

An approach for image noise identification using minimum distance classifier

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Abstract :- This paper deals with the problem of identifying the nature of noise in order to apply the most appropriate algorithm for de-noising. The key idea involves isolation of some representative noise samples and extraction of their features for noise identification. The isolation of the noise samples is achieved through application of filters. Statistical features are extracted and the minimum distance classifier is applied for identification of the noise type present.

Keywords :- Noise, noise identification, statistical features, minimum distance classifier.

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1. INTRODUCTION

The identification of the nature of the noise affecting an image is an important stage in all information interpretation systems by vision when the nature of the degradation is unknown. The majority of filtering algorithms (Lee, Kuan, ...) [1] [2] and certain algorithms of contour detection (Canny, Deriche, ...) [3] [4] found in literature, assume that the nature of the noise and its statistical parameters are known. Whereas in most practical cases we have not a priori knowledge on these data [5]. For this reason the statistical parameters of the noise must be estimated as they condition the quality of the filtering or the analysis of the images [6]. In [7], we proved that it is possible to identify the nature of the noise by recording variations of local statistics (the standard deviation as a function of the average) computed in the homogeneous regions of the observed image. If the recording is parallel to the average axis, then the noise is declared as an additive one and its standard deviation is equal to the sampling average of the different values of the local standard deviation. If the recording can be assimilated by a line passing through zero, then the noise is declared as a multiplicative one and its standard deviation is given by the slope of the line. And finally, if the recording can not be viewed as a line passing through zero, then the noise is declared as an impulsive one. The previous methods presented in [7] [8] [9] are based on the criterion of maximum likelihood for the selection of the most homogeneous masks (Lee, Nagao etc.), from which the value of the local standard deviations are calculated. However, the disadvantage with this approach is the estimation of parameters from pixels belonging to masks a priori decked. This means that the estimates of standard deviations are sometimes necessarily biased and the final identification rates inevitably decreased in the case of

images degraded either by a weak multiplicative or an impulsive noise.

The search for efficient image de-noising methods is still a valid challenge at the crossing of functional analysis and statistics. In spite of the sophistication of the recently proposed methods, most algorithms have not yet attained a desirable level of applicability. All show an outstanding performance when the image model corresponds to the algorithm assumptions but fail in general and create artifacts or remove image fine structures

In order to increase the rate of identification and to improve the estimation of statistical noise parameters, we propose a new method. The statistical parameters kurtosis and skewness are calculated and the Minimum Distance Classifier is applied. Classification includes a broad range of decision-theoretic approaches to the identification of images. All classification algorithms are based on the assumption that the image in question depicts one or more feature and that

each of these features belongs to one of several distinct and exclusive classes. Classification analyzes the numerical properties of various image features and organizes data into categories.

2. THE PROPOSED METHOD

In principle, the noise identification method proposed here consists of three key steps:

- Step 1. Extract some representative noise samples from the given noisy image,
- Step 2. Estimate some of their statistical features, and
- Step 3. Use a simple pattern classifier to identify the type of noise.

In this paper, we consider four different types of commonly occurring image noise, namely,

uniform white, Gaussian white, speckle, and salt-and-pepper noise. Among these four types, speckle noise is of multiplicative type, whereas the other three are additive in nature. The filters selected for the above four types of noise are: Wiener filter [10] for uniform or Gaussian white noise, Homomorphic filter [11] for speckle noise, and median filter [10],[11] for salt-and-pepper noise. Also, the statistical

features studied here include "kurtosis" and "skewness". Table 1 lists the probability density functions, "kurtosis" and "skewness" values, and the selected filters for the four types of noise. From Table 1, we can see that different type of noise has different kurtosis or skewness values and those differences can be used to identify the noise type.

Table 1
 PDF, Kurtosis,Skewness and Filter selected for four type of noises.

	Probability Density Function	Kurtosis	Skewness	Selected Filter
Non-Gaussian White	$f(x) = \begin{cases} \frac{1}{b-a}, & a \leq x \leq b \\ 0, & \text{otherwise} \end{cases}$	1.8	0	Wiener Filter
Gaussian White	$f(x; \mu, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$	3	0	Wiener Filter
Speckle (exponential distribution)	$f(x) = \begin{cases} \frac{1}{\sigma^2} \exp(-\frac{x}{\sigma^2}), & x \geq 0 \\ 0, & x < 0 \end{cases}$	9	2	Homomorphic filter
Salt-and-Pepper	$f(x) = \begin{cases} p_a, & \text{for } x = \text{salt} \\ p_b, & \text{for } x = \text{pepper} \\ 0, & \text{otherwise} \end{cases}$	Large (typically greater than 20 or so, depending on the noise density)	0	Median Filter

3. IDENTIFYING THE NATURE OF NOISE

3.1 The Algorithm

1. Fetch the input images.
2. Introduce noise(through imnoise or rand).
3. Filter the image and hence obtain the noise sample.
4. Extract the features from the noise sample.
5. Apply the Minimum Distance Classifier and classify noise

3.2 The statistical features

3.2.1 Kurtosis

Kurtosis is any measure of the "peakedness" of the probability distribution of a real-valued random variable. It is a descriptor of the shape of a probability distribution and there are different ways of quantifying it for a theoretical distribution and corresponding ways of estimating it from a sample from a population.

3.2.2 Skewness

Skewness is a measure of the asymmetry of the probability distribution of a real-valued random variable. The skewness value can be positive or negative, or even undefined. Skewness has benefits in many areas. Many models assume normal distribution; i.e., data are symmetric about the mean. The normal distribution has a skewness of zero. But in reality, data points may not be perfectly

symmetric. So, an understanding of the skewness of the dataset indicates whether deviations from the mean are going to be positive or negative.

3.3 Evaluation of the features

The evaluation of features is carried out using Matlab simulations. The functions kurtosis(X) and skewness(X) are used to calculate the respective values for the feature kurtosis and skewness for the image sample X. A range of feature values are calculated for each image sample and then the mean value is calculated using the mean(x1, x2, x3...) function which returns the mean value of input specified.

3.4 Application of Minimum Distance Classifier

This is applied so as to find out the minimum distance & classify as to which class the image belongs to. The distances are calculated on the values of the features being extracted as before i.e kurtosis and skewness. Euclidean distance is calculated by the formula:

$$d_i = \sqrt{(K_i - K_m)^2 + (S_i - S_m)^2}$$

For every image the distances are calculated for every mean value of the features. The minimum the distance to a class, the image belongs to that category of noise. The distance calculated thus helps to lead to a conclusion.

3.4 Experimental Results

The algorithm is applied on a set of images with Uniform, Gaussian, Speckle and Salt & Pepper Noise. The following confusion matrix shows the result:

Table 2
Confusion Matrix for Minimum Distance Classifier

	Uniform	Gaussian	Speckle	Salt & Pepper
Uniform	86.2	10	3.8	0
Gaussian	6.4	90	3	0.6
Speckle	0	2.3	90.19	7.5
Salt & Pepper	1.5	5	3.5	90

4.CONCLUSION

A simple technique for identifying the type of noise present in a noisy image is proposed in this paper. The proposed technique is quite general in nature and can be used with a variety of de-noising filters. The results of simulation studies seem to indicate that the method is capable of accurately determining the type of noise.

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