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Statistical Simulation Methods

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ABSTRACT

This paper contains studying speckle characteristic, (the main problem in coherent images), some digital techniques for simulation have been presented in this paper to generate noise similar to speckle noise, this done by adopting (Chi-square, 2-Gaussian, Multi Method, and Sinusoidal) with different number of looks (1 to 5 look). Images can be simulated by multiplying, point to point, an in coherent image array by the simulated speckle data file. The size of the image and the speckle file must be equals.

Index Terms- Simulation, Speckle, Multiplicative noise, Chi-square distribution, Gaussian distribution.

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INTRODUCTION

Speckle patterns are produced when light with sufficient and temporal coherence is scattered by a medium or surface that introduces random optical path fluctuations comparable to the optical wavelength. Different authors to describe phenomena that differ in detail form one another frequently use the term 'speckle' [1,2].

Speckle occurs in all types of coherent imagery, such as Synthetic Aperture Radar imagery (SAR), a caustics imagery, and laser illuminated imagery. It is due to the random information of the wavelets scattered by the microscopic fluctuations of the object surface one resolution element [3,4]. Speckle pattern often, consist of multitude of bright and dark spots. The bright spots are generated as a result of highly constructive interference, while dark spots are due to highly destructive interference, while intermediate gray levels will be between these two extremes [5].

The amount of speckle is inversely proportional to the square root of the number of look, whilst the increase in size of the resolution cell is directly proportional [4,6].

Speckle is usually modeled as a random multiplicative noise:

$$I(x, y) = R(x, y).F(x, y)$$

where $I(x, y)$ denotes the intensity, $R(x, y)$ denotes the reflectivity, and $F(x, y)$ denotes the speckle noise. So $F(x, y)$ is supposed to a Gamma distribution is not always the true probability density function of the speckle intensity. But even in the case where it is only an approximation, it is the distribution which is the most often used, for it is close to experimental measured speckle distributions for natural clutters [2,7,8].

Various simulation methods have recently introduced to produce images look a like speckly image like (SAR). In our present work, we shall discuss four different methods, used to generate the speckle data files of any size.

SIMULATION METHODS

1- FIRST METHOD

In this study, several speckle data files, with different number of looks, have been simulated and used to study the speckles characteristics and to compare the results with that obtained by utilizing;

$$P(F) = F^{L-1} e^{-F/2} \Big/ 2^{L}\Gamma(L)$$

i.e. the normalized Chi-square distribution.

2- SECOND METHOD

Many images can be simulated with different regions and with different number of looks. Each of these images has been corrupted with multiplicative noise which is selected from two independent random Gaussian distribution, each have zero mean and half variance i.e.:

$$F(x, y) = G_1^2(x, y) + G_2^2(x, y)$$

where $G_1^2(x, y)$ and $G_2^2(x, y)$ are two random numbers obtained from two independent zero mean Gaussian distribution, and of one half variance.

3- THIRD METHOD

Multi Chi-square distributions can be generated by using multi (two Gaussian distributions).

Speckle noise data can be simulated by using (Multi Method (MM)):

$$NF(x, y) = MG_1^2(x, y) + MG_2^2(x, y)$$

where, $N =$ number of speckle noise data obtained by M multi random numbers.

$M =$ multi random number obtained from two independent zero mean Gaussian distribution and one half variance.

4- FOURTH METHOD

If the surface which supposed to be illuminated by coherent Electric Magnetic Wave (EMW) is rough, compacted with the wavelength of the incident EMW, therefore we can write the generated wave as the following form;

$$U = Ae^{(i2\pi\mu t)}$$

$$A = \sum_{K=1}^{C} |a_K| . e^{(i\Phi_K)}$$

$$A = \sum_{K=1}^{C} |a_K| . \cos\Phi_K + i\sum_{K=1}^{C} |a_K| . \sin\Phi_K$$

where, a_K and Φ_K represent the amplitude and the phase, respectively of the contribution from the $K-th$ scattering area, C is the total number of scatterers. The intensity from of the speckle pattern can be representing as [5];

$$I = |A|^2$$

If we assumed that $|a_K| = 1$ the intensity can be represent as the form;

$$I = \left[(\sum_{K=1}^{C} \cos\Phi_K)^2 + (\sum_{K=1}^{C} \sin\Phi_K)^2 \right] f$$

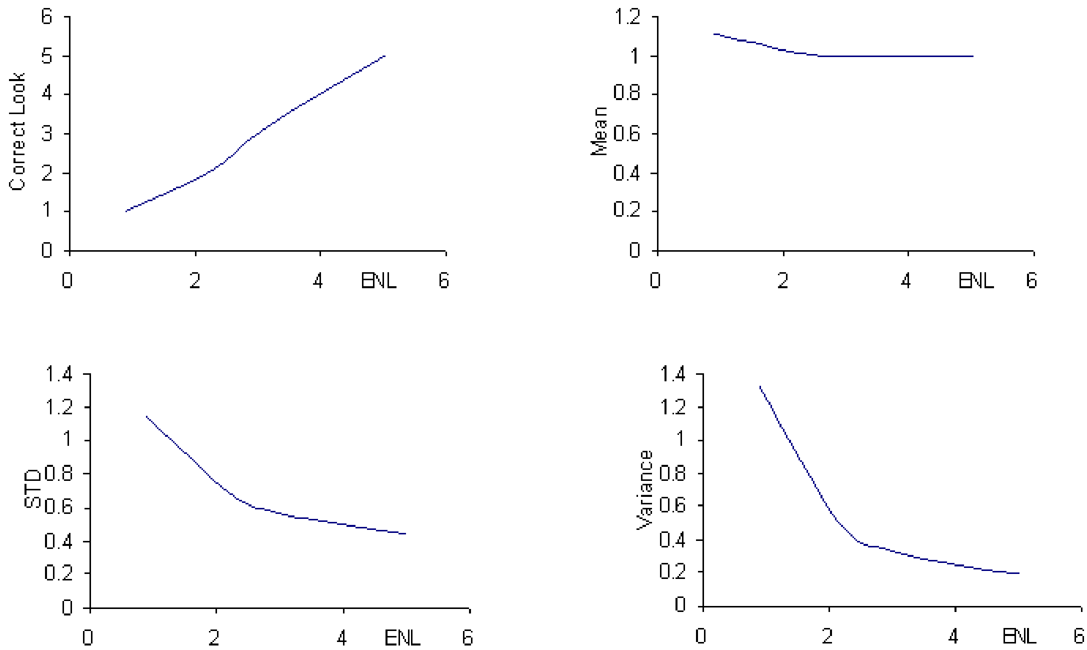
where f is a conservative factor. The conservative factor is utilized to keep the energy constant and to reduce the expected losses in intensity. The first step to compute the conservative factor is assuming as initial value $f_0 = 1$ then generating speckle pattern, and calculating the mean μ after that we can determine this factor by this form;

$$f = \frac{1}{\mu}$$

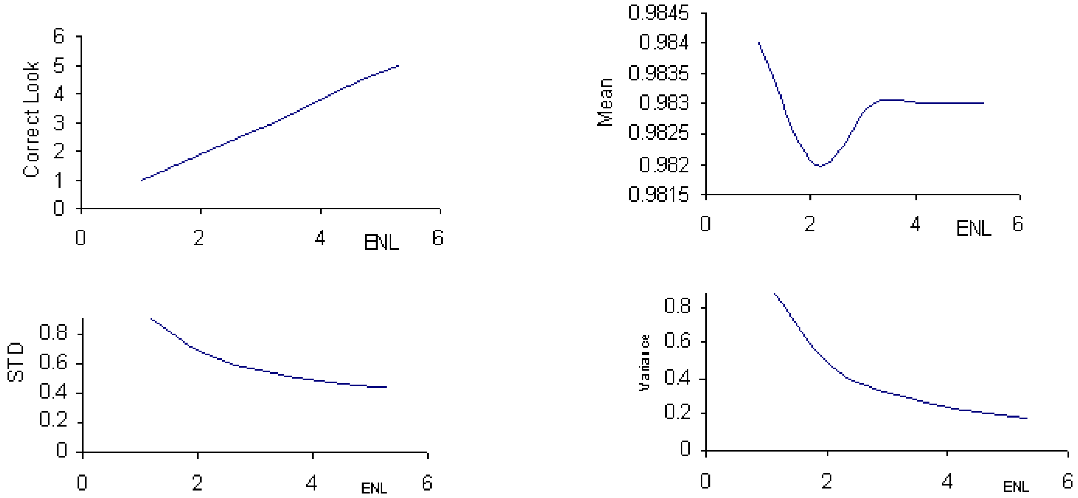
EXPERIMENTAL RESULTS

In this paper, four methods concerning generation of speckle data files have been study. The results of previous speckle generation methods, shown in figures (1,2,3,4) where these figures explain the relation ship between Equivalent Number of Look (ENL) and the {real look(Correct Look) (L), mean (μ), variance (σ^2), and the standard deviation (STD) }.

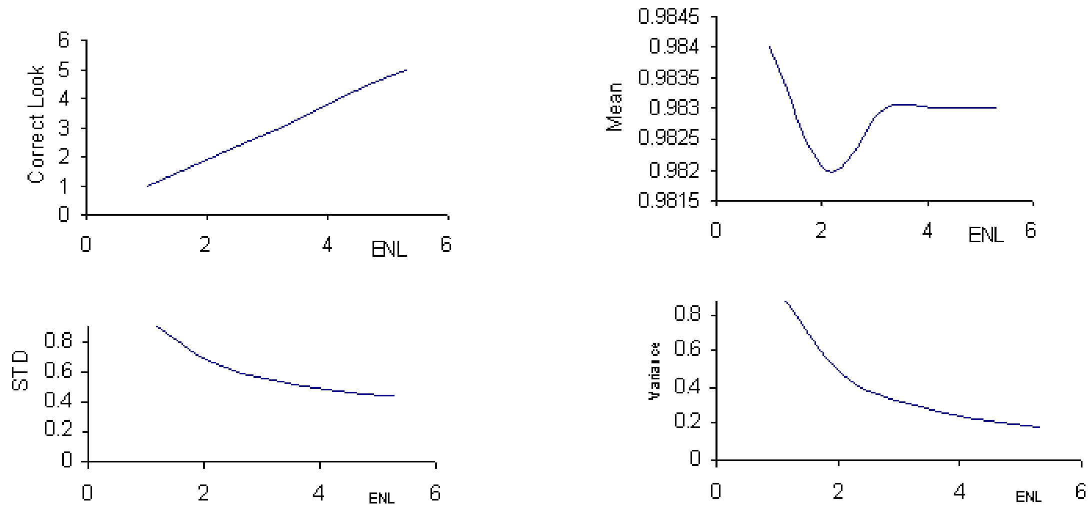
The result of statistical properties of the speckles simulated by the adopted methods (Chi-square, 2-Gaussian, Multi Method, and Sinusoidal) will be explained below.



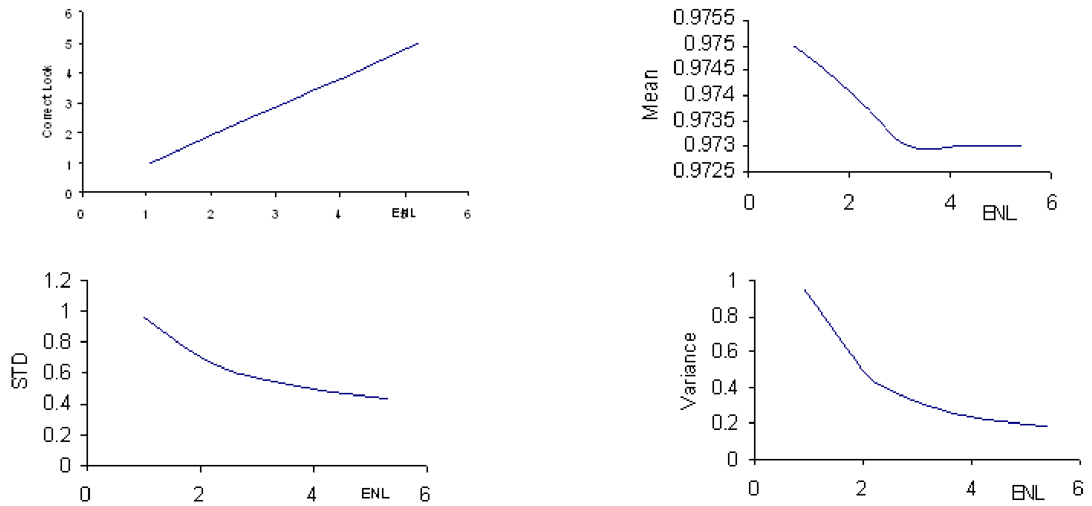
Figs.-(1) The relationship between (ENL, Correct Look, Mean, and Variance) from the 1st method.



Figs.-(2) The relationship between (ENL, Correct Look, Mean, and Variance) from the 2nd method.



Figs.-(3) The relationship between (ENL, Correct Look, Mean, and Variance) from the 3rd method.



Figs.-(4) The relationship between (ENL, Correct Look, Mean, and Variance) from the 4th method.

V. CONCLUSION

- From the result obtained it can be prove that the speckle noise represents a multiplicative noise.
- The adopted speckle generation methods give similar results, so any one can be used as an effective speckle generation method. But the faster one is Chi-square distribution method.
- In the case of 1-look $(L=1)$ Chi-square behave as exponential distribution, but in case of $L-$look it behave as Gamma distribution.

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