

DESIGN OF A NOVEL IMAGE FUSION ALGORITHM FOR IMPULSE NOISE REMOVAL IN REMOTE SENSING IMAGES BY USING THE QUALITY ASSESSMENT

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ABSTRACT

Image fusion is important technique used in Remote Sensing application. It plays a very important role in Satellite based communication. Here, introduces a new technique fusion followed by filtering for remove impulse noise in remote sensing images. The Non-Linear filtering algorithms, Vector Median Filter (VMF), Rank Conditioned VMF, Rank Conditioned and Threshold VMF, Center Weighted VMF and Absolute Deviation VMF are introduced. These filtered images are combined to single image called image fusion. The performance evaluation for filtered and fused image with respect to original image by calculating the Mean Square Error (MSE), Peak Signal To Noise Ratio (PSNR) and Structural Similarity Index (SSIM).

Keywords: impulse noise, image fusion, non-linear filters.

I.INTRODUCTION

Noise is undesired information that contaminates an image. In digital images, there are different types of noises are introduced such as Gaussian Noise, Impulse Noise, Uniform Noise, Gamma Noise etc. Impulse noise is very common in digital images. The images are corrupted during acquisition, transmission or due to faulty memory location hardware [1]. There are several ways through which noise can be introduced into an image depending on how image is created. This is the main problem in remote sensing application. Satellite image containing the noise signals and lead to a distorted image not being able to understand. So, to study it properly requires the use of appropriate filters to limit or reduce much of noise.

Median filter is non-linear filtering technique which exhibit better performance as corrupted to linear filters [2] when restoring images corrupted by impulse noise or salt and pepper noise. The ordering of vector pixel data is carried by considering suitable distance measure. The vector pixels in kernel are ordered depending on sum of distances between each vector pixel and other vector pixels in window or kernel. The vector pixel with smallest sum of distances forms the vector median.

In most of the imaging applications, for example remote sensing, the images captured by different sensors are combined to a single image, which retains the important features of the images

from individual sensors. Only removal of noise is not sufficient for further processing in case remote sensing applications. The filtered images must be processed into a single image which is most suitable than individual image. This task accomplished by a process called image fusion[3]-[4]. Image fusion is defined as the process of combining substantial information from several sensors using mathematical techniques in order to create a single composite image that will be more comprehensive and thus, more useful for a human operator.

II.PREVIOUS WORK

Jingo zhang[5],et, al., proposed the multi focus image fusion using quality assessment of spatial domain and genetic algorithm. The basic idea is to divide source images into blocks and then select the corresponding blocks with higher quality assessment value to construct the resultant fused image. Genetic algorithm is used for suitable block size. The performance analysis reveals that our method out performance the fusion by haar wavelet and morphological wavelet methods.

Laksar[6],et,al., proposed the removal of impulse noise from color image. This paper presents a vector median filter that includes new mechanism for the detection of impulses in color image. The performance of this filter is better for removal of impulse noises generated by impulse noise model at low noise percentage per channel.

Yanruili[7],et, al., proposed a new region of interest based image quality assessment algorithm, IQA algorithm have been put forward with high correlation with human perception. One strategy is proposed based on region of interest in which some alternations on SSIM are made to enhance correlation with human perception. The performance of ROI became important on IQA when image has distinctive background.

Yichen[8],et, al., proposed localized Iris image quality using 2D wavelets. The paper represents a wavelet based quality measure for iris images is proposed. Its ability to deliver good spatial adaptivity and determine local quality measures. The performance of iris recognition system can be undetermined by quality images and result in high false reject rates.

III.PROPOSED METHOD

In order to remove the impulse noise in remote sensing images fusion followed by filtering techniques is proposed.

A. *Image fusion:*

With the availability of multi-sensor data in many fields such as remote sensing, medical imaging, machine vision and military applications, sensor fusion has emerged as a new and promising research area. The current definition of sensor fusion is very broad and the fusion can take place at the signal,

pixel, and feature and symbol level. Multi sensor data often presents complementary information about the region surveyed, so image fusion provides an effective method to enable comparison and analysis of such data. The goal of image fusion is to create new images that are more suitable for the purposes of human visual perception, object detection and target recognition. The use of multi-sensor data such as visible and infrared images has led to increased recognition rate in applications such as automatic target recognition.

Image fusion is defined as the process of combining substantial information from several sensors using mathematical techniques in order to create a single composite image that will be more comprehensive and thus, more useful for a human operator or other computer vision tasks. Current technology in image sensors offers a wide variety of information that can be extracted from an observed scene.

B. Filtering operation:

Vector Median Filter (VMF): In the vector median filter for the ordering of vectors in a particular kernel or mask a suitable distance measure is chosen. The vector pixels in the window are ordered on the basis of the sum of distances between each vector pixel and the other pixels in the window. The sum of the distances is arranged in ascending order and then the same ordering is associated with vector pixels. The vector pixel with the smallest distances is the vector median pixel.

Rank – Conditioned Vector Median Filter (RCVMF): The rank conditioned vector median filter improves the performance of the vector median filter. The vector median of the kernel replaces the central pixel when the rank of the central pixel is greater than a predefined rank of a healthy vector pixel inside the window. To find out a rank of the healthy vector pixel the code simulating RCVMF is executed on a noiseless image. Then, the mean value of the obtained ranks of the central vector pixel is calculated. This value is rounded off to a whole number, and it is considered to be rank of the healthy vector pixel of a kernel. Then this rank is used for simulations at various noise percentages.

Rank-Conditioned and Threshold Vector Median Filter (RCTVMF): The rank-conditioned and threshold vector median filter aims to further enhance the RCVMF by incorporating an additional test – a distance threshold for the detection of impulses. In RCVMF a central vector having greater than the predefined rank implies a corrupt vector. However, it may not be true always, because the vectors may be close as per the distance measure. Hence another criterion is taken into account. It is the distance between the central vector pixel and the vector pixel corresponding to the predefined rank. To find out the value of this pre-determined distance threshold, the code simulating RCTVMF is executed on a noiseless image. Then the mean of the obtained values is calculated and used for the simulations at various noise percentages. This value is used in the program to help select only the corrupt central vector pixels.

Center Weighted Vector Median Filter (CWVMF): In the case of center weighted median filter the kernel vector pixels are assigned some non negative values called weights. The central vector pixel is

assigned a non negative weight while the weight of the neighboring pixels is kept unity. The weights denote the number of copies is obtained.

Absolute Deviation Vector Median Filter: In this filter, the impulse noise detection mechanism does not require the distance calculation and subsequent ordering of the vectors of a kernel. The algorithm deals with the difference values of the red (R) and the green (G) intensities.

C. *Quality assessment:*

Quality assessment of images has been successfully employed in the authentication area, such as iris and fingerprint verification, which is used to evaluate the quality of the captured images. Fingerprint quality is usually defined as a measure of the clarity of the ridge and valley structures. In the multi-focus image fusion, it is the first step to investigate whether the region of the image is clarity or not, so we incorporate the quality assessment into multi-focus image fusion algorithm. Generally speaking, the quality assessment can be classified into two ways, namely the frequency domain assessment and the spatial domain assessment. We incorporate the latter one into this algorithm.

In order to assess the image quality in a local region, we partition a given image into a lattice of blocks of size $b \times b$. For each block B , let $g_s = (g_s^x, g_s^y)$ denote the gradient of the gray level intensity at site $s \in B$. The covariance matrix of the gradient vectors for all b^2 sites in this block is given by

$$J = \frac{1}{b^2} \sum_{s \in B} g_s^T g_s = \begin{bmatrix} j_{11} & j_{12} \\ j_{21} & j_{22} \end{bmatrix}$$

The symmetric matrix is positive semi definite with Eigen values

$$\lambda_1 = \frac{1}{2} \left(\text{trace}(J) + \sqrt{\text{trace}(J)^2 - 4 \det(J)} \right)$$

$$\lambda_2 = \frac{1}{2} \left(\text{trace}(J) - \sqrt{\text{trace}(J)^2 - 4 \det(J)} \right)$$

Where $\text{trace}(J) = j_{11} + j_{22}$, $\det(J) = j_{11}j_{22} - j_{12}^2$ and $\lambda_1 \geq \lambda_2$. The quality assessment defined as

$$\lambda = \lambda_1 - \lambda_2$$

This measure reflects the clarity of the local region. The clearer the local region is, the bigger the measure is.

D. *Algorithm Description*

The block diagram for multi sensor image fusion is shown in fig1. The algorithm for the multi sensor image fusion using quality assessment is as follows:

The images captured by different sensors are filter using five different filtering algorithms. These five filtered images are fused into a single image having all objects in focus without producing details that are non-existent in the given images. The algorithm consists of the following steps:

- [1] Let I^1, I^2, \dots, I^5 be the noisy images of an object or scene captured by sensors S^1, S^2, \dots, S^5 respectively. Let I^i be of size $N \times N$ where $i = 1, 2, \dots, 5$.
- [2] Filter the noisy images using five different filtering algorithms. The filtered images are denoted as R^i .
- [3] The recovered images R^i for $i=1, 2, \dots, 5$ are divided into non-overlapping rectangular blocks (or regions) with size of $m \times n$. The j^{th} image blocks of R^i are referred by R_j^i
- [4] Quality assessment value (λ) of R_j^i is calculated and the results of R_j^i are denoted by λ_j^i .

In order to determine the sharper image block, the quality assessment value of image blocks from 5 recovered images are sorted in descending order and the same ordering is associated with image blocks. The block with the maximum quality assessment is kept in the fused image. The fusion mechanism is represented as follows:

If λ_j^i is the quality assessment value of block R_j^i , the ordering of assessment values is given by

$$\lambda_{(1)} > \lambda_{(2)} > \dots > \lambda_{(5)}$$

and this implies the same ordering to the corresponding blocks

$$R_{(1)} > R_{(2)} > \dots > R_{(5)}$$

Where the subscripts are the ranks of the image blocks. Since the block with the largest quality assessment value is in the fused image, it will correspond to rank 1 of the ordered blocks ie;

$$Fused\ Block = R_{(1)}$$

In this project, five noisy images are captured by sensors are filtered using Vector Median Filter (VMF), Rank Conditioned VMF, Rank conditioned and Threshold VMF, Center Weighted VMF and Absolute Deviation VMF. These filtered images are fused into a single image while retaining the important features of each image which is called image fusion.

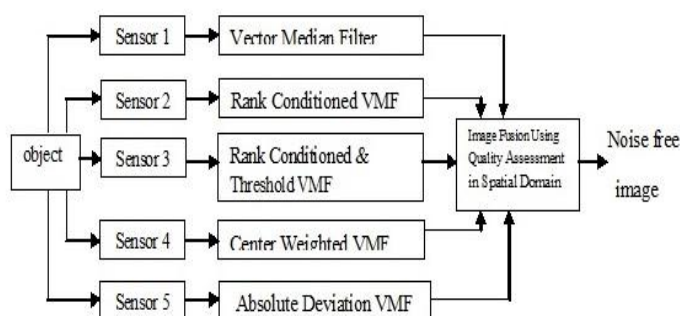


Fig 1: Block Diagram of Multi focus Image Fusion

IV.RESULTS

To evaluate the performance of each filter and fused image, the image quality measures Mean Square Error(MSE), Peak Signal to Noise Ratio(PSNR), Structural Similarity Index(SSIM) are measured. Table shows the comparison of different filters performance and fused image with respect to original image using these quality measures. we conclude that the fused image has less mean square error, high peak signal to noise ratio and high structural similarity index compared to individual filtered images.

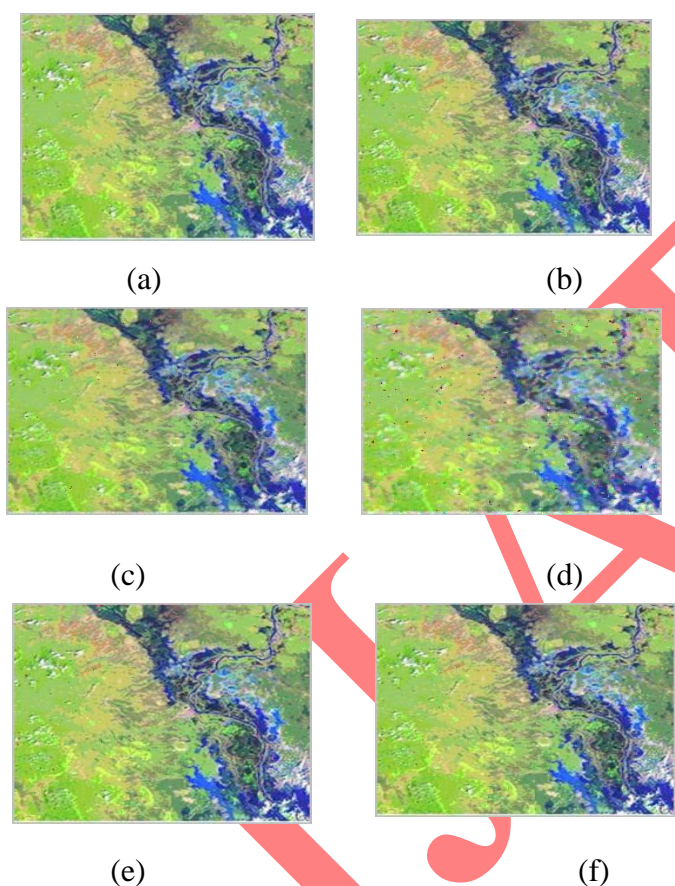


Fig 2: Images filtered by different Filters. (a) Vector Median Filter (b) Rank conditioned Vector Median Filter (c) Rank conditioned & threshold Vector Median Filter (d) Center weighted Vector Median Filter (e) Absolute Deviation Vector Median Filter (f) Fused Image.

Noise %	Filter	MSE	PSNR	SSIM
10	VMF	48.47 7	31.25	0.9744 6
15	RCVMF	57.52 3	30.522	0.9712
20	RC&TVM F	104	27.961	0.9797
25	CWVMF	344.9 5	22.73	0.9477 9
3S0	ADVMF	70.55	29.46	0.9785 8
Fused Image		28.4	33.6	0.9874 2

Table : comparison of performance of the different filters and fused image with respect to original River image

V.CONCLUSION

In this paper a novel fusion technique is implemented i.e., fusion followed by filtering used to remove impulse noise from remote sensing images which is based on Satellite Communication. The sensed images are filtered by non-linear filtering algorithms. The filtered images are combined into single image, called image fusion based on quality assessment. The novel technique is used in real-time application and attained high quality images. The performance of individual filtered images and fused image with respect to input image is done by using Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE) and Structural Similarity Index (SSIM).

The proposed algorithm can further be extended to some other filter techniques like Density based non-linear filters, Traditional non-linear filters and other noise models.

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