# PERFORMANCE OF IMPULSE NOISE DETECTION METHODS IN REMOTE SENSING IMAGES

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Abstract

Remote sensing (RS) images are affected by different types of noises like Gaussian noise, speckle noise and impulse noise. These noises are introduced into the RS images during acquisition or transmission process. The main challenge in impulse noise removal is to suppress the noise as well as to preserve the details (edges). Removal of the impulse noise is done by two stages: detection of noisy pixel and replacement of that pixel. Detecting and Removing or reducing impulse noise is a very active research area in image processing. In this paper three different existing detection methods are discussed with the intension of developing a new one.

***Keywords***: ***Image processing, nonlinear filter, impulse noise, noise reduction.***

## 1. INTRODUCTION

Remote sensing[2] usually refers to the instrument based technology of acquiring information about the earth's surface (land and ocean) and atmosphere, using sensors onboard airborne (aircraft, balloons) or space-borne (satellites, space shuttles) platforms. The electromagnetic radiation is normally used as an information carrier in RS. Remote sensing employs passive and/or active sensors. Passive sensors are those which sense natural radiations, either reflected or emitted from the earth. On the other hand, the sensors which produce their own electromagnetic radiation, are called active sensors (e.g. LIDAR, RADAR). Remote sensing can also be broadly classified as optical and microwave. In optical remote sensing, sensors detect solar radiation in the visible, near-, middle- and thermal-infrared wavelength regions, reflected/scattered or emitted from the earth, forming images resembling photographs taken by a camera/sensor located high up in space. Different land cover features, such as water, soil, vegetation, cloud and snow reflect visible and infrared light in different ways.

Interpretation of optical images requires the knowledge of the spectral reflectance patterns of various materials (natural or man-made) covering the surface of the earth. Measurement of spatially organized (most commonly, geographically distributed) data/information on some property(ies) (spectral; spatial; physical) of an array of target points (pixels) within the sensed scene that correspond to features, objects, and materials, doing this by applying one or more recording devices not in physical, intimate contact with the item(s) under surveillance (thus at a finite distance from the observed target, in which the spatial arrangement is preserved); techniques involve amassing knowledge pertinent to the sensed scene (target) by utilizing electromagnetic radiation, force fields, or acoustic energy sensed by recording cameras, radiometers and scanners, lasers, radio frequency receivers, radar systems, sonar, thermal devices, sound detectors, seismographs, magnetometers, gravimeters, scintillometers, and other instruments.

The output of a remote sensing system is usually an image representing the scene being observed. Many further steps of digital image processing and modeling are required in order to extract useful information from the image. This not only increases the sensor's sensitivity, but, unfortunately, also increases the noise or ''grain,'' thus, generating images that are contaminated with random noise effects. Noise can be defined as any disturbance that changes the original signal information. Image noise is a random, usually unwanted, variation in brightness or color information in an image. Image data recorded by sensors on a satellite or aircraft contain errors related to geometry and brightness values of the pixels. These errors are corrected using suitable (filters) mathematical models, which are either definite or statistical models.

Noise can be summarized as the visible effects of an electronic error or interference in the final image from a digital camera or any remote sensor. Noise is a function of how well the image sensor and digital signal processing systems inside the digital camera are prone to and can cope with or remove these errors or interference. Noise significantly degrades the image quality and increases the difficulty in discriminating fine details in the image. It also complicates further image processing, such as image segmentation and edge detection. Images are more prone to stuck-pixel noise(impulse) and other interference noises. The three different detection schemes are analyzed and implemented for benchmark remote sensing images. The simulations are done in matlab 7.7 version.

The organization of this paper is as follows: Section 2 describes noise model Section 3 discusses three impulse noise detection schemes; Section 4 discusses the experimental setup and results Section 5 presents the conclusion.

## 2. NOISE MODEL

Noise can be defined as any disturbance that changes original signal information. Image noise is a random, usually unwanted, variation in brightness or color information in an image. Image noise can originate in film grain, or in electronic noise in the input device, sensor and circuitry, or in the unavoidable shot noise of an ideal photon detector. Digital images are prone to a variety of types of noise. Noise is the result of errors in the image acquisition or transmission process that result in pixel values that do not reflect the true intensities of the real scene. There are several ways that noise can be introduced into an image, depending on how the image is created. For example: If the image is scanned from a photograph made on film, the film grain is a source of noise. Noise can also be the result of damage to the film, or be introduced by the scanner itself. If the image is acquired directly in a digital format, the mechanism for gathering the data (such as a CCD detector) can introduce noise. Electronic transmission of image data can introduce noise [1].The spatial component of noise is based on the statistical behavior of the intensity values. These may be considered as random variables, characterized by a probability density function (pdf). A probability density function (pdf), or density, of a random variable is a function which describes the density of probability at each point in the sample space. The probability of a random variable falling within a given set is given by the integral of its density over the set. Some commonly found noises are Gaussian noise, Speckle noise, uniform noise Rayleigh noise, Gamma noise, Exponential noise, Impulsive noise etc.

Here we are analyzing the impulse noise which can be classified into two **(SPN)**salt and pepper noise and random valued impulse noise[3]**(RVIN)**. The pdf function of impulse (bipolar) noise is given by

$$x(t,f) = \begin{cases} \eta(t,f) \text{ with probability } p \\ y(t,f) \text{ with probability } 1-p \end{cases}$$

Where x(i,j) is corrupted image, y(i,j) is noise free image and η (i,j) is noise at i,j. By calculating and comparing the PSNR values and Mean squared error the performance of different algorithms are evaluated.

The following are the formulae for

$$PSNR = 10 \log_{10}\left[\frac{255^2}{MSE}\right]$$

$$MSE = \frac{1}{MN}\sum_{(i,j)}(X_{i,j} - Y_{i,j})^2$$

$$PSP = \frac{\text{Number of nonnoisy pixels changed their gray value}}{\text{Total number of non} - \text{noisy pixels}} \times 100$$

Linear filters are not suitable for impulse noise because they cannot handle high frequency informations. So nonlinear filtering techniques are considered for impulse noise removal in order to preserve the edges. These schemes differ in their basic methodologies applied to suppress noise. Some schemes utilize detection of impulsive noise followed by filtering whereas others filter all the pixels irrespective of corruption. The algorithms are classified based on the following schemes.

- ***Filtering without Detection***

In this type of filtering a window mask is moved across the observed image. The mask is usually of size $(2N+1)2$, where $N$ is a positive integer. Generally the center element is the pixel of interest. When the mask is moved starting from the left-top corner of the image to the right-bottom corner, it performs some arithmetical operations without discriminating any pixel.

- ***Detection followed by Filtering***

This type of filtering involves two steps. In first step it identifies corrupted pixels and in second step it filters those pixels. Here also a mask is moved across the image and some arithmetical operations are carried out to detect the noisy pixels. Then filtering operation is performed only on those pixels which are found to be noisy in the previous step, keeping the non-noisy intact.

- ***Hybrid Filtering***

In this type of filtering schemes, two or more filters are used to filter a corrupted location. The decision to apply a particular filter is based on the noise level at the test pixel location or performance of the filter on a filtering mask.

Conventional median filtering approaches apply the median operation to each pixel unconditionally, that is, without considering whether it is uncorrupted or corrupted. As a result, even the uncorrupted pixels are filtered, and this causes image quality degradation. An intuitive solution to overcome this problem is to implement an impulse-noise detection mechanism prior to filtering; hence, only those pixels identified as “corrupted” would undergo the filtering process, while those identified as “uncorrupted” would remain intact. By incorporating such noise detection mechanism or “intelligence” into the filtering framework, had shown significant performance improvement.

In order to solve this problem, number of detecting scheme are studied to give a new focus on this aspect. The results of the above schemes are discussed.

## 3. IMPULSE NOISE DETECTION SCHEMES

The impulse detection is usually based on the following two assumptions: 1) a noise-free image consists of locally smoothly varying areas separated by edges and 2) a noisy pixel has tendency of very high or very low gray value compare to its neighbors.

### *3.1.Impulse detector based on second order difference*

Generally First-order derivatives produce thicker edges in an image. Second-order derivatives have stronger response to fine detail, such as thin lines and isolated points. First order derivatives generally have a stronger response to gray level step. (4) Second order derivatives produce a double response at step changes in gray level. It is also noted for second-order derivatives that, for similar changes in gray level values in an image, their response is stronger to a line than to a step and to a point than to a line. This behavior of second difference is exploited in the proposed schemes to determine the sanctity of a pixel. An impulse is nothing but change in gray level profile of an image. The second difference of an impulse will result in a spike. Also there will be a spike for an edge. In order to differentiate between these two spikes a second order difference based impulse [3] detection mechanism is employed at location of the test pixel. Once a test pixel is identified as an impulse it is immediately filtered by replacing it with the weighted median of the surrounding pixels. This filtered pixel also takes part in the noise detection phase of the next test pixel and subsequent filtering, if needed [1].

The detection algorithm is based on the second order difference[3] (SOD) among pixels in a test window to determine the noise status of the centre pixel. The SODs have a stronger response to fine details, such as thin lines and isolated points. For an isolated noise point, the SOD yields a value of larger magnitude. This property has been exploited in the proposed impulse detctor. Consider a 3 × 3 window W symmetrically surrounding the test pixel $x(i, j)$ as

$$W = \{(i+s, j+t) \mid -1 \le s, t \le 1\} \ldots\ldots\ldots\ldots\ldots (1)$$

Edges aligned with four main directions are captured by computing the SODs as in 2

$$d_k = |x(i+u, j+v) + x(i-u, j-v) - 2x(i, j)| \ldots\ldots\ldots\ldots\ldots (2)$$

where, (k, u, v) = {(1, 1, 1), (2, 0, 1), (3,−1, 1), (4,−1, 0)}

Then, the minimum of these four second-order-differences are used for impulse detection, which can be denoted as

$$d = min\{d_k : 1 \le k \le 4\} \ldots\ldots\ldots (3)$$

Depending on the value of d, the following three decisions are made

1. The test pixel is a noise-free flat region pixel as all the four direction differences are small if d is small.
2. A test pixel when falls on an edge shall yield smallest SOD along the edge resulting in a smaller value of d. Hence, the test pixel is noise-free.
3. A large value of d implies that the test pixel is noisy as it has all large SODs. The above analysis infers that the impulse can be identified by applying a hard limiting operation on d by suitably choosing a threshold **T.**

### *3.2. Impulse detection based on Rank Ordered Absolute Difference(ROAD)*

Let $x = x_{ij}$ be the location of the pixel under consideration , and let $X_x$ be the set of the pixels in a (2N +1) X (2N +1) neighborhood centered at x for some non-negative integers N. Let the set of pixels excluding the center pixel be defined as $\mathbf{X_x^{(0)} = X_x - \{x\}}$. For each pixel $\mathbf{y = \Sigma\, X_x^{(0)}}$ , let the absolute difference between gray value I of the pixel x and y be defined as $s_{x,y} = | I_x - I_y |$. Then find rank of the eight $S_{x,y}$ values such that $\mathbf{S_{x,y}^{(r)} <= S_{x,y}^{(r+1)}}$**.** Hence , Rank Ordered Absolute Differences[5][4](ROAD) may then be defined **as** $\mathbf{ROAD_m (x) = \Sigma\, S_{x,y}(r)}$ **where r= 1,..7.**

The following is an example of ROAD statistic generation.

$$\text{Original Neighborhood} = \begin{bmatrix} 140 & 130 & 80 \\ 160 & 180 & 190 \\ 101 & 180 & 60 \end{bmatrix}$$

$$\text{Absolute differences} = \begin{bmatrix} 40 & 50 & 100 \\ 20 & - & 10 \\ 79 & - & 120 \end{bmatrix}$$

Four smallest absolute differences:

$S^{(1)}_{x,y} = 10$ , $S^{(2)}_{x,y} = 20$ , $S^{(3)}_{x,y} = 40$ , $S^{(1)}_{x,y} = 50$

**ROAD= ROAD$_4$(x) = 10+20+40+50=120**

ROAD statistic provides a measure of how close a pixel value is to its four similar neighbors in a 3 X 3 window. Noisy pixels should have intensities vary greatly from those of its neighbors (i.e. their ROAD values will be large), whereas noise-free pixels should have at least half of the neighbors having similar intensity (i.e. their ROAD values will be small), even for pixels on the edges, see [28]. Thus one can use ROAD to detect impulse noise, i.e. if the ROAD value of a pixel is greater than a certain fixed threshold, then consider it as a noisy pixel otherwise the pixel is considered noise-free.

### *3.3. Rank Ordered Logarithmic Difference (ROLD)*

The ROAD[4] is already a good statistic. However, for random-valued impulse noise, some noise values may be close to their neighbors' values, in which case, the ROAD value of the pixel may not be large enough for it to be distinguished from the noise-free pixels. Thus one way to improve the ROAD statistic is to find a way to increase these ROAD values, and yet keep the small ROAD values from increasing much. Here, a logarithmic function is used to realize this goal.

Using the logarithmic function on the absolute difference *dst*

$$D_{st}(y_{i,j}) = \{\log_a |y_{i+s,j+t} - y_{i,j}|\}$$

for all (s,t ) in the set of coordinates in a (2N +1) X (2N +1) window centered at (0,0) . For any value of a>1 , the number $D_{st}$ is always in (-∞,0). In order to keep it in the dynamic range [0,1] , we use a truncation and a linear transformation:

$$D_{st}(y_{i,j}) = 1 + \max\{\log_a |y_{i+s,j+t} - y_{i,j}| - b\}/b, \text{ for all } (s,t),$$

Where a and b are positive integers to be chosen. Here a controls the shape of the curve and b decides the truncation position. The selection of a and b have great effects on the accuracy of detection. To choose them properly, consider the function

$$D_{st}(y_{i,j}) = 1 + \max\{\log x - b\}|b, (x \geq 0)$$
$$h_{a,b}(x) = 1 + max\{\log_a x, -b\}|b, (x \geq 0)$$

ROLD[5] can be defined

**$ROLD_m(y_{i,j}) = \Sigma R_k (y_{i,j})$ k =1…m .** A pixel is detected as noisy if ROLDm **$(y_{i,j})$ > threshold T** and otherwise it is noise free pixel.

## 4. EXPERIMENTAL SETUP AND RESULTS

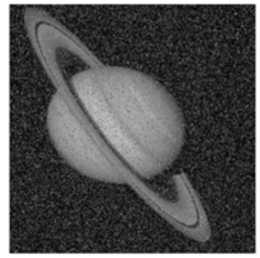
The performance of the filters are based on the capability of noise detection. Here, three different noise detecting methods lists the number of missed noisy pixels ("miss" term) and the number of "false-hit" pixels are shown in table 1. For random-valued impulse noise, the noisy pixel values may not be so different from those of their neighbors, therefore it is very difficult for a noise detector to identify the noisy pixel or wrongly detect a noise-free pixel. A good noise detector should be able to identify most of the noisy pixels, and yet its "false-hit" rate should be as small as possible. Comparing with other methods, SODID method can distinguish more noise pixels with fewer mistakes. Even when the noise level is as high as 60%, this method can still identify most of the noisy pixels. In fact, if one computes the sum of the "miss" term and the "false-hit" term. Though the number of missed pixels seems to be large in SODID method, they are able to locate more number of noisy pixels even at high densities.

These techniques are applied to Saturn image of size 512 X 512 X 3 then they are filtered using median filter. In order to use median filter RGB image is converted to gray image. The performance of SODID method is better than other methods. By reviewing the merits and demerits of these methods can be used to develop a proposed method using soft computing techniques.

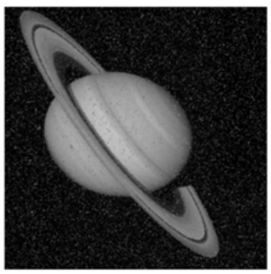
Original image

40% RVIN

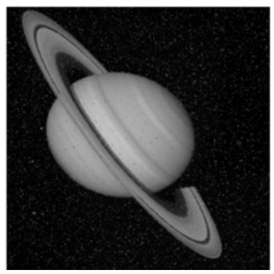
ROAD



ROLD



SODID



| Method | 40% noise density | | 50% noise density | | 60% noise density | |
|---|---|---|---|---|---|---|
| | Miss | False-hit | Miss | False-hit | Miss | False-hit |
| **ROAD** | 13476 | 8079 | 13771 | 10055 | 17212 | 9330 |
| **ROLD** | 12010 | 7404 | 13329 | 7761 | 14967 | 9109 |
| **SODID** | **10746** | **12021** | **14087** | **16187** | **17867** | **19897** |

## 5. CONCLUSION

In this paper three different random valued impulse noise detectors are discussed and applied on remote sensing images to detect RVIN that are either present in the image during capturing or injected in to the image during transmission. Remote Sensing images when captured usually have RVIN, interference noise and other noises. In this work, three different RVIN detectors are compared and the second order differential impulse detector gives better results than other methods. From this study a new detection can be developed by using all the three methods to a neural network to have a better method to detect the noisy pixel.

## References

[1]. Kyu-Cheol Lee, Hwan-Jong Song and Kwang-Hoon Sohn "Detection-estimation based approach for impulsive noise removal" Electronics Letters *5th March 1998 Vol. 34 No. 5*

[2]. Ranganath R., Navalgund, V. Jayaraman and P. S. Roy "Remote sensing applications: An overview" Special Section: Indian Space
Programme Current Science, Vol. 93, No. 12, 25 December 2007

[3]. B.Majhi,P.K.Sa and G.Panda , " Second Order Differential Impulse detector " in IEE International conference on Intelligent Systems , Ser . ICIS -2005 , Kuala Lumpur ,Malaysia, December 2005

[4]. Igor Aizenberg, C.Butakoff," Effective Impulse detector based on Rank Order Criteria", IEEE Signal processing letters Vol 11 No.3 Mar 2004.

[5] Y.Q. Dong, R. H. Chan and S.F. Xu, "A New Detection Statistic for Random-Valued Impulse Noise Removal".

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