

Preface

The vast majority of ground-based image capture (e.g. for general photography, surveillance and industrial machine vision) is currently performed using RGB filters on imaging sensors. This is particularly true for digital photography which, since its inception in the 1980s, has almost exclusively employed trichromatic cameras based on CMOS or CCD sensors using Bayer arrays, three-CCD cameras or a set of stacked photodiodes with a layer for each colour channel. Despite their differences, all of these sensor types involve capturing light at the wavelengths of the three additive primary colours (red, green and blue). These bands are used because they are a close approximation to the bands to which the human eye is sensitive. Therefore, they are well suited to capturing photos and videos for immediate human perception.

Nowadays, the image data is not only used for immediate human perception as originally intended, but also for a wide range of processing, contributing to camera utility, quality and performance. Over the past five years, many digital cameras have featured integrated circuits and firmware for sophisticated image processing (such as Canon's DIGIC and Nikon's Expeed chips). These chips initially performed functions such as automatic focus, exposure and white balance. More recently, such chips have performed a wider range of higher-level scene analysis features such as face detection, smile detection and object tracking. Such scene analysis features provide a high value to professional and consumer camera users and are typically significant selling points in particular models. Many industrial cameras now also include high-level scene analysis functions such as people counting for surveillance and object recognition for industrial machine vision.

In practise, every scene comprises a rich tapestry of light sources, material reflectance, lighting and other photometric effects due to object curvature and shadows. Despite being reasonably effective for scene analysis, trichromatic (i.e. RGB) technology does have limits in its scene analysis capabilities. For example, a camera with an RGB sensor cannot determine the constituent material of an object in the scene. Similarly, cameras with RGB sensors cannot, in general, deliver photometric invariants characteristic to a material and independent of the lighting condition, for robust tracking, identification and recognition tasks.

In this book, we explore the opportunities, application areas and challenges concerning the use of imaging spectroscopy as a means for scene understanding. This is important, since scene analysis in the scope of imaging spectroscopy involves the ability to robustly encode material properties, object composition and concentrations of primordial components. The combination of spatial and spectral information promises a vast number of application possibilities. For instance, spectroscopic scene analysis can enable advanced capabilities for surveillance by permitting objects to be tracked based on their composition. In computational photography, image colours may be enhanced taking into account each specific material type in the scene. For food security, health and precision agriculture the analysis of spectroscopic images can be the basis for the development of non-intrusive diagnostic, monitoring and surveying tools.

The ability to combine spatial and compositional information of the scene requires solving several difficult problems. With these problems solved, spectroscopic scene analysis offers the possibility of performing shape analysis from a single view for non-diffuse surfaces (Huynh and Robles-Kelly 2009), recovering photometric invariants and material-specific signatures (Fu and Robles-Kelly 2011a), recovering the illuminant power spectrum (Huynh and Robles-Kelly 2010a) and visualising digital media (Kim et al. 2010).

With the availability of imaging spectroscopy in ground-based cameras, it will no longer be necessary to limit the camera data captured to three RGB colour channels. Hyperspectral cameras offer an alternative number and range of bands that provide the best trade-off between functionality, performance and cost for a particular market segment or application need. Rather than having the same spectra captured as displayed, it will be practical to decouple them, capturing a rich spectral representation, performing processing on this representation and then rendering it in trichromatic form when needed.

The use of the information-rich representation of the scene that spectral imaging provides is, by itself, a new approach to scene analysis which makes use of the spectral signatures and their context so as to provide a better understanding of materials and objects throughout the image. The use of polarisation and reflection to recover object profiles akin to those in phase imaging can deliver novel methods capable of recovering an optimal representation of the scene which captures shape, material, object profiles and photometric parameters such as index of refraction.

Furthermore, the high dimensionality inherent in spectroscopy data implies that these algorithms may not be exclusive to imaging spectroscopy, but could also be applied to the processing of other high-dimensional data. Thus, these methods may be extendible to many other sensing technologies beyond just spectral imagery.

References

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