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PSEUDOCOLOR PROCESSING FOR MEDICAL IMAGES-A SURVEY

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ABSTRACT

Medical imaging is the technique and process of creating visual representations of the interior of a body for clinical analysis and medical intervention, as well as visual representation of the function of some organs or tissues. Medical Images play a major role in analyzing the abnormal condition in human body. For better treatment and diagnosis we are able to produce different views of images from modern medical instruments. To save human lives processing of medical images using computers will help the medical experts to take right decision in right time. In this paper, a survey on pseudocolor processing for various formats of images based on storage in computers and the different types of medical imaging based on various medical applications are discussed. Medical imaging is the idea to improve the content of the images taken from different imaging tools like X-Rays, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET), Ultrasound, Single Photon Emission Computed Tomography (SPECT), etc. The various types of Medical images, their advantages and disadvantages along with the format of medical images, their characteristics and the comparison of CT, MRI & Ultra sound imaging are discussed briefly in this paper.

Keywords – Medical imaging , CT, DICOM, Image formats, Image types, Medical Imaging, MRI, PET, SPECT, Ultrasound, X-Ray.

1. Introduction

"1001 words is worth more than a picture", complex method or scheme can be conveyed easily with just a single image. Image processing has become unavoidable in computers now-a-days. When working with computers, whether we are in need or not, we are pooled with lots of images. An image when processed using computers is called a digital image. A digital image is an array, or a matrix, of square pixels (picture elements) represented using a set of bits (zeroes and ones). The set of bits is decided by a specific Digital Image Format [1]. There are two main categories of Digital Images - one is *Vector Images* and the other is *Raster Images*. The size of an image is determined directly from the width (number of columns) and the height (number of rows) of the image matrix I(r, c) [2]. Each value in the Image Matrix is called Pixel Value. An individual pixel depends on the type of image [2].

1.1. Digital image Processing

Digital image processing is the use of computer algorithms to perform image processing on digital images. As a subcategory or field of digital signal processing, digital image processing has many advantages over analog image processing. It allows a much wider range of algorithms to be applied to the input data and can avoid problems such as the build-up of noise and signal distortion during processing. Since images are defined over two dimensions (perhaps more) digital image processing may be modeled in the form of multidimensional systems.. Digital image processing, as a computer-based technology, carries out automatic processing, manipulation and interpretation of such visual information, and it plays an increasingly important role in many aspects of our daily life, as well as in a wide variety of disciplines and fields in science and technology, with applications such as television, photography, robotics, remote sensing, medical diagnosis and industrial inspection, Forensic Studies, Textiles, Material Science, Military, Film industry, Document processing, Printing Industry, Industrial Inspection, Satellite Imaging, Telecommunication, etc. The various techniques use in Image Processing are Image Representation, Image Preprocessing, Image Enhancement, Image Restoration, Image Analysis, Image Segmentation, Image Reconstruction and Image Data Compression. Among all the Image Processing Techniques, Compression is used for transferring data especially in DICOM images and Segmentation plays major role in most of the Medical Image Analysis.

1.2. Image Compression

Nowadays, large amount of data is stored, processed and transmitted digitally. image compression produces a very high quality output without any loss in content of the image. Image Compression reduces irrelevance and redundancy of the image data in order to be able to store or transmit data in an efficient form. Image compression is achieved when one or more of the following redundancies are reduced or eliminated.

1.2.1 Coding Redundancy: The uncompressed image usually is coded with each pixel by a fixed length. For example, an image with 256 gray scales is represented by an array of 8-bit integers. Using some variable length code schemes such as Huffman coding and arithmetic coding may produce compression.

1.2.2. Interpixel Redundancy: It is a redundancy corresponding to statistical dependencies among pixels, especially between neighboring pixels.

1.2.3. Psychovisual Redundancy: It is a redundancy corresponding to different sensitivities to all image signals by human eyes. Therefore, eliminating some less relative important information in our visual processing may be acceptable.

The effectiveness of the Image Compression Technique is based on the Compression Ratio with acceptable reduction in quality of the compressed images. Compression Ratio is defined as the ratio of number of bits before compression to the number of bits after compression. There are 2 major types of Compression – Lossy Compression and Lossless Compression

1.3. Image Segmentation

Segmentation of medical images is a major step in diagnosing diseases from various medical images. The techniques available for segmentation of medical images are precise to application and type of body part to be studied image segmentation is the process of partitioning a digital image into multiple segments. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image. Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic(s). When applied to a stack of images, typical in medical imaging, the resulting contours after image segmentation can be used to create 3D reconstructions with the help of interpolation algorithms like Marching cubes.

1.4. Image Types

Generally, images are classified into three types

1.4.1. Binary Image: simplest type of image and can take two values typically black and white or 0 and 1, is a data matrix of pixel values 0s and 1s.

1.4.2. Gray-Scale Image :a data matrix whose values represent shades of gray. The elements of a gray-scale image are of integer values [0 - 255] of class unit8 [3].

1.4.3. RGB Color Image: M × N × 3 array of color pixels, where each color pixel corresponds to the red, green, and blue components of an RGB image at a specific spatial location [3], where each color represents a pixel value ranges from 0 to 255.

1.5. Image File Formats

Without Image File Formats, Image Processing is incomplete. To select a file format for a particular application, the following details are to be known:

- Type of Image
- Storage Size
- Compatibility
- Application Domain

The most common image file formats used for cameras, printing, scanning, and internet are discussed below:

1.5.1. Bitmap: Bitmap (.bmp) file format was created by IBM and Microsoft in the year 1988 for the operating system Windows OS/2. BMPs are Raster Image files ranging from high quality large files to lesser quality small files based on the applications / devices.

Graphics Interchange Format: Graphics Interchange Format (.gif) was created by CompServe in the year 1987 for the replacement of black and white RLE (Run Length Encoding) format.

1.5.2. JPEG: JPEG (.jpg) is a popular format designed especially for the rate of Compression that can be adjusted to accommodate smaller file size, designed by Joint Photographic Experts Group in August 1990.

1.5.3. Portable Network Graphics: Portable Network Graphics (.png) was created specially to replace the GIF format. These files are smaller than GIF files. It was developed by the Portable

Network Graphics Development Group of the World Wide Web Consortium on 14th October 1996.

1.5.4. Scalable Vector Graphics: Scalable Vector Graphics (.svg) was created for open standard XML format for 2D graphics in the year 1999 by W3 Consortium.

1.5.6. Tagged Image File Format: Tagged Image File Format (.tiff) is created for the standard file format for image distribution in scanning, faxing, word processing, etc. This format is created by Aldus in the year 1985.

1.5.7. Photoshop Document: Photoshop Document (.psd) is raster image format designed by Adobe in the year 1990 to incorporate image layers, color information, masks, etc.

2. Pseudocoloring

Pseudocolor (false color) image processing consists of assigning colors to gray values based on a specified criterion. The term "Pseudocolor" emphasizes that the colors were assigned artificially opposing to the true (real) colors. The principal use of Pseudocolor is for human visualization and interpretation of gray scale details on an image or their sequence. Intensity slicing and color coding is one of the simplest kinds of pseudocolor image processing.

2.1. Intensity slicing

First we consider an image as a 3D function mapping spatial coordinates to intensities (that we can consider heights).Now consider placing planes at certain levels parallel to the coordinate plane. If a value is one side of such a plane it is rendered in one color, and a different color if on the other side.

In general intensity slicing can be summarized as:

Let [0, L-1] represent the grey scale. l0 represent black [f (x, y)= 0] and let lL- 1represent white [f (x, y)= L-1]Suppose P planes perpendicular to the intensity axis are defined at levels l1,l2, …, lp. Assuming that 0 < P < L-1then the P planes partition the grey scale into P +1intervals V1, V2,…,VP+1.

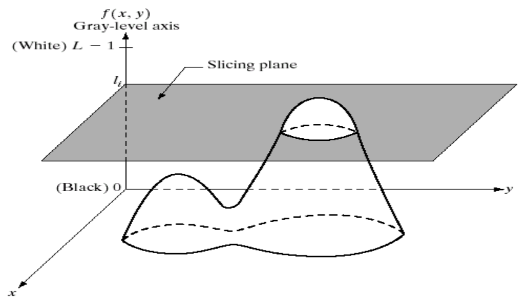

Figure.1 Intensity Slicing

Grey level color assignments can then be made according to the relation: where *ck* is the color associated with the *kth* intensity level *Vk* defined by the partitioning planes at $l = k - 1$and $l = k$

3. Medical Images

In modern medicine, medical imaging has undergone major advancements. Today, this ability to achieve information about the human body has many useful clinical applications. Over the years, different sorts of medical imaging have been developed, each with their own advantages and disadvantages. Due to the advancement of imaging techniques in medical field, so many diseases are identified in its earlier stages. Identifying and analyzing the abnormalities are done through various Image Processing Techniques. Varieties of specialized hardware devices, i.e., Scanners are widely used in capturing such images. In this paper, the different types of Medical imaging devices and Image formats obtained using such devices are discussed. Images of the human body used for Medical Diagnosis are called Medical Images. Medical Imaging is a technique used to process images of the human body for clinical purposes [1]. The methodology of producing a medical image by radiographic techniques is called Medical Imaging [2].

Other types of medical imaging are magnetic resonance imaging (MRI) and ultrasound imaging. Unlike conventional X-ray, CT and Molecular Imaging, MRI and ultrasound operate without ionizing radiation. MRI uses strong magnetic fields, which produce no known irreversible biological effects in humans.Diagnostic ultrasound systems use high-frequency sound waves to produce images of soft tissue and internal body organs.

3.1. Types of Medical Images

Common types of Imaging include the following:

3.1.1. Plain X-ray: X-rays are waves that have a relatively high frequency along the electromagnetic spectrum. They are absorbed or transmitted by different body tissues in varying amounts, producing different shades of black and white on an x-ray image. X-ray based methods of medical imaging include conventional X-ray, computed tomography (CT) and mammography. To enhance the X-ray image, contrast agents can be used for example for angiography examinations

Figure 2:X-ray

3.1.2. Computed tomography (CT)

Computed tomography (CT) is an imaging procedure that uses special x-ray equipment to create detailed pictures, or scans, of areas inside the body. It is also called computerized tomography and computerized axial tomography (CAT).

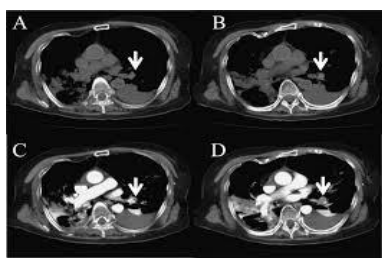

Figure 3: CT scan image

3.1.3. Nuclear medicine imaging

Molecular imaging is used in nuclear medicine and uses a variety of methods to visualize biological processes taking place in the cells of organisms. Small amounts of radioactive markers, called radiopharmaceuticals, are used for molecular imaging.

Ultrasound: Ultrasound waves have a frequency just beyond that of audible sound. Similar to sonar used by submarines, these waves are emitted and bounce back once they strike an object. As a clinical tool, ultrasound imaging (ultrasonography) can detect differences between solid and liquid material in the body.

Figure 4: ultrasound of a heart

3.1.4. Magnetic resonance imaging (MRI): Magnetic resonance imaging (MRI), unlike x-ray imaging, does not use radiation. Instead, MRI works based on magnetic waves and the spin of protons. Data is processed by a computer to form the images that clinicians use.

Figure 5: MRI of spine

4. Pseudocoloring for medical images

4.1. Producing pseudocolor images for diagnostic ultrasound imaging-William T Mayo

A method for displaying the values of two parameter at a plurality of points in an image. The intensity of each pixel in the display is modulated in accordance with the value of the first parameter at corresponding points in the image. The hue of each pixel is modulated to a first color whenever the value of the second parameter at the corresponding point in the image is greater than a reference value and to a second color whenever the value of the second parameter is less than the reference value. The saturation at each pixel is modulated as a function of the absolute value of the deviation of the second parameter from the reference value at the corresponding point in the image. In a preferred embodiment, the first parameter corresponds to the amplitude of echoes in a diagnostic ultrasound image and the second parameter corresponds to the instantaneous frequency deviation of the echoes.

4.2. Colorization of CT images to improve tissue contrast for tumor segmentation- Marisol Martinez-Escobar, jungle gfoo, eliotwiner.

Segmenting tumors from grayscale medical image data can be difficult due to the close intensity values between tumor and healthy tissue. In his paper a study that demonstrates how colorizing CT images prior to segmentation can be addressed. Colorizing the data a priori accentuates the tissue density differences between tumor and healthy tissue, thereby allowing for easier identification of the tumor tissue(s). This method allows pixels representing tumor and healthy tissues to be colorized distinctly in an accurate and efficient manner. The associated segmentation process is then tailored to utilize this color data. It is shown that colorization significantly decreases segmentation time and allows the method to be performed on commodity hardware. To show the effectiveness of the method, a basic segmentation method, thresholding, is implemented with and without colorization. To evaluate the method, False Positives (FP) and False Negatives (FN) were calculated from 10 datasets (476 slices) with tumors of varying size and tissue composition. The colorization method demonstrated statistically significant differences for lower FP in nine out of 10 cases and lower FN in five out of 10 datasets.

4.3. Pseudocolor Displays in B-Mode Imaging Applied to Echocardiography and Vascular Imaging: An Update-Keith Allen Comess, Kirk W. Beach, Tom Hatsukami

Cardiac and vascular ultrasound systems incorporating colorized gray-scale display options to supplement the staard B-mode gray-scale image have recently reappeared on the market from several manufacturers. As yet, the clinical benefit of this "new" technology is unknown, and recommendations and protocols for its best application are not available. In his paper he reviews the limitations of the gray-scale displays currently used, the rationale of the color-supplemented B-mode image, and some of the potential applications to cardiac and vascular ultrasound. This technique is useful and will probably achieve acceptance for some cardiac applications.

4.4. Pseudocolour Image Processing in Digital Mammography-M.Y. Sanavullah and R. Samson Ravindran

Mammography is not a simple radiological technique alone, which is used to image breast tissues as it was known for the past two decades till 1996. Mammography is the leading method for breast imaging today. Pseudo coloring is applied for the 2D images taken in two plain film (X-ray) mammography at an angle 450 / 900 between them and the details are collected in digital form in a computer for segmentation and reconstruction. In this diagnostic process, Pseudo coloring plays a vital role in the detection of presumptive breast cancer or occult carcinoma.

4.5. Enhancement of Angiogram Images Using Pseudo Color Processing-Mohammed A.U Khan, Raby Bahadur Khan, Asad Jamil

An angiogram is an X-ray image that uses fluoroscopy to take pictures of the blood flow within an artery. Due to the overlap of non-vascular structures, the small vessels with low contrast are hardly visible. Pseudo-color processing is an enhancement technique that accentuates certain features that are essential for a given application but hidden with low contrast otherwise. The author has applied pseudo color to an angiogram image on the basis of scale. Vessels are colored in such away that they are differentiated well. Further, the images have been enhanced by applying transparent colors to the images.

4.6. Frequency Domain Pseudo-color to Enhance Ultrasound Images- Jakia Afruz ,Va'Juanna Wilson,Dr. Scott E Umbaugh

In digital image processing, image enhancement is employed to give a better look to an image. Color is one of the best ways to visually enhance an image. Pseudo-color refers to coloring an image by mapping gray scale values to a three dimensional color space. In this paper the author used a pseudo-color technique in frequency domain to enhance ultrasound images. They used three different types of transforms to do this. These are the Fourier transform, Discrete Cosine transform and Walsh- Hadamard transform. After obtaining these pseudo-color images, they applied a high frequency emphasis filter or histogram stretch as a post process. In this paper they used a subjective study to compare images. First they compared pseudo-color images to their original monochrome images. Secondly, they compared all the three different types of transforms. Lastly, they compared the post processing techniques.

5. Conclusion

In this paper we survey and analyze different techniques in pseudocoloring for medical images to improve the visibility of the image. The techniques discussed above are useful to reveal an image's hidden texture. Thus extensive survey is done in this paper and medical images are pseudo colored which we can analyze the abnormal condition in human body, For better treatment and diagnosis we are able to produce different views of images from modern medical instruments.

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