3-D VOLUME RECONSTRUCTION FOR MEDICAL APPLICATON

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Abstract*:*

The early detection of malignant skin lesions is critical to preventing death. Conventional analysis of suspicious skin lesions involves visual examination by a trained expert aided with surface lighting and magnification to analyze the visible structure of a nevus. However, the deeper pigmentation structure is often overcome by the surface light reflection, and thus, important information regarding the depth extent of the malignancy is obscured. Deeper subsurface information, such as indications of increased blood flow (angiogenesis) are critical factors in early melanoma detection Even if cross-polarization is used, the majority of surface light is reflected back within the first few layers of skin, which limits the visualization of deeper structures. To overcome this limitation, a system based automatic skin disesase detection have been implemented to find out the skin disesase. Light diffuses through the skin tissue beneath the lesion through scattering and absorption events, forming a backscattered transilluminated image of light which scatters up from behind the lesion. If this technique is implemented the various kinds of skin diseases and effects can be identified.

Key Terms: transillumination, multispectral imaging, dermoscopy, volume reconstruction

1. Introduction:

In imaging science, image processing is any form of signal processing such as aphotograph or video frame; the output of image processing may be either an image or a set of characteristics or parametersrelated to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

Image processing usually refers to digital image processing, but optical and analog image processing also are possible. This article is about general techniques that apply to all of them.

The acquisition of images (producing the input image in the first place is referred to as imaging. An image defined in the “real world” is considered to be a function of two real variables, for example, a(x,y) with a as the amplitude (e.g. brightness) of the image at the real coordinate position (x,y).

In a sophisticated image processing system it should be possible to apply specific image processing operations to selected regions. Thus one part of an image (region) might be processed to suppress motion blur while another part might be processed to improve color rendition.

Modern digital technology has made it possible to manipulate multi-dimensional signals with systems that range from simple digital circuits to advanced parallel computers. The goal of this manipulation can be divided into three categories: * Image Processing image in -> image out * Image Analysis image in -> measurements out * Image Understanding image in -> high-level description out Image processing is referred to processing of a 2D picture by a computer. Basic definitions:

An image defined in the “real world” is considered to be a function of two real variables, for example, a(x,y) with a as the amplitude (e.g. brightness) of the image at the real coordinate position (x,y). An image may be considered to contain sub-images sometimes referred to as regions-of-interest, ROIs, or simply regions. This concept reflects the fact that images frequently contain collections of objects each of which can be the basis for a region. In a sophisticated image processing system it should be possible to apply specific image processing operations to selected regions. Thus one part of an image (region) might be processed to suppress motion blur while another part might be processed to improve color rendition. Sequence of image processing:

The most requirements for image processing of images is that the images be available in digitized form, that is, arrays of finite length binary words. For digitization, the given Image is sampled on a discrete grid and each sample or pixel is quantized using a finite number of bits. The digitized image is processed by a computer. To display a digital image, it is first converted into analog signal, which is scanned onto a display.

Closely related to image processing are computer graphics and computer vision. In computer graphics, images are manually made from physical models of objects, environments, and lighting, instead of being acquired (via imaging devices such as cameras) from natural scenes, as in most animated movies. Computer vision, on the other hand, is often considered high-level image processing out of which a machine/computer/software intends to decipher the physical contents of an image or a sequence of images (e.g., videos or 3D full-body magnetic resonance scans).

In modern sciences and technologies, images also gain much broader scopes due to the ever growing importance of scientific visualization (of often large-scale complex scientific/experimental data). Examples include microarray data in genetic research, or real-time multi-asset portfolio trading in finance.

Before going to processing an image, it is converted into a digital form. Digitization includes sampling of image and quantization of sampled values. After converting the image into bit information, processing is performed. This processing technique may be, Image enhancement, Image reconstruction, and Image compression

1.1 Image Enhancement

It refers to accentuation, or sharpening, of image features such as boundaries, or contrast to make a graphic display more useful for display & analysis. This process does not increase the inherent information content in data. It includes gray level & contrast manipulation, noise reduction, edge crispening and sharpening, filtering, interpolation and magnification, pseudo coloring, and so on

1.2 Image restoration

It is concerned with filtering the observed image to minimize the effect of degradations. Effectiveness of image restoration depends on the extent and accuracy of the knowledge of degradation process as well as on filter design. Image restoration differs from image enhancement in that the latter is concerned with more extraction or accentuation of image features.

1.3 Image compression:

It is concerned with minimizing the no of bits required to represent an image. Application of compression are in broadcast TV, remote sensing via satellite, military communication via aircraft, radar, teleconferencing, facsimile transmission, for educational & business documents , medical images that arise in computer tomography, magnetic resonance imaging and digital radiology, motion , pictures ,satellite images, weather maps, geological surveys and so on.

Text compression – CCITT GROUP3 & GROUP4

Still image compression – JPEG

Video image compression –MPEG

1.4 Transillumination

Transillumination is the technique of sample illumination by transmission of light through the sample. Transillumination is used in a variety of methods of imaging.

- Microscopy
- Medicine

1.4.1 Microscopy

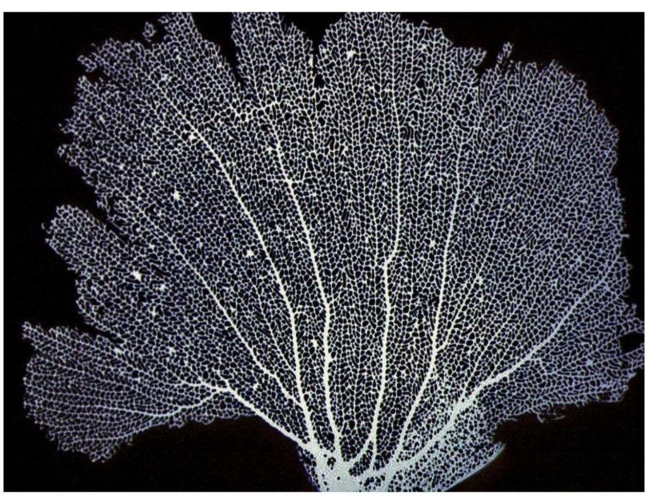
In microscopy transillumination refers to the illumination of a sample by transmitted light. In its most basic form it generates a bright field image,and is commonly used with transillumination techniques such as phase contrast and differential interference contrast microscopy.

1.4.2 Medicine

In medicine transillumination generally refers to the transmission of light through tissues of the body. A common example is the transmission of light through fingers, producing a red glow due to red blood cells absorbing other wavelengths of light. Organs analysed include the sinuses, the breasts and the testes.

It is widely used by pediatricians to shine light in bodies of infants and observe the amount of scattered light. Since their skeleton is not fully calcified, light can easily penetrate tissues. Common examples of diagnostic applications are Light penetrates to the inside of the skull of the infant. If there is an excess of cerebrospinal fluid (CSF), light is scattered to different parts of the skull, producing patterns characteristic to hydrocephalus. The device used in this operation is a Chun gun that uses a 150 watt projection bulb as a light source.Bright light penetrates the thin front chest wall and reflects off the back chest wall to indicate the degree of pneumothorax.

To treat it, a physician inserts a needle attached to a syringe into the area of collapse to remove the air between lungs and chest wall, causing the lung to reinflate.



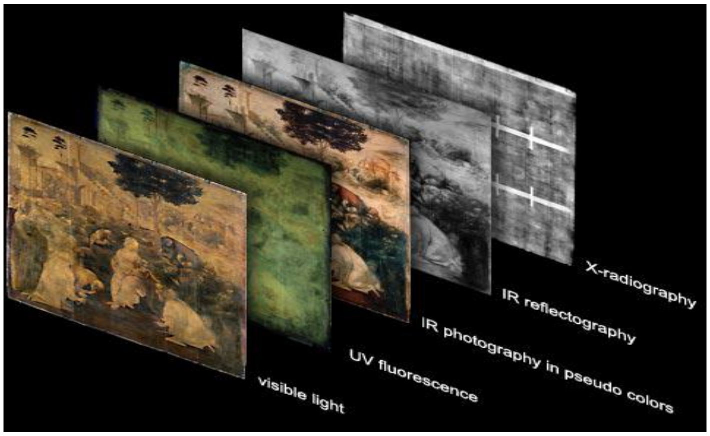
Gorgonacea shadow photo by transillumination

1.5 Multispectral Imaging

A multispectral image is one that captures image data at specific frequencies across the electromagnetic spectrum. The wavelengths may be separated by filters or by the use of instruments that are sensitive to particular wavelengths, including light from frequencies beyond the visible light range, such as infrared. Spectral imaging can allow extraction of additional information the human eye fails to capture with its receptors for red, green and blue. It was originally developed for space-based imaging. Multispectral images are the main type of images acquired by remote sensing (RS) radiometers.

Dividing the spectrum into many bands, multispectral is the opposite of panchromatic, which records only the total intensity of radiation falling on each pixel. Usually, satellites have three or more radiometers (Landsat has seven). Each one acquires one digital image (in remote sensing, called a 'scene') in a small band of visible spectra, ranging from 0.7 µm to 0.4 µm, called red-green-blue (RGB) region, and going to infrared wavelengths of 0.7 µm to 10 or more µm, classified as near infrared (NIR), middle infrared (MIR) and far infrared (FIR or thermal).

In the Landsat case, the seven scenes comprise a seven-band multispectral image. Spectral imaging with more numerous bands, finer spectral resolution or wider spectral coverage may be called hyperspectral



. An example of a **multispectral image**

This technology has also assisted in the interpretation of ancient papyri, such as those found at Herculaneum, by imaging the fragments in the infrared range (1000 nm). Often, the text on the documents appears to be as black ink on black paper to the naked eye. At 1000 nm, the difference in light reflectivity makes the text clearly readable. It has also been used to image the Archimedes palimpsest by imaging the parchment leaves in bandwidths from 365-870 nm, and then using advanced digital image processing techniques to reveal the under text of Archimedes work.

1.5.1 Spectral bands

The wavelengths are approximate; exact values depend on the particular satellite's instruments:

- Blue, 450-515..520 nm, is used for atmospheric and deep water imaging, and can reach within 150 feet (50 m) deep in clear water.
- Green, 515..520-590..600 nm, is used for imaging of vegetation and deep water structures, up to 90 feet (30 m) in clear water.
- Red, 600..630-680..690 nm, is used for imaging of man-made objects, in water up to 30 feet (9 m) deep, soil, and vegetation.
- Near infrared, 750-900 nm, is used primarily for imaging of vegetation.
- Mid-infrared, 1550-1750 nm, is used for imaging vegetation, soil moisture content, and some forest fires.
- Mid-infrared, 2080-2350 nm, is used for imaging soil, moisture, geological features, silicates, clays, and fires.
- Thermal infrared, 10400-12500 nm, uses emitted radiation instead of reflected, for imaging of geological structures, thermal differences in water currents, fires, and for night studies.
- Radar and related technologies are useful for mapping terrain and for detecting various objects.

1.5.2 Spectral band usage

Further information: False-color.For different purposes, different combinations of spectral bands can be used. They are usually represented with red, green, and blue channels. Mapping of bands to colors depends on the purpose of the image and the personal preferences of the analysts. Thermal infrared is often omitted from consideration due to poor spatial resolution, except for special purposes.True-color uses only red, green, and blue channels, mapped to their respective colors. As a plain color photograph, it is good for analyzing man-made objects, and is easy to understand for beginner analysts.

- Green-red-infrared, where the blue channel is replaced with near infrared, is used for vegetation, which is highly reflective in near IR; it then shows as blue. This combination is often used for detection of vegetation and camouflage.
- Blue-NIR-MIR, where the blue channel uses visible blue, green uses NIR (so vegetation stays green), and MIR is shown as red. Such images allow seeing the water depth, vegetation coverage, soil moisture content, and presence of fires, all in a single image.

Many other combinations are in use. NIR is often shown as red, making vegetation-covered areas appear red.

1.6 Tomography

Tomography refers to imaging by sections or sectioning, through the use of any kind of penetrating wave. A device used in tomography is called a tomograph, while the image produced is a tomogram. The tomography was invented by Sir Godfrey Hounsfield, the computed tomographic (CT) scanner, and thereby made an exceptional contribution to medicine. The method is used in radiology, archaeology, biology, geophysics, oceanography, materials science, astrophysics, quantum Information, and other sciences. In most cases it is based on the mathematical procedure called tomographic reconstruction.

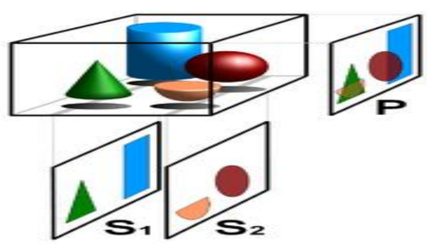


Fig no 2 Tomography

In conventional medical X-ray tomography, clinical staff makes a sectional image through a body by moving an X-ray source and the film in opposite directions during the exposure. Consequently, structures in the focal plane appear sharper, while structures in other planes appear blurred. By modifying the direction and extent of the movement, operators can select different focal planes which contain the structures of interest. Before the advent of more modern computer-assisted techniques, this technique, developed in the 1930s by the radiologist Alessandro Vallebona, proved useful in reducing the problem of superimposition of structures in projectional (shadow) radiographyMore modern variations of tomography involve gathering projection data from multiple directions and feeding the data into a tomographic reconstruction software algorithm processed by a computer. Different types of signal acquisition can be used in similar calculation algorithms in order to create a tomographic image. Tomograms are derived using several different physical phenomena listed in the following table.

Physical phenomenon	Type of tomogram
X-rays	CT
gamma rays	SPECT
radio-frequency waves	MRI

Some recent advances rely on using simultaneously integrated physical phenomena, e.g. X-rays for both CT and angiography, combined CT/MRI and combined CT/PET. The term volume imaging might subsume these technologies more accurately than the term tomography. However, in the majority of cases in clinical routine, staff request output from these procedures as 2-D slice images. As more and more clinical decisions come to depend on more advanced volume visualization techniques, the terms tomography/tomogram may go out of fashion. Many different reconstruction algorithms exist. Most algorithms fall into one of two categories: filtered back projection (FBP) and iterative reconstruction (IR). These procedures give inexact results: they represent a compromise between accuracy and computation time required. FBP demands fewer computational resources, while IR generally produces fewer artifacts (errors in the reconstruction) at a higher computing cost.

Although MRI and ultrasound make cross sectional images they don't acquire data from different directions. In MRI spatial information is obtained by using magnetic fields. In ultrasound, spatial information is obtained simply by focusing and aiming a pulsed ultrasound beam.

1.7 Dermoscopy

Dermatoscopy (also known as dermoscopy or epiluminescence microscopy) is the examination of skin lesions with a dermatoscope. This traditionally consists of a magnifier (typically x10), a non-polarised light source, a transparent plate and a liquid medium between the instrument and the skin, and allows inspection of skin lesions unobstructed by skin surface reflections. Modern dermatoscopes dispense with the use of liquid medium and instead use polarised light to cancel out skin surface reflections. When the images or video clips are digitally captured or processed, the instrument can be referred to as a "digital epiluminescence dermatoscope".

Genetic algorithm

In the computer science field of artificial intelligence, a genetic algorithm (GA) is a search heuristic that mimics the process of natural evolution. This heuristic is routinely used to generate useful solutions to optimization and search problems. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover.

In a genetic algorithm, a population of strings (called chromosomes or the genotype of the genome), which encode candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem, is evolved toward better solutions. Traditionally, solutions are represented in binary as strings of 0s and 1s, but other encodings are also possible. The evolution usually starts from a population of randomly generated individuals and happens in generations. In each generation, the fitness of every individual in the population is evaluated, multiple individuals are stochastically selected from the current population (based on their fitness), and modified (recombined and possibly randomly mutated) to form a new population. The new population is then used in the next iteration of the algorithm. Commonly, the algorithm terminates when either a maximum number of generations has been produced, or a satisfactory fitness level has been reached for the population. If the algorithm has terminated due to a maximum number of generations, a satisfactory solution may or may not have been reached.

A standard representation of the solution is as an array of bits. Arrays of other types and structures can be used in essentially the same way. The main property that makes these genetic representations convenient is that their parts are easily aligned due to their fixed size, which facilitates simple crossover operations. Variable length representations may also be used, but crossover implementation is more complex in this case. Tree-like representations are explored in genetic programming and graph-form representations are explored in evolutionary programming; a mix of both linear chromosomes and trees is explored in gene expression programming.

The fitness function is defined over the genetic representation and measures the quality of the represented solution. The fitness function is always problem dependent. For instance, in the knapsack problem one wants to maximize the total value of objects that can be put in a knapsack of some fixed capacity. A representation of a solution might be an array of bits, where each bit represents a different object, and the value of the bit (0 or 1) represents whether or not the object is in the knapsack. Not every such representation is valid, as the size of objects may exceed the capacity of the knapsack. The fitness of the solution is the sum of values of all objects in the knapsack if the representation is valid, or 0 otherwise. In some problems, it is hard or even impossible to define the fitness expression; in these cases, a simulation may be used to determine the fitness function value of a phenotype (e.g., computational fluid dynamics is used to determine the air resistance of a vehicle whose shape is encoded as the phenotype), or even interactive genetic algorithms are used.

Inverse Volume Construction algorithm

The initial volume of distribution is a pharmacological term used to quantify the distribution of a drug throughout the body relatively soon after oral or intravenous dosing of a drug and prior to the drug reaching a steady state equilibrium. Following distribution of the drug, measurement of blood levels indicates the apparent volume of distribution. Calculation of the initial volume of distribution is the same calculation as that for the apparent volume of distribution.

The detection of malignant skin lesions is critical to preventing death. Conventional analysis of suspicious skin lesions involves visual examination by a trained expert aided with surface lighting and magnification to analyze the visible structure of a nevus. However, the deeper pigmentation structure is often overcome by the surface light reflection, and thus, important information regarding the depth extent of the malignancy is obscured. Deeper subsurface information, such as indications of increased blood flow (angiogenesis) are critical factors in early melanoma detection. As a result, much effort is being put into the evaluation of novel noninvasive optical imaging techniques as a way to detect and analyze the morphological changes associated with tumorigenesis, thereby improving patient diagnosis accuracy with minimal need for invasive and time consuming biopsy procedures.

Two Layered Skin Model

It is well-known that a pigmented skin lesion consists of additional melanin compared to the background skin. Furthermore, a skin lesion may possess a distinct vascular pattern beneath the lesion. This network of blood vessels is more prevalent in malignant lesions than in benign lesions. With this in mind to assist in reconstruction, a two-layered skin lesion model is implemented.

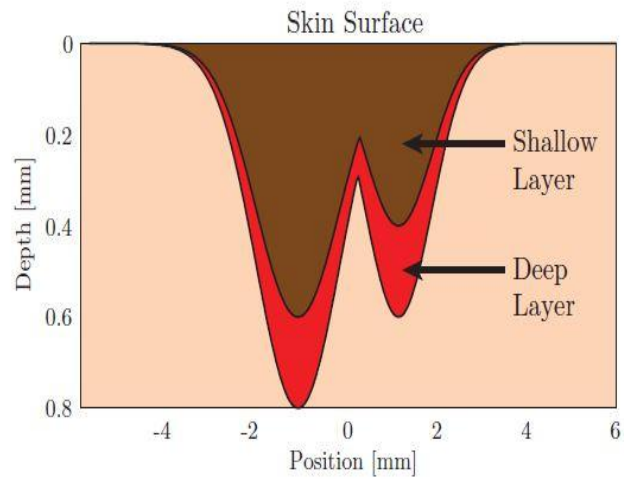
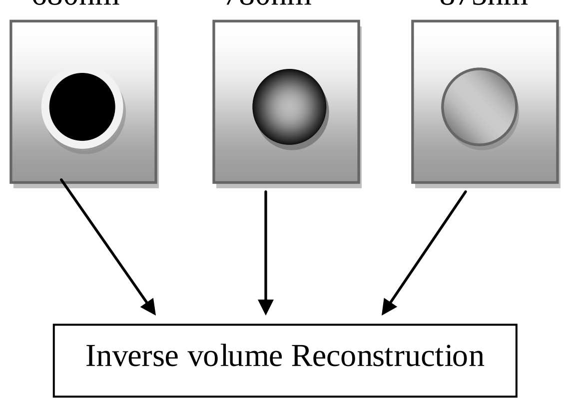
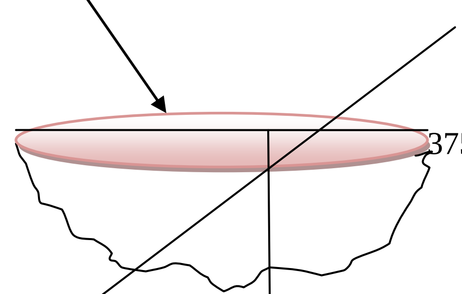


Figure No 3.2 Two-layered skin lesion model

The volume bounded by the skin surface and the shallow layer boundary consistsof some volume fraction of melanin CM, while the volume bounded by the shallow layer boundary and the deep layer boundary consists of some volume fraction of blood CB. Sucha simplified two-layered model has been used before in lesion reconstruction. The blood layer contains a mixture of Hband HbO2 depending on the oxygen saturation level, [SO2].





Inverse volume Reconstruction

Therefore the dose required to give a certain plasma concentration can be determined if the V_D for that drug is known. The V_D is not a real volume; it is more a reflection of how a drug will distribute throughout the body depending on several physicochemical properties, e.g. solubility, charge, size, etc. The V_D may also be used to determine how readily a drug will displace into the body tissue compartments relative to the blood:

CONCLUSION

The methods presented successfully demonstrate use of features derived from volumetric reconstruction and chromophore quantification for the analysis and classification of pre-malignant lesions using multispectral imaging in a clinical setting. While further validation will need to be performed over a larger set of images, these preliminary clinical results show a promising ability to differentiate classes of lesion severity based on multispectral trans-illumination Nevoscope imaging with the inverse volume reconstruction algorithm. This ability could lead to fast screening, tracking, and detection of early skin cancers such as melanoma.

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