Session 10

Posters:

BLIND IMAGE RESTORATION FROM ISOTROPIC BLUR BY AUTOMATIC BEST STEP-EDGE DETECTION

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Abstract

Image restoration algorithms often require previous a knowledge of the point spread function (PSF) of the disturbance. Deriving the PSF manually from a degraded ideal step-edge in the image is a well known procedure intended mainly for isotropic degradations. A common image degradation that can be approximated as isotropic is the atmospheric blurring in long distance imaging. This paper proposes an efficient method that automatically finds the best (closest to ideal) step-edge from the degraded image. The identified PSF is then used to restore the image. The existence of a good step-edge in the image may be assumed in cases such as imaging of urban areas, which is common in applications such as visual surveillance and reconnaissance. The criteria employed include the straightness and length of the edge, its strength, and the homogeneity of the step. An efficient algorithm is proposed, and results of automatic blind image restoration based on the automatically extracted PSF are shown.

MINIMIZING EDGE EFFECT IN HYPERSPECTRAL POINT TARGET DETECTION

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Our work deals with point target detection in multispectral and hyperspectral imagery. When using a well known RX matched filter algorithm for this purpose, one often assumes that all image signatures act as random stationary Gaussian processes. Some changes to the traditional RX method can be made in order to eliminate the need for this assumption and to generalize the algorithm. Specifically, a local mean RX algorithm was developed, producing stable results (low false alarms) in flat areas of the datacubes being tested. However, this method depends on the ability to estimate signature background around each tested pixel using first order statistics. This ability is limited in the edge regions characterized by rather large fluctuations in intensity values between adjacent pixels in each band and large spectral angles between adjacent signatures, leading to the creation of false alarms.

In our work, we purpose a new filter to be used in the RX matched filter method, called the directional filter. When applying the directional filter, we take the same approach of estimating the tested pixel's background as in the local mean filter, but we avoid taking all adjacent signatures for the estimation calculation. Instead, we take only two adjacent signatures suspected of having the same background characteristics as the pixel being tested. This way we wish to eliminate the strong dependency existing between the degree of edge content and the false alarms calculated using the local mean filter.

Two different methods were developed in order to check the strength of correlation between the anomaly vector and the "edginess" values in a datacube subtracted by applying Frey and Chen edge detection filters. The dependency graphs for the local mean filter and the directional filter were created.

The results of running the tests on a set of hyperspectral datacubes indicate that there is a strong dependency when using the local mean filter in some images, while it is being lowered drastically after applying the directional filter method. For some image characteristics, the dependency is being inversed.

Enhancement of the space-bandwidth product of imaging systems by compressed sensing

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ABSTRACT

Due to the ever increasing demands for imaging systems with higher resolution and larger field-of-view there is a constant endeavor to minimize the number of sensor elements that capture enough information to represent the image with reasonable accuracy. Traditionally, the efforts were concentrated to optimize, or to better exploit, the space-bandwidth product (SBP) of the imaging with respect to the scene to be imaged. The SBP, which defines the degrees of freedom, should be large enough to provide the required resolution within given filed of view. On the other hand, too large SBP implies redundancy and waste of resources (i.e, sensing pixels, and bandwidth). However even with optimally matched SBP, often the captured images are redundant and compression techniques are employed to reduce the redundancy. The fact that typical images are compressible implies that it should be possible to capture fewer samples without compromising the quality of reconstruction. The technique to reconstruct accurately compressible images from fewer measurements than the nominal number of pixels is provided by a recently developed mathematically theory named compressed sensing (CS). Here we present a novel imaging technique that implements the CS concept. For objects that are compressible in some known domain (eg. Fourier or wavelet) the novel imaging systems has larger effective SBP than conventional imaging systems. This implies, for example, that more object pixels may be reconstructed and visualized than the number of pixels of the image sensor. We present simulation results on the utility of the new approach.

Characterizing and imaging optically diffusive media with the Kramers-Kronig method

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One of the most popular methods to characterize a diffusive medium is analyzing its impulse response, which includes all the information required for the medium's analysis. In principle, this can be done by sending a short pulse into the medium and measuring the transmitted and/or reflected signal with a sufficiently fast detector, known as the time-domain method. However, to obtain high resolution image the incoming pulses must be very narrow temporally, and more important, the detectors must be very fast. As a consequence such an imaging technique requires cumbersome and expensive equipment. This is one of the main motivations for developing spectral techniques, i.e., techniques which work in the spectral domain instead of the temporal one. In these techniques the spectral response of the medium $H(\omega)=A(\omega)\exp[i\varphi(\omega)]$ is measured for each wavelength in a wide spectral range and the temporal impulse response can easily be generated by a simple inverse Fourier transform. While the amplitude $A(\omega)$ measurement is quite straightforward the phase $\varphi(\omega)$ measurement is more complicated, and in general requires interferometric measurements, which are relatively complicated and inherently noisy. To overcome this problem we implement, we believe for the first time, the Kramers-Kronig [KK] algorithm for diffusive medium. In this method, retrieving the phase from the amplitude spectral measurement is used to reconstruct the impulse response of a diffusive medium. In a recent work, we have demonstrated by experiment that the impulse response of a diffusive medium can be reconstructed with high accuracy by a modification of the KK method; we measure the sub-picosecond (200fsec temporal resolution) optical impulse response of a diffusive medium. Our results show that KK is a very powerful and affordable tool. Unlike the temporal techniques, where the intensity is measured, in the KK technique the complex light-field information is acquired, and therefore includes more information on the sample than the temporal techniques can give. This technique has important applications for medical and security-related imaging.