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A New Method for Impulse Noise Removal in Remote Sensing Images

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A NEW METHOD FOR IMPULSE NOISE REMOVAL IN REMOTE SENSING IMAGES

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A New Method for Impulse Noise Removal in Remote Sensing Images

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Abstract - Existing filtering algorithms use all pixels within a window to filter out the impulse noise. They increase the size of neighboring pixels with the increase of noise density. In this paper, we propose an impulse noise removal algorithm for remote sensing images, that emphasis on few noise-free pixels. The detection map (DM) is constructed from the input noisy image, by assigning a binary value 1 for each corrupted pixel in the input image. By using the detection map, the proposed iterative algorithm searches the noise free pixels with in a small neighborhood. The noisy pixel is then replaced with the median value estimated from noise free pixels. In-order to better appraise the noise cancellation behavior of our filter from the point of view of human perception, we perform segmentation via spline regression on remote sensing image for both noisy image and filtered image. Experimental results show that the filtering performance of the proposed approach is very satisfactory providing better feature extraction in remote sensing images.

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I. Introduction

Digital images are often corrupted during acquisition, transmission or due to faulty memory locations in hardware [1]. The impulse noise can be caused by a camera due to the faulty nature of the sensor or during transmission of coded images in a noisy communication channel [2].Consequently, some pixel intensities are altered while others remain noise free. The noise density (severity of the noise) varies depending on various factors namely reflective surfaces, atmospheric variations,noisy communication channels and so on.The restoration of noise-free images is carried out as a preprocessing task in a wide range of applications such as medical imaging, remote sensing images. Order-static filters are nonlinear filters [3][4]whose response is based on the ordering (ranking) the pixels contained in the image area encompassed by the filter, and then replacing the value of the center pixel with the value determined by the ranking result.The filtering should be applied to corrupted pixels only while leaving those uncorrupted ones intact. Therefore a noise detection process to discriminate the uncorrupted pixels from the corrupted ones prior to applying nonlinear filter is highly desirable.This noise detection provides the noisy density in the input image, which is often unknown in priori, will cause substantial degradation on the filtering performance.In this paper, we proposed a new iterative approach for noise removal in remote sensing images that emphasis on noise-free pixels within small neighborhood. In this scheme, first, the pixels affected by salt-and-pepper noise are detected. If we did not find a certain number of noise-free pixels within neighborhood, then the central pixel is leftunchanged. Otherwise, the noisy pixels are estimated from the noise-free pixels. The process iterates until all the noisy pixels are estimated. The paper is organized as follows: Section II presents the Impulse Noise in Digital Images, Section III presents the Noise Filtering Method, Section IV presents segmentation algorithm via Spline Regression, Section V presents the Experimental results, finally Section VI reports conclusion.

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II. Impulse Noise in Digital Images

Impulse noise [5] corruption is very common in digital images. Impulse noise is always independent and uncorrelated to the image pixels and is randomly distributed over the image.Hence unlike Gaussian noise, for an impulse noise corrupted image all the image pixels are not noisy, a number of image pixels will be noisy and the rest of pixels will be noise free. There are different types of impulse noise namely salt and pepper type of noise and random valued impulse noise.

In salt and pepper type of noise the noisy pixels takes either salt value (gray level -225) or pepper value (grey level -0) and it appears as black and white spots on the images. If p is the total noise density then salt noise and pepper noise will have a noise density of $p/2$.This can be mathematically represented as

$$y_{ij} = \begin{cases} \text{Zero or 255 with probability } p \\ x_{ij} \text{ with probability } 1-p \end{cases} \quad (1)$$

Where y_{ij} represents the noisy image pixel, p is the total noise density of impulse noise and x_{ij} is the uncorrupted image pixel. At times the salt noise and pepper noise may have different noise densities $p1$ and $p2$ and the total noise density will be $p=p1+p2$.

In case of random valued impulse noise, noise can take any gray level value from zero to 225. In this case also noise is randomly distributed over the entire image and probability of occurrence of any gray level value as noise will be same. We can mathematically represent random valued impulse noise as

$$y_{ij} = \begin{cases} n_{ij} \text{ with probability } p \\ x_{ij} \text{ with probability } 1-p \end{cases} \quad (2)$$

Where n_{ij} is the gray level value of the noisy pixel.

III. Noise Filtering Algorithm

In this method, the detection map is constructed from the input noise image X. In case of salt-and-pepper noise image, the maximum and minimum intensity values of the image provide information about the corrupted pixels. For 8-bit gray scale image, the maximum and minimum intensity values are 0 and 255, indicating the pixel is corrupted with salt and pepper noise image. Considering this assumption, we assign a binary value to each elements $d_{i,j} \in D$ of the detection map D. The detection map is computed from the noisy image as follows:

$$d_{i,j} = \begin{cases} 1, \text{ if } X_{i,j} = 255. \\ 1, \text{ if } X_{i,j} = 255 \\ 0, \text{ otherwise.} \end{cases} \quad (3)$$

The entries 1 and 0 in the detection map D represent the noisy and noise free pixels respectively. The noise density is calculated as follows:

$$ND = \frac{\text{sum of 1's in Detection map (D)}}{\text{N*N (total number of pixels in input image)}} \quad (4)$$

The noise density value ranges between 0 and 1. The Filtering algorithm for noise removal is as follows:

1. We use a small window W_{xy} neighborhood of size 3X3 at each pixel location (x,y) of the noisy image X and the detection map D.
2. For Each iteration, we count the number of noisy pixels in the detection map D. If the value of count K is positive integer and the central pixel within 3X3 window is noisy, then an array R is populated with noise free pixels. The length of the array, depending upon the noise density varies from zero to eight within the window.
3. We estimated the value of the noisy pixel by taking the median value of all noise-free pixels in array R.
4. Update the detection map $d_{i,j}$, based on the estimated value.
5. Steps 1 to 4 are repeated until we get the image with K=0, ie; noise –free image.

IV. Segmentation Algorithm Via Spline Regression

The algorithm for Image Segmentation using Spline Regression [6] is as follows:

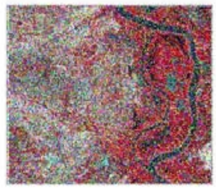
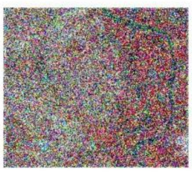
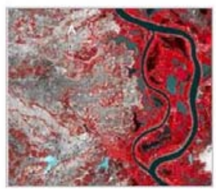
Input : The image I with n pixels to be segmented; the user specified stokes about the foreground object and its background, F and B; the number of clusters K for clustering F and B.

Output : The segmentation of I.

1. Construct the feature vector set $X=\{x_i\}$, for i=1 to n, in which $x_i = \{r,g,b,x,y\}^T$ corresponds to the feature vector of pixel p_i.
2. Construct two subsets of feature vectors according to the user specified strokes about the Foreground object and its background: $U_f=\{x_{if}\}$ where i=1 to n_f and $U_b=\{x_{ib}\}$ where i=1 to n_b.
3. if $k > 0$ then
4. Cluster U_f with K-means clustering algorithm, replace U_f by the k-cluster centers, and let $k= n_f$.
5. Cluster U_b with K-means clustering algorithm, replace U_b by the k- cluster centers, and let $k= n_b$.
6. end if
7. Construct the spline based on U_f and U_b.
8. Allocate an array S with n zero elements.
9. for each pixel p_i, i=1,…,n do
10. Calculate the spline regression value with $f(x_i)$.
11. Accumulate $f(x_i)$. to S[i] : $S[i]=S[i]+ f(x_i)$
12. Accumulate $f(x_i)$ to the eight neighbors of the i^{th} pixel and record them in the corresponding elements of S.
13. end for
14. for each pixel p_i, i=1,…,n, do
15. Average S[i], namely, S[i]=S[i]/9.
16. Assign class label for each pixel, ie., If S[i]>=0 then S[i]=255. Then (Foreground); otherwise, S[i]=0 , (Background).
17. end for
18. Output the binarized image S by reshaping it to be an image with the same size of source image I.

V. Experimental Results

The performance evaluation of our filtering algorithm is tested on the true color remote sensing image with 269X269 pixels. The salt-and-pepper noise is added into the image with two different noise densities 0.3 and 0.6. The images are filtered by using our proposed filtering algorithm.The performance of our algorithm is evaluated by computing segmentation using spline regression for the filtered image and the noise image.The experimental results are shown in Figure 2.

Original Image	Noisy Image (0.3)
	
Noisy Image (0.6)	Filtered image for noise density 0.3
	
Filtered image for noise density 0.6	
	

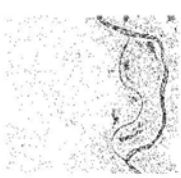
segmented Noisy Image (0.3)	Segmented Filtered Image
	

Figure 2 : Experimental Results

VI. Conclusion

In this paper we proposed a Noise filtering algorithm for removal of salt-and-pepper noise in Remote sensing images.The algorithm searches the noise free pixels with in a small neighborhood. The noisy pixel is then replaced with the median value estimated from noise free pixels.The experimental result shows that the proposed method is capable of removing salt-and-pepper noise more effectively, while preserving the fine image details and edges for the features extraction in remote sensing images.

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