Chapter 20

Image Enhancement Under Gaussian Impulse Noise for Satellite and Medical Applications

Hazique Aetesam
Indian Institute of Technology, Patna, India

Suman Kumar Maji
Indian Institute of Technology, Patna, India

Jerome Boulanger
MRC Laboratory of Molecular Biology, Cambridge, UK

ABSTRACT

Remote sensing technologies such as hyperspectral imaging (HSI) and medical imaging techniques such as magnetic resonance imaging (MRI) form the pillars of human advancement. However, external factors like noise pose limitations on the accurate functioning of these imaging systems. Image enhancement techniques like denoising therefore form a crucial part in the proper functioning of these technologies. Noise in HSI and MRI are primarily a mixture of Gaussian and impulse noise. Image denoising techniques designed to handle mixed Gaussian-impulse (G-I) noise are thus an area of core research under the field of image restoration and enhancement. Therefore, this chapter discusses the mathematical preliminaries of G-I noise followed by an elaborate literature survey that covers the evolution of image denoising techniques for G-I noise from filtering-based to learning-based. An experimental analysis section is also provided that illustrates the performance of several denoising approaches under HSI and MRI, followed by a conclusion.

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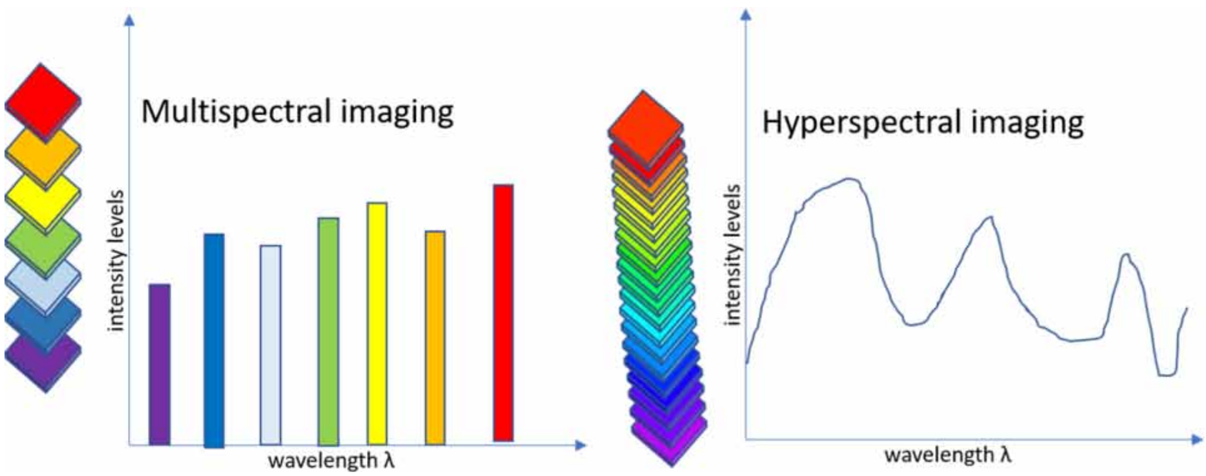
Figure 1. Difference between HSI and MSI



INTRODUCTION

Gaussian noise is the most common type of noise present in the image acquisitions systems. Since modelling Gaussian noise is simple and convenient, most of the optimization methods design the criterion function under this noise assumption. However, errors due to transmission errors, malfunctioning detector elements and faulty memory locations replace the underlying pixel intensity levels with random values. Since the intensity levels of these corrupted pixels are very different from the neighboring ones, they do not possess any information about the original pixel intensity or Gaussian corrupted pixels. Applying an algorithm designed for Gaussian noise to these kinds of images results in sub-optimal results. Since this is the result of impulse noise which heavily corrupt a limited number of pixels randomly, this random error cannot be properly modelled using Gaussian distribution. Since image denoising is a low-level computer vision task, its successful application helps in the accurate delivery of high-level vision-tasks like image classification, object detection, target tracking and semantic segmentation.

This chapter starts with the discussion on two different imaging domains corrupted by mixed Gaussian-impulse noise; namely hyperspectral imaging (HSI) and magnetic resonance imaging (MRI). Since Gaussian-impulse noise is the dominant character of noise in these imaging domains, image formation model under this noise assumption is imperative to appreciate the advantages obtained by applying denoising schemes specific to Gaussian-impulse noise. The next section talks about the image denoising schemes under four different solution strategies with emphasis on the types of Gaussian-impulse noise (i.e., fixed-valued or random-valued) and their limitations. In the last section, rigorous experimental evaluation on the two imaging domains; namely HSI and MRI are performed; followed by a conclusion.

Hyperspectral Imaging

Hyperspectral Imaging (HSI) is a notable development in the spectral imaging technology where images are captured using spectrometers over a wide range of electromagnetic spectrum; even beyond the visible parts. This helps in the visualization of those regions which are not captured using conventional RGB cameras. The typical range of EM spectrum used is $\mathbf{400}\boldsymbol{nm}$ to $\mathbf{2500}\boldsymbol{nm}$.