Noise Enhanced Imaging of Weak Objects

Stephen Daedalus Separa, Giovanni Tapang, May Lim, and Caesar Saloma*
National Institute of Physics, College of Science
University of the Philippines
Diliman, Quezon City 1101 Philippines
E-mail: csaloma@nip.upd.edu.ph

ABSTRACT

A method that allows the imaging of weak objects is demonstrated through the use of additive noise. Additive noise (characterized using a variance parameter σ) is used to drive the intensity of the test object so that a threshold detector detects it. Performing the simulation with a sufficiently large number of trials decreases the optimum value of noise required for a good image quality.

Keywords: noise dithering, image recovery

INTRODUCTION

Objects with low intensities are below detection levels. A class of noise-induced cooperative phenomena, called Stochastic Resonance (SR) (Bulsara & Gammaitoni, 1996; Gammaitoni et al., 1998) has been shown to enhance and sustain the dynamic response of a nonlinear system to input stimuli in numerous studies (Lindner et al., 1998). In SR, an optimum, nonzero value of noise maximizes the counter-intuitive cooperation between noise and the input signal. However, a non-optimal value, will not maximize the output but either minimize or annihilate it completely.

Most imaging systems function by decreasing or eliminating noise from the input. In this paper, we demonstrate a method that allows the imaging of objects with sub-threshold intensities, using additive noise. Additive noise is used to drive the intensity of the test object so that it is detected by a threshold detector. We also demonstrate that performing the simulation with a sufficiently large number of trials, decreases the optimum value of noise required for a good image quality.

The process of Noise Enhanced Imaging (NEI) is demonstrated in a setup composed of a noise generator, a charged-coupled device (CCD), and a computer for post-processing. In the simulation, a 470x400, 256-level grayscale test image was used as the test object. A pulse with a random intensity is added to the input as additive noise. Both uniform white and gaussian white noise were used in this simulation. The distributions of these noise functions are defined in Eq. (1) for gaussian, and Eq. (2) for uniform white. We define the noise variance σ as the range of possible values for the random variable i. In Eq. (1), it is the full-width at half maximum (FWHM) of the gaussian envelope. σ in Eq. (2)

$$(1)\quad P(i)=\frac{1}{\sqrt{2\pi\sigma}}\exp\left(\frac{-i^2}{2\sigma^2}\right)$$

$$(2)\quad P(i)=\frac{1}{\sigma},\ \text{for } |i|\leq\sigma/2$$

**Corresponding Author*