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Comparison of Random Impulse Noise Detection Techniques

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ABSTRACT
In this project we are presenting techniques to detect random value impulse noise from color image. The paper compares the computational time required for finding the noisy pixels. From this the efficiency of the system can be determined. The main goal of this paper is to reduce the running time of detection stage by comparing the two techniques: Directional Detector (DD) and Euclidean distance method.The performance criteria of detection technique are verified using Recall, Specificity, Accuracy and Precision.

Keywords
Impulse noise, Impulse noise detection using directional detector, Euclidean distance

1. INTRODUCTION
IMAGES and videos belong to the most important information carriers in today's world (e.g., traffic observations, surveillance systems, autonomous navigation, etc.). The images are likely to be corrupted by noise due to bad acquisition, transmission or recording. Such degradation negatively influences the performance of many image processing techniques and a preprocessing module to filter the images is often required[7].

In many practical applications images are corrupted by noise caused either by faulty image sensors or due to transmissions corruption resulting from artificial or natural phenomena. Transmission noise, also known as salt-and-pepper noise in grey-scale imaging, is modeled by an impulsive distribution. However, a problem in the study of the effect of the noise in the image processing community is the lack of commonly accepted multivariate impulse noise model[4].

Based on trichromatic color theory, color pixels are encoded as three scalar values, namely, red, green and blue (RGB color space). Since each individual channel of a color image can be considered as a monochrome image. The color noise model should be considered as a 3-channel perturbation vector in color space [1].

Let Xibe the vector, characterizing a pixel of a noisy image, Vi– the vector describing impulse noise model, Zi is the noise-free color vector, p – impulse noise probability, then

$$Xi = \begin{cases} Vi & \text{with probability } p \\ Zi & \text{with probability } 1-p \end{cases}$$

Depending on the type of vector Vi researchers consider either fixed-valued or random-valued impulse noise models. In the case of fixed-valued impulse noise Vi is characterized by the following expression:

$$Vi= \begin{cases} (d, z_i^R, z_i^B), & \text{with probability } p_1 \\ (z_i^G, d, z_i^B), & \text{with probability } p_2 \\ (z_i^R, z_i^G, d), & \text{with probability } p_3 \\ (d, d, d), & \text{with probability } p_4 \end{cases}$$

Where, d - An impulse value and $\sum pm=1$

Random-valued impulse noise can be defined in several ways. In this paper we use the following model:

$$Vi= \begin{cases} (d_1, z_i^R, z_i^B), & \text{with probability } p_1 \\ (z_i^G, d_2, z_i^B), & \text{with probability } p_2 \\ (z_i^R, z_i^G, d_3), & \text{with probability } p_3 \\ (d_1, d_2, d_3), & \text{with probability } p_4 \end{cases}$$

Where, d1, d2, d3- uniformly distributed independent random numbers.

2. BLOCK DIAGRAM
Block diagram of random value impulse noise detection in color images consists for processing modules:

1. Input color image (noisy image)
2. Separation of color image in R-G-B components
3. Noise detection module

We are comparing the directional detector and Euclidean distance method for random value noise detection.

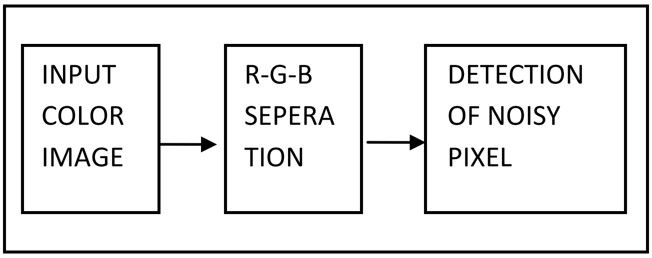

Fig 1. Block diagram of random value impulse noise detection in color images consists for processing modules

3. NOISE DETECTION USING DIRECTIONAL DETECTOR
Directional detector works as follows. Let $\mathbf{X_{i,j}}$ be the current

pixel of the distorted image with coordinates (i, j), $\mathbf{V_{i,j}}$- the corresponding pixel of the processed image [1]. On the stage of detection four basic directions passing through the central pixel by indexes k =1, ...,4. For each direction sum of brightness value are calculated as:

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- Step 1: The sum of brightness value differences $dL^k_{i,j}$(k =1...4) between pixels lying on the given direction $\mathbf{x_{i,j}}^{\mathbf{K}}$ and the central pixel $\mathbf{x_{i,j}}$.
- Step 2: The brightness of a pixel is calculated from its color component values by the following formula:

$L(\mathbf{x})$ =0.3R +0.59G +0.11B

Where R, G, B - are red, green, and blue component values of pixel x.

Among all calculated sums $dL_{i,j}^k$ the minimum is found: rL<min dL^k k | k =1,...,4

- Step 3: The resulted values rL is compared to threshold values TL. If rL<TL, then pixel $\mathbf{X_{i,j}}$ remains without changes. Otherwise, the current pixel is considered

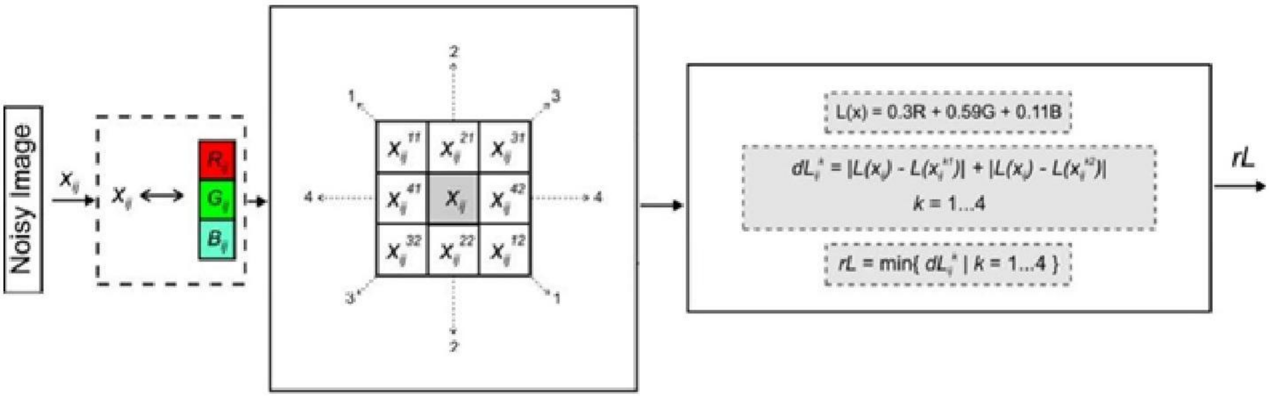

Fig 2: Operation Noise Detection Using Directional Detector

Detectors performance can be compared using five measures: recall measure, specificity, precision, and accuracy. Recall measure (R) shows the ratio between correctly deduced corrupted pixels and the overall number of corrupted pixels. Specificity (S) is the relation between the total number of pixels, correctly deduced as non-corrupted, and the number of non-corrupted pixels on the image. Precision (P) is the proportion of true corrupted pixels within the deduced corrupted pixels. Accuracy (A) is the proportion of correctly deduced pixels within the total number of pixels on the image. Let TP and TN be the number of pixels, correctly deduced as corrupted and non-corrupted respectively. FP and FN denote respectively the number of pixels that was falsely deduced as corrupted and non-corrupted. Using the notation, the measures can be given by:

$$R = \frac{TP}{TP + FN}$$

$$S = \frac{TN}{TN + FP}$$

$$P = \frac{TP}{TP + FP}$$

$$A = \frac{TN + TP}{TP + FN + TN + FP}$$

4. NOISE DETECTION USING EUCLIDEAN DISTANCE METHOD

Euclidean distance method involves classifying each RGB pixel in the image as having the specified average color or not. i.e. similar pixels are grouped together. Euclidean distance is chosen as the measuring parameter. Let the average pixel chosen be represented as 'a'. Any image pixel 'z' is said to be similar to 'a' if the Euclidean distance between them is less than a specified threshold D0. The Euclidean distance between 'z' and 'a' is,

$D(z,a) = [(zR-aR)^2+ (zG-aG)^2+ (zB-aB)^2]^{1/2}$

The following table shows the comparison of the noise detection techniques i.e. noise detection using directional detector with Euclidean distance method.

Table 1.Comparison of Detectors' Performance for Color Images

P	Measure	Euclidean Distance	Directional Detector
0.15	R	59	94
	S	89	99
	P	59	94
	A	83	98
0.2	R	51	81
	S	86	96
	P	51	81
	A	78	93
0.3	R	43	69
	S	81	93
	P	43	69
	A	72	88

The detectors used for comparison are: Euclidean distance detector and directional detector. The simulation results are shown in Table 1.

Fig.3 :Original Image

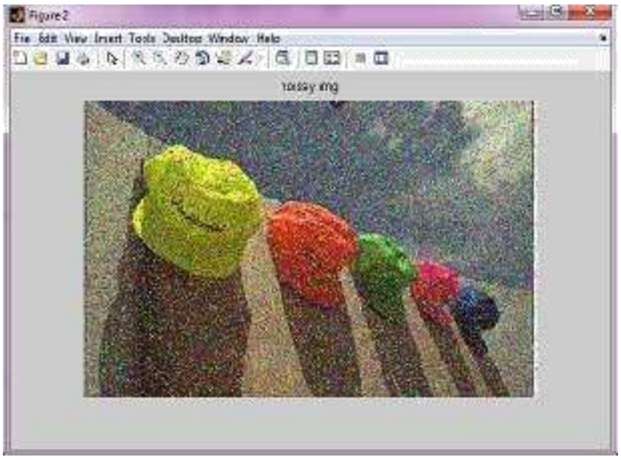

Fig.4: p= 0.15

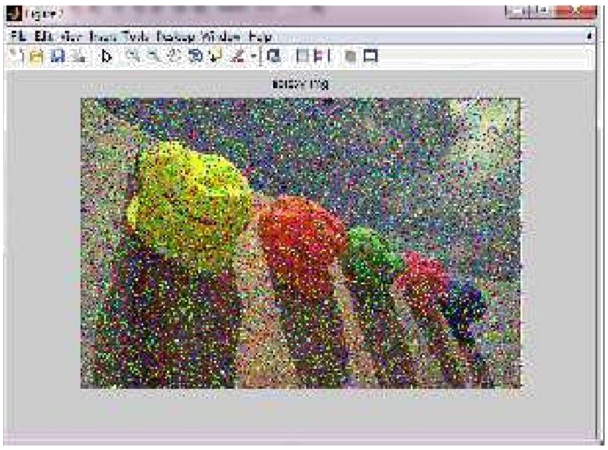

Fig.5: p=0.20

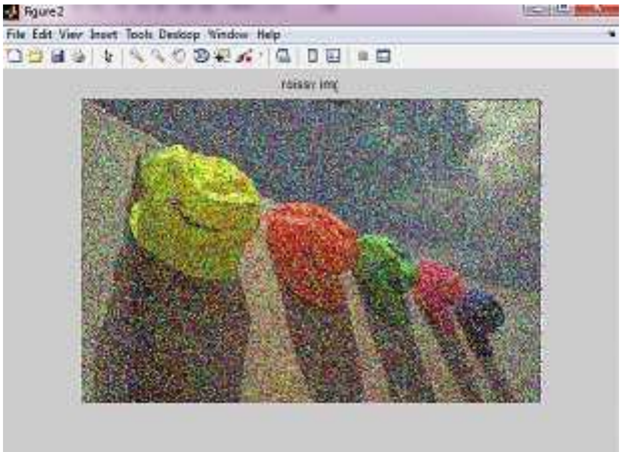

Fig.6: p=0.30

In this section, we have shown the similar analysis of impulse noise detectors for color RGB-images. The color test images used are NCD. Each vector pixel is of 24 bits, with 8 bits for every channel. The resolution of all images is 496×320.

Based on the simulation results, the following interpretations can be made. The DD has approximately close value for recall (because of the less number of false negative errors) in comparison with ideal detector.

For low impulse noise probability p<0.1the proposed DD algorithm advantageous over Euclidean distance method. For the increased impulse noise probability p>0.1 the reduction in accuracy values of Euclidean distance method is comparably greater than DD method.

The main drawback is Euclidean distance method requires the original image for computation of noisy pixel detection. Computational time required for Euclidean distance method is much greater than DD which is not feasible for real time applications [1] [2].

5. CONCLUSION

In this paper, we present a comparison between two different noise detection techniques namely, Directional detector method and Euclidean distance method. This study states different detection strategies by discriminating noisy pixels in moving and non-moving areas. It utilizes the spatial properties of impulse noise.

Different noise filtering techniques such as median filtering, average filtering can be incorporated in the detection techniques we have designed to get noise free image. Noise detection techniques plays important role in non-linear filtering which filters only noisy pixels. Various genetic algorithm such as ant colony optimization ,particle swarm optimization can utilize the directional detector method for filtering operation. Directional detector method can be successfully applied to color image sequences.

Our experimental results show that, among the methods compared for noise detection, directional detector method is better. However, these methods are suitable for impulse noise detection of noise density is low as well as high noise density. If the noise density is too high, suppose>90%, then the methods like directional detector method may yield better de-noising performance.

6. ACKNOWLEDGMENTS
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