2D-3D CNN based architectures for spectral reconstruction from RGB images

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Abstract

Hyperspectral cameras are used to preserve fine spectral details of scenes that are not captured by traditional RGB cameras that comprehensively quantizes radiance in RGB images. Spectral details provide additional information that improves the performance of numerous image based analytic applications, but due to high hyperspectral hardware cost and associated physical constraints, hyperspectral images are not easily available for further processing. Motivated by the performance of deep learning for various computer vision applications, we propose a 2D convolution neural network and a 3D convolution neural network based approaches for hyperspectral image reconstruction from RGB images. A 2D-CNN model primarily focuses on extracting spectral data by considering only spatial correlation of the channels in the image, while in 3D-CNN model the inter-channel co-relation is also exploited to refine the extraction of spectral data. Our 3D-CNN based architecture achieves very good performance in terms of MRAE and RMSE. In contrast to 3D-CNN, our 2D-CNN based architecture also achieves comparable performance with very less computational complexity.

1. Introduction

Hyperspectral imaging is a technique which captures numerous bands of electromagnetic wavelengths ranging from infrared spectrum to ultraviolet spectrum. Every matter has different spectral characteristics, capturing the differences in these characteristics can be of critical importance in a wide variety of applications like medical imaging [12] [31][36], remote sensing [6][7][9][27][38] and forensics[19]. Hyperspectral images capture the details of the scene by sensing multiple narrow band intensities. The additional spectral information embedded in hyperspectral data has enabled the use of hyperspectral images for various applications in computer vision tasks i.e recognition [40][39][44], tracking [24][41], document analysis and pedestrian detection [19][23]. It has also been used in applications such as geosensing [32], food [45] and other image analysis. Though hyperspectral imaging is highly advantageous, the cameras are very costly to manufacture. This creates a bottleneck for low-cost consumer applications. Further hyperspectral imaging requires high spectral resolution, it also needs more exposure time to create a noiseless hyperspectral image[26].

The development of a simple, compact and cost-effective system is limited by conventional hyperspectral imaging systems. These hyperspectral systems usually depend on the use of an imaging spectrograph, a mechanical filter or a liquid crystal filter. A spectrometer-free imaging system is required to build an affordable and compact system for hyperspectral imaging to spread its utilization. To implement these types of systems, it would require an algorithm which can effectively regenerate complete spectral information from RGB image. Various methods have been explored for spectral reconstruction from RGB data [10][35][33][29].

1.1. Related Work

Hyperspectral images are used in remote sensing application for more than three decades [17]. NASA's AVIRIS[18] uses hyperspectral imaging systems which acquire images by using 'whisk broom' scanning method. In this method, set of mirrors and fiber optics are used to redirect the incoming light to a bank of spectrometers. Recent systems use the 'push broom' scanning strategy [20] in which, hyperspectral image is obtained in a line-by-line manner by using optical elements and light sensitive (i.e. CCD) sensors. Some applications such as medical imaging uses tuneable or interchangeable narrow band filters [28] [37] to collect spectral data. However, hyperspectral images with the spatial and temporal resolution with special-

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