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Statistics of Natural Stochastic Textures*

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Abstract

Statistics of natural images have become an important subject of research in recent years. The highly kurtotic, non-Gaussian, statistics known to be characteristic of many natural images are exploited in various image processing tasks. We focus on Natural Stochastic Textures (NST), an important subset of natural images. In the first part of this report, we show their abundance in natural images and explore their statistical properties: Gaussianity, statistical self-similarity, stationary increments and long-range dependencies. These properties and, in particular, the Gaussianity, stand in contrast to known properties of the wider class of natural images. In the second part of this report, the importance of the Fourier phase in NST representation and processing is explored. A magnitude-phase variational flow is presented. This flow allows restoration/enhancement of images, combining statistical properties with the phase structure of a images.

1 Introduction

Statistics of natural images have been the subject of intensive studies in recent years [1–3]. With the increased use of statistical image enhancement algorithms, suitable priors play a crucial role in the enhancement and restoration of images, especially in ill-posed problems where only severely degraded images are available.

Various studies have consistently shown that natural images exhibit non-Gaussian behaviour. This has been observed by inspecting the 1D, 2D, or joint histogram of the wavelet coefficients of an image [4,5]. These histograms, evaluated on numerous images, provide a good indication of their statistical structure. Natural images exhibit highly kurtotic, non-Gaussian, behaviour, indicated by heavy tails in both 1D and 2D (joint) distributions [6]. Many models capture this behaviour successfully, such as Gaussian scale mixtures (GSM) [4, 5] or generalized normal [7].

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