SURVEY ON MEDICAL IMAGE MODALITIES

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Abstract In various fields of medical investigations as well as clinical observations Imaging turn out to be a vital part. Medical Images take part a primary role in exploring deformity in the human body. The fast growth of medical science and the discovery of dissimilar medicines have gained mankind and the entire civilization. Moreover current science has been doing wonders in the surgical field. However, the apt and accurate diagnosis of diseases is the prime necessity ahead of the treatment. The more sophisticate the bio-instruments are, superior diagnosis will be feasible. The medical images plays a key part in clinical diagnosis along with the therapy of doctor besides training and investigations etc. Due to the expansion of imaging procedures in medical field, numerous of diseases are recognized in its prior stages. Classifying and evaluating the irregularities are made through a variety of Image Processing methods. Incessant augmentations in terms of techniques as well as applications is required in Medical image processing to recover quality of services in health concern industry.

The various types of Medical image processing methods, their benefits and drawbacks together with the format of medical images, their characteristics in addition to the assessment of CT, MRI & Ultra sound imaging are conferred in brief in this paper. Also numerous medical image processing techniques and its ability to control the hardware resources for refining quality of clinical observations in terms of rapidity, precision, modernization, and globalization are discussed. From the investigation of the literature it is implicit that the health concern field has got a lot of possibility for further investigations in the areas of diagnosing life threatening diseases, handling of remote health monitoring applications for real time operation to aware healthcare persons.

Keywords—Tomography, Telemedicine, diagnosis, Dicom format

1. INTRODUCTION

The rapid progress of medical science and the invention of various medicines have benefited mankind and the whole civilization. Modern science also has been doing wonders in the surgical field. But, the proper and correct diagnosis of diseases is the primary necessity before the treatment. The more sophisticate the bio-instruments are, better diagnosis will be possible. The medical images plays an important role in clinical diagnosis and therapy of doctor and teaching and researching etc. Medical imaging is often thought of as a way to represent anatomical structures of the body with the help of X-ray computed tomography and magnetic resonance imaging. But often it is more useful for physiologic function rather than anatomy. With the growth of computer and image technology[1] medical imaging has greatly influenced medical field. As the quality of medical imaging affects diagnosis the image processing [2] for medical has become a hotspot and the clinical applications wanting to store and retrieve images for future purpose needs some convenient process to store those images in details. This paper is a tutorial review of the medical image processing and repository techniques appeared in the literature. Medical imaging refers to the techniques and processes used to create images of the human body (or parts thereof) for various clinical purposes such as medical procedures and diagnosis or medical science including the study of normal anatomy and function. In the wider sense, it is a part of biological imaging and incorporates radiology, endoscope, thermograph, medical photography, and microscopy. Measurement and recording techniques[3] such as electroencephalography (EEG) and magneto encephalography (MEG) are not primarily designed to produce images but which produce data susceptible to be represented as maps, can be seen as forms of medical imaging. In the clinical context, medical imaging is generally equated to radiology or "clinical imaging". Research into the application and interpretation of medical images is usually the preserve of radiology and the medical sub-discipline relevant to medical.

The remaining paper is prearranged as follows: Section 2 presents related work on dissimilar image modalities in the medical field. Different medical image modalities are discussed and compared in section 3. Further DICOM format is also illustrated in this section only. Lastly, the given paper is concluded in section 4.

2. RELATED WORK

Medical imaging which has been expanded since 19th century onwards is well thought-out as a part of biological imaging. A concise review of medical imaging is in this way [4]: Roentgen in 1895 coincidentally discovered X-rays. Usually for the most part radiography has been prevalent as medical imaging method eternally. Radionuclide's were for therapy in addition to metabolic tracer studies as of 1896 before imaging. γ- ray imaging rectilinear scanner was invented consequently. Ultrasound happened to be broadly accessible in 1970's in medicine all through World War 2 Sonar Technology. Right through 20th century the mathematical rules in the wake of tomographic reconstruction have been inherent, moreover positron emission tomography (PET) as well as X-ray computed tomography (CT) were widened. In support of imaging Nuclear magnetic resonance has been utilized in magnetic resonance imaging (MRI). In

21st century X-rays, MRI, ultrasound kept dominating but more interesting techniques especially imaging is getting included with microscopic as well as macroscopic biological structures (thermal imaging, electrical impedance tomography, scanned probe techniques etc). In future the emphasis will be increased on obtaining functional and metabolic information along with structural (image) information. This can be done to some extent with radioactive tracers (e.g. PET) and magnetic resonance spectroscopy [5].

3. MEDICAL IMAGE MODALITIES

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 [6]. The methodology of producing a medical image by radiographic techniques is called Medical Imaging [7].

3.1. 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 [8].

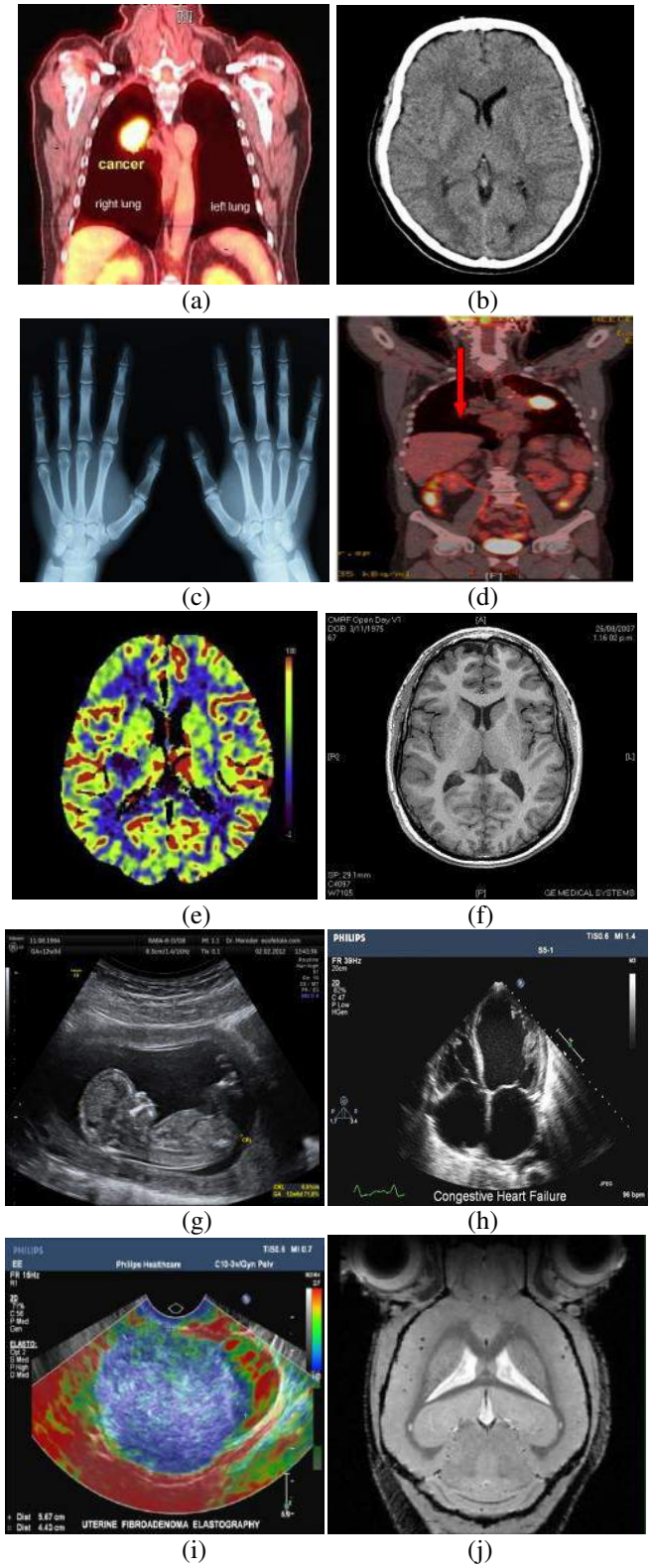
1. The "Store and Forward" technology transfers digital images from one location to another.
2. The two-way Interactive Television (IATV).

3.2. 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.

3.2.1 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.

3.2.1.1. 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.1 (a). 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 [9].



(a) (b) (c) (d) (e) (f) (g) (h) (i) (j)

Fig. 1. (a) X-ray of Human Hands, (b) CT Scan Slice of Human Brain, (c) PET scan of a patient with Lung Cancer, (d) PET-CT scan of a patient with left central lung cancer (arrow).

(e)SPECT scan of brain, (f) MRI Brain Slice of Human Brain, (g) Ultrasound Image of 12 week fetus, (h)Fetal – 4 Chamber Heart, (i) Gynecological Elastography Image, (j) Mouse brain

3.2.1.2.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.1 (b).. Doctors use CT scans to identify broken bones, Cancers, Blood clots, Signs of heart disease, Internal bleeding, etc. if any in a human body.

3.2.1.3.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.1 (c). shows the PET scan of a patient with Lung Cancer.

3.2.1.4.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.1 (d). 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.

3.2.1.5.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.1 (e). 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.

3.2.2. 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.1 (f)..

3.2.3. 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.1 (g). shows the ultrasound image of 12 week fetus in mother's womb.

3.2.4. Echocardiography: Capturing the image of heart using Ultrasound signals is called Echocardiography seen in Fig.1 (h).

3.2.5. 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.1 (i).

3.2.6. 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.

3.2.7. Photo-acoustic Imaging: Photo-acoustic Imaging 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.

3.2.8. 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 [10].

3.2.9 . 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.1 (j). All the above mentioned images are finally stored in DICOM (.dcm) format

3.3 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.

3.3.1 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.

3.3.2 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.

3.3.3 Data Model:

DICOM is a Static Data Model shown in Fig. 2. The Classes of this model are called SOP (Service Object Pair) Classes with IODs (Information Object Definition).

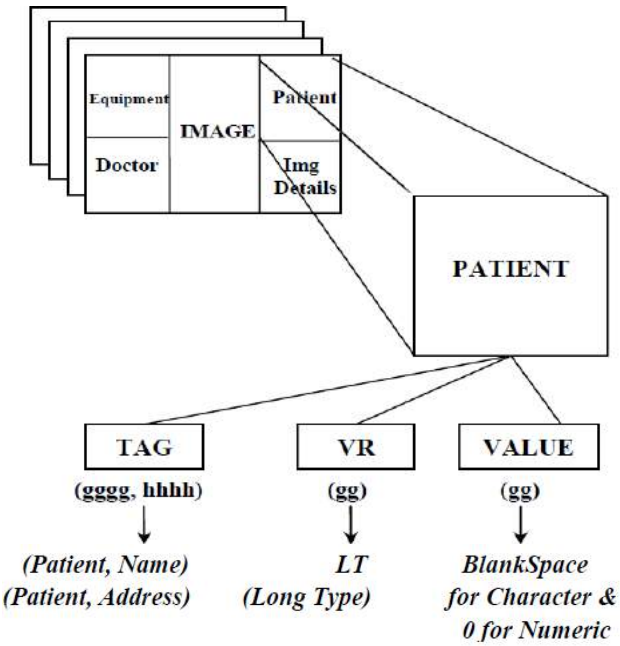


Fig. 2. DICOM Framework

3.4. COMPARISON OF CT, MRI & ULTRASOUND

As an outcome of the oral discussion we had with the Radiologist [11], 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).

Thus 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. Imaging can be very useful in helping to diagnose the cause of your symptoms, but is not always necessary. Be well informed about your imaging and ask your doctor any questions you may have. Medical imaging can be very useful to show what is happening inside the body and can help diagnose the cause of your symptoms. However, your doctor will only refer you for medical imaging if it is likely to help in the diagnosis or management of your condition or injury.

Advantages and Did advantages of different types of imaging

The Table.1. directs special types of imaging (X-ray, CT scans, nuclear medical imaging, MRI and ultrasound) and their usage, together with several benefits and drawbacks of all the methods.

Table.1.Comparison of different Image modalities

PLAIN X-RAY	
Purpose	Uses X-rays to show images of bones, some tumors and other dense matter
Advantages	Quick, non-invasive and painless. Can help diagnose various diseases and injuries, including broken bones, some cancers and infections.
Dis advantages	Very small increased risk of cancer in future from exposure to ionizing radiation (X-rays). Risk is greater for children.
COMPUTED TOMOGRAPHY (CT SCANS)	
Purpose	Uses multiple X-rays to produce cross-sectional layers that show detailed images inside the body, including bones, organs, tissues, and tumors
Advantages	Quick and painless. Can help diagnose and guide treatment for a wider range of conditions than plain X-ray. Can detect or exclude the presence of more serious problems. Can be used to check if a previously treated disease has recurred.
Dis advantages	Small increased risk of cancer in future from exposure to ionizing radiation (X-rays). Risk is greater for children. Uses higher doses of radiation than plain X-ray, so the risks (while still small) are generally greater than for other imaging types. Injection of a contrast medium (dye) can cause kidney problems or result in allergic or injection-site reactions in some people. Some procedures require anesthesia.
NUCLEAR MEDICINE IMAGING INCLUDING POSITRON-EMISSION TOMOGRAPHY (PET)	
Purpose	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.
Advantages	Usually painless. Can help diagnose, treat, or predict the outcome for a wide range of conditions. Unlike most other imaging types, can show how different parts of the body are working and can detect problems much earlier. Can check how far a cancer has spread and how well treatment is working.
Dis advantages	Involves exposure. to ionizing radiation (gamma-rays) Radioactive material may cause allergic or injection-site reactions in some people. PET scanners cause some people to feel claustrophobic, which may mean sedation is required.
MAGNETIC RESONANCE IMAGING (MRI)	
Purpose	Uses magnetic fields and radio waves to show detailed images of organs, soft tissues, bones, ligaments and cartilage.
Advantages	Usually non-invasive and painless. Uses no ionising radiation. Can help diagnose and guide treatment for a wide range of conditions. Can provide similar information to CT in some types of investigations.
Dis advantages	Can be a lengthy and noisy procedure. Slight movement can ruin the image, requiring retesting. Can make some people feel claustrophobic Sedation or anesthesia may be required for young children or others who can't remain still. Injection of a contrast medium (dye) if needed can cause kidney problems or result in allergic or injection-site reactions in some people Can't be undertaken in some situations (e.g. when a heart pacemaker is present).
ULTRASOUND	
Purpose	Uses high-frequency sound waves to produce moving images onto a screen of the inside of the body, including organs, soft tissues, bones, and an unborn baby.
Advantages	Usually non-invasive, safe and relatively painless. Uses no ionizing radiation. Does not usually require injection of a contrast medium (dye). Can help diagnose a range of conditions in different parts of the body, such as the abdomen, pelvis, blood vessels, breast, kidneys, muscles, bones and joints. Can be used to check on the health of a baby during pregnancy.
Dis advantages	Quality and interpretation of the image highly depends on the skill of the person doing the scan. Other factors can affect image quality, including the presence of air and calcified areas in the body (e.g. bones, plaques and hardened arteries), and a person's body size. Use of a special probe (e.g. for the esophagus, rectum or vagina) is required in some ultrasounds. Special preparations may be required before a procedure (e.g. fasting or a full bladder.

4 CONCLUSION & FUTURE SCOPE

Recent medical appliances are capable to build dissimilar outlook of images which can be utilized for improved diagnoses and precise treatment. Processing of medical images through computers will assist the medical specialist to acquire the exact judgment in right instant to save the lives of human. In this paper different medical image modalities are discussed and compared with their benefits and drawbacks. Further, DICOM which is a standard file format for storing and transmitting all medical images is also interpreted. The techniques used for processing (pre-processing, segmentation, detection analyzing and diagnosis) are to be enhanced with rising troubles in the industry and many technologies pertaining to mobile computing, cloud computing, etc which are emerging.

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