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The Importance of Phase in Image Processing

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Abstract

The phase of a signal is a non-trivial quantity. It is therefore often ignored in favor of signal magnitude. However, phase conveys more information regarding signal structure than magnitude does, especially in the case of images. It is therefore imperative to use phase information in various signal/image processing schemes, as well as in computer vision. This is true for global phase and, even more so, for local phase. The latter is sufficient for signal/image representation, while totally ignoring the magnitude information. The implementation of localized methods requires substantial computation resources. Thanks to the major progress in available computing resources during the last decade, the implementation of localized methods has become feasible. Thus, there is a growing interest in localized approaches, including those that incorporate phase in, both theory and application. We address the importance of phase, in image processing with special emphasis on its application in edge detection and segmentation.

Introduction

One of the most important and widely used tools for image representation and analysis is the spatial frequency transform, which can be represented in terms of magnitude and phase. The importance of phase in images was first shown in the context of global phase [7]. Since usually the content of a signal is not stationary, the localized frequency analysis has become an important and powerful tool in signal representation [9, 10]. In order to deal with such non-stationary signal, it is advantageous to analyze the signal frequency and spatial information simultaneously, with maximal possible resolution in both position and frequency. The joint resolution is however, limited by the uncertainty principle. The drawbacks of the Fourier transform (such as lack of spatial localization), and the tools to overcome these limitations (spatial-frequency analysis schemes) were discussed in [11].

The importance of phase information in images has inspired its implementation in various tasks such as edge and corner detection [12], image segmentation [13, 14], and more... Phase is highly immuned to noise and contrast distortions- features desirable in image processing.