Analysis on SWT based Image Fusion Techniques using Intuitionistic Fuzzy Set Operations

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Abstract: Image fusion is just the combination of two or several images into single one that has more information than the source images. There are various types of image fusion techniques such as principle component analysis (PCA), Intensity-hue-saturation (IHS), discrete wavelet transform (DWT) etc. In this paper, we discuss four method of image fusion using stationary wavelet transform (SWT) with the help of intuitionistic fuzzy set (IFS) operations. It has membership and non-membership values. In IFS, less number of parameters is very useful for calculating membership value. On the other hand, SWT has shift invariance capacity over the DWT. For this reason, this paper discusses SWT based image fusion techniques with various IFS operation for different data set and compared the results with each other.

Keywords: Image fusion, stationary wavelet transform (SWT), intuitionistic fuzzy sets (IFSs), image analysis.

1. INTRODUCTION

Image fusion is the most important part of image processing in where particular information could be finding from two or several images. The application area of this field is increasing dramatically.In medical science; remote sencing, hidden weapon detection etc are the basic application area of image fusion.Image fusion technique can be classified as three levels such as pixel level, feature level and decision level.Pixel level fusion technique is easy to implement than others teachniques.This method directly hanle the image pixel. In this image fusion method, wavelet transform decompose both images into low frequency and high frequency subbands. Fusion rules apply to corresponding low frequency and high frequency sub-bands. Apply inverse wavelet transform for the final fused image. Total procedure discuss in [1].M.A Rahman apply fuzzy logic with wavelet transform for better fused result [2].Neuro-fuzzy is the combination of neural network and fuzzy logic. By getting the input data from the sensor, neuro-fuzzy system helps to train up the data for more appropriate results that is discuss in [3].Various pixel level image fusion techniques such as principle component analysis (PCA), Intensity-hue-saturation (IHS), wavelet etc transformation etc describe in this paper [4].This paper compare different methods of image fusion with quantitative analysis [5].Mr. desale, explain PCA, DCT and wavelet based image fusion techniques with proper measurement for more details see [6].Pankaj [7] proposed an algorithm in 2014 about image fusion using wavelet transform and adaptive neuro-fuzzy. Intuitionistic fuzzy set (IFS) and its application in described by P. A. Ejegwa in 2014 [8].This paper highlights the Intuitionistic fuzzy multiset and its application in medical diagnosis [9].

2. STATIONARY WAVELET TRANSFORMS (SWT)

Stationary wavelet transforms (SWT) decompose the images into approximation (A), horizontal (H), vertical (V) and diagonal (D) details. It provides improved approximation over the discrete wavelet transform (DWT).Traditional DWT is not shift invariant capacity. As a result, DWT of the original version and the translated version are not same. On the other hand, SWT has the shift invariant capacity and also it's redundant and linear. Therefore, for better image fusion quality we use SWT over DWT with intuitionistic fuzzy sets (IFS).

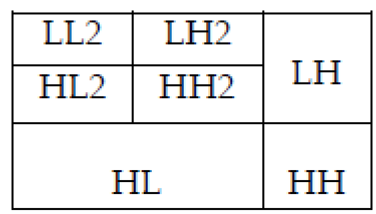

Fig.1. *SWT decomposition for 2nd level.*

2.1 INTUITIONISTIC FUZZY SETS (IFS)

Let, M be a finite set where M= {m_1, m_2, m_3…,m_n}. If N is a intuitionistic fuzzy set it can be express as $N = \{M, \mu_N(m), v_N(m) : m \in M\}$ Here μ_N (m) is the membership function and its mathematical range of μ_N (m) is $\mu_N : m \to [0,1]$.Non-membership function V_N (m) can be denoted as V_N =1-μ_N (m) where $v_N : m \to [0,1]$.The boundary of membership and non-membership functions is $0 \le \mu_N$ (m) + V_N (m) ≤ 1 for each $m \in M$.

For calculate the membership function here we use bell membership function.

$$1/(1+|(x-c)/a|^{2b}) \qquad (1)$$

Here a,b,c are the parameters.

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3 Various Fusion Rules using SWT with IFS

In case of better fusion results, average the approximation details (A_1,A_2)of SWT decomposition of both images in maximum,minimum and multiplication rules.If A_1 (i,j) and A_2 (i,j)are two approximation details of two images then average them-

$$(A\,(i,j)+B\,(i,j))/2$$

Then find the membership value (μ) and non-membership value (V) for other sub-bands.

1. IFS based fusion method using maximum rules

Maximum rules is that if the membership value (μ) of image A is greater then image B then select the pixel value from image A.Otherwise collect the pixel value from image B.Same maximum rules apply for non-membership value (V) and finally select the maximum value from two images by appling same procedure for membership (μ) and non-membership value (V) by using the following equ.

$$\mu = \begin{cases} \mu_A & \text{if } \mu_A >= \mu_B \\ \mu_B & \text{if } \mu_B >= \mu_A \end{cases}$$

$$V = \begin{cases} V_A & \text{if } V_A >= V_B \\ V_B & \text{if } V_B >= V_A \end{cases}$$

$$I_f = \begin{cases} \mu & \text{if } \mu >= V \\ V & \text{if } V >= \mu \end{cases}$$

In where μA, μB are the membership value of image A and B and VA, VB are the non-membership value of both images.

2. IFS based fusion method using minimum rules In minimum image fusion rules using IFS with SWT, alwalys priority the minimum pixel value of the respective subband from both images.This rule can be describe as-

$$\mu = \begin{cases} \mu_A & \text{if } \mu_A <= \mu_B \\ \mu_B & \text{if } \mu_B <= \mu_A \end{cases}$$

$$V = \begin{cases} V_A & \text{if } V_A <= V_B \\ V_B & \text{if } V_B <= V_A \end{cases}$$

$$I_f = \begin{cases} \mu & \text{if } \mu <= V \\ V & \text{if } V <= \mu \end{cases}$$

3. IFS based fusion method using multiplication rules If A and B are the two different images then the multiplication rules describe as-

$\mu = \mu A * \mu B$
V=VA +VB -(VB*VA)
I_f= min (μ ,V)

Here μ is the product of membership values of both images. On the otherhand, I*f* is the fused image.

3.1 FUSION ALGORITHM

Algorithm for image fusion is described as follows-

1. According to image fusion, decompose the images such as A and B into four individual sub-bands. The sub-bands are approximation (A), vertical (V), horizontal (H) and diagonal (D) details of both images. For better fusion quality average the Approxima tion details of both images.
2. According to IFS rules, find the membership value of other sub-bands of both images using equ. (1) And by using membership value calculate the nonmembership value that is discussed in section 2.1.
3. Then apply the fusion rules of corresponding subbands of both images with the help of section 3.
4. Apply inverse SWT for fused images.
5. Lastly for better image resolution apply clip function and get the final fused image.

The block diagram of image fusion techniques are as follows –

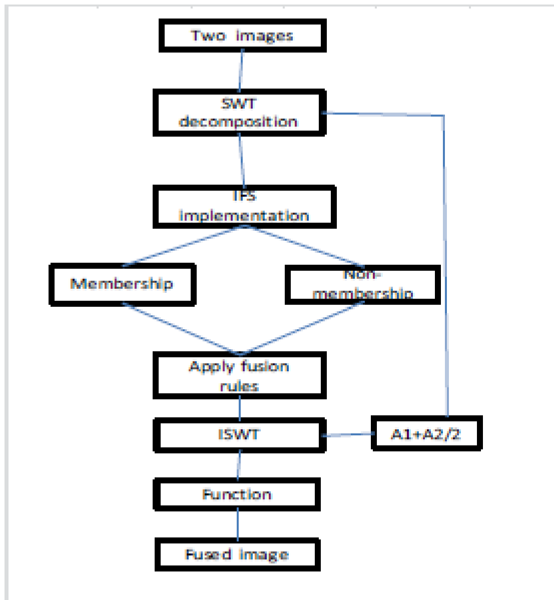

Fig2: *Image fusion using IFS rules*

4 COMPARATIVE ANALYSIS

Experiment shows that different methods of image fusion using SWT with fuzzy rules provide the better fusion results. Experiment applied on various types of images such as medical images, multi-clock images etc.The comparative results are general average method, IFS_maximum, IFS_minimum and IFS_multiplication.The comparative analysis discuss in bellow.

Fusion scheme	MEAN	STD	RMSE
AVG	118.0303	59.0344	0.0868
IFS_MAX	155.3007	75.7534	0.1664
IFS_MIN	117.8397	59.0131	0.0864
IFS_MUL	129.4697	65.8419	0.1131

Table-1: *comparative performance analysis on different fusion method using SWT,IFS with fuzzy rules for medical images.*

This table explains that, for medical images the MEAN value of IFS_multiplication rules is the highest comparatively with other rules where as the lowest STD value acquired by IFS_minimum rules and highest is IFS_multiplication rules. On the otherhand IFS_multiplication rules has the lowest RMSE value.The camparative results mention that the IFS_MUL techniques collects more information than others IFS based fusion methods.

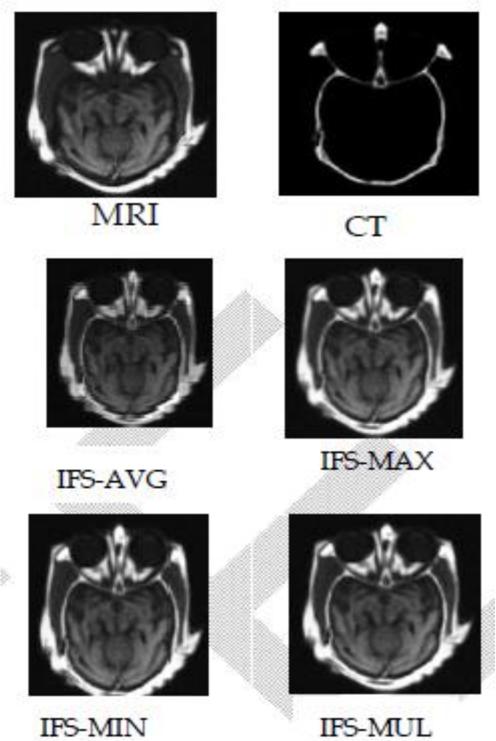

Fig.3. *Experiment applied for medical images for different fusion techniques.*

Fusion scheme	MEAN	STD	RMSE
IFS_AVG	64.8962	63.9644	0.3027
IFS_MAX	65.1037	63.9459	0.3032
IFS_MIN	64.6267	63.9737	0.3019
IFS_MUL	68.4775	63.2723	0.2842

Table-2: *comparative performance analysis on different fusion method using SWT, IFS with fuzzy rules for multi clock images.*

For the multi-clock images,in case of IFS_MUL mean value is high at the same time RMSE is comparatively low than the other methods.So this method provide better fused result. After measuring the performence, it is clear that intuitionistic fuzzy set with SWT provide qualityful fused image with high resolution.

Fig.4. *Experiment applied for multi clock images for different fusion techniques*

4 CONCLUSION

This paper discusses and compares the output of different techniques of image fusion using stationary wavelet transform (SWT) and intuitionistic fuzzy set (IFS) operation.The summary of this paper is that,the IFS_multiplication techniques provide better fused images compared with other IFS operation. The output will be enhance by editing the membership and non membership value of intuitionistic fuzzy set (IFS).

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