2. Medical Imaging

2.1 Medical Imaging

It is the process by which physicians evaluate an area of the subject's body that is not externally visible. Medical imaging may be clinically motivated, seeking to diagnose and examine disease in specific human patients. Alternatively, it may be used by researchers in order to understand processes in living organisms. Many of the techniques developed for medical imaging also have scientific and industrial applications.

Medical imaging refers to the application of imaging which is used as diagnostic procedure in this the human living object and the X-rays, Computer Tomography (CT), Magnetic Resonance Imaging (MRI) are used to diagnose and examine disease in specific human patients. Alternatively, it may be research - motivated; attempting to understand processes in humans and radiology is the branch which uses medical imaging. Radiology is a diagnostic specialization of medicine that employs X-rays and other modalities like CT, Ultrasound, MRI, etc. for diagnostic imaging. As Roentgen found first image in 1895 till today images are being developed from 2D to 3D images and now a days development is up to 6D. [1] The improvement is found in the quality of images like its sharpness, distortion, contrast, and noise. [2] The main aim of medical imaging is to diagnose the disease very accurately using different kinds of tests and by taking photographs of the disease and measuring various parameters and make a correct diagnosis.

Medical imaging often involves the solution of mathematical inverse problems. This means that cause (the properties of living tissue) is inferred from effect (the observed signal) [1]. For example in the case of ultrasonography the probe consists of ultrasonic pressure waves and echoes inside the tissue show the internal structure and in the case of radiography, X-ray radiation which is absorbed at different rates in different tissue types such as bone, muscle and fat.

Origins:

In its most primitive form, imaging can refer to the physician simply feeling an area of the body in order to visualize the condition of internal organs. This was used historically to diagnose aortic aneurysms; fractures enlarged internal organs, and many other conditions. It remains an important step today in making initial
assessments of potential problems, although additional steps are often used to confirm a diagnosis. The primary drawbacks of this approach are that the interpretation may be quite subjective and that recording the ‘image’ is very difficult.

### 2.2 Different Modalities of Bio-Medical Imaging

Modern imaging technology [1] includes various kinds of modalities to acquire an image and to make a correct diagnosis. These are as follows –

#### 1. Radiography

Radiographs are more commonly known as X-rays. In 1885, Rontgen first discovered X-rays. These X-rays could pass completely through solid materials such as paper, lead, cardboard and wood. However, the rays could be stopped by descent material i.e. Lead. Rontgen quickly discovered the potentiality of new radiation in Medicine (Ionizing Radiation). When he placed a hand in between the tube and the piece of a cardboard coated with barium platenocynide and he was excited to see the bones depicted on the cardboard coated with barium platenocynide called as fluoroscopic screen for the first time. The X-ray production is obtained when fast electron stream enters the tube target, the electron interacts with the target atoms by means of beams radiation and characteristic radiation. X-rays affect the photographic film, producing a latent image, which can be developed chemically can cause fluorescence of certain crystals making possible there use in fluoroscopy and in radiographic intensifying screens. X-rays can be visualized the bones by the virtue of edge detection. For example, X-rays to determine the type and extent of a fracture as well as for detecting pathological changes in the lungs. With the use of radio-opaque contrast media, such as Barium, they can also be used to visualize the structure of the stomach and intestines - this can help diagnose ulcers or certain types of colon cancer. The phenomenon of boundary detection in image processing can be done in X-ray imaging. For example, A well defined tumor mask. The X-ray will cast a shadow of 2D nature only but to see it 3D image we need stereo radiography.

#### 2. Xeroradiography

It is useful due to its unique property called as an edge effect. It means an accentuation of the border between images of different densities. It is useful to detect micro calcification in breast cancer means micro calcium deposits.
3. Tomography

It simplifies radiographic appearances by giving a sharp image of any selected plane within the patient; the images of planes above and below that selected are blurred. This is achieved by causing the images of unwanted planes to move across the film during exposure where as the image of the selected plane remains stationary on the film.

The disease at a particular depth level can be visualized with this method. For example, Radiography of the lungs.

Tomography is the method of showing a single plane, or slice, of an object. There are several forms of Tomography:

**Linear Tomography:**

This is the most basic form of Tomography. The X-ray tube moves from point "A" to point "B" above the patient, while the cassette holder (or "bucky") moves simultaneously under the patient from point "B" to point "A." The fulcrum, or pivot point, is set to the area of interest. In this manner, the points above and below the focal plane are blurred out.

**Poly Tomography:**

This is a complex form of Tomography. With this technique, a number of geometrical movements can be programmed, such as hypocycloidal, circular, and elliptical. The desired image will dictate the use. Philips Medical Systems produced one such device called the 'Polytome.'

**Computed Tomography (CAT or CT)**

A CT-scan, also known as a CAT scan (Computed Axial Tomography scan), is a Helical Tomography, which traditionally produces a 2D image of the structures in a thin section of the body. It uses X-ray, which is ionizing radiation. Although the actual dose is typically low, repeated scans should be limited.
4. Mammography

It is the soft tissue radiography. Two structures are found that are water density (muscle, glands, blood vessels) and fats.

5. Cine Radiography

In 1930, it was used for diagnostic and educational purposes. This was based on the principle of photographing the image produced on a fluorescent screen. This was used to detect tumors with various high and low brightness.

6. Fluoroscopy

Fluoroscopy produces real-time images of internal structures of the body in a similar fashion to Radiology but employs a constant input of X-rays. Contrast media such as barium, iodine and air are used to visualize internal organs as they work. Fluoroscopy is also used in image-guided procedures when constant feedback during a procedure is required. It is used in diagnostic radiography, makes possible the visualizations of organs in motion. It is also used for positioning of the patient for spot filming, instillation of opaque media in to hollow organs, insertion of catheters in to arteries.

7. Digital X-Ray Imaging

1) Subtraction Technique

It is conventional autobiography to enhance the images pacified arteries when they are concealed by superimposed bone. For Example, Carotid and vertebral arteries overlaying cervical vertebrae. Manual subtraction is done, after processing the arteriographic series by a delayed subtraction technique accordingly in 3 steps:

1. Copy the best early non-pacified radiograph on to a special, high contrast, single emulsion film by exposure to light by use of a modified – front cassette or subtraction printer. This copy film after processing serves as a mask; it is a positive, the original image negative. The tones and the mask are reserved from the original black to clear and clear to black.

2. Superimpose in this order in the printer: the mask (positive), the selected Arterio-gram (negative) and unexposed sheet of subtraction type film and close the printer.
3. Expose to a source of light such as fluorescent illuminator for an appropriate time interval and process the subtraction film.

4. This has good image quality; short-scale contrast is derived.

II) Digital Fluroscopy

When we use digital radiography with fluoroscope with image intensification. This is used in digital autobiography. Subtraction technique is used. This is automatically done during autobiography.

In this case the quality of image gets increased.

8. Ultrasonography

In this case, an image is obtained by transmitting through the body part longitudinal vibrations of frequency of 1 to 10 MHz. Here, cross section images of soft tissue are produced by a short duration of ultra sound wave in to the body and detect reflections at tissue boundaries piezoelectric effect concept is used. Ultrasound offers interactive visualization of the underlying anatomy and has the ability to image dynamic structures within the body For example, Tumor –abdomen (ovary study).

This image is taken on a printer also. This image is stored on floppy also. We can zoom at particular location in the image. Today it is the most useful equipment. Medical ultrasonography uses high frequency sound waves of between 2.0 to 10.0 megahertz that are reflected by tissue to varying degrees to produce a 2D image, traditionally on a TV monitor. This is often used to visualize the fetus in pregnant women. Other important uses include imaging the abdominal organs, heart, male genitalia and the veins of the leg. While it may provide less anatomical information than techniques such as CT or MRI, it has several advantages which make it ideal as a first line test in numerous situations, in particular that it studies the function of moving structures in real-time. It is also very safe to use, as the patient is not exposed to radiation and the ultrasound does not appear to cause any adverse effects, although information on this is not well documented. It is also relatively cheap and quick to perform. Ultrasound scanners can be taken to critically ill patients in intensive care units saving the danger of moving the patient to the radiology department. The real time moving image obtained can be used to guide drainage and biopsy procedures. Doppler capabilities on modern scanners allow the blood flow in arteries and veins to be assessed.
9. Color Doppler
   The Doppler Effect is used here. In this, the wavelength and frequency are being used. If one increases other will be decreased and vice versa. For example, flow of blood in an artery, Heart valve mobility.

10. MRI (Magnetic Resonance Imaging)
   It is based on nuclear magnetic resonance. MRI image is produced when RF pulse excites the hydro nuclei of the atoms of the body in static and changing magnetic fields. It has resolution around 1.0 mm. It has different techniques to improve the quality of an image like T1, T2, proton density contrast. These matrix obtained by computer processing is 2D.

   MR images are used in neuron imaging spine and brain. An MRI uses powerful magnets to excite hydrogen nuclei in water molecules in human tissue, producing a detectable signal. Like a CT scan, an MRI traditionally creates a 2D image of a thin "slice" of the body. The difference between a CT image and an MRI image is in the details. X-rays must be blocked by some form of dense tissue to create an image, therefore the image quality when looking at soft tissues will be poor. An MRI can ONLY "see" hydrogen based objects, so bone, which is calcium based, will be avoid in the image, and will not affect soft tissue views. This makes it excellent for peering into joints. As an MRI does not use ionizing radiation, it is the preferred imaging method for children and pregnant women.

   Medical Imaging MRI, or "NMR" as it was originally known, has only been in use since the 1980's. Effects from long term, or repeated exposure, to the intense magnetic field is not well documented.

11. MR Angiography
   It means a dye is injected and how is followed and detects how much heart vessels are blocked. Whole body imaging is also available.

12. PET SCAN
   It measures the metabolic activity of the human body cells. PET produces images of the body’s basic biochemistry or function. A PET scan is a very simple procedure. It involves small amount of radioactive material called as radioactive
tracer, which is attached with compounds like glucose and water, which are familiar to human body. For example, Glucose labeled with positron emitting. Fluorine is a PET radiotracer. A PET scanner generates images by sensing positrons emitted by the decaying radioactive atoms used as tracers.

**Electron Microscopy**

The electron microscope is a microscope that can magnify very small details with high resolving power due to the use of electrons as the source of illumination, magnifying at levels up to 2,000,000 times. Electron microscopy is employed in anatomic pathology to identify organelles within the cells. Its usefulness has been greatly reduced by immuno-histochemistry but it is still irreplaceable for the diagnosis of kidney disease, identification of immotile cilia syndrome and many other tasks.

All the above techniques are being developed for patient's convenience and easy diagnosis for a doctor. The development of image processing in bio-medical field began from 1895 till date, with different aspects and techniques. In the present study, hereby considering and applying various types of images and by applying different techniques on images like image enhancement, image segmentation and feature extraction and prove that image processing plays an important role in diagnostic medicine with low cost and less processing.

### 2.3 Creation of three-dimensional images

Recently, techniques have been developed to enable CT, MRI and Ultrasound scanning software to produce 3D images for the physician. Traditionally, CT and MRI scans produce 2D static output on film. To produce 3D images, many scans are made and then combined by computers to produce a 3D model, which can then be efficiently used by the physician. 3D ultrasounds are produced using a somewhat similar technique.

With the ability to visualize important structures in great detail, 3D visualization methods are a valuable resource for the diagnosis and surgical treatment. It was a key resource (and also the cause of failure) for the famous, but ultimately unsuccessful attempt by Singaporean surgeons to separate Iranian twins Ladan and Laleh Bijani in 2003. The 3D equipment was used previously for similar operations with great success. [3]
2.4 Introduction of Ultrasound

Nowadays, Ultrasound plays an important role in diagnostic imaging. The use of ultrasound is widely used all over the world and it grows from 2D to 6D. [1] It is particularly used in Obstetrics but it is also useful in abdomen as well as soft tissues. [2] As in ultrasound there is no radiation harm to patients due to radiation, it became more & more popular. Ultrasound is an acoustic energy with frequency above the audible range (e.g. 3.25 MHz). It will penetrate into the human body, for instance to a depth of 14 cm as in the image. The image is obtained by repeated transmissions of sound pulses from a probe. The sound is reflected from the structures in the body and then received by the probe. The signal is then processed and interpreted with respect to depth and direction, and displayed as an image on a screen. Ultrasound examinations are performed with the use of a probe (also called a transducer) that emits sound waves, listens to their reflection, and makes an image from that reflection. Piezoelectric effect concept is used. This procedure is non-invasive and painless. Diagnostic ultrasound is performed for a wide variety of indications, including obstetrical evaluation, identifying stones, gallstones, and evaluating aneurysms, fetus, tumor in abdomen, ovarian study, body's internal organs, including the heart, liver, gallbladder kidney. Much attention is now being focused on techniques to improve the quality and information content of ultrasonic images of the body. Many of these techniques employ digital pre-processing of coherent echo signals prior to image generation. Examples of these procedures include: resolution enhancement; contrast enhancement (using frequency-domain techniques) to suppress speckle; and imaging of spectral parameters (which sense the sizes and concentrations of sub-resolution tissue constituents). Combinations of spectral parameters and ancillary clinical data (e.g. PSA blood levels) are also being used with statistical classifiers (e.g. discriminate analysis neural network) to generate color-coded, images that indicate tissue type (e.g. cancer) or tissue regions responding to therapy. Sets of these images, obtained from serial-plane scans, promise to be particularly useful when presented in interactive three-dimensional (3-D) formats. [4]
2.5 Block diagram of ultrasound machine

The block diagram of ultrasound machine [5] is as follows:-

![Block Diagram of Ultrasound Machine](image)

**Figure 2.1: Block Diagram of Ultrasound Machine**

2.6 Advantages of ultrasound:-

The advantages of ultrasound machine are [3]:-

- A hard copy of image is taken or printed out on paper.
- On floppy image can be saved.
- In one floppy of 3 images are to be stored.
- No harm to patients with ultrasound waves
- As the machine is portable it can be handled everywhere for patient’s as well as doctor’s convenience
- It is less expensive and less complicated.
- An image is found in 3D, 4D, 6D

2.7 Common problems For A Radiologist with the Ultrasound Machine are:-

The problems faced with Ultrasound by a Radiologist are as follows [9]:-

- Small lesions are not clearly seen.
- Boundary of lesion is greatly obscured, making difficult to draw a boundary line.
- There is too much noise on ultrasound images.
- The contrast between a lesion and surrounding area is suboptimal, so it is difficult to diagnose a fibrosis.
- If the probe is not at proper position or water taken by the patient is insufficient then a poorly penetrated image is obtained.
- Movement artifacts make the picture unclear.
• If we want to see a particular part of a body in an image, it is very difficult to see.
• It can not image the lungs, fractures or most skeletal abnormalities.
• It is operator dependant because a training and experience is required while handling a machine, means cost effective.

2.8 Factors Affecting An Ultrasound Image Quality:-

There are main four factors which affect an image quality [7] in any medical ultrasound are:

1. **Contrast:** - Contrast means the difference. The image is formed by different points having different gray levels or light intensities. Thus the difference in optical density on an image represents a contrast. In ultrasound machine as the monitor is used for seeing the image so it depends upon a doctor to choose the better contrast for diagnosis. High contrast for wide range and low contrast result in enhanced contrast in ultrasound

2. **Blur or Lack of Sharpness:** - The boundaries of an organ or lesion may be very sharp but the image shows a lack of sharpness. Every image introduces a certain degree of blurring. In ultrasonographic image the blur is due to lack of sharpness due to motion of the patient or lack of receptor sharpness like monitor.

3. **Distortion and artifacts:** - Unequal magnification of various structures and the inability to give an accurate impression of the size, shape and relative positions in artifacts.

4. **Noise:** - Information that is not useful is called as noise. The speckles in an ultrasound image are a noise. Generally, an ultrasound image is a 3D real scene. Ultrasonic imaging has become an indispensable tool in many medical examinations. Direct diagnostic values of such a method rely upon a skilled and objective interpreter of the acquired images. Therefore, assistance of a computer-based processing algorithms may play an important role on the way to a successful recognition of crucial information contained in the ultrasound recordings. As the image is obtained by repeated transmissions of sound pulses from a probe. The sound is reflected from the structures in the body and then received by the probe. The signal is then processed and interpreted with respect to depth and direction, and displayed as an image on a screen. The image
represents a cut through the body. For this image capturing various probes and modes [8] are to be used. Probes are also called as transducers. These probes are of 3 types:

Table 2: Probes used in Ultrasound

<table>
<thead>
<tr>
<th>Name of the probe</th>
<th>Size</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear array</td>
<td>Rectangular</td>
<td>Scanning breast &amp; thyroid, obstetrics</td>
</tr>
<tr>
<td>Sector scanner</td>
<td>Fan shaped (triangular) for small space</td>
<td>Upper abdomen gynecological &amp; cardiological examinations</td>
</tr>
<tr>
<td>Convex transducer</td>
<td>Linear &amp; Sectorized</td>
<td>Echo cardiology</td>
</tr>
</tbody>
</table>

And the modes of operation [9] are of 4 types:

Table 3: Mode of Operation of Probes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Use &amp; its advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-mode</td>
<td>Echoes are peaks, used for measuring the distance between various structures in 2D images</td>
</tr>
<tr>
<td>B-mode</td>
<td>Tissue traversed by ultrasound scan for B-mode sections</td>
</tr>
<tr>
<td>Real-Time mode</td>
<td>Motion by showing the image of the part of the body under the transducer is being scanned, fetus or pulsating artery it can be held also for further study</td>
</tr>
<tr>
<td>M-mode</td>
<td>Displaying motion, result is wavy line for cardiac ultrasound</td>
</tr>
</tbody>
</table>

A quality image is produced considering the improvement of all above factors. For this purpose, various algorithms are still being developed for this purpose we can take different algorithms and different ultrasound images for study. With all the issues keeping in mind, a good quality image gets captured by the doctor. But it is not sufficient as said by the Doctor, by applying image enhancement and image analysis techniques, the diagnosis level gets increased.

Generally in ultrasound images, waves can pass through liquid but if water retention is low or if any gas material is there then it becomes very hard to capture
appropriate image for diagnosis. Here, in the present work different images are considered for the study with a view to improve the quality of image in less time and with cost factor under consideration.

Image improvement factors [10] includes resolution enhancement; contrast enhancement (using frequency-domain techniques) to suppress speckle; and imaging of spectral parameters (which sense the sizes and concentrations of sub-resolution tissue constituents). Combinations of spectral parameters and ancillary clinical data are also being used with statistical classifiers to generate color-coded, images that indicate tissue type (e.g. cancer) or tissue regions responding to therapy. Sets of these images, obtained from serial-plane scans, promise to be particularly useful when presented in interactive three-dimensional (3-D) formats. For diagnostic point of view we have to improve the image quality in terms of spatial resolution, noise suppression, accuracy of finding object, image rotation, etc.

In brief, in this work different algorithms are used to improve and obtain good quality images as required for the doctor’s requirement.
References

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7. D. Philips Medical Imaging Vol. 12 No.2, June 2004