Abstract

Use of stochastic resonance for image application is a very challenging task. This thesis presents novel techniques for image enhancement, segmentation and watermark detection using stochastic resonance.

The mathematical foundation of stochastic resonance for image enhancement has been presented here. Two stochastic resonance (SR) based methods are introduced for enhancement of very low contrast images. The novel SR based techniques enhance the information without introducing any artifacts and spots in the images. SR is a phenomenon wherein addition of random noise of optimum intensity to a week noisy signal and passing through a non-linearity enhances output signal-to-noise ratio (SNR). This was first reported by Benzi et al. [10]. Nonlinearity is taken as hard thresholding operation. Output (SNR) depends upon threshold Δ and noise standard deviation σ. In the proposed SR based image enhancement technique-1, an expression for optimum threshold has been derived. Gaussian noise of increasing standard deviation has been added iteratively to the low contrast image until the quality of enhanced image reaches maximum. A quantitative parameter ``Distribution Separation Measure (DSM)" [79] is used to measure the enhancement quality. In order to reduce the required number of iterations in the second enhancement technique we have derived an expression for optimum noise standard deviation $\sigma_{optimum}$ that maximizes SNR. Image enhancement is obtained by iterating only with few noise standard deviations around $\sigma_{optimum}$. This reduces number of iterations drastically. The experimental results have been compared with the different existing techniques qualitatively and quantitatively.

The problem of segmenting noisy, blurred images having different brightness levels have been investigated using suprathreshold stochastic resonance. The algorithm is tested on multi-object multi-colored image. The segmentation accuracy in terms of correlation coefficient, number of mismatch pixels, and change in object position is very appreciable. The effectiveness of the proposed method is compared with the existing methods and found satisfactory.

Data authentication is a challenging task for image/signal processing community. Watermarking is the existing technique which provides the authentication of data. Two methods are introduced for watermark detection called stochastic resonance and single threshold, and stochastic resonance and maximizing network. In both the methods the

correlation between original watermark and the stochastic resonance based discrete wavelet transform coefficients of the watermarked image improved. The proposed methods are compared with the existing methods and found suitable. The detector response is very appreciable for distorted watermarked images.

Finally, we proposed a novel logo detection method from the distorted watermarked images. The method is based on combined discrete wavelet transform (DWT) and discrete cosine transform (DCT) with dynamic stochastic resonance (DSR). Basically, watermarked image property like standard deviation and dynamic double well system parameters are tuned to give stochastic resonance. For comparison of the combined DWT and DCT with DSR based detection method, DWT with DSR based detection results are also computed. The effectiveness of the proposed method is compared with the existing methods and found suitable. The detected logo from distorted watermarked images is almost similar to the original logo.

Keywords: Stochastic resonance, suprathreshold stochastic resonance, image enhancement, image segmentation, digital watermarking