# Introduction to multispectral imaging essay

Design, Photography

Introduction to Multispectral imagingMultispectral imaging or MSI, is a technique that involves acquiring several optical images at only a few wavelengths. This technique was developed in the early 1990s to decode parts of the Dead Sea Scrolls, by Gregory Bearman – an engineer at NASA's Jet Propulsion Laboratory. This technique was based on an imaging technique that was already used by satellites (Engber D 2005) Multispectral image processing encompasses the disciplines of mathematics, computer sciences, electrical and mechanical engineering, physics, photogrammetry, and biological sciences. Multispectral Imaging compared with eyeThe advantage of Multispectral imaging is that digital cameras with filters can record fine distinctions that are invisible to the naked eye. Though our eyes can perceive many different wavelengths of light as color, this sense isn't very refined or complete with respect to all wavelength (Engber D 2005). This can be explained as below. It is a common fact that the visible light is made up of a mixture of wavelengths that our eyes interpret as color.

Although we can distinguish millions of different colors or color combinations, we cannot perceive the entire range of wavelengths i. e. the full spectra of light or information which is usually present in our visual environment. This is because our eyes separate visible light, no matter how spectrally complex, into only three color bins: red, green, and blue i.

e. RGB. In fact this is also true with conventional color films and color digital cameras (CRI instruments) This is demonstrated in the figure 1 below. It shows how sampling is done using RGB and spectral imaging methods: Fig -1 (CRI instruments)It is perfectly possible for lights with completely different spectral content to have precisely the same RGB coordinates. As an

example, when we see the white color as we know is not from a pure white source, it is in fact a mixture of all the three wavelengths red, green and blue. However, this is possible to see in case of Multispectral imaging.

(CRI instruments)“ This scenario is possible as Multispectral imaging provides images of a scene at multiple wavelengths and can generate precise optical spectra at every pixel. After this Image processing software can be used to extract the maximum information from the spectral image. Multispectral imaging in the visible and the near infrared wavelength range is routinely used in remote sensing ; the analysis of landscapes and structures from aircraft or satellites.” (CRI instruments)In addition, the various differences that can be seen in the spectra can also be used for the detection of different crops or mineral deposits.

Spectral imaging is infact used routinely in the field of industrial process control, fruit and vegetable sorting to detect otherwise invisible bruising, vascular integrity in transplanted organs etc. (CRI instruments)A further use of Multispectral imaging is also in the medical field. The process finds its applications in surgical pathology, multicolor fluorescence, immunohistochemistry, and in DNA expression arrays, among others (CRI instruments). Multispectral Imaging – Detailed DescriptionRadiation and the Energy SpectrumElectromagnetic radiation or merely any radiation is the waves of energy which travel through space. These can be of many types based on different intensities i. e. the number of waves received or emitted within a certain period, different wavelengths i. e.

the distance between their peaks as they travel. For any particular wavelength the energy is inversely proportional to length i. e. shorter wavelength has more energy (Easton Knox Christens-Barry 2003)The entire spectrum of radiation consists of long radio waves which are at one extreme end of the spectrum cto Gamma rays which have very small wavelength or the order of microns. Visible wavelength falls somewhere between the two extremes for a small interval of time. This is commonly known as white light. This is the only visible part of the spectrum because humans have evolved to recognize it that way via their eyes, through the process of Natural Selection. Isaac Newton demonstrated that white light is actually made up of different spectra; red, green and blue.

Thus, white light is often referred to as RGB light. At slightly longer wavelengths is infra-red light, invisible to humans but received by the skin, and recognized as heat by the body. At the shorter wavelength end of the visible spectrum are the Ultra violet (UV) lights, which have higher energy level. These lights are also received by the skin, and can damage it on over exposure. In fact this is the cause of sunburn on the skin. Hence it can be seen that different electromagnetic radiations interact with matter in different ways, depending upon its wavelength. It is quite possible that something which is invisible in RGB light will be visible, to a sensor sensitive enough like that in a camera, in Infra-red light (Easton Knox Christens-Barry 2003)The energy and wave spectrum is shown in the figure 2 below: Fig 2 (Easton Knox; Christens-Barry 2003)Multispectral imagingMultispectral imaging is a digital imaging technique.

It uses the property of radiations to enhance quality. The technique consists of taking multiple photographs of a particular area, at different wavelengths or spectral bands of light, resulting in a digital stack of images. For example, a common digital color camera usually takes three separate images for the red, green and blue components of light. After this various algorithms are used to enhance particular characteristics of the imaged area. Collecting several spectral bands generally provides more information than would be obtained from a single monochrome image.

This idea has been applied in the field of remote sensing for over two decades. LANDSAT Earth observation satellites are capable of acquiring 57 spectral bands spanning visible and non-visible wavelengths such as infra-red (Deep MSI Processing)The most basic multi-spectral imaging system usually consists of three parts – optical stage, an image capture camera, and a controller. The optical stage has a light source which is used for the purpose of illumination and optical means for producing images in a number of spectral bands. The image capture camera includes, simultaneously capturing the spectral images and generating electrical signals corresponding to the captured images. The controller controls the operation of the image capture camera and the light source and includes means for converting the electrical signals into a data form suitable for further processing. The image data produced also permits the use of human-expert review for confirmation (Raz R S 2002). This kind of imaging has also given rise to the development of spectrometers which study the chemical and physical characteristics of the materials by recoding spectral and spatial iamging of the substance together (Chieu D Tran 2001)Multispectral Imaging

in Forensic ScienceMultispectral imaging (MSI) involves recording multiple images of the same scene, each at a different wavelength. If each of the multispectral images of a particular scene is tacked, one on top of each other, an image cube is formed.

Fingerprint ImagingThis characteristic is used in forensics for both documentation and finger print taking. Finger print imaging was traditionally done using sensors. This technique was susceptible to many kinds of technical troubles which resulted in poor quality images. These troubles were due to the dry skin, wet skin; poor contact with the sensor, or poorly defined finger prints on the hands.

There was also trouble due to spoofing which occurred when people intentionally smeared their hands with silicone, latex or gelatin to avoid finger print detection. These measured the prints at very near surfaces, as given in figure 3 below. Fig -3 (Rowe n. d)Hence, the need was for a technique which would give better quality prints and have less chances of spoofing, and also will not be affected by the quality of skin or require to have precise form of contact.

In the customized multispectral imaging system for finger prints the optical geometry is such that the image can be taken for the skin subsurface also. Here, the stress is laid on the skin not the contact area between the skin and the sensor. It uses linear polarizers for this purpose which also avoids the critical angle phenomena.

The main difference is the use of multiple wavelengths for the imaging which creates multiple images for different depths and structures. The Multispectral imaging for use in finger print sensing is as given in figure 4 below: Fig -4 (Rowe n. d)The contrast of the image is low, but it can be present for a wide range of conditions. In addition the information received is very strong and is resistant to the composition too thus resulting in the spoof detectionThe images given below (figure 5, 6) show the differences in the images produced by conventional sensor and using the MSI technique. Fig 5 – Conventional Fig 6 – Using MSI Thus it is seen that the multispectral imaging of the finger provides a means to detect complementary biometric features of the finger. Hence, MSI provides the ability to increase the ease of collection and information content of finger images. Document ImagingThis technique, given above, can also be used for the forensic examination of documents with a few changes.

For document examination, MSI would be an extension of the infrared analysis commonly used when comparing inks. The narrow MSI bandwidth improves contrast and depth of focus over that obtained with normal photography and/or video camera imaging. The differences between two MSI images may also be computed. This often reveals detail not visible in the individual images. Spectral classification allows the grouping of pixels with similar spectral reflectance vectors and can distinguish between different inks, allowing for further comparative ink analysis in a non-destructive way.

The technique was used for the fist time to study the Dead Sea scrolls. NASA’s engineers modified the technique to suit the application, which is

since then being used for examining ancient parchment and rolls. A recent experiment was made to look into the study of Archimedes texts by the scientist. “ In this the multispectral images successfully separated the spectral signature of the Archimedes ink from the parchment underneath it, and that of the prayer book on top of it.

To bring out the Archimedes text even more, they then made the prayer book ink look like the parchment.” (Easton Knox Christens-Barry 2003)The figure 7 below shows the areas of text and diagrams that are extremely hard to discern, under RGB lightFig 7 (Easton Knox Christens-Barry 2003)However, experts still feel the need for more advanced techniques than the Multispectral imaging. This is because while the images produced are not blurry as in case of the RGB imaging they are still very difficult to read. In addition the scheme of imaging was also a problem and caused the final images to be out of line with each others, resulting in the indiscernible image.  ConclusionThe Multispectral imaging technique has solved a lot of problems for the forensic scientists. The images produced by this technique provide more information, and thus can be analyzed more thoroughly.

Thus the method is not perfect and still needs better algorithms for obtaining a near perfect image, the future of the technology has been firmly established in the forensic community. References CRI Instruments, “ Nuance Multispectral Imaging Systems…let you see more than meets the eye”, www. lot-oriel. com/site/site_down/nu_nuance_uken. pdf“ Deep MSI Processing”, http://www.

cs. kent. ac. uk/people/staff/pgk/DeepMultispectral. htmlChieu D Tran “ Development and Application of Multispectral Imaging Techniques: An Overview” Fresenius Journal of Analytical Chemistry Vol 369 2001 313-319.

Easton, R. L., Jr.; Knox, K.

T.; Christens-Barry, W. A, “ Multispectral imaging of the Archimedes palimpsest”, 15-17 October 2003, http://www. archimedespalimpsest. org/imaging_initialtrials1. html5. . Engber D, “ How to read a dirty papyrus: First Call NASA”, 18th April 2005, http://www. slate. com/id/2116902Raz R S, “ Multi-spectral imaging system and method for cytology”, 25th July 2002, http://www. freepatentsonline. com/20020097388. htmlRowe R K, “ Multispectral Fingerprint Image”, Lumdingum, n. d., https://www. egr. msu. edu/ece/Content_Management/read. php? filename= CSE-Rowe-Seminar. pdVo-Dinh Y, Stokes D L. Wabuyele M, Martin M E, Song J M, Jagannathan R, Michaud E, Lee R J, Pan X, “ A Hyperspectral Imaging System for In Vivo Optical Diagnostics”, Molecular Imaging II, September / October 2004, http://ieeexplore. ieee. org/iel5/51/29844/01360407. pdf? arnumber= 1360407Ware G A, “ Multispectral Imaging: A new view of Documents”, October 25-28 2006, Association of Forensic Document Examiners, www. afde. org/afdeprogram2006. pdf