Estimation of Dynamic Noise in Mandelbrot Map

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ABSTRACT

Julia and Mandelbrot sets have been studied continuously attracting fractal scientists since their creation. As a result, Julia and Mandelbrot sets have been analyzed intensively. In this article, researchers have studied the effect of noise on these sets and analyzed perturbation. Continuing the trend in this article, they analyze perturbation and find the corresponding amount of dynamic noise in the Mandelbrot map. Further, in order to recover a distorted fractal image, a restoration algorithm is presented.

KEYWORDS

Additive Noise, Dynamic Noise, Mandelbrot Map, MSE, Multiplicative Noise, Perturbation, PSNR
1. INTRODUCTION

Fractal noise is a basic technique proposed by Ken Perlin in 1983 for Hollywood films, also called as Perlin noise or 1/f noise (2005). Chris Zwar (2006) played an important role in creating background designs using fractal noise. To set up a seamless looping animation, fractal noise determines the revolutions in animation. The potential applications of fractal noise are in texture creation of wood, building a marble pattern, Stanford bunny designs (Miné and Neyret, 1999), surface design of pots (Olano, 2005), texture created with fractal noise in after effects in water droplets, wood grain, map, hammered bronze, smoke fabric etc. (Zwar, 2006).

The most attracting fractals Julia and Mandelbrot sets were perturbed due to noise by Argyris et al. in 2000, see also (2002). Noise in fractals can be analytic, non-analytic or dynamic. The dynamic noise can be additive or multiplicative. In 2008, Negi and Rani introduced general noise, which was a mixture of additive and multiplicative noises. Further, only a handful researcher analyzed noise-perturbed Julia and Mandelbrot sets. See Wang et al. (2007; 2009), Andreadis et al. (2010) and Sun et al. (2016). For noise in chaotic attractors, one may refer to (Argyris and Andreadis, 2000; Argyris et al., 1998; 1994).

The first superior Mandelbrot and Julia sets were introduced by Rani and Kumar (2004). The study of perturbation due to additive, multiplicative or mixed noises, and also control on perturbation in superior Mandelbrot and Julia sets were given by Agarwal and Agarwal (2012), Negi and Rani (2008), and Rani and Agarwal (2010; 2012).

Thus perturbation in the Julia and Mandelbrot maps due to noise has received good attention, but no research has been done on reverse engineering, i.e., to identify the amount of noise in the Julia and Mandelbrot maps by analyzing perturbation in it except a mild recent study on reverse engineering of Mandelbrot set with analytic noise done by Rani, Jha and Agarwal (2016). It seems that there is a good scope to devise methods to identify amount of noise in a perturbed Julia and Mandelbrot maps.

In this paper, we pick up the Mandelbrot map, and devise a method to identify the amount of dynamic noise in a noise-perturbed Mandelbrot map and restore it. We calculate \(MSE\)-value and \(PSNR\)-value to identify the amount of noise and quality in the Mandelbrot maps respectively. Background of our work is contained in Section 2. In Sections 3 and 4, a noise identification method in the Mandelbrot map is devised. Section 5 gives the algorithm for restoration of a perturbed Mandelbrot map. The paper is concluded in Section 6.

2. PRELIMINARIES

The quadratic polynomial equation to obtain Mandelbrot map, denoted by \(Q_c\) is represented by

\[
x_{n+1} = x_n^2 - y_n^2 + c_1 \quad \text{and} \quad y_{n+1} = 2x_n y_n + c_2
\]

where, \(c_1, c_2 \in R\) (reals).
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