Enhanced Image Fusion Algorithm with Neural Networks for Sonar Images

K.S.Jeen Marseline, C.Meena

Abstract: This paper proposes a simple neural network based image fusion algorithm. Image fusion is defined as a process where a new image is constructed by integrating complementary, multi-temporal or multi-view information from a set of source images. Particle swarm Optimization (PSO) is used to find out the optimal size of the blocks to be fused. A detailed experimentation is done with different performance metrics for different set of images. We have compared the results and the proposed method outperforms the existing methods visually as well as quantitatively.

Keywords: PSO, optimal, multi-temporal, multi-view.

I. INTRODUCTION

Image fusion technique with the existing image fusion techniques. The experimental results show that the is a sub-field of image processing in which images of the same scene are combined and a resultant image is produced which gives more details and resolves the ambiguities in the input images. The process of image fusion takes place either in spatial domain or in transformed domain. In spatial domain, the pixel values are directly incorporated in fusion process where as in transformed domain; the input images are transformed first using wavelet decomposition or pyramid decomposition to exploit information at different scales or multi-resolutions.

Image fusion applications has its own importance as it is used in remote sensing, medical sciences, forensic, defense and machine vision departments. Many situations in image processing require high spatial and spectral resolution in an image [4] most of the equipments which are available now are not capable of providing such data. The image fusion techniques allow the integration of different information sources. Image fusion can be processed using multi focus and multi sensor images of the same picture. In multi focus image fusion the images considered will not be in focus everywhere. Some objects in the scene may be in focus and some in out of focus. This takes place because the sensors cannot produce objects in the same scene at various distances with equal sharpness. Multi-sensor images are captured with different sensors but multi-focus images are captured with same sensor. [3].

The perfect image with all objects are in focus can be achieved with two processes of image fusion in spatial domain process, pixel values are directly incorporated[12] whereas in transformed domain the images are transformed into multiple levels of resolution[5].

There are a number of different levels in which image fusion is performed. Simple techniques like weighted average method are performed directly on the images.

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Mrs K.S.Jeen Marseline, Assistant Professor, Sri Krishna Arts & Science College, Coimbatore.

Dr.C.Meena,Center Head, Avinashilingam institute for home Science and Higher education for Women, Coimbatore.

In pixel level simple mathematical operations like max or mean are applied on the pixel values of the source images to generate fused image. This normally smooths the sharp edges and leaves the blurred effects in the fused image [6], [7]. In feature level image fusion the source images are segmented and then the feature values are calculated [8]. In decision level the objects are detected first and then the images are fused using a comfortable fusion technique.

Block based image fusion techniques at pixel level are used in our proposed method. The input images are first divided into blocks and then on the basis of spatial frequency or visibility level of the block, one of the blocks from the input images is copied for the fused image. The size of the block is considered to be one of the important factors to achieve fusion results. The block size cannot be fixed for every image the regions which are under focus will be different for each input image. So the block size must be found adaptively. In our proposed method the optimal block size for image fusion is done using particle swarm optimization (PSO).

Particle Swarm Optimization (PSO).

Particle swarm optimization (PSO) is a population based stochastic algorithm developed for continuous oType equation here.ptimization problem by J. kennedy et al. [9] in 1995. It is encouraged by societal behavior of bird flocking and fish schooling in nature. Particle swarm optimization (PSO) and its variants have been used in different areas such as image processing, classification , sensor networks etc., C.Wang et al. introduced an invariant of PSO based on double mutation [10] . J.Nagashima et al. proposed an efficient technique using PSO to maintain flooding in sensor networks for the effective utilization of bandwidth [11].

In PSO, each bird is called a particle. In the search space, every particle is a solution of the problem. At the start, the velocity and position of every particle is initialized randomly in the search space. Every particle is given a fitness value and this fitness value is evaluated using fitness function to be optimized. [2].

II. PROPOSED METHOD:

In this paper a new method is proposed for image fusion and it is discussed in the following sections. The performance of the proposed method was calculated and described in section III. Experimentation details are provided in the section IV. And section V provides the conclusion.

In the proposed method PSO is used to estimate the block size. The block size is important here to differentiate the blurred and un blurred sections from each other. To accomplish this we used the Particle Swarm Optimization. The image is decomposed into MXN blocks After the images are divided into MXN blocks the feature values of each block of the entire image is calculated .

The important task in image fusion is selection of distinct features. Two images of the same scene are taken as input for this method. Different parts of each image are blurred (ie out of focus) . The clarity of the images are reduced by the blurred objects. In our method we have used five different features to illustrate the information level contained in the particular part of *the* image. The feature set consists of variance, energy of gradient, contrast visibility, spatial frequency, and edge information.

1.Contrast visibility: The deviation of block of pixels from its blocks mean value is calculated, which is related to the clearness of the block. The visibility is calculated using the equation

$$\mathbf{VI} = \frac{1}{m*n}\sum_{(i,j)eBk}\frac{|I(i,j)-\mu_k|}{\mu_k}$$

Here μ_k and m*n are the mean and size of the block B_k respectively.

2. Spatial frequency: It is used to measure the activity level and the frequency changes in rows and columns of the image.

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

$$\mathbf{RF} = \sqrt{\frac{1}{m+n}\sum_{i=1}^{m}\sum_{j=2}^{n}[I(i,j) - I(i,j-1)]^2}$$

$$\mathbf{CF} = \sqrt{\frac{1}{m+n}\sum_{j=1}^{n}\sum_{i=2}^{m}[I(i,j) - I(i-1,j)]^2}$$

I is considered as image and m*n is the image size. If the value of spatial frequency is large , it describes the large information level in the image and so it is used to measure the clearness of the image.

3 Variance: The extent of focus in an image block is measured by variance.

$$\text{Variance} = \frac{1}{m*n}\sum_{i=1}^{m}\sum_{j=1}^{n}(i(i,j) - \mu)]^2$$

4.Energy of Gradient (EOG) : The amount of focus in an image is calculated using EOG

$$EOG = \sum_{i=1}^{m-1}\sum_{j=1}^{n-1}(fi^2 + fj^2)$$

Here m and n represents the dimensions of the image block. The amount of focus depends on the value of the EOG.

5.Edge Information: The edge pixels in the image block is found using canny edge detector. The Value one returned represents that the current pixel belongs to some edge in the image otherwise zero is returned. The edge feature is the number of edge pixels within the image block.

III. PROPOSED ALGORITHM

1. Two images A and B of the same scene are taken as input images.
2. PSO is used to optimize the block size of the image.
3. The images are decomposed into MXN blocks.
4. Feature extraction takes place in each block of both the images.
5. Create a Neural network with sufficient number of layers. Train the newly formed neural network with enough number of patterns selected from the features.
6. By using the trained neural network identify the clearness of all the blocks of the pair of images to be fused.
7. Fuse the given pair of images block by block according to the classification result of the neural network.

Performance Metrics:

There are difference metrics available which are used to evaluate the performance of the Fusion techniques. We have used three measures PSNR (Peak signal to Noise Ratio), determines the degree of resemblance between the input and the fused image .The Higher value shows the good quality of results FoM (figure of merit), Determines the edge preservation capacity. The higher the value the amount edges will be good. MSSI (mean structural similarity index) determines the maintenance of the overall structure of the image.

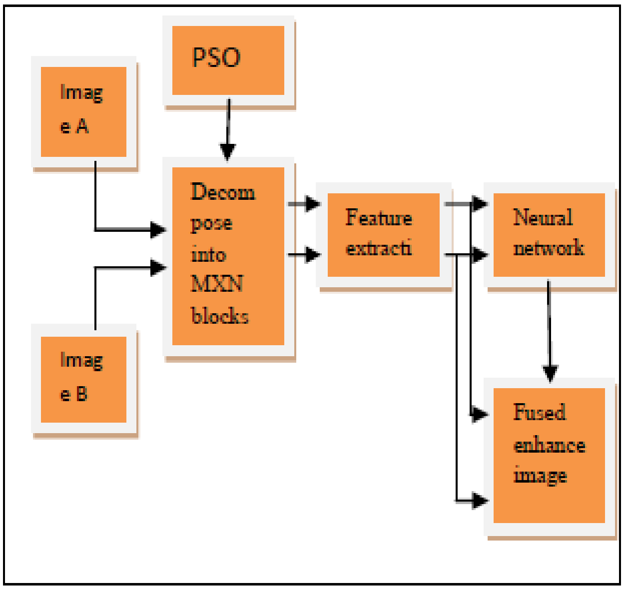
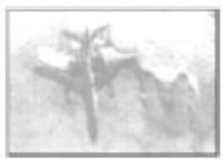
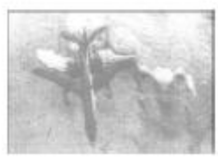


Fig 1: Block Diagram of the proposed method

IV. EXPERIMENTAL RESULTS

The visual results of the proposed method is shown below along with the values obtained by various performance metrics discussed above compared with the existing neural network based image fusion in the table given below.

	
Image A	**Image B**
	
NN Based IF	**Enhanced NN Based IF**

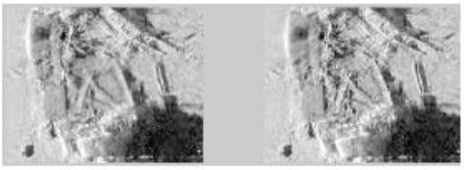


Image A and B

NN Based IF

Enhanced NN Based IF

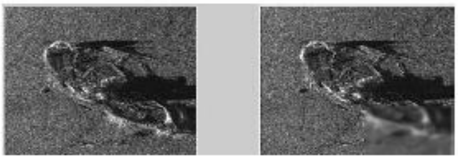
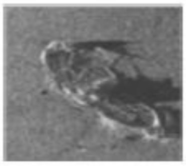


Image A and B



NN Based IF

Enhanced NN Based IF

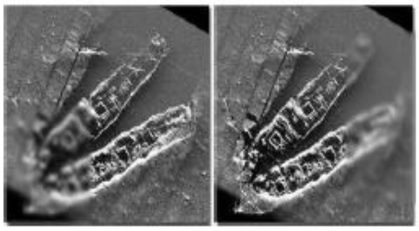
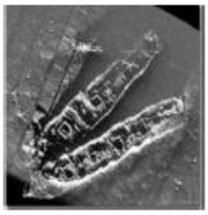


Image A and B

NN Based IF



Enhanced NN Based IF

PEAK SIGNAL TO NOISE RATIO(PSNR)

	NN BASE IF	Enhanced NN Based IF
Airplane	28.32	37.29
Boat	28.77	37.74
Boat1	27.11	36.53
m1	28.56	37.61
m6	27.12	36.67
m13	27.61	36.82
seabed	28.84	37.91
Titantic Wreck	28.33	37.40

EDGE PRESERVATION CAPACITY (FoM)

	NN BASE IF	Enhanced NN Based IF
Airplane	0.7846	0.8830
Boat	0.7881	0.8867
Boat1	0.7822	0.8816
m1	0.7879	0.8864
m6	0.7829	0.8820
m13	0.7838	0.8823
seabed	0.7890	0.8869
Titantic Wreck	0.7870	0.8843

STRUCTURE PRESERVATION CAPACITY (MSSI)

	NN BASE IF	Enhanced NN Based IF
Airplane	0.8823	0.9046
Boat	0.8876	0.9065
Boat1	0.8801	0.9021
m1	0.8865	0.9064
m6	0.8808	0.9031
m13	0.8815	0.9033
seabed	0.8897	0.9081
Titantic Wreck	0.8858	0.9056

V. CONCLUSION

In this paper the proposed image fusion technique Particle swarm optimization PSO is used to find the optimal block size of the images and a feature set including contrast visibility, spatial frequency, energy of gradient, edges and variance is used which improves the clarity of the image block. Neural network is trained to identify the clear blocks and fuse the pair of images. Experimentation results show that the proposed method performs better than the existing method.

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Mrs. K.S. Jeen Marseline currently working as Asst. Professor Department of Information and Computer Technologies in Sri Krishna Arts and Science College, Coimbatore. She has 16 years of teaching experience and her area of interest is Digital Image Processing. She has attended and presented papers in many National and International Conferences.

Dr. C. Meena presently designated as Head of Computer Center/Computer Manager, Department of Computer Science in Avanishalingam University for Home Science and Higher Education for Women, Coimbatore. She has 15 years of rich & extensive experience in teaching, System Analysis, Technical Information and Programming Skills. She is expertise in Project Personals and Budget Estimation. Resourceful at strategizing techniques for new project implementation. She has research experience in various areas. She is a Member in Research Review Committee of Mother Teresa University for Women and Doctoral Committee Member, in Anna University Chennai. She has presented papers in many countries like Malaysia, USA etc. Produced many M.Phil and Ph.D., Scholars. She has more than 45 publications in National and International Journals to her credit. She has undertaken many UGC sponsored projects.