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A SURVEY ON MEDICAL IMAGES

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Abstract:-

Medical Images play a major role in analyzing the abnormalities in human body. Modern medical instruments are able to produce different views of images which can be used for better diagnoses and accurate treatment. Processing of medical images using computers will help the medical experts to take right decision in right time to save human lives. In this paper, 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, image types, image formats, X-Ray, CT, MRI, Ultrasound, PET, SPECT, DICOM.

1. INTRODUCTION

"A Picture Worth Thousand Words", of course a complex scheme can be conveyed easily with just a single still image. Image processing has become inevitable in computers now-a-days. When working with computers, whether we need it 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

Image Processing is a technique to enhance raw images received from cameras/sensors placed on satellites, space probes and aircrafts or pictures taken in normal day-to-day life for various applications [4].

The term Digital Image Processing refers to processing of a two-dimensional picture by a digital computer [5].

Digital Image Processing concerns the transformation of an image to a digital format and its processing by a computer or by dedicated hardware [6] (both input and output are digital images).

Image Processing is used in various fields such as: Remote Sensing, Medical Imaging, Forensic Studies, Textiles, Material Science, Military, Film industry, Document processing, Printing Industry, Industrial Inspection, Satellite Imaging, Telecommunication, etc.

The various Image Processing Techniques [4] 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.

1.1.1 IMAGE COMPRESSION

Nowadays, large amount of data is stored, processed and transmitted digitally. Image Compression is used to represent the original image in low bit rate without losing the content to a certain extent. Image Compression [7] is to reduce 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) Coding Redundancy – when less than the optimal code words are used.

(2) Interpixel Redundancy – it is the relationship between the redundancies of the neighboring pixels. It is also called as spatial redundancy.

(3) Psychovisual Redundancy – data that is ignored by the Human Visual System

The effectiveness of the Image Compression Technique is assessed based on the Compression Ratio with acceptable reduction in quality of the compressed images. Compression Ratio [8] 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.

1.1.2 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 [6]. Image segmentation is generally used to discover objects and boundaries, i.e., lines, curves, etc.

1.2. IMAGE TYPES

Generally, images are classified into three types based on the intensity values and are shown in Fig.1.

- A Binary Image is a data matrix of pixel values 0s and 1s.
- A Gray-Scale Image is a data matrix whose values represent shades of gray. The elements of a gray-scale image are of integer values [0 - 255] of class uint8 [3].
- An RGB Color Image is an 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.

(a)Binary Image (b) Gray-Scale Image (c) Color Image

Figure. 1: Types of images

1.3 IMAGE FILE FORMATS

Without the awareness of 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:

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.

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.

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.

Scalable Vector Graphics:

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

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.

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. MEDICAL IMAGE

Medical Images play a major role in analyzing the abnormalities in human body. 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].

2.1. TELEMEDICINE

Telemedicine is a telecommunication technology which is integrated with the advancements in the field of Information Technology. This technology supports to transfer the imaging reports of patients across the telemedicine networks to provide consultation by specialists located globally.Most of the telemedical applications use any one of the following two available technologies [3].

1. The ‘Store and Forward’ technology transfers digital images from one location to another.
2. The two-way Interactive Television (IATV).

2.2. TYPES OF MEDICAL IMAGES

The process of capturing image (Imaging) depends on the doctors’ requirements. Hence, a variety of devices are used to capture images of the structures and activities inside human body. The following are the different types of medical images used for various purposes.

2.2.1 Tomography

Tomography is the method of imaging an organ in a single plane (slice). Various forms of Tomography are X-Rays, Computed Tomography (CT) or Computed Axial Tomography (CAT), OrthoPanTomography (OPT), Positron Emission Tomography used in conjunction with CT (PET-CT) and MRI (Magnetic Resonance Imaging) called PET-MRI.

X-Rays

It is the first method of imaging, in which Electromagnetic waves are used. The images produced by X-rays show the parts of the body in different shades of gray as in Fig.2. As the calcium in bone absorbs X-ray radiation easily, the x-rays are always preferred for imaging bones. Nowadays, X-rays are also used to diagnose Mammograms for identifying breast cancer [7].

Figure. 2: X-ray of Human Hands

Computed Tomography (CT)

CT is a type of imaging which uses special X-ray equipment to image cross-sectional pictures of human body as in Fig. 3. Doctors use CT scans to identify broken bones, Cancers, Blood clots, Signs of heart disease, Internal bleeding, etc. if any in a human body.

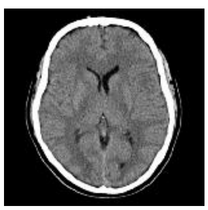

Figure. 3: CT Scan Slice of Human Brain

Positron Emission Tomography (PET)

PET is a nuclear imaging technique that provides physicians with information about how tissues and organs are functioning. PET is often used in combination with CT imaging. It uses a scanner and a small amount of radiopharmaceuticals which are injected into a patient's vein to assist in making detailed, computerized pictures of areas inside the body. Nuclear Medicine Imaging including Positron Emission Tomography involves injecting, inhaling or swallowing a radioactive 'tracer'. The Gamma-rays emitted by this material are used by the scanner to show images of bones and organs. PET is often used to evaluate Neurological diseases such as Alzheimer's and multiple sclerosis, cancer, effectiveness of treatments, Heart problems. Fig.4 shows the PET scan of a patient with Lung Cancer.

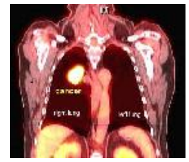

Figure. 4: PET scan of a patient with Lung Cancer

Positron Emission Tomography-Computed Tomography (PET-CT)

In PET-CT, physicians use a medical imaging technique that combines PET and CT. This allows images acquired from both devices to be taken sequentially and combined into a single superposed image. PET-CT serves as a prime tool in the delineation of tumour volumes, staging and the preparation of patient treatment plans as seen in Fig. 5. The combination has been shown to improve oncologic care by positively impacting active treatment decisions, recurrence monitoring and patient outcomes such as disease-free progression.

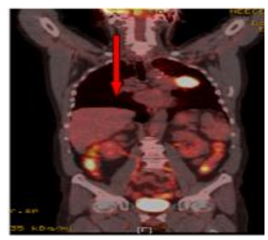

Figure. 5: PET-CT scan of a patient with left central lung cancer (arrow).

Single Photon Emission Computed Tomography (SPECT)

SPECT scan is a type of nuclear imaging test that shows the process flow of the blood to tissues and organs through arteries and veins in the brain as in Fig. 6. Tests have shown that it might be more sensitive to brain injury than either MRI or CT scanning because it can detect reduced blood flow to injured sites. A SPECT scan integrates two technologies to view the human body: Computed Tomography (CT) and a Radioactive Material (tracer). The tracer allows doctors to see how blood flows to tissues and organs. The type of tracer used depends on what the doctor wants to measure. For example, if the doctor is looking at a tumour, he or she might use radio-labeled glucose (FDG) and watch how it is metabolized by the tumour. The amount of radiation a body is exposed to is less than what we receive during a chest X-ray or CT scan. Women who are pregnant or nursing should not undergo a SPECT scan.

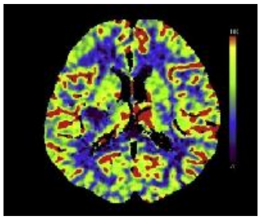

Figure. 6: SPECT scan of brain

2.2.2 Magnetic Resonance Imaging (MRI)

MRI scanners use a powerful magnetic field and radiofrequency pulses to generate detailed images of the body's internal structures as cross-sectional images or slices. It does not emit any ionizing radiation. MRI is used for identifying brain tumors and inflammation of the spine to slipped discs, assessing blood flow and functioning of the heart as in Fig. 7.

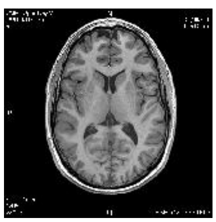

Figure. 7: MRI Brain Slice of Human Brain

2.2.3 Sonography (Ultrasound)

Sonography (Ultrasound Imaging) is a type of imaging that uses high-frequency sound waves to produce dynamic visual images of organs, tissues or blood flow inside the body. The sound waves are transmitted to the area to be examined and the returning echoes are captured. Fig. 8 shows the ultrasound image of 12 week fetus in mother's womb.

Figure. 8: Ultrasound Image of 12 week fetus

Echocardiography

Capturing the image of heart using Ultrasound signals is called Echocardiography seen in Fig. 9.

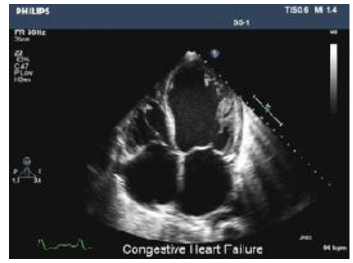

Figure. 9: Fetal – 4 Chamber Heart

2.2.4 Elastography

Elastography is a new emerging modality. It maps the elastic properties of soft tissues. This uses Ultrasound, MRI and Tactile Imaging and its image is shown in Fig. 10.

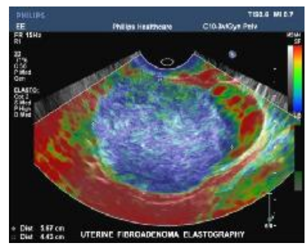

Figure. 10: Gynecological Elastography Image

2.2.5 Tactile Imaging

Tactile Imaging is a new modality that converts the sense of touch into a digital image. This type of imaging is used for imaging the prostate, breast and myofascial trigger points in muscle.

2.2.6 Photo-acoustic Imaging

Photo-acoustic Imaging given in Fig. 11 is a hybrid biomedical imaging modality based on the Photo-acoustic effect which is recently developed. It combines the advantages of optical absorption contrast with ultrasonic spatial resolution. Recent studies have shown that this imaging can be used in-vivo for tumor angiogenesis monitoring, blood oxygenation mapping, functional brain imaging, and skin melanoma detection, etc.

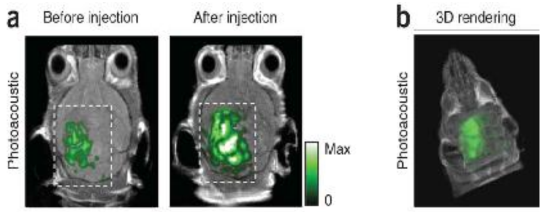

Figure. 11: Photo Acoustic Image

2.2.7 Thermography

This is the Digital Infrared Imaging technique basically used for breast imaging in which visible or near infrared light is scattered across areas where the density of tissues is high [8] seen in Fig. 12.

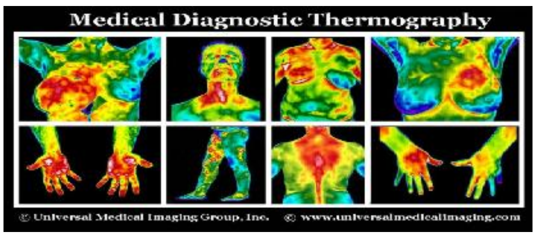

Figure. 12: Thermographic Images

2.2.8 Molecular Imaging

Molecular Imaging gives detailed information about the biological processes taking place in the body at cellular and molecular levels which will help in identifying the diseases in their earliest stages as in Fig. 13.

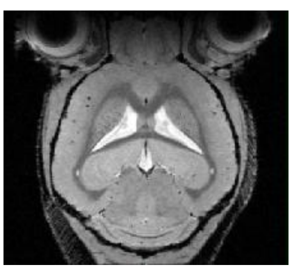

Figure. 13: Mouse brain

All the above mentioned images are finally stored in DICOM (.dcm) format.

2.3 DICOM IMAGE FORMAT

DICOM (Digital Imaging and Communication in Medicine) is a standard file format for storing and transmitting all medical images. The DICOM format comprises of some meta-information such as patient Details, disease details, device details, etc. and the actual image data (compressed using any of the existing lossless compression techniques). DICOM images can only be viewed using special types of software that are meant for DICOM images.

Data Format / Storage of DICOM:

A DICOM image is built with number of elements. Each element is data information, values and representations of the DICOM image, which are placed in the order of Tag, VR and Values.

- Tag

A Tag is a 2 four-digit numbers (gggg, hhhh), which are the representation of the group (gggg) and the values (hhhh) of the tag. The first four digits represents about what the data defines. The next four digits represents the actual element (eg.: name, address, etc.) of the image.

- VR

VR (Value Representation) represent the data type of the element, i.e., it shows what type of the value of the tag has been stored in the element.

Eg.: LT – Long Text, UI – Unique Identifier

- Value

Value is a part of the element indicates that DICOM is a binary protocol. The lengths of the elements are equal to one another and value is a single character, 2 byte value.

A value is shown and separated by SPACE when the value is a string and ZERO if it is a binary.

Object:

Object is a secondary stage of a captured image with thousands of elements. A DICOM image is complete when the elements are grouped in an object.

Data Model:

DICOM is a Static Data Model shown in Fig. 14. The Classes of this model are called SOP (Service Object Pair) Classes with IODs (Information Object Definition).

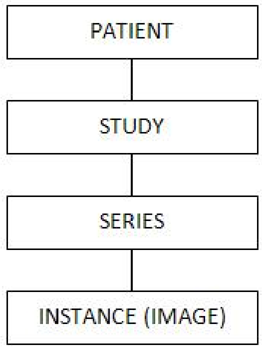

Figure. 14: DICOM Data Model

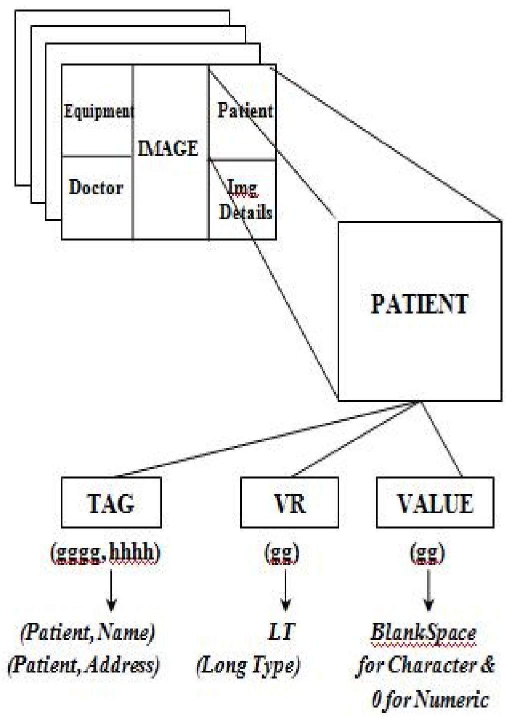

Figure. 15: DICOM Framework

2.4 COMPARISON OF CT, MRI & ULTRASOUND:

As an outcome of the oral discussion we had with the Radiologist [9], we came to know that the following are the limitations faced with the various images.

Computed Tomography:

CT devices use multiple X-Rays through which 3D images are obtained. In CT, contrast resolution is high when compared to Ultrasound. In a CT image, 400 cm (4 sides) axial view of the human body can be observed. The thickness of the slice varies from 1mm to 10mm in a step-by-step procedure till the problem is identified. Nowadays, a 0.63mm image slice can also be obtained from advanced CT Scanners for analyzing even a very small portion. It mainly focuses only on hard tissues of the body like Bones not on soft tissues.

Magnetic Resonance Imaging (MRI)

MRI produces 3D images of human body. MRI Scanners capture images based on the rearrangement of Hydrogen atoms in the body. In hard tissue areas like Bones, the rearrangement of hydrogen atoms is fast, whereas in fluid area (soft tissues) the rearrangement is slow. Due to the movement of the organs inside the body, blurred images are obtained, i.e., more artifacts are there in the output image.

Ultrasound

Ultrasound Imaging depends on the quantum of sound waves that are reflected from the body. Since sound travels in straight line, this imaging is dependent on the operator. It is used only for soft tissues, especially abdomen incase of pregnancy. When compared to CT and MRI, the spatial resolution in Ultrasound is high. The diagnosis can be done easily and accurately only for a small area of size 65 cm (varies from machine to machine).

CONCLUSION

Evolution of Medical Imaging has been critical to Medical Research. Without Medical Imaging, nothing would be known about the human body or issues surrounding it. In this paper, the various Medical Imaging technologies such as X-Ray, Computer Tomography and MRI scans, Medical Image formats especially about DICOM have been briefly discussed.

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