Chapter-III

MEDICAL IMAGING
3.1 Introduction

Medical Signal processing is a paramount important research area because of its wide variety of images and problems encountered in medicine and biology. It ranges from the analysis of traditional physiological signals such as electrocardiogram (ECG), to the very recent imaging modalities like MRI, PET and CT scan. It is very much essential to acquire such signals and store for further analysis. Our research work is to propose a new approach for reconstruction of low resolution signals of medical images (MRI), by preserving its features with better reconstruction quality.

3.2 Medical Imaging Systems

During the last five to six decades there has been a huge increase in the use of electrical and electronics equipment in the medical field for clinical and research purpose. It provides automation in medical and also helpful to analysis disease at right time. Now a days computer plays an important role in every domain, there is more impact of computer based systems in medical field which enhance the accuracy and precise treatment to patient. The analysis is done by processing on different types of signals and getting results by transforming to it. Following are some signals related to medical field.

3.2.1 ECG Signals

Cardiovascular disease is the world’s leading fatal disease, about 30% of total global deaths every year. In past five decades, rates of coronary disease Organization (WHO) estimate that more than 60% of the world’s cardiac patients will be Indian by 2020. Dr. Timothy Gill, an Asia-Pacific estimated that South Asian have by far the worst problems when it comes to heart disease. ECG’s (Electrocardiograms) are used to diagnose heart disease along with some other
tests. The ECG information is to be extracted and analyzed before any useful and meaningful interpretations. Hence ECG signals processing has become an indispensable and effective tool for clinically significant information, for reducing the subjectivity of manual analysis and for developing advanced aid to the physician in making well founded decisions. [33, 34]

### 3.2.2 2-D Medical Signals

Medical imaging system detects different physical signals arising from a patient and produce images as well as videos. An imaging modality is an imaging system which uses a particular technique. The introduction of advanced imaging modalities has significantly improved diagnostic information available to physician. Some of these modalities used us ionizing radiation, radiation with sufficient energy to ionize atoms and molecules within the body, and others use non-ionizing radiation. Ionizing radiation in medical imaging comprises x-rays and gamma-rays while non-ionizing radiations, such as ultrasound and radio, frequency does not have potential to damage the body [33,34].

### 3.2.3 X-Ray

X-Rays of forms of ionizing radiation. Ionizing radiation means radiation with sufficient energy to ionize atoms & molecule within the body. X-rays imaging has been used in clinical diagnosis almost from the time of Roengton’s discovery of x ray. In projection or planer X ray radiography the image is a simple two dimensional projection of a three dimensional objects.

Images of the human body can be acquired or displayed in three main orientations the coronal plane divides the body in to front and back. Where the x rays entre from the patients back and are collected by a film placed at his front. The acquired image is a superposition of
many coronal images at different depths within the body. X-rays are used to distinguish subtle difference in tissue type and detect very small object while minimizing the absorbed close the breast. Since the breast are radio logically similar the dynamic range of mammograms is low. It also used to find some hair cracks to bones and abnormalities occurred in bones [33,34].

3.2.4 CT-Scan Image

X-rays and gamma rays produces planer image that are projection of three dimensional objects on to two dimensional planes. This results in considerable loss of information the super positing of overlaying organs complicates their identification.

But computer tomography (CT) is a technique that was developed for producing transverse image by scanning a slice of tissue from multiple directions using narrow fan shaped beam. The data from each direction comprise a one dimensional projection of the object, and transverse image can be retrospectively reconstructed from multiple projections. Computer tomography image is used for quantitative processing [33,34].

3.3 MR Images

Magnetic resonance Imaging (MRI) is non ionizing technique that uses radio frequency (200 MHZ to 2GHZ ) electromagnetic radiation and large magnetic field around 1 – 3 tesla. The large magnetic fields are produced by superconducting magnets in which current is passed through coils of superconducting wire whose electric resistance is virtually zero. MRI images provide anatomical & physiological detail. i.e. structure and function with full three dimensional capabilities excellent soft tissue visualization and high spatial resolution it is a topographic imaging modality. MRI scanners are several times as costly as a CT scanners because of the expensive superconducting magnet required.
All such Medical imaging techniques produce very large amounts of data, especially from CT, MRI, and PET modalities. As a result for storage, communication and proper diagnoses of electronic images required super resolution of images.

Magnetic resonance imaging, or MRI, is a way of obtaining very detailed images of organs and tissues throughout the body without the need for x-rays or "ionizing" radiation. Instead, MRI uses a powerful magnetic field, radio waves, rapidly changing magnetic fields, and a computer to create images that show whether or not there is an injury, disease process, or abnormal condition present. For this procedure, the patient is placed within the MR scanner typically a large, tunnel or doughnut-shaped device that is open at both ends. The powerful magnetic field aligns atomic particles called protons that are present in most of the body's tissues. The applied radio waves then cause these particles to produce signals that are picked up by a receiver within the MR scanner. The signals are specially characterized using the rapidly changing magnetic field, and, with the help of computer processing, very sharp images of tissues are created as "slices" that can be viewed in any orientation. An MRI exam causes no pain, and the magnetic fields produce no known tissue damage of any kind. The MR scanner may make loud tapping or knocking noises at times during the procedure using earplugs prevents problems that may occur with this noise [33, 34, 35].

### 3.3.1 History of the MRI

MRI is being most important system for correct diagnosis of disease. Now a days different configuration MRI machines are available in market. Though their cost is as much high but recently development and researches are going on to enhance the quality and reducing the MRI machine.

The time line history and development of MRI system is given in brie as below,
• **Felix Bloch and Edward Purcell (1946)** - came up with the idea to use magnets to take pictures of a living being.

• **Nuclear Magnetic Resonance (1950-1970)** – during this period first analyze molecules then taken images of inside a body and the first brain MRI images took 72 hours to develop.

• **Raymond Damadian (1971)** - proved that magnetic resonance could be used to help detect diseases by the different nuclear magnetic relaxation times between tissues and tumors.

• **The second MRI image was taken (1972).** It was two dimensional which showed the length and width.

• **Paul Lauterbur (1973)**- demonstrated magnetic resonance imaging on test tubes.

• **Dr. Raymond Damadian (1977)** - completed the first whole body MRI scanner which he called "Indomitable", and performed the first whole body scan using Indomitable. It lasted four hours and 45 minutes to complete.

• In 1986 the time to receive an image decreased to five seconds.

• In 1993 the functional MRI was developed. The images showed the different regions of the brain.

### 3.3.2 Need of MRI

Magnetic resonance imaging (MRI) is done for many reasons. It is used to find problems such as tumors, bleeding, injury, blood vessel diseases, or infection. MRI also may be done to provide more information about a problem seen on an X-ray, ultrasound scan, or CT scan. Contrast material may be used during MRI to show abnormal tissue more clearly.
An MRI scan can be done for the:-

- **Head**: MRI can look at the brain for tumors, an aneurysm, bleeding in the brain, nerve injury, and other problems, such as damage caused by a stroke. MRI can also find problems of the eyes and optic nerves, and the ears and auditory nerves.

- **Chest**: MRI of the chest can look at the heart, the valves, and coronary blood vessels. It can show if the heart or lungs are damaged. MRI of the chest may also be used to look for breast or lungs cancer.

- **Blood vessels**: Using MRI to look at blood vessels and the flow of blood through them is called magnetic resonance angiography (MRA). It can find problems of the arteries and veins, such as an aneurysm, a blocked blood vessel, or the torn lining of a blood vessel (dissection). Sometimes contrast material is used to see the blood vessels more clearly.

- **Abdomen and pelvis**: MRI can find problems in the organs and structures in the belly, such as the liver, gallbladder, pancreas, kidneys, and bladder. It is used to find tumors, bleeding, infection, and blockage. In women, it can look at the uterus and ovaries. In men, it looks at the prostate.

- **Bones and joints**: MRI can check for problems of the bones and joints, such as arthritis, problems with the temporomandibular joint, bone marrow problems, bone tumors, cartilage problems, torn ligaments or tendons, or infection. MRI may also be used to tell if a bone is broken when X-ray results are not clear. MRI is done more commonly than other tests to check for some bone and joint problems.
• **Spine**: MRI can check the discs and nerves of the spine for conditions such as spinal stenosis, disc bulges, and spinal tumors [33, 34, 35].

### 3.3.3 Advantages of MRI

1) MRI produces sectional images of equivalent resolution in any projection without moving the patient

2) MR image acquisition does not use ionizing radiation.

3) It requires little patient preparation and noninvasive, patient acceptability is high

4) MRI contrast agents are well tolerated and are much less likely than X-ray contrast agents to cause allergic reactions or alter kidney function

5) MRI provides information that differ from other imaging modalities. Its major technological advantage is that it can characterize and discriminate among tissues using physical and biochemical properties

### 3.4 Concluding Remarks

In this chapter, the different medical imaging techniques used for developing the medical images such as ECG, CT scan, PET, MRI etc. It also gives the brief review related to MR imaging with their timeline history. The exhaustive advantages of MR imaging are also explained above with its limitations.