A SURVEY ON MULTISPECTRAL IMAGING: APPLICATIONS FOR MEDICAL DIAGNOSTICS

1Dr. Geeta R Bharamagoudar , 2, Malathi S , 3Dr.Shashikumar G. Totad
1,3Professor ,2Research scholar,
1,2,3Dept of. Information Science and Engineering, KLE Institute of Technology, VT University, Hubballi, Karnataka,
geetàtotad@yahoo.co.in1 Malati.sy@gmail.com2, sgtotad@bvb.edu3

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Abstract

Hyperspectral imaging plays a vital role in the medical field. Major success of a surgeon's work depends on his or her ability to identify problems of patients and cure them, particularly those that were not anticipated. Thus, this problem was solved by the invention of hyperspectral imaging modalities. Hyperspectral imaging techniques, along with associated algorithms and image processing methodologies have been developed by the military for detecting, classifying and identifying targets amid background clutter. Applying this technology to medicine will solve most of the problems associated with anatomy and identification of diseases.
1 INTRODUCTION

Human vision can be extended by hyperspectral imaging. Medical diagnostics is not limited by human eye or vision. There is a huge set of data and precious information which can be used by physicians or surgeons. These data can be retrieved from specific wavelength and analyzed and can be presented in the visual format. Hyperspectral Imaging (HSI) also called as imaging spectrometer, originated from remote sensing and has been used in medical diagnostics. The development and refinement of hyperspectral imaging technology has been driven by a myriad of defense and non-defense remote sensing applications over the past several decades. Fundamental to the concept is the ability to both spatially and spectrally resolve a heterogeneous surface topography for the purpose of detecting and classifying otherwise indiscernible features or targets, both natural and manmade, by exploiting known spectral reflectance characteristics. Classical hyperspectral imaging techniques combine a set of optical filters with a digital camera spanning the wavelength band of interest. Combining the images from the individual filters enables the identification of features that have strong spectral reflectance peaks in the individual spectral bands. Image processing algorithms that incorporate detailed classification procedures are used to extract and identify specific features or targets.

Hyperspectral imagers or imaging spectrometers extend the multispectral concept through the use of gratings or other spectral separation mechanisms to achieve a high degree of spectral resolution of the imaged surface. Spectral bandwidths for individual channels are typically on the order of 1-5 percent of the spectral range of the camera, and image data with a high degree of spectral resolution is typically referred to as a hypercube. Imaging spectrometers may have as few as 20 channels or as many as 300 channels, and may operate in the UV, visible, near-infrared, midrange infrared, or thermal infrared wavelength regimes, depending on the application. Detector requirements for specific wavelength bands generally preclude the development of a single instrument with the capability to span multiple wavelength regimes, and while some crossover is possible, the extent is usually limited.

DoD applications for multispectral and hyperspectral imagers generally involve the detection, classification, and identification of
low-contrast target in a high-noise or high-clutter background, and a substantial amount of research has been dedicated to developing robust image processing/analysis algorithms for this purpose. The Army, Navy, and Marine Corps, for example, have put extensive study into the development of multispectral technology and analysis methods for the purpose of detecting and positively identifying mine fields.

2 DISCUSSION

Extension of these technologies and analysis techniques to medical diagnostic applications has incredible potential in terms of extending the medical sensorium. This is of immediate importance in the realm of endoscopic procedures, where the usual information provided by touch and biopsy are quite limited. More broadly, the types of information which can be obtained with the hyperspectral imaging techniques described will enable us to clearly see many characteristics of various tissues and organs in health and disease which have not previously been able to be investigated so directly. A limited amount of work is starting to appear in the scientific literature. For example, the potential application of hyperspectral imaging as a diagnostic for certain ophthalmic conditions is currently being explored(1). Lewis, et al are using an imaging spectrometer covering the near-to-mid infrared wavelengths to image brain tissue sections in monkeys and silicone gel in human breast tissue(2,3) and the School of Pharmacy at the University of Kentucky is studying the use of near-infrared imaging in conjunction with surgical procedures(4). Going back to basics, we need to retrace some of the past medical data collection with this new sensory expander. Where the old anatomists carefully examined specimens and described them in detail, we need to describe and classify signatures for normal tissues and organs. Where the physiologists interrupted a given blood supply and watched what happened, we need to examine the different constituents that accumulate during ischemia. Where the pathologists made careful notes about the observed differences in diseased versus normal organs, we need to delineate and amplify specific differences in the images obtained for rapid and accurate identification of specific pathology. This kind
of systematic approach will lead to the creation of a spectral data bank which will allow us to assess the structural and especially functional pathologic status of any given organ or tissue examined.

The limitation of this technique is that it examines only areas of tissue near the surface. This is obviously less of a problem to the surgeon, who is directly observing most of the organs that he is interested in. Fortunately, however, organ surfaces are now more readily accessible via any of a number of minimally invasive and endoscopic techniques.

From the surgical perspective, one of the features of this technique that is most inviting is that it provides us with data in real time. This is a major difference from many of the advanced techniques such as MRI or PET scanning which is performed, processed and analyzed before therapy implemented. In other words, such technologies must be done preoperatively. In other words, such technologies are not interactive. The optimum surgical sensory extender must be applicable in the operating room and it must be interactive.

The advantage of real time imagery to the surgeon is overwhelming. Not only can one make or confirm a diagnosis, but one can evaluate surgical therapy in an ongoing fashion. Cardiac surgeons have come to appreciate this kind of input recently, as real time transesophageal echocardiography has revolutionized the repair of heart valves. The availability of such direct feedback in the operating room has allowed the perfection of valve repair techniques.

\section{CONCLUSION}

To develop this kind of real time data acquisition, analysis and presentation, we are making use of the expertise gained in multispectral and hyperspectral imagery by the military in extracting strategic targets from the background noise of the environment. We are deriving techniques, algorithms and spectral libraries to identify medical targets in the background noise of the tissues. Preliminary experiments are in progress and results will be presented.
References


