all examples of features that can be recognized either manually or automatically (e.g. The points (differing points, line endpoints, gravity centers) referred to by these types of points can be represented by their control points in the subsequent processing process.This is an example of feature matching. As a result of this phase, a correlation between the detected image and the referral image can be established.

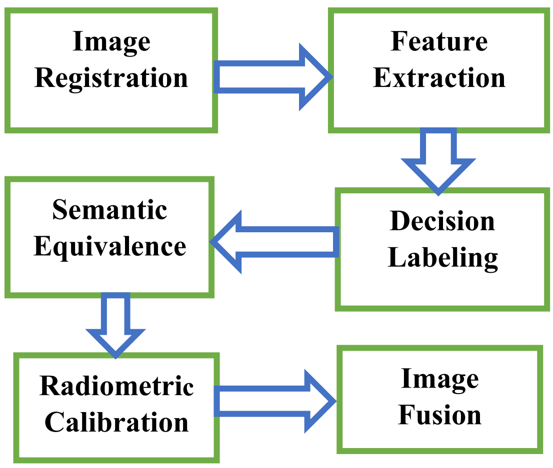
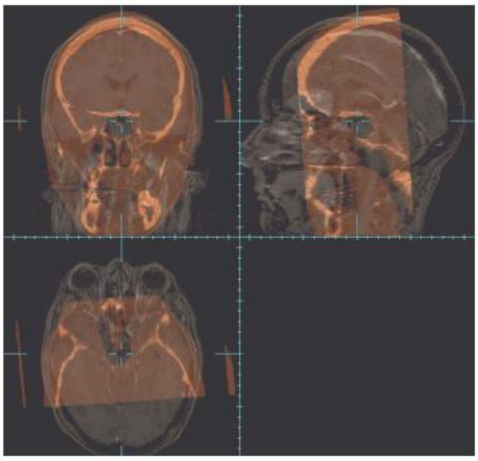
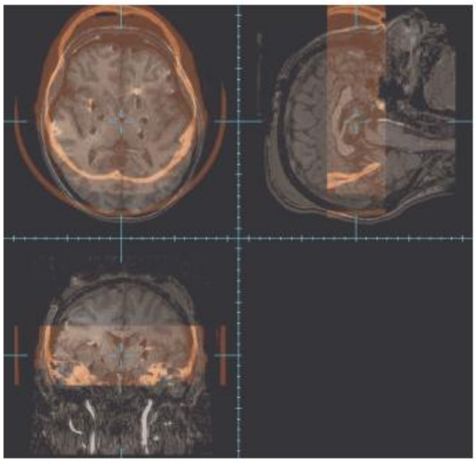


Fig 1.2: The main steps of the image fusion procedure

A wide range of traits and similarity measures are utilized to describe the spatial linkages between the variables in this study.The mapping functions that align the sensed image with the reference picture are calculated and the parameters are estimated. Function correspondence is often used to calculate mapping function parameters.Images are resampled and converted using mapping function mapping. Image values in non-integer coordinates are estimated through the application of an appropriate interpolation technique.According to a generalization, under the registration framework, the goal is to maximize similarity or decrease cost. To put it another way, a parametric transformation $T_g(.)$ is applied to the input (target) images during the registration process. It's done so that they're as comparable to the reference image as possible. It is vital to keep in mind that the target similarity (cost) function, P(.) influences the desired similarity. One way to express the optimization target is as shown in Equation (1)





(b)

Fig : 1.3 a & b : MRI- CT Registration image

B. Feature extraction:

The typical features of the registered images are extracted and one or more feature maps are produced for each of the input photos in this stage.

C. Decision labeling:

A set of decision maps is generated based on a specified set of criteria by using a decision operator that seeks to label the pixels or feature maps of the registered images.

D. Semantic equivalence:

Feature/decision maps may not always refer to the same object/phenomenon. To aid the fusing process, semantic equivalence is used to relate these mappings to common objects/phenomena notably, the same method is unnecessary for sensor inputs.

E. Radiometric calibration:

The input images and features are spatially aligned in this step. The maps are scaled to a common scale, resulting in a common representation format that may be used as an input to the next step in the process.

F. Image fusion :

An output image with a better depiction of the scene than any of the input photos is created at this point. Images fused together are more accurate because of the information they include. Other advantages include [4]: expanding the scope of operations, improving spatial and temporal coverage, lowering uncertainty, enhancing reliability, achieving resilient system performance, and more compactly representing the information. [5] Are also advantages.

3. EVOLUTION OF TYPES OF IMAGE FUSION

Fusion research began with simple images that perform basic operations on pixels, such as addition, subtraction, the average, and division. This was the first step in the process. Fusion methods usually rely on simple operations on the pixels of the input images. Now, we are going to talk about the following things.

3.1 Addition

In addition, the simplest fusion procedure. Worked by figuring out what the average intensity value of the images was for each one. An alignment of semantics and radiometric is made with great precision with this method. The technology's main benefit is that it can remove any noise from the images that are sent into it.

3.2 Average:

The pixel-average method tends to keep high image pushes that look "washed-out" from making a low contrast image.

3.3 Subtraction:

A change detection algorithm can use a simple fusion operator called "subtraction" to look for changes in the way things look.

3.4 Multiplication:

Multiplication isn't used very often as an image fusion operator. Image fusion can be used for many things, but one of the most important uses is Brovey. Spectral modeling underlies the Brovey transformation, which was designed to boost the histogram's visual contrast at the extreme highs and lows. Each pixel is multiplied by the ratio of the matching panchromatic pixel intensity to the sum of all the multispectral intensities.

4. COMBINED CATEGORIZATION AND CLASSIFICATION OF IMAGES

It is the process through which the source image and the reference image are combined into a single image. For the purpose of achieving the desired fusion objective, various strategies were foreseen by various authors. Several important groups of such methods are illustrated in the diagram below. These include a single sensor, multiple sensor, multimodal, Multiview, multi-focus, and multi-temporal methods, to name a few. Image Fusion System with Single Sensor

4.1 Single Sensor

The illustration to the right shows a represent-tation of an image fusion system using a single camera sensor. It's possible that the sensor depicted is similar to a digital camera's band-visible sensor. This sensor captures the real world as a sequence of images, which are then processed. This sequence is then integrated into an image, which is subsequently used to accomplish a task by either a human operator or a machine, depending on the situation. A human operator investigates the scene in a safe area for things such as those detected by the object detection system. This type of technology has some limitations due to the limited capacity of the imaging sensor that is being employed. The image quality, resolution, and other characteristics are all limited by the sensor's operational capabilities within the conditions under which the system may operate.

A digital camera is suitable for a lighting scenario in a bright environment, such as daylight scenes, but it is not suited for a lighting situation in a dark environment or under adverse lighting conditions, such as fog or rain, due to poor illumination**.**

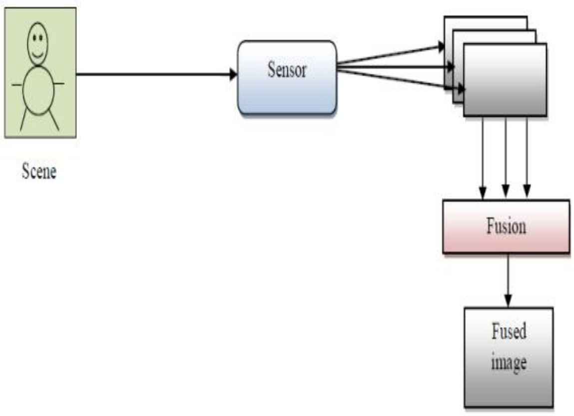


Fig1.4: Image Fusion System with Single Sensor

4.2 Multi-Sensors

To achieve a fused image in this scenario, a digital camera is augmented by an infrared camera, and the individual images captured by each camera are combined. This strategy overcomes the issues noted

above, and although a digital camera is appropriate for shooting daylight settings, an infrared camera is appropriate for shooting lighted scenes.The integration of data from several sensors has now developed into a discipline in which a growing number of application situations necessitate the development of more and more general formal solutions. A high level of spatial and spectral information is required in numerous image processing settings at the same time, and this information must be contained in a single image. However, due to observational limitations or instrument design, the instruments are unable to provide this type of information. Image fusion is one possibility for resolving the problem. [5]

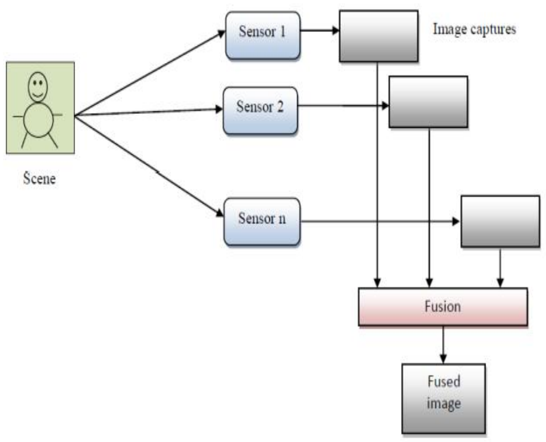


Fig 1.5: Multi-sensor Image Fusion System

The advantages of multi-sensor picture fusion include:

Multiple sensors working under various operating circumstances might increase the effective operating range. For example, separate sensors can be employed for day and night operations. Enhanced spatial and temporal coverage-spatial coverage can be extended by combining information from sensors with different spatial resolutions. The temporal aspect is the same. Multi-sensor joint information reduces ambiguity in the sensing or decision-making process. Reliability can be improved by taking numerous measures to reduce noise and improve the accuracy of the measurement. The system's robustness can be aided by the use of many sensors. Excellent performance from the system as a whole. It is possible for the system to rely on other sensors, or the performance of a single sensor is harmed when one or more sensors fail. Fusion results in concise representations of information. Rather than saving images from various spectral bands.

4.3 Multiview Fusion:

At the same moment, you may see many or diverse perspectives in this photograph. Fusion of images from many models such as panchromatic, multispectral, visible, infrared, and remote sensing are combined. Image fusion techniques that are commonly used

1. Weighted averaging pixel by pixel
2. Fusion in the transform domain
3. Fusion at the object level

4.4 Multi-Modal & Focus Fusion:

Images from many imaging modalities may be combined to improve the quality of a single picture. Multispectral, panchromatic, infrared, remote sensing, and visible pictures are all examples of several types of models, and focus fusion is an efficient way to combine information from many photographs with a similar perspective into a single image that covers a vast area. Composite pictures have a higher Informative content than their individual components.

4.5 Multi-TimelineFusion:

Multi-temporal fusion captures the same picture at different moments by combining images taken at different points in time. Observations of both long and short durations are necessary in order to accurately predict changes on the ground. Remote sensing photos

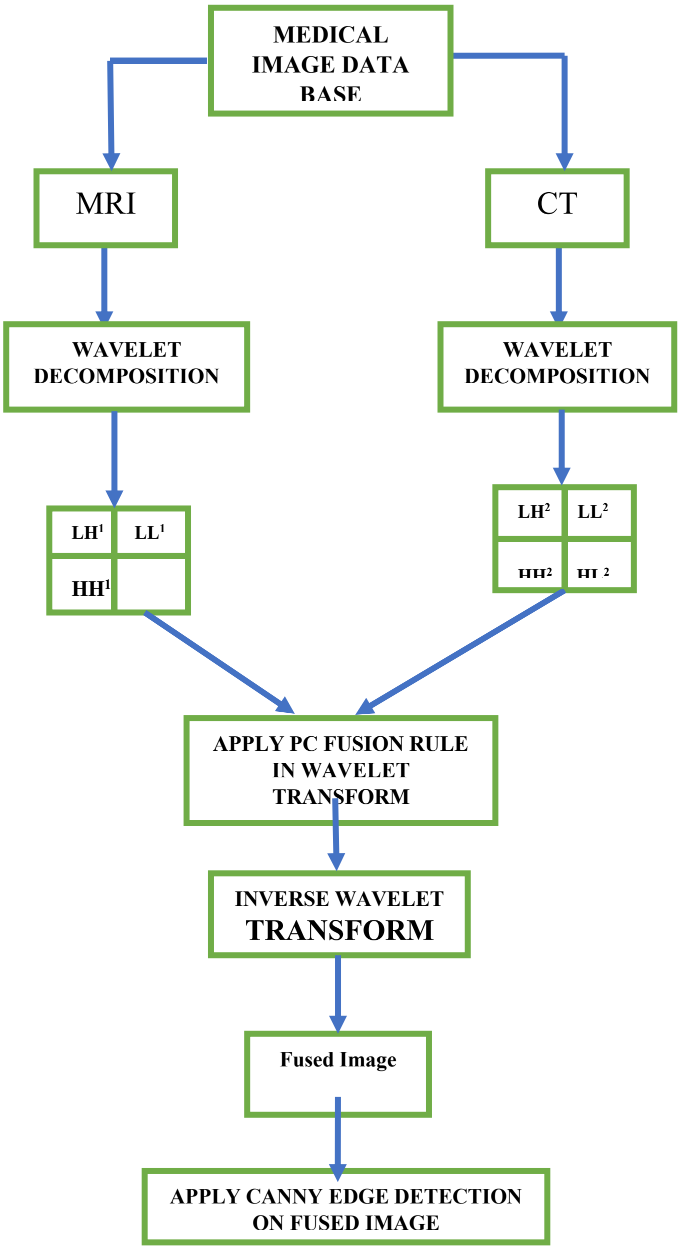
ISSN: 2057-5688

may be received at different periods for the same location because of the revisit satellites. When studying large geographic regions, multi-temporal pictures are essential..

5. PROPOSED METHOD COHESIVE WAVELET PRINCIPAL COMPONENT (CWPC)

PC (Principle component), is a data-adaptive orthonormal transform, it is a standard method to reduce the dimensionality of hyperspectral images whose projections have the propensity to have the maximum variance possible for N-spectral subspace at all values of N.PCA does not take account of spatial information. An unordered set of big pixels is treated as the spectral image. Wavelets represent edges and image data in multiple spatial scales efficiently. By filtering the wavelet coefficients on the Image at a specified scale, filters can be immediately Improved.

Wavelets can be more useful than pixels for many tasks [5]. Therefore, in a reduced dimension of pictures, in order to maximize edge information, we consider a reduction in the PC dimension of Wavelet coefficient. Be aware that the wavelet transformation is spatially performed over each image band, while the PC transformation is carried out over the image set. Both transformations therefore operate across different domains. PC with the full set of wavelet coefficients will give the same Eigen spectra as PC on the pixels [5]. However, in order to identify Eigen spectrums which maximize the energy of this subset of wavelet, PC can be used over a subset of wavelet coefficients. For instance, the PC will result in Eigen spectrums maximizing vertical wavelet energy only on the vertical wavelet sub bands. The term " Integrated wavelet PC" refers to computing main components for the identification of Wavelet PC Eigen spectrum in a masked or modified set of wavelet coefficients, and then projects the image to the Wavelet PC Eigen spectrum. Thus, the computed projection basis indirectly highlights features at a given scale, thus increasing images of reduced dimension without filtering artifacts. The artifacts which are introduced during image capturing and transmission must be reduced in order to avoid the difficulties that may arise during fusion process. The PC wavelet is computerized by the own spectra of scaled wavelet (e.g. masked) and the PC wavelet by calculating the own spectra of the pixels resulting from a transformation of modified wavelet [2]. Integrated Wavelet PC, where the main component pictures are computed, is projected to the own spectrum with the



pixel image and the main component photographs are computed

INTERNATIONAL JOURNAL OF TECHNO-ENGINEERING
IJTE
ISSN: 2057-5688

Fig 1.6: Block Diagram of Integrated Wavelet Principle Component with wavelet pictures projecting them onto

the own spectra and then transforming the inverse wavelet[2] and fused image is obtained after that applying canny edge detection on fused image for better diagnosis

The figure 1.5 represents the proposed IWPC method which involves image acquisition process via medical image data base. Here two different imaging modalities MRI and CT images consider for fusion process. These images are fed to wavelet decomposition to achieve its wavelet layers and then subjected to PC method to yield transformed image. Later inverse transform is applied, subsequently image fusion process and then subjected canny edge detection process to detect abnormalities

.5.1. IMAGE QUALITY METRICS

STANDARD DEVIATION (SD):

The SD, which is the square root of variance and it reflects the distribution of the data. Greater variance results high contrast image and a low contrast image is of a low difference. This shows the proximity of the fused image to the original pixel image I. The optimum value is 0 [12].

$$\sigma = \sqrt{\sum_{i=1}^{M} \sum_{j=1}^{N} (I(i,j) - M)^2} \qquad (2)$$

Covariance:

Covariance means that the corresponding elements of two sets of ordered data move in the same way. The covariance formula is very much like the variance formula. To calculate covariance the following formula is used.

$$COV(X,Y) = \frac{\sum_{i=1}^{n} (X_i - \bar{X})(Y_i - \bar{Y})}{(n-1)} \qquad (3)$$

Entropy:

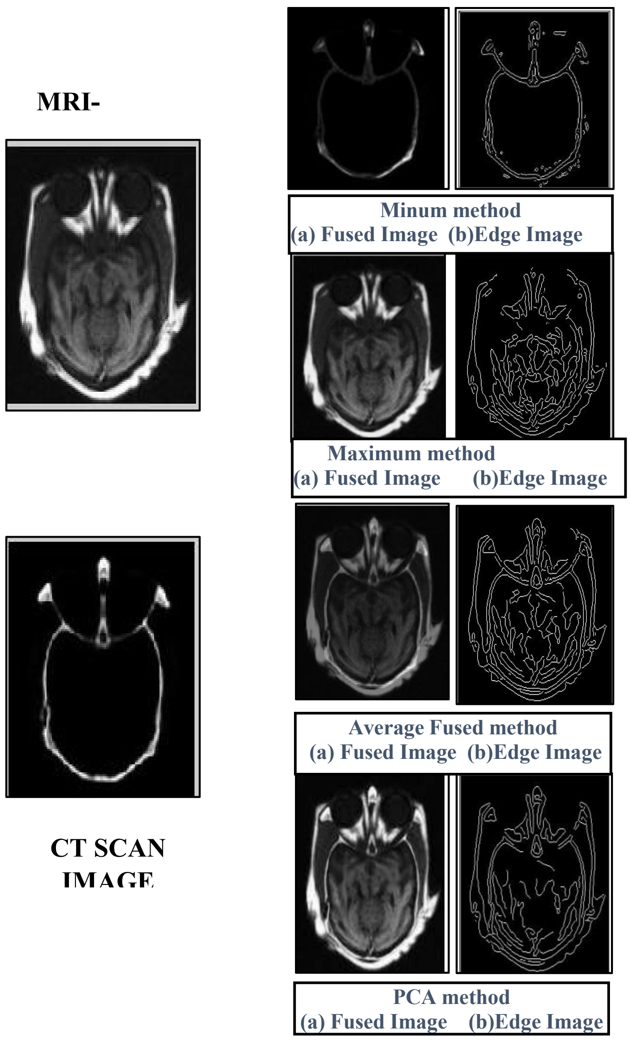
To evaluate the information contained in an image Entropy is considered as one of the vital image quality index. It is formulated as

$$E = -\sum_{i=0}^{N} p(x_i) \log p(x_i) \qquad (4)$$

Where x_i is the gray level value at i^{th} pixel with corresponding probability 'p'. Images which are containing more the information are having the larger entropy value

Mean:

The mean of all statistical measures is most fundamental. in geometry and analysis Mean is frequently used, for which a wide-ranging of means were developed. The medium filters are classified as space filters in image processing contests and are used to reduce noise. The mean filter, also known as the average filter, is used to calculate the mean of all pixels in the window, by



slipping on a' m portion ' window, replacing the center pixel value with the result.The formula is given below

ISSN: 2057-5688

$$f(x,y) = \frac{1}{mn}\sum_{r,c\in W} g(r,c) \qquad (5)$$

Fig 1.7: Various Spatial fused images

Where noisy image is the ‘g’, restored image is f(x,y), and the row ‘r’ and column ‘c’ are the coordinates respectively, within a window size of ‘W’

6. Results and Discussion

Minimal, maximum, average, and primary component of the spatial domain (PCA). Among these methods, the Maximum method delivers the most information about the fused image. In comparison to the other methodologies, the entropy, mean, standard deviation, covariance, and correlation are higher. A method with a higher entropy value, a picture with more information, a picture with a higher standard deviation value, and a picture with a higher image contrast The higher contrast image will havea greater variance. If the two images, i.e. the input image and the output image, are comparable, the correlation coefficient is close to one, and the greatest coefficient in the above approaches is just 0.29.

Table 6.1: Data-influencing factors in simple spatial image fusion analysis

Methods / Properties	Minimum	Maximum	Average	PCA
Entropy	2.28	3.16	5.92	6.75
Mean	8.73	20.56	24.67	60.38
Standard Deviation	24.14	30.15	34.74	58.44
covariance	1.76	2.30	3.26	6.79

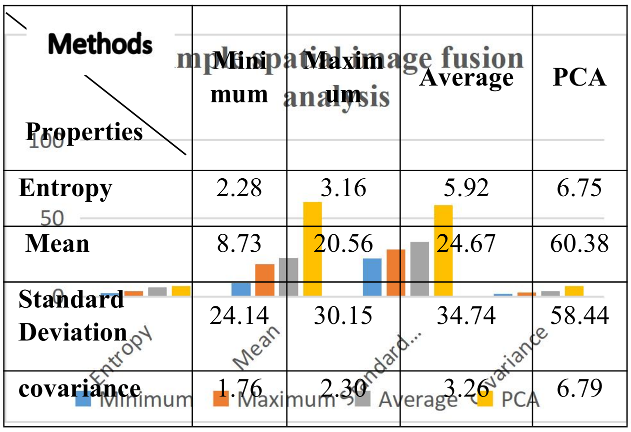


Fig 1.8: Various Spatial images fusion

FUTURE SCOPE

Experimental analysis on various wavelet transform methods, applying canny edge detection on resultant fused images, and analyzing the output visually as well as statistically with the help of quality measuring parameters (such as Mean, Standard deviation, Correlation coefficient, covariance, Entropy)) which are regularly used to measure the image quality, tabulate the values, and also represented the values by means of a representation. This is the future extension of the work, and it is concerned with the experimental analysis on various wavelet transform methods.

REFERENCES

1. Vishwakarma, A.; Bhuyan, M.K. Image Fusion Using Adjustable Non-subsampled Shearlet Transform. IEEE Trans. Instrum. Meas. 2018, 68, 3367–3378. [CrossRef]
2. Ouahabi, A. A review of wavelet denoising in medical imaging. In Proceedings of the 2013 8th International Workshop on Systems, Signal Processing and their Applications (WoSSPA), Algiers, Algeria, 12–15 May 2013; IEEE: New York, NY, USA, 2013; pp. 19–26.
3. Ahmed, S.; Messali, Z.; Ouahabi, A.; Trepout, S.; Messaoudi, C.; Marco, S. Nonparametric Denoising Methods Based on Contourlet Transform with Sharp Frequency Localization: Application to Low Exposure Time Electron Microscopy Images. Entropy 2015, 17, 3461–3478. [CrossRef]
4. Unser, M. Texture classification and segmentation using wavelet frames. IEEE Trans. Image Process. 1995, 4, 1549–1560. [CrossRef]
5. Meriem, D.; Abdeldjalil, O.; Hadj, B.; Adrian, B.; Denis, K. Discrete wavelet for multifractal texture

classification: Application to medical ultrasound imaging. In Proceedings of the 2010 IEEE International Conference on Image Processing, Hong Kong, China, 26–29 September 2010; IEEE: New York, NY, USA, 2010; pp. 637–640.

6. Hatt, C.R.; Jain, A.K.; Parthasarathy, V.; Lang, A.; Raval, A.N. MRI—3D ultrasound—X-ray image fusion with electromagnetic tracking for transendocardial therapeutic injections: In-vitro validation and in-vivo feasibility. Comput. Med. Imaging Graph. 2013, 37, 162–173. [CrossRef]
7. Labat, V.; Remenieras, J.P.; BouMatar, O.; Ouahabi, A.; Patat, F. Harmonic propagation of finite amplitude sound beams: Experimental determination of the nonlinearity parameter B/A. Ultrasonics 2000, 38, 292–296. [CrossRef]
8. Dasarathy, B.V. Medical image fusion: A survey of the state of the art. Inf. Fusion 2014, 19, 4–19. [CrossRef]
9. Zhao, W.; Lu, H. Medical Image Fusion and Denoising with Alternating Sequential Filter and Adaptive Fractional Order Total Variation. IEEE Trans. Instrum. Meas. 2017, 66, 2283–2294. [CrossRef]
10. El-Gamal, F.E.-Z.A.; Elmogy, M.; Atwan, A. Current trends in medical image registration and fusion. Egypt. Inf. J. 2016, 17, 99–124. [CrossRef]
11. Li, S.; Kang, X.; Fang, L.; Hu, J.; Yin, H. Pixel-level image fusion: A survey of the state of the art. Inf. Fusion 2017, 33, 100–112. [CrossRef]
12. Li, S.; Kwok, J.T.; Wang, Y. Multifocus image fusion using artificial neural networks. Pattern Recognit. Lett. 2002, 23, 985–997. [CrossRef]
13. Li, S.; Kwok, J.-Y.; Tsang, I.-H.; Wang, Y. Fusing Images with Different Focuses Using Support Vector Machines. IEEE Trans. Neural Netw. 2004, 15, 1555–1561. [CrossRef]
14. Vijayarajan, R.; Muttan, S. Iterative block level principal component averaging medical image fusion. Optik 2014, 125, 4751–4757. [CrossRef]
15. Naidu, V.; Raol, J. Pixel-level Image Fusion using Wavelets and Principal Component Analysis. Def. Sci. J. 2008, 58, 338–352. [CrossRef]
16. Singh, S.; Anand, R.S. Multimodal Medical Image Fusion Using Hybrid Layer Decomposition with CNN-Based Feature Mapping and Structural Clustering. IEEE Trans. Instrum. Meas. 2020, 69, 3855–3865. [CrossRef]
17. Du, J.; Li, W.; Lu, K.; Xiao, B. An overview of multi-modal medical image fusion. Neurocomputing 2016, 215, 3–20. [CrossRef]
18. Kappala, V.K.; Pradhan, J.; Turuk, A.K.; Silva, V.N.H.; Majhi, S.; Das, S.K. A Point-to-Multi-Point Tracking System for FSO Communication. IEEE Trans. Instrum. Meas. 2021, 70, 1–10. [CrossRef]
19. Mitianoudis, N.; Stathaki, T. Pixel-based and region-based image fusion schemes using ICA bases. Inf. Fusion 2007, 8, 131–142. [CrossRef]
20. Toet, A.; van Ruyven, L.J.; Valeton, J.M. Merging Thermal And Visual Images By A Contrast Pyramid. Opt. Eng. 1989, 28, 287789. [CrossRef]
21. Toet, A. Image fusion by a ratio of low-pass pyramid. Pattern Recognit. Lett. 1989, 9, 245–253. [CrossRef]
22. Li, X.; Guo, X.; Han, P.; Wang, X.; Li, H.; Luo, T. Laplacian Redecomposition for Multimodal Medical Image Fusion. IEEE Trans. Instrum. Meas. 2020, 69, 6880–6890. [CrossRef]
23. Li, H.; Manjunath, B.S.; Mitra, S.K. Multisensor Image Fusion Using the Wavelet Transform. Graph. Model. Image Process. 1995, 57, 235–245. [CrossRef]
24. Lewis, J.J.; O'Callaghan, R.J.; Nikolov, S.G.; Bull, D.R.; Canagarajah, N. Pixel- and region-based image fusion with complex wavelets. Inf. Fusion 2007, 8, 119–130. [CrossRef]