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An Efficient Image Enhancement Technique using Stationary Wavelet Transform Based Image Fusion

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Abstract*: As far as the image processing area is concerned it is observed that it is comprised of various subfields, one such is the image fusion sub field. The devised responsibility of the Image fusion subfield is that it is expected to aggregate the various images of a particular scene together, this obtained final image has been found to provide additional information regarding the concerned scene and is further found to resolve the ambiguities in the selected input images. Another form of image fusion technique is the multi-sensor image fusion technique, in this technique the various images of a particular scene have been found to be obtained from different sensors possessing different resolution ranges. The next form of image fusion technique is the multi-focus image fusion technique, here the images pertaining to a particular scene would be collected from the same sensor and these images when aggregated together would result in the formation of an image that essentially comprises of all the objects that are in focus. Two different types of domains have been observed to exist in the image processing zone, these are known as the spatial and the transformed forms of domains, it is in these domains that the image fusion procedures would essentially take place. The procedure accomplished in the spatial domain is that the contained pixel values would be directly adopted into the fusion procedure, on the other hand in the transformed domain the input images would be initially converted by means of incorporating the wavelet decomposition mechanism or the pyramid decomposition strategy so as to exploit the available contents at various scales or multi-resolutions.

***Index Terms*: Principal Component Analysis , Discrete Wavelet Transform, Image fusion.**

I. INTRODUCTION

In general an image is found to comprise of physically relevant features at various scales or resolutions. Exploitation of this fact can be essentially brought about by means of the Multi-scale or multi-resolution approaches [1]. Once the image conversion process ceases, these converted images would be then fused or aggregated together by incorporating certain fusion procedures or operations, the final fused image is then obtained by taking the inverse transforms. The process of multi-resolution based image fusion procedure has been suitably illustrated in the Figure 1. The procedure of Image fusion has been observed to be accomplished at three different levels of information representation, this is found to comprise of the pixel level, the feature level and the decision level respectively [2]. The pixel-level type of fusion has been found to be the simplest form of fusion levels, further it accommodates simple operational procedures[3]. Linear wavelets like the Haar wavelet suffers from the following limitation, during the signal decomposition or the analysis procedure the process essentially fails to safeguard the original data[4]. As the wavelets perform low-pass filtering they are found to essentially smooth out the edges, this ultimately leads to the reduction of the contrast levels in the concerned fused images[5]. Figure 2 portrays the DWT-based (multi-scale decomposition) image fusion process. The process of range compression[6] has been accomplished by them on the concerned target gradients in order to solve the dynamic range problem[7].

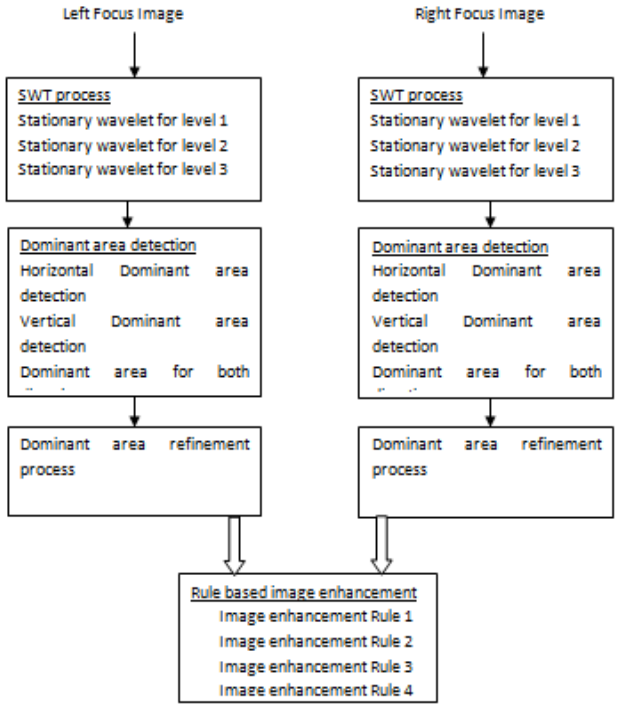

Fig 1: Architecture diagram of the proposed method

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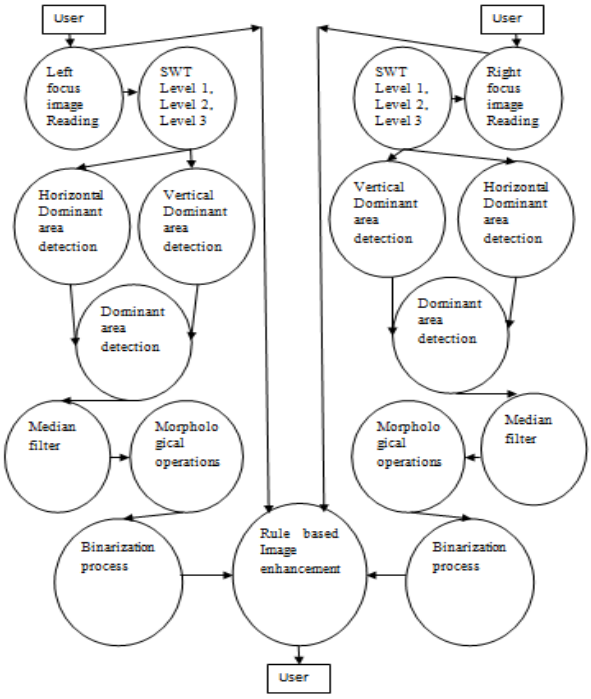


Fig 2: Data flow diagram of the proposed method

II. EXPERIMENTAL RESULTS AND ANALYSIS

This paper presents a new image enhancement method for multi focus images. The enhancement is supported by dominant area detection using SWT and morphology operations. The rule based system reconstructs or enhances the multi focus images. In this paper 75 set of Left-and-right focus images are tested. Also this paper tests another 75 sets of top-and-bottom focus images. The experimental results are in fine manner for both left-and-right focus images as well as top-and-bottom focus images.

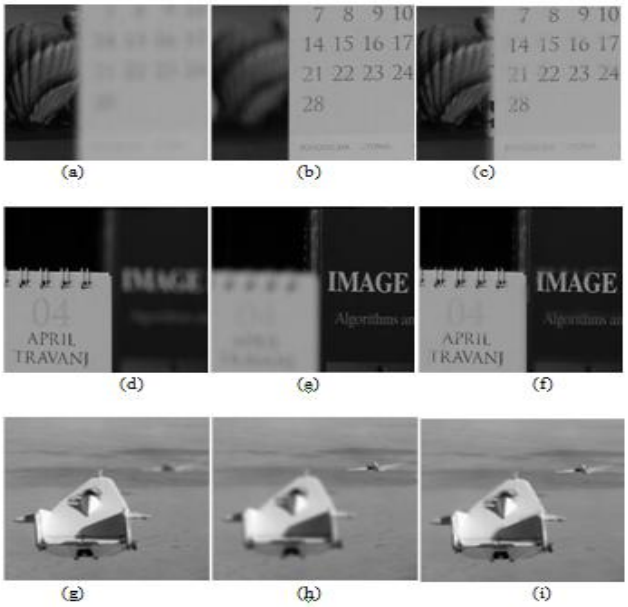


Fig 3: image enhancement results for left and right focus images. a), d), g) Original Left focus images. b), e), h) Original right focus images. c), f), i) Enhanced images by proposed method.

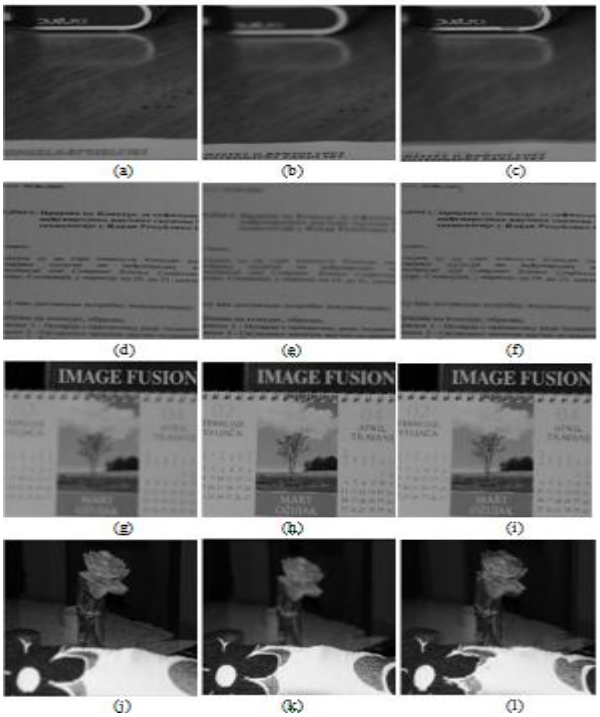
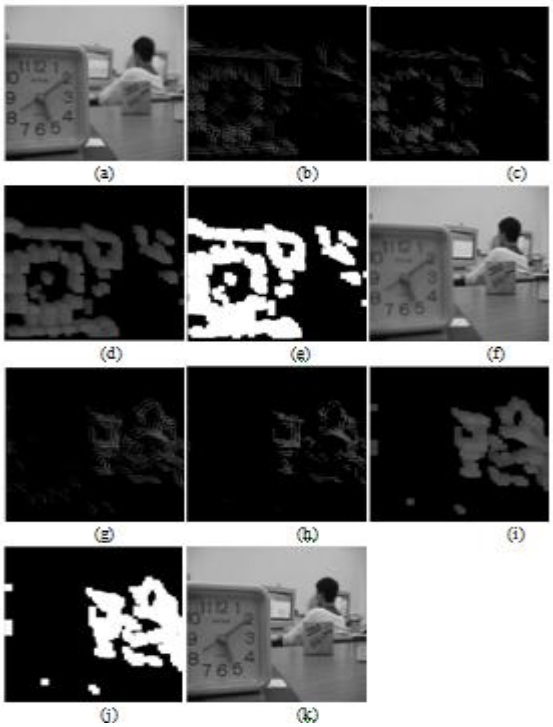


Fig 4: image enhancement results for top and bottom focus images. a), d), g), j) Original top focus images. b), e), h), k) Original bottom focus images. c), f), i), l) Enhanced images by proposed method.



. Fig 5: Multi focus image enhancement outputs of proposed method a) Original Left focus image b) Dominant area detection using SWT c) Median filter output d) Morphological process result e) Binarized image f) Original Right focus image g) Dominant area detection using SWT h) Median filter output i) Morphological result j) Binarized image k) Rule based enhancement image.

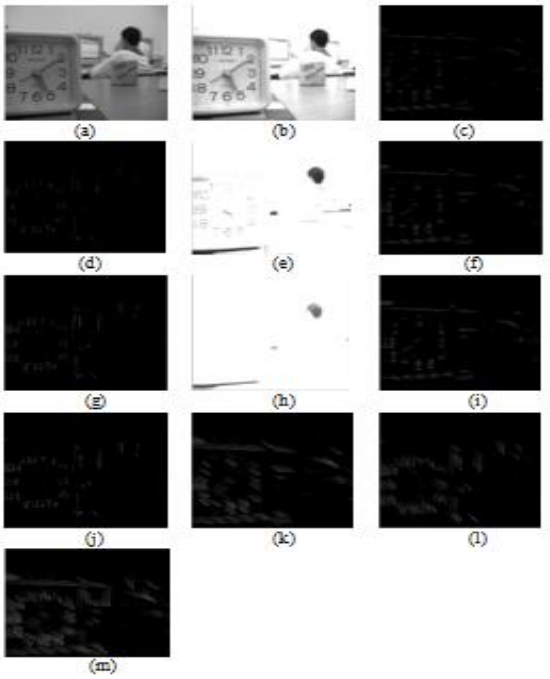


Fig 6: Intermediate steps of SWT based dominant area detection a) Original Left focus image b) Approximation of SWT Level 1 c) Horizontal component of SWT Level 1 d) Vertical component of SWT level 1 e) Approximation of SWT Level 2 f) Horizontal component of SWT Level 2 g) Vertical component of SWT level 2 h) Approximation of SWT Level 3 i) Horizontal component of SWT Level 3 j) Vertical component of SWT level 3 k) Horizontal Dominant area detection l) Vertical dominant area detection m) Dominant area detection.

Estimation Methods

1) Entropy (EN)

The entropy of an image is a measure of information content. It is the average number of bits needed to quantize the intensities in the image. It's definition as

$$EN = -\sum_{g=0}^{L-1} p(g)\log_2 p(g)$$

where p(g) is the probability of grey g, and the range of g is [0,...,L-1].

2) Standard deviation (STD)

Standard deviation is shown as follows.

$$STD = \sqrt{\frac{1}{M\times N}\sum_{m=1}^{M}\sum_{n=1}^{N}(F(m,n)-MEAN)^2}$$

where $MEAN$ is the average denoted by

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3) Similarity (S)

The magnitude of gradient *G(m,n)* at a point *(m,n)* of image F is obtained by

$$G(m,n) = \frac{1}{2}\{|F(m,n)-F(m+1,n+1)| + |F(m,n+1)-F(m+1,n)|\}$$

For two multi- focus images the gradient images G1 and G2 are obtained first. Then G1 and G2 are combined into G' by taking the maximum gradient value at each position. And G' can be seen as the gradient image of the ideal fusion image. The gradients of the actual fusion image G are also calculated. The Similarity S between the ideal fusion image and the actual fused image is calculated by formula (9). The details of similarity refer to [6].

$$S(G,G') = 1 - \frac{\sqrt{\sum(G(m,n)-G'(m,n))^2}}{\sqrt{\sum(G(m,n))^2}+\sqrt{\sum(G'(m,n))^2}}$$

4) Spatial Frequency (SF)

The spatial frequency, which originated from human visual system, indicates the overall active level in an image. The row and column frequencies of the image block are given by

$$RF = \sqrt{\frac{1}{MN}\sum_{m=0}^{M-1}\sum_{n=1}^{N-1}[F(m,n)-F(m,n-1)]^2}$$

$$CF = \sqrt{\frac{1}{MN}\sum_{n=0}^{N-1}\sum_{m=1}^{M-1}[F(m,n)-F(m-1,n)]^2}$$

The spatial frequency of the image is then

$$SF = \sqrt{(RF)^2+(CF)^2}$$

Table 1. Time Measurement for Proposed Method

S.No	Image Name	Process Name	Time Taken for proposed method (in seconds)
1	Clock Image	Left Focus SWT	3.8688
		Left Focus Dominant area detection	0.6396
		Left Focus Dominant area refinement	2.5428
		Right Focus SWT	5.0232
		Right Focus Dominant area detection	0.9984
		Right Focus Dominant area refinement	3.1980
		Rule based restoration	0.3900
2	Calender Image	Left Focus SWT	3.5880
		Left Focus Dominant area detection	0.6240
		Left Focus Dominant area refinement	2.7144
		Right Focus SWT	4.9140
		Right Focus Dominant area detection	1.0140

		Right Focus Dominant area refinement	3.0732
		Rule based restoration	0.3900
3	Flight image	Left Focus SWT	3.3696
		Left Focus Dominant area detection	0.7332
		Left Focus Dominant area refinement	2.7300
		Right Focus SWT	5.0700
		Right Focus Dominant area detection	0.9516
		Right Focus Dominant area refinement	3.1824
		Rule based restoration	0.3588

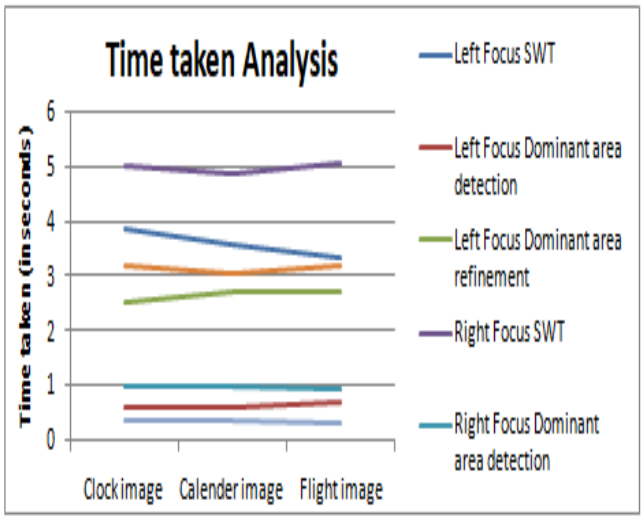

Table 2: Average Time taken measurement of Proposed Method

S.No	Process Name	Average Time Taken for proposed method (in seconds)
1	Left Focus SWT	3.6088
2	Left Focus Dominant area detection	0.6656
3	Left Focus Dominant area refinement	2.6624
4	Right Focus SWT	5.0024
5	Right Focus Dominant area detection	0.9880
6	Right Focus Dominant area refinement	3.1512
7	Rule based restoration	0.3796

S. No	Image Name	Eye perception quality index value (Higher value indicates better image quality)		
		Akira et al method (Existing method)	Bin Yang et al method (Existing method)	Proposed method
1	Clock Image	1	2	3
2	Calender Image	2	1	3
3	Flight image	2	1	3
4	Fusion image	1	2	3
5	Rose image	1	2	3

Table 3. Measurement of Eye Perception QI

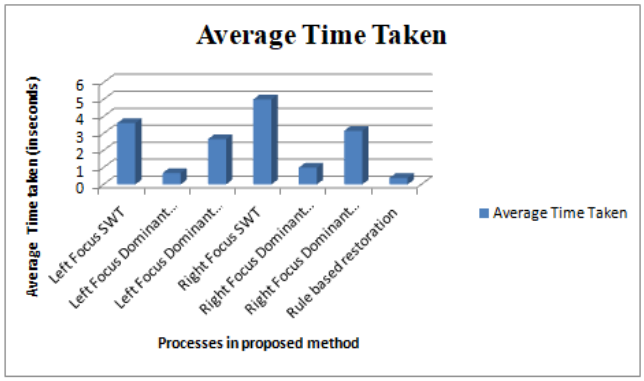

Fig 8.Average Time Taken Analysis of Proposed Method

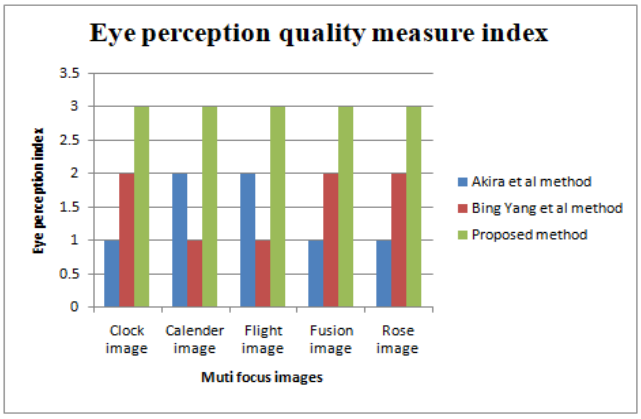

Fig 9. Eye Perception Quality Measure of Proposed Method

Table 4. Measurement of Entropy Analysis

S. No	Image Name	Entropy Analysis		
		Akira et al method (Existing method)	Bin Yang et al method (Existing method)	Proposed method
1	Clock Image	6.9386	6.9716	6.9751

2	Calender Image	6.0752	6.0118	6.2063
3	Flight image	6.4111	6.3848	6.4374
4	Fusion image	6.4903	6.5488	6.6310
5	Rose image	6.8612	6.9067	6.9273

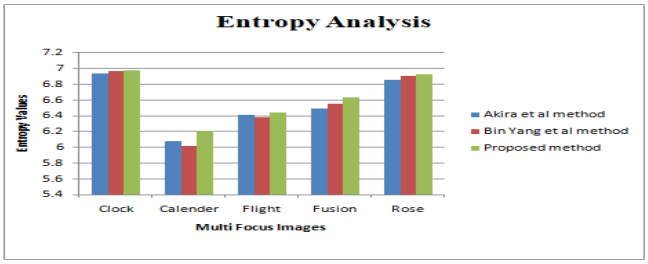

Fig 10. Entropy Analysis of Proposed Method

Table 5. Measurement of Standard Devation

S. No	Image Name	Standard Deviation Analysis		
		Akira et al method (Existing method)	Bin Yang et al method (Existing method)	Proposed method
1	Clock Image	5.2863	5.3827	5.4038
2	Calender Image	8.0600	7.2120	8.2668
3	Flight image	14.0836	13.4406	14.5176
4	Fusion image	6.5665	7.1806	7.3618
5	Rose image	24.0075	24.0617	25.0856

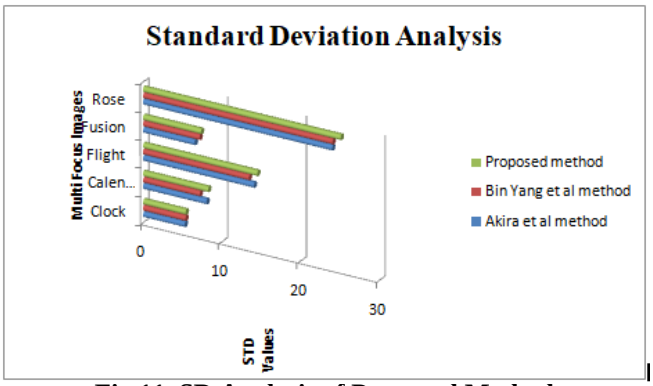

Fig 11. SD Analysis of Proposed Method

Table 6: Measurement of Similarity Measurement Analysis

S. No	Image Name	Similarity Measurement Analysis		
		Akira et al method (Existing method)	Bin Yang et al method (Existing method)	Proposed method
1	Clock Image	0.0840	0.0924	0.1075
2	Calender Image	0.0911	0.0474	0.1059
3	Flight image	0.0681	0.0467	0.0766
4	Fusion image	0.1239	0.1807	0.2066
5	Rose image	0.1388	0.1668	0.2062

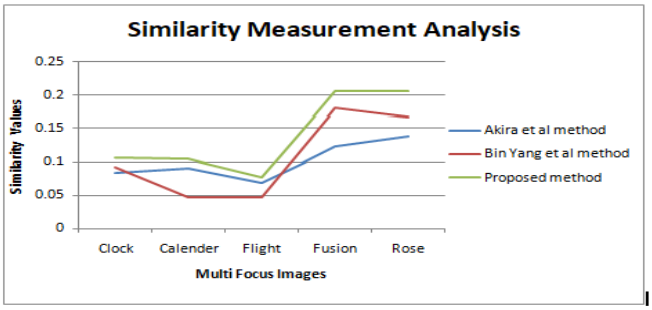

Fig 12. Similarity Measurement Analysis of Proposed Method

Table 7. Measurement of Spatial Frequency

S. No	Image Name	Spatial Frequency Analysis		
		Akira et al method (Existing method)	Bin Yang et al method (Existing method)	Proposed method
1	Clock Image	8.6609	9.7335	10.5634
2	Calender Image	9.2950	4.3866	9.9279
3	Flight image	7.1650	4.8049	7.6712
4	Fusion image	13.2400	20.1695	20.4438
5	Rose image	13.3844	16.1234	17.5880

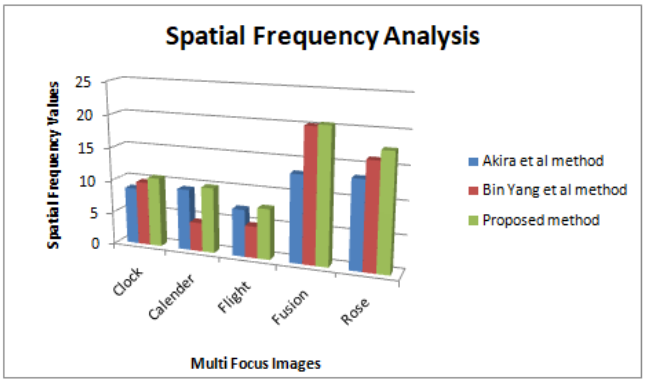

Fig 13. Time Taken Analysis of Proposed Method

III. CONCLUSION

This paper presents an image fusion method based on the stationary wavelet transform techniques. In addition, the dominant area is detected both horizontally and vertically. Median filters and Morphological operations are used to enhance the image. The proposed system is evaluated under various scenarios such as objective and subjective evaluation. The objective evaluation includes the visual observation and subjective evaluation include various parametric computations such as Entropy (EN), Standard deviation (STD), Similarity (S)and Spatial Frequency (SF).As the conclusion, the proposed image fusion method shows promising improvement in the entire evaluation process.

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