Noise-aided Contrast Stretching, Dynamic Range Compression, and Denoising: Image Enhancement using Dynamic Stochastic Resonance

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Abstract

This thesis addresses the problems of image enhancement: contrast enhancement, denoising, and dynamic range compression, using the concept of noise-aided dynamic stochastic resonance (DSR). Stochastic resonance (SR) is a counterintuitive phenomenon where addition of noise can be utilized to amplify a weak signal. It can be applied to images through an iterative process modeled from the motion dynamics of a particle oscillating in a quartic double-well potential. A processing model comprises a processing equation, and the method for choosing its parameters. Broadly speaking, the thesis presents two sets of contributions: the analysis of existing SR models to dark image enhancement in various domains, and the development of a novel intensity-specific model for dynamic range compression. The noise in the current context is the inherent *internal* degradation in a dark/low-contrast image due to insufficient illumination, and is non-separable from the image information.

Earlier DSR models chose their parameters from input and/or output image statistics, and required one or both parameters to be chosen from a range of favorable values. These models are analyzed here for contrast enhancement of dark images in Fourier and hybrid domains. The performance is characterized and compared with state-of-the-art enhancement algorithms in terms of contrast enhancement, perceptual quality, logarithmic contrast measures, subjective scores, and color enhancement. A preliminary study of the input statistics-dependent SR model for wavelet-based denoising of Gaussian-corrupted images showed marginal improvement over conventional methods.

While the existing SR models give noteworthy enhancement of dark images, they suffer from certain shortcomings in terms of parameter selection. Also, the existing models are not derived specific to image domain, and are unable to preserve bright regions in images with both bright and dark areas. Addressing these issues, a novel intensity-specific value-dependent SR model is proposed to produce dynamic range compression in such images, while using entropy as the iteration termination criterion. While characterizing dynamic range compression, some existing image quality metrics were found incoherent with visually optimal outputs. Therefore, a new metric called image quality for dynamic range compression (IQ-DRC), by revising the existing universal image quality metric, is proposed and tested on several images.

***Keywords*:** dynamic stochastic resonance, contrast enhancement, dynamic range compression, image denoising, image quality assessment, intensity-specific parametric models, discrete Fourier transform, discrete wavelet transform, hybrid transform domains