American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)
ISSN (Print) 2313-4410, ISSN (Online) 2313-4402

http://asrjetsjournal.org/

A Study on Multiresolution based Image Fusion Rules using Intuitionistic Fuzzy Sets

Tania Sultana[a*], B. M Ashiqur Rahman[b], Mohammad Motiur Rahman[c]

[a,c]*Department of CSE, MBSTU,Tangail,Bangladesh*
[b]*Department of Textile, MBSTU,Tangail,Bangladesh*
[a]*Email: tania_educational@yahoo.com*

Abstract

The purpose of image fusion is to create a single image that optimizes the amount of data also highlight the necessary information from two or more source images**.** There are various types of pixel based image fusion methods such as AVG, Principle Component Analysis (PCA), Intensity Hue Saturation (IHS), Brovey Transform (BT), Discrete Wavelet Transform (DWT) etc. But Stationary wavelet Transform (SWT) based fusion method provides better fusion result with less color distortion. On the other-hand, Intuitionistic Fuzzy Set (IFS) helps to remove the barrier of vagueness and uncertainties from the fused image. That is why; this paper focus several types of fusion methods using SWT with different IFS operations for find the better one that is helpful for human perception also for next generation image processing.

Keywords: Image fusion; wavelet transform; Intuitionistic fuzzy set; image analysis.

1. Introduction

Image fusion plays an efficient role in the field of image processing. According to the traditional definition, 'image fusion is the combination of two or several images into a single one that is more informative in compared with input images'. In medical science, remote sensing, robotics or these types of sector only single image is not enough to represent appropriate information. In this case, image fusion provides better solution to capture highest relevant information from source images. Similarly**,** the combination of high resolution panchromatic (PAN) image with low spatial resolution multispectral (MS) image provides high spatial resolution fused image**.**

---

* Corresponding author.

The goal of image fusion is to reduce redundancy, optimize the errors from the fused image. It has three individual levels such as pixel level, decision level and feature level. Pixel level image fusion is more popular to the researchers because of its simple structure easy implementation procedure. Now a day's wavelet transform specially, Stationary Wavelet Transform (SWT) is more popular among all of the pixel based image fusion techniques because of its linear structure, simplicity and shift invariance capacity.

Wavelet based pixel level maximum selection rules are used to instigate two or more different images into single one [1]. Combination of neural network and fuzzy logic provide improved fusion results [2]. Wu and his colleagues compare different methods of image enhancement using wavelet [3]. Pixel level image fusion gives better image quality with minimum noise [4]. Complex intuitionistic fuzzy set with generalized form in addition to non-membership function is introduced by Abdulazeez and his colleagues [5]. Membership and non-membership functions are the part of intuitionistic fuzzy set [6]. Comparison of various fusion method is important to evaluate the better fusion method [7]. Said and his colleagues has shown some new operations based on intuitionistic fuzzy soft sets and its applications [8]. In urban environment image fusion plays an important role [9]. Necessity ,probability ,closure operators makes the intuitionistic fuzzy sets more popular [10]. Various multi-resolution based fusion algorithm provides different fusion results with respect to their decomposition level [11]. Image fusion plays a vital role in medical images. Wavelet transform based fusion methods for medical images provides better result than other methods [12]. Several pixel level image fusion algorithms discussed by K.P summon and his colleagues [13].

1. SWT based image fusion :

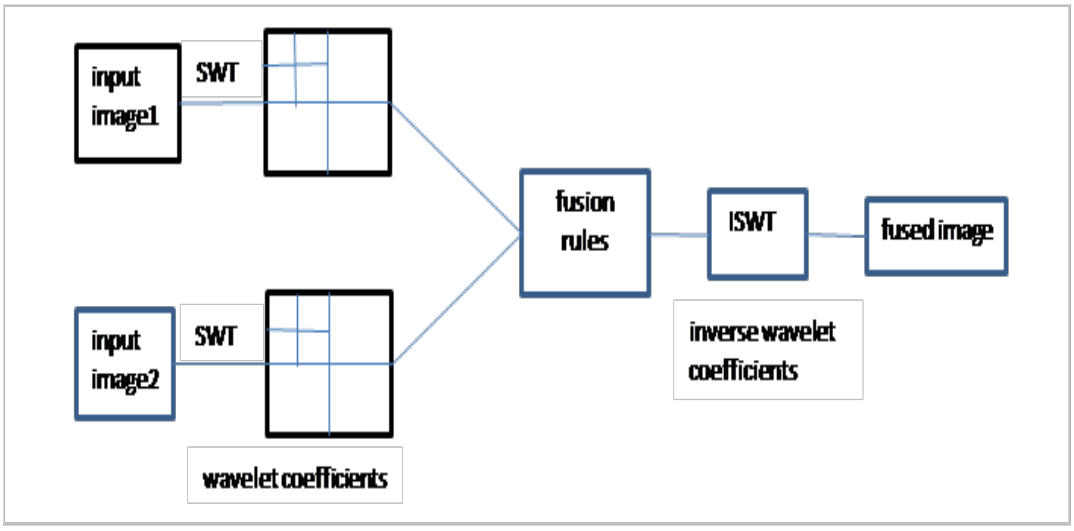


Figure 1: General diagram for image fusion using SWT

In image processing, Stationary Wavelet Transform (SWT) gives productive outcomes in the barrier of image contrast, quality, image resolution etc. SWT provides improved approximation because of its shift invariance capacity in compared with traditional Discrete Wavelet Transform (DWT). SWT is linear, easy to implement and provides the same number of output at each level in compared with the inputs. In this fusion methods, input images decomposed by (SWT) into particular sub-bands such as Approximation (A),Vertical (V),Horizontal

(H),Diagonal (D) details. Fusion is performed by using the Intuitionistic Fuzzy Sets (IFS) rules with respective sub-bands. Then apply inverse stationary wavelet transform to get to final fused image that is more informative, high image quality with less noise. Various types of image fusion rules using SWT with Intuitionistic Fuzzy Sets (IFS) is discusses in below.

2. Various intuitionistic fuzzy Sets based (IFS) fusion rules:

According to Atanassov, IFS is mention as follows [10].

If X is a non-empty set then a fuzzy set A from x defined as,

$$\boldsymbol{A} = \{\boldsymbol{x}, \boldsymbol{\mu_A}(\boldsymbol{x}), \boldsymbol{V_A}(\boldsymbol{x}), \boldsymbol{x} \in \boldsymbol{X}\}$$

Where $\mu_A(x)$ is the membership function and its value is defined as $\mu_A(x) \rightarrow [0,1]$ and the non-membership function is described as $V_A(x) \rightarrow [0,1]$. The degree of non-membership and membership function is always $0 \leq \mu_A(x) + V_A(x) \leq 1$ for all values of x ∈ X. In IFS, $\pi_A(x)$ is defined as hesitation of x in A. $\pi_A(x) = 1 - \mu_A(x) - V_A(x)$, the range of mention as $\pi_A(x) \in [0,1]$ and $0 \leq \pi_A(x) \leq 1$.

If I (m,n) and J (m,n) are the two different images and $\mu_I(x), \mu_J(x)$ are the membership functions, $V_I(x), V_J(x)$ are the non-membership functions then some fusion rules can be express as-

$$\text{Avg } operation = \left\{\frac{\left(\mu_I(x)+\mu_J(x)\right)}{2}, \frac{\left(V_I(x)+V_J(x)\right)}{2}\right\}$$

$$Uniou\ operation = \left\{max\left(\mu_I(x), \mu_J(x)\right), min\left(V_I(x), V_J(x)\right)\right\}$$

$$\text{intersection } operation = \left\{min\left(\mu_I(x), \mu_J(x)\right), max\left(V_I(x), V_J(x)\right)\right\}$$

$$Addition = \left\{\mu_I(x) + \mu_J(x) - \mu_I(x)\mu_J(x), V_I(x), V_J(x)\right\}$$

$$Multiplication = \left\{\mu_I(x)\mu_J(x), V_I(x) + V_J(x) - V_I(x), V_J(x)\right\}$$

$$moderate\ intersection = \left\{min\left((1 - V_I(x)), (1 - V_J(x))\right), max\left((1 - \mu_I(x)), (1 - \mu_J(x))\right)\right\}$$

$$\text{New } operation = \left\{max\left(V_I(x), \min(\mu_I(x), \mu_J(x))\right), min\left(\mu_I(x), \max(V_I(x), V_J(x))\right)\right\}$$

3. Experimental results and comparative analysis :

Experiment applied on various types of images such as medical images, multi-clock images, aircraft images etc. The visual result of medical image fusion shown in Figure 2 and Figure 5 represents the fusion results of multi-clock images. Standard deviation (SD) is the measurement component of image contrast. Highest value of SD mentions the superior image contrast. Spatial frequency (SF) is used to represent the universal activity of the

fused image. Massive SF results provide better image fusion results. On the other hand, huge amount of Mutual Information (MI) gives the improved image quality. Fusion results of various IFS rules for medical image shown in below-

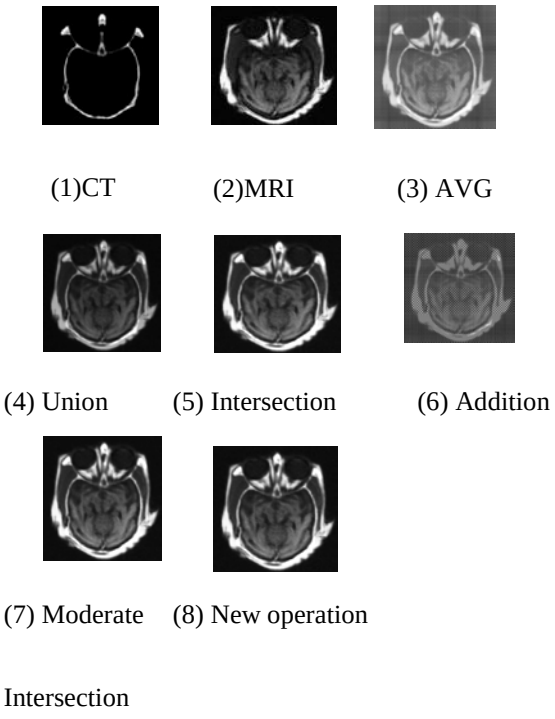


Figure 2: Output results of different IFS fusion methods for medical images.

Table-1 shows that, according to the experimental results among all of the IFS operations 'New operations' provide better fusion results in compared with other IFS rules. Intersection and Moderate intersections outputs are very closure to the 'New operations'. 'New operations' have high values of SF, that indicate the fused image has more functional activity compared with others. It has also high values of STD and MEAN and lowest value of RMSE that represents better image quality with optimum error level.

Table1: Experimental results comparison of Medical images for various IFS rules.

Fusion methods	MEAN	c	STD	RMSE
Average	65.2105	2.07	47.8329	0.5571
Union	63.0943	2.40	61.9395	0.3327
Intersection	64.9986	2.49	63.8943	0.3026
Multiplication	60.3642	1.95	43.6279	0.6962
Addition	54.0943	2.06	59.8895	0.4683
Moderate intersection	64.7239	2.50	64.0312	0.3024
New operations	65.0204	2.68	64.1030	0.3022

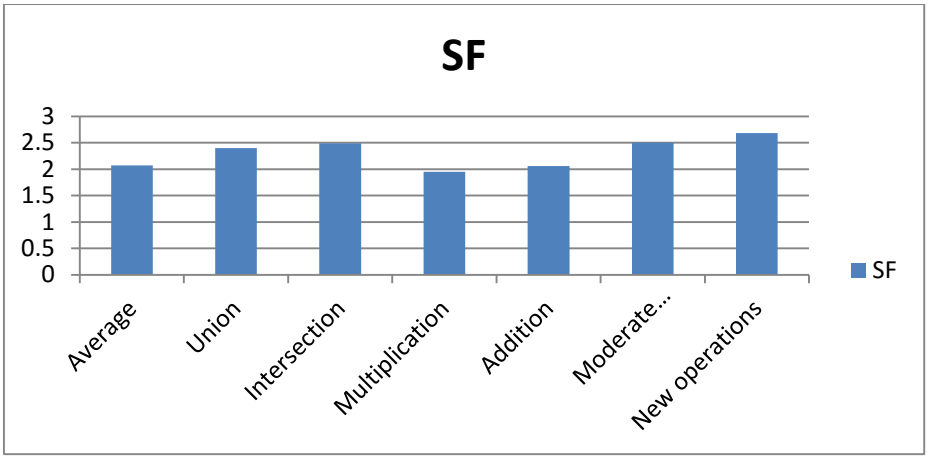


Figure 3: Performance analysis of SF values for medical images.

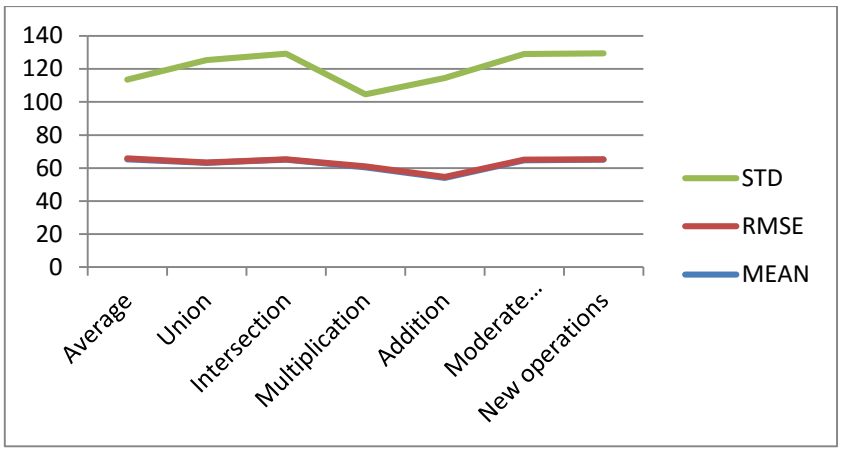
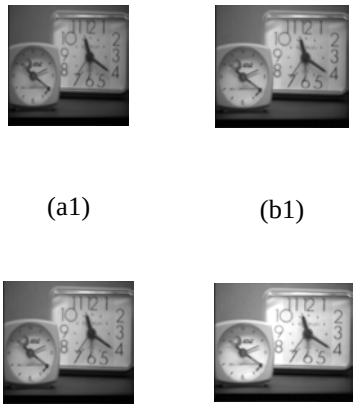


Figure 4: Performance analysis of MEAN, RMSE and STD values for medical images.

Visual outcomes of multi-clock also shows that the 'New operation' provides better fusion result in compared with Union, Intersection, Moderate Intersection and other IFS rules.



(a1) (b1)

Figure 5: Experimental outcome of (a1) Union, (b1) Intersection, (c1): Moderate intersection, (d1): New operation of different IFS methods for multi-clock images.

Table2: Experimental results comparison of multi-clock images for different IFS rules

Fusion methods	MEAN	SF	STD	RMSE
Average	103.3762	1.03	57.4990	0.3539
Union	94.3484	1.15	47.2459	0.0366
Intersection	139.0637	2.41	65.0830	0.0497
Multiplication	92.5429	1.10	54.6888	0.3745
Addition	91.3637	1.13	66.3394	0.5452
Moderate intersection	140.8791	2.40	70.3884	0.1363
New operations	141.2788	2.43	70.3900	0.1339

The fusion result for multi-clock images using SWT with different IFS rules also shows that three methods are almost same in compared with other methods. But 'New operation' provides highest value of SF, STD and lowest value of RMSE that means it gives best solution from other rules.

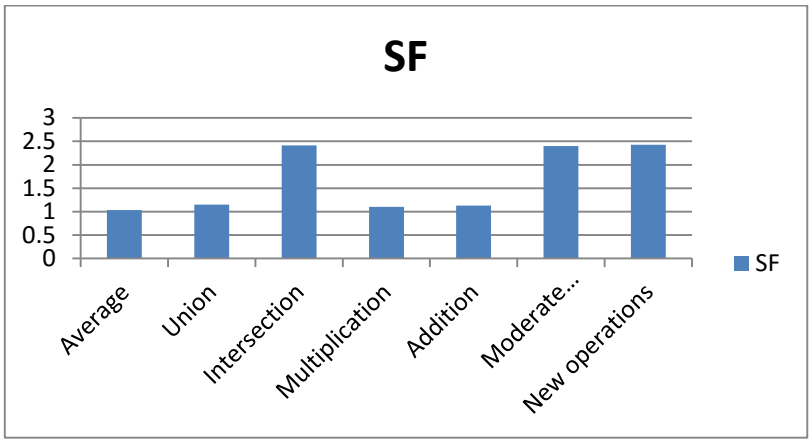


Figure 6: Performance analysis of SF values for Multi-clock images.

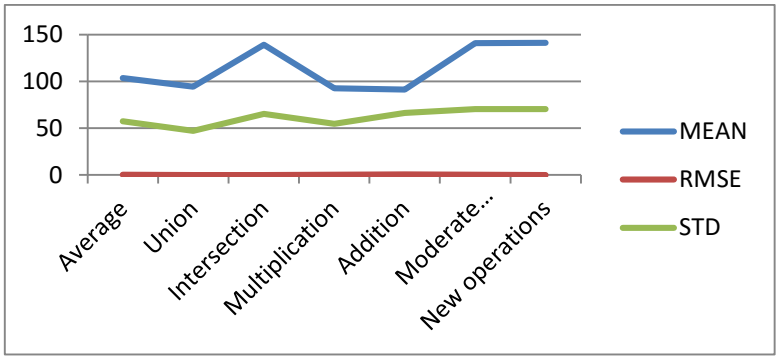


Figure 7: Performance analysis of MEAN, STD and RMSE values for Multi-clock images.

4. Conclusion

According to experimental results and overall performance it is clear that three methods are almost similar to each other. But after carefully observation, it is proof that the 'New operation' of IFS using SWT provide better fusion results in compared with other methods because of its less complex structure with simple shape of membership and non-membership function. That means, SWT with IFS 'New operation' fusion method capture highest amount of information from source images with slight error.

Reference

[1] O. Prakash, A. kumar, A. khare,"Pixel-level image fusion scheme based on steerable pyramid wavelet transform using absolute maximum selection fusion rule", International Conference on Issues and Challenges in Intelligent Computing Techniques (ICICT),IEEE,2014.

[2] S. Dammavalam, Seetha,H. Munaga," Iterative Image Fusion using Neuro Fuzzy Logic and Applications",IEEE,2012.

[3] Feng, gang, Jin, ming, jun,"Comparative analysis of different methods for image enhancement", springer, PP- 4563−4570,2014.

[4] N. Kathiresan , J. Samuel Manoharan," A Comparative Analysis of Fusion Techniques Based on Multi Resolution Transforms",springer, PP- 61-65,2015.

[5] Abdulazeez,A. Razak Salleh," Complex Intuitionistic Fuzzy Sets",International conference on fundamental and applied science, PP- 464-470,2012.

[6] P. A.Ejegwa, S.O. Akowe, P.M. Otene, J.M. Ikyule," An Overview On Intuitionistic Fuzzy Sets", international journal of scientific & technology research volume 3, issue 3, march 2014.

[7] Z. Wang, D. Ziou, C. Armenakis, D. Li, and Q. Li," A Comparative Analysis of Image Fusion Methods", IEEE transactions on geoscience and remote sensing, vol. 43, no. 6, June 2005.

[8] S. Broumi,P. Majumdar,F. Smarandache," New Operations on Intuitionistic Fuzzy Soft Sets based on Second Zadeh's logical Operators", I.J. Information Engineering and Electronic Business, PP-25-31,2014.

[9] S. Dahiya, P. K. Garg, M. K. Jat ," A comparative study of various pixel based image fusion techniques as applied to an urban environment", International Journal of Image and Data Fusion,Vol-4,No-3, PP-197-213,2013.

[10] K.T. Atanassov," intuitionistic fuzzy sets", Fuzzy Sets and Systems, Elsevier ,PP-87-96,1986.

[11] S.Li, B.Yang, J.Hu,"performance comparison of different multi-resolution transforms for image

fusion", Elsevier,2014.

[12] M.D. Nandeesh and Dr.M. Meenakshi ,"Image Fusion Algorithms for Medical Images-A Comparison", Bonfring International Journal of Advances in Image Processing, Vol. 5, No. 3, July 2015.

[13] S. Krishnamoorthy, K P Soman,"Implementation and Comparative Study of Image Fusion Algorithms", International Journal of Computer Applications (0975 – 8887) Volume 9– No.2, November 2010.