CHAPTER 2
IMAGING TECHNIQUES, MAMMOGRAM AND COMPUTER AIDED DETECTION SYSTEM

2.1 INTRODUCTION

The major emphasis of this chapter is on the several imaging methods used in breast carcinoma finding and the reason choosing mammogram images for the study. Further, it focuses on the need for CAD algorithms for accurate detection of cancerous masses in mammogram images. This chapter also provides the underlying background information about the mammogram that will be useful for our study.

2.2 DIGITAL IMAGE PROCESSING

The term monochrome image or simply image refers to a two-dimensional light intensity function \( f(x,y) \), where \( x \) and \( y \) denotes spatial coordinates and the value of \( f \) at any point \( (x,y) \) is proportional to the brightness of the image at that point. Figure 2.1 illustrates the axis convention used for image representation. A digital image is an image \( f(x,y) \) that has been discretized both in spatial coordinates and brightness. A digital image can be considered a matrix whose row and column indices identify a point in the image and corresponding matrix element value identifies the gray level at that point. The elements such as a digital array are called image elements, picture elements, pixels or pels.
2.3 COMMON TACTIC IN IMAGE PROCESSING

Digital image processing encompasses a broad range of hardware, software and theoretical underpinnings. Digital image processing involves five major steps as depicted in Figure 2.2. These steps include

1. Image acquisition
2. Image preprocessing
3. Image segmentation
4. Image representation and description
5. Recognition and interpretation
Figure 2.2 Steps in Digital Image Processing

2.3.1 Image Acquisition

The first step in the process is image acquisition. This is to acquire a digital image. An image sensor and the component to digitize the signal produced by sensor is required. It is defined as the process of capturing real images in some media. Generally analog images are captured on photographic plates. The analog images are scanned and quantized to get digital images. Only digital images can be processed by a computer.

2.3.2 Image Preprocessing

Image preprocessing is the process of improving the quality of an image so that it becomes more suitable for some applications. Through this process appearance of the image can be improved for visual satisfaction by removing the noise and artifacts in the image. Preprocessing can be performed in spatial or frequency domain.
2.3.3 Image Segmentation

Image segmentation is the process of partitioning the image into a set of objects and background. Identifying a particular object within an image is an important task of some applications. Number of objects present in the image can also be identified using this technique.

2.3.4 Feature Extraction and Representation

The information extracted by the above methods is incomplete in consideration to a proper and application oriented abstract representation of an image. Extraction of features can be based on shape, size, orientation, texture or color of objects. These features are generally used, by representing them in a suitable form as pattern inputs for classification process. These information have to be represented in a standard compact form so that they become considerably more useful for higher level of computation.

2.3.5 Feature Selection

Feature selection is one of the major task in any automatic pattern recognition system. Since a pattern may contain many features, most of which are relatively unimportant, they may unduly complicate the classification and decision making processes. Hence, before applying classification techniques, patterns may need to be preprocessed for selection of significant features and elimination of the others. This preprocessing step is called as feature selection.
2.3.6 Classification

Artificial neural network are a kind of computation tools that helps us in recognizing patterns by classification. The recognition capability of human being is due to potential of nerve cells to store and propagate information. Keen observation over the biological neuro system enables us with the insight of the learning process. This knowledge has been applied in the design of Artificial Neural Network (ANN) that works in a manner similar to biological system.

2.4 IMAGING TECHNIQUES

New modalities and several imaging techniques have been developed for accurate prediction of breast cancer. It includes mammography such as full-field digital mammography, sonoelastography and CAD system which facilities lesion detection. MRI, Ultrasound and Nuclear medicine techniques were used to the specificity of breast carcinoma finding. No single imaging system is capable of characterizing and identifying all breast cancer abnormalities and a combined modality is considered necessary (Warner et al. 2000).

2.4.1 Mammography

One of the widely used imaging techniques for breast carcinoma screening is mammography. Mammography has effectively reduced breast cancer mortality rate (Alberto et al. 2016). The accomplishment of the screening program is subject to the detection of subtle and small lesion. Various
improvements had been made over the last decade in improving the quality of performance of the imaging system (National Cancer Institute, 2001).

Mammography is a specific type of breast screening technique in which low dose X-rays are used to detect cancer. Mammography technique is used for detection of breast carcinoma at a primary stage. The sensitivity of mammogram screening is between 75% and 80%, but in case of high risk women with dense breast is of 50%.

2.4.1.1 Limitations of Mammograms

Mammography screening detects abnormalities requires further evaluation which eventually turn out to be benign. Mammograms are not perfect which increases the survival risk in patients. It cannot prove that the abnormal area is cancer and hence biopsy has to be conducted in such cases. Mammogram screening is considered an effective test for finding breast cancer early. It is not 100% accurate in detecting cancerous masses. Mammogram for normal case has a minimum chance even if cancer is present. Even after screening mammogram since it showed an abnormality, further screening is recommended for some women (Robert et al. 2004). For most of these women, the mammogram is found to be normal and breast carcinoma is not found. It is impossible to tell exactly the nature of breast carcinoma which can become life threatening and which may not. Modern mammography machines use the smallest amount of radiation.
2.4.2 Ultrasound

Breast ultrasound makes use of sound waves for imaging. It is often used as follow-up test when an abnormal finding is seen on mammogram. This type of imaging is called as sonography. The main benefit of this technique is that there is no radiation exposure to patients. It is a non-invasive medical test. This method is used to estimate blood flow or lack of flow in breast mass. It mainly determines the nature of breast abnormality. This method is considered a supplement for breast cancer screening. Hence, ultrasound is recommended for high-risk breast cancer patients (Christopher et al. 2015).
2.4.2.1 Limitations of Ultrasound

At times, it may identify a normal area as malignant and recommend for biopsy. Many causes cannot be detected using ultrasound images. It requires skilled operator to detect malignant lump. It is used only when suspicious lesions are detected by mammography (Helmut and Madjar 2008)

2.4.3 Magnetic Resonance Imaging (MRI)

This technology produces cross sectional detailed view of the body using magnets and radio waves (Christopher et al. 2015). It does not use X-rays. No radiation exposure is involved. It is mainly used for the following:

1. Screening high risk women
2. Information of the suspicious lesion is collected
3. Monitor after treatment recurrence

![Figure 2.5 MRI](image)

2.4.3.1 Limitations of MRI

Precautions should be incorporated in MRI scanning because it makes use of strong magnet. The increased sensitivity may even cause normal area to
appear abnormal which results in increased false positive result. It is more expensive than mammography (Susan 2008).

2.4.4 Positron Emission Tomography (PET)

It detects suspicious lesion by obtaining images of the body cells. A lesser quantity of radioactive material and substance made of sugar is injected into the body. As the cancer cells absorb more radioactive sugar they tend to be more active compared to normal cells. Highlighted areas on computer screen are picked up using a special camera scans (Gheonea 2011).

Figure 2.6 PET Image

2.4.4.1 Limitations of PET

It is limited to low sensitivity in detecting small tumors and lobular carcinomas. This technique is costly. This tool is not suggested for routine diagnosis of primary cancer. Research article in cancer weekly digest specified the case of the nodular-sclerotic subtype, it results in comparatively low detection rate of bone metastases, and relatively high rate of false positive results (Lind et al. 2004).

2.5 COMPUTER AIDED DETECTION SYSTEM

The combination of Computer models with radiological imaging system increases the accuracy in image classification. Two types of models
happen to be in breast carcinoma analysis like Computer Aided Detection (CADe) (Gilbert et al. 2004) and Computer Aided Diagnosis (CADx). Location and identification of abnormalities in radiological images are done using CADe model. CADx is considered as the decision aid for characterizing the findings from radiologic images through CADe model.

### 2.6 NEW TECHNOLOGIES IN BREAST IMAGE SCANNING

The imaging technique tests usually by transmitting light into the breast. Finally, measures the intensity of the light that passes or returns over the tissue, is optical imaging. No radiation or breast compression is used. At present, this type of imaging is combined with other imaging techniques like 3D mammography or MRI in order to predict and diagnose breast cancer (Michel and Alvaro 2012).

A new type of nuclear medicine imaging technique used for breast cancer detection is molecular breast imaging. This type of imaging is mainly used to diagnose the continuation of breast cancer problems such as a tumor or an irregular mammogram. In addition to mammograms for women with dense breasts this type of imaging technique for diagnosis is recommended to determine the secondary’s (Berg 2016).

Another new technique used for breast cancer examination is Positron Emission Mammography (PEM). In this type sugar is attached to a radioactive particle in order to detect cancer cells. U.S. Food and Drug Administration (FDA) approve the PEM scanner. The working of the nuclear medical imaging is similar to a PET scan. A PEM scan detects small clusters of cancer cells better within the breast. Lumps are cancerous during breast cancer
diagnosis is now being studied in women with using this type of imaging technique (Shannon and Zeeshan 2013).

2.7 EXISTING BREAST CARCINOMAS COMPUTER AIDED DETECTION AND DIAGNOSIS SYSTEM

The national horizon scanning report for CAD system in mammography in 2004 clearly indicates the various systems used for mammogram screening and detection of cancerous masses and its accuracy as specified in table 2.1 below.

Table 2.1 Present CAD systems

<table>
<thead>
<tr>
<th>Type of CAD</th>
<th>Study</th>
<th>Overall Accuracy</th>
<th>Microcalcification (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image Checker V2.0</td>
<td>Vyborny et al. (2000)</td>
<td>84%</td>
<td>100</td>
</tr>
<tr>
<td>v. 1.2</td>
<td>Nakahara et al. (1998) Thurfjell et al. (1998)</td>
<td>73%-86%</td>
<td>100</td>
</tr>
<tr>
<td>v. 1.0</td>
<td>Brem and Schoonjans 2001</td>
<td></td>
<td>98%</td>
</tr>
<tr>
<td>MammoReader™</td>
<td>FDA PMA Data</td>
<td>83% - 89%</td>
<td>91%</td>
</tr>
<tr>
<td>Second Look™</td>
<td>FDA PMA ROSE-1D and Malich et al. (2001)</td>
<td>90%</td>
<td>89%-98%</td>
</tr>
<tr>
<td>R2 Image Checker CAD</td>
<td>Carl et al. (2005)</td>
<td>85.7%</td>
<td>-</td>
</tr>
<tr>
<td>Kodak's Mammography CAD System</td>
<td>-</td>
<td>95%</td>
<td>-</td>
</tr>
<tr>
<td>M-vision</td>
<td>Helvie et al. (2004)</td>
<td>91%</td>
<td>-</td>
</tr>
</tbody>
</table>