CHAPTER 1

INTRODUCTION

1.1. OVERVIEW OF CARCINOMA

The human body is made of trillions of living cells. A normal body cell grows, divides and expires in a methodical manner. During childhood stage, the cells divide at a faster rate allowing the person to grow. As an individual grows into an adult, cells divide at a faster rate to replace the worn-out or dying cells. The Deoxyribo Nucleic Acid (DNA) plays a vital role and directs all actions of a cell. In a normal cell, after the DNA is damaged, it is either repaired or the cell dies. The causes of DNA damage are evident, though no clear reason is found. Cells become cancerous, as a result of the damage and the DNA is not repaired, instead it is copied. Carcinoma is considered to be a result of malfunctioning of the DNA, due to the damage or inherited mutation.

Carcinoma cells invade or grow into the tissues of organs and form a tumor in most cases, retrieved from http://www.cancer.org, (2010). Some carcinomas like leukemia rarely form tumors. Certain carcinomas involve blood or blood-forming organs and circulate through tissues to other parts of the body to form new tumors and replace the normal tissue. This progression is known as metastasis. A cancer is named for the place it has originated. Mammary carcinoma spread to liver is called as mammary carcinoma; prostate cancer spread to the bone is called as metastatic prostate cancer. Different types of cancers behave differently. Lung cancer and mammary
carcinoma are two different diseases. They grow at different rates and respond to different treatments.

1.1.1. **Types of Mammary Carcinoma**

There are several kinds of mammary carcinoma. In certain cases, a mammary carcinoma is a combination or a mixture of invasive and in situ cancer, retrieved from http://www.breastcancer.org, (2009).

- **Ductal Carcinoma In Situ**

  Ductal Carcinoma In Situ (DCIS) or intra-ductal carcinoma is the most common type of non-invasive mammary and is curable. DCIS indicates the occurrence of cancer cells within the ducts and does not spread to the surrounding breast tissue, reported by Taslidere et al (2006). There is one occurrence of DCIS for every five new mammary carcinoma cases diagnosed. The pathologist examines the tissue sample for the presence of dead or dying cancer cells or an area, called necrosis. The occurrence of DCIS with necrosis indicates the aggressive nature of the tumor and is termed as comedocarcinoma.

- **Lobular Carcinoma In Situ**

  Lobular Carcinoma In Situ (LCIS) is the abnormal cell growth in the lobules; the milk-producing glands at the end of breast ducts. LCIS is an area of unusual cell growth and increases the risk of developing an invasive mammary carcinoma. A neoplasia is a collection of abnormal cells. The occurrence of LCIS with more than one lobule affected is termed as “lobular neoplasia” instead of “lobular carcinoma.” LCIS is usually diagnosed before menopause between the ages of 40 and 50 and is uncommon in men. LCIS is
rare condition and is unseen on a mammogram. It tends to be diagnosed as a result of a biopsy performed on the breast for other reasons.

- **Invasive Ductal Carcinoma**

  Invasive Ductal Carcinoma (IDC) is the most common type of mammary carcinoma, starting in the milk passage (duct), breaks through the wall of the duct and grows into the fatty tissue by spreading (metastasize) to other parts of the body through the lymphatic system and bloodstream stated by Tasildere et al (2006). Out of ten mammary carcinoma cases, eight are IDC.

- **Invasive Lobular Carcinoma**

  Invasive Lobular Carcinoma (ILC) starts in the milk-producing glands (lobules) and spreads (metastasize) to other parts of the body. For every ten mammary carcinoma cases, one is identified as an ILC. Invasive lobular carcinoma is hard to be detected by a mammogram.

1.1.2. **Statistics on Mammary Carcinoma**

Mammary Carcinoma is the second leading cause of death in women, preceded by lung cancer, retrieved from http://www.breastcancer.org, (2009). The chance of developing invasive mammary carcinoma in a woman’s life is one in eight (12%). The chance of death in women due to mammary carcinoma is 1 in 36, accounting to 3%. The American Cancer Society’s most recent estimates for mammary carcinoma in the United States for 2012, retrieved from http://www.cancer.org, (2010) are:

- 226,870 new cases of invasive mammary carcinoma diagnoses in women
- 63,300 new cases of Carcinoma In Situ (CIS) are to be diagnosed
- 39,510 women death cases due to mammary carcinoma.

In the last two decades, female mammary carcinoma incident rates decreased by 2% per year from 1999 to 2005 among women. The basis for the reduction is associated to a study published by Women’s Health Initiative in 2002 regarding the use of hormone therapy to an increased risk of mammary carcinoma and heart diseases. Other reasons include early detection through screening, increased awareness and improved medical treatments.

### 1.1.3. Risk Factors for Mammary Carcinoma

A woman with risk factors develops mammary carcinoma and it is difficult to know the level of contribution of the risk factor. Certain factors like age, race and gender are immutable, while others are linked to cancer-causing factors in the environment. DNA mutations related to mammary carcinoma occur in single breast cells during the life of a woman rather inherited. The acquired mutations of oncogenes and/or tumor suppressor genes are a result of factors like radiation or cancer causing chemicals. Mammary Carcinoma possesses several acquired gene mutations. Some factors for mammary carcinoma are related to personal behaviors: smoking, drinking and diet. Other factors influencing the risk and change over time are aging and lifestyle.

### 1.2. Imaging and Scanning Techniques

El-Shenawee et al (2011), reviews the current screening and imaging techniques such as mammography, ultrasound and MRI combined in
novel way provide 73% accuracy in detecting breast cancer. This motivates researchers to investigate new electromagnetic (EM) techniques to advance the screening techniques aiming for early detection of breast cancer. The most widely used imaging and scanning techniques for mammary carcinoma are:

- Mammogram
- Magnetic Resonance Imaging (MRI)
- Ultrasound Imaging

### 1.2.1. Mammogram

A mammogram is an X-Ray of the breast. A diagnostic mammogram is used to produce a black and white image of the breast tissue either on a large sheet of film or as a digital computer image; read, or interpreted by a radiologist. The goal of mammography is the early detection of breast cancer through detection of characteristic masses and/or microcalcifications. Digital mammography helps doctors to read accurately a mammography in a research by Nassif et al (2009). Mammograms show a breast lump before it is felt as a cluster of tiny specks of calcium. These specks are called micro-calcifications.

**Limitations of Mammograms**

A mammogram is not sufficient to prove the existence of cancer for the reasons:

- Diagnostic mammograms focus on specific area of the breast
- Women with breast implants need additional pictures
- Tumor is hidden in young women with dense breast
- Unsafe for pregnant women.
For these reasons, the American Cancer Society recommends either a biopsy or a MRI scan in addition to mammograms.

1.2.2. Magnetic Resonance Imaging

Magnetic Resonance Imaging (MRI) is a diagnostic procedure using a combination of a large magnet, radio-frequencies and a computer to produce detailed images of organs and structures within the body, retrieved from http://www.cancer.org, (2010). A breast MRI requires the use of a contrast dye, injected into a vein in the arm. The dye helps to create clear images outlining the abnormalities easily. MRI locates small breast lesions missed by mammography. MRI detects mammary carcinoma in women with breast implants and dense breast tissues. MRI is recommended for women with high risk for mammary carcinoma, usually due to a strong family history and/or a mutation in genes. Kalpathi et al (2004), suggested MRI evaluates the size, precise location of the lesions and possibility of occurrence of more than one area of the breast for changing the treatment options.

Limitations of MRI

The limitations of Breast MRI are:

- More false positive and false negative results; either missed or a benign lump is misdiagnosed as a cancer
- MRI is not suggested for patients with pacemakers, pregnant women and patients with epilepsy
- The use of contrast dye, risks for allergic reactions.
For these reasons, ultrasound is advised, to determine the lump, solid mass, calcification or a newly diagnosed cancer.

1.2.3. Ultrasound Imaging

Ultrasound imaging is a painless test using sound waves to create images of organs and structures inside human body, retrieved from http://www.cancer.org, (2010). An operator places the probe on the skin to be examined. Pulses of ultrasound are sent from the probe through the skin into the body. Ultrasound waves echoed from the structure is detected by the probe and displayed as a picture. The picture is constantly updated and the scan shows the movement and the structure. The operator moves the probe over the surface of the skin to get different views from different angles. Ultrasonic imaging uses frequencies of 2 Megahertz and higher; the shorter wavelength, the better resolution of small internal details in structures and tissues. The power density is less than 1 Watt per square centimeter. High and ultra-high ultrasound waves are used in acoustics, with frequencies up to 4 Gigahertz.

Specialized and emerging technologies include tissue characterization and image segmentation, microscanning and intravascular scanning, elasticity imaging, reflex transmission imaging, computed tomography, Doppler tomography, photoacoustics and thermoacoustics. The underpinning technologies include transducers, beam forming, pulse compression, tissue harmonic imaging, contrast agents, techniques for measuring blood flow and tissue motion and three-dimensional imaging.

A breast ultrasound is an imaging technique that sends high-frequency sound waves through breast tissues and converts them into images on a viewing screen, retrieved from http://www.breastcancer.org, (2009). Ultrasound is corrupt with high level speckle noise and appears as a jumble of
randomly placed bright and dark spots. This noise makes it difficult to accurately identify edges. In some regions the noise produces artificial edges, in other regions there are no echoes present and the edges are ambiguous. In low-quality images, generic algorithms do not identify the border accurately.

In the last two decades, breast ultrasound images are an adjunct to mammography to differentiate benign from malignant lesions, detailed in Nassif et al, (2009). They differentiate solid and cystic breast masses. They define the nature and extent of a mass and show all areas of the breast, including the area closest to the chest wall; difficult to study with a mammogram. The ultrasound has some limitations - low resolution, low contrast, speckle noise, blurry edges and diagnosis is dependent on a doctor's experience. Using digital image processing and pattern recognition techniques to deal and apply to clinical breast cancer detection is of critical importance.

**Importance of Ultrasound Imaging**

Ultrasound imaging applications in medicine and various fields is enormous. It has several advantages over other medical imaging modalities. The use of ultrasound in diagnosis is well established for the following reasons:

- Noninvasive nature
- Low cost
- Real time imaging
- Improved image quality.

It is estimated in Yujun Guo et al (2005), one out of every four medical diagnostic image studies in the world use ultrasonic techniques.
1.3. PROBLEM SPECIFICATION

The focus of the thesis is on Mammary Carcinoma. A diagnostic tool capable of removing noise, increasing the perceptual quality and accurately identifying the segmented lesion is required to aid the early detection and supervision of Mammary Carcinoma.

1.4. OBJECTIVE OF THE RESEARCH

The main objective of the research is to develop an efficient speckle noise removal and image enhancement technique to effectively segment and classify the cancerous region by detecting the boundary with the help of soft computing techniques.

1.5. METHODOLOGY

The proposed methodology uses proficient techniques for developing an effective diagnostic mammary carcinoma segmentation system. This system involves four phases: preprocessing, contrast enhancement, segmentation and boundary detection, Figure 1.1:


iii. Segmentation of Breast Cancer using Modified Fuzzy Possibilistic C-Means algorithm (MFPCM) with Repulsions.
iv. Boundary Detection of the segmented lesion using the Snake Generalized Gradient Vector Flow (GGVF) Algorithm.

![Methodology of the system](image)

Figure 1.1 Methodology of the system

1.6. ORGANISATION OF THE THESIS

The work focused on the use of soft computing techniques to perform segmentation on ultrasound images for detecting mammary carcinoma. The thesis consists of eight chapters including the introductory chapter. The early chapters provide background information about the theory and fundamentals of neuro fuzzy filter, fuzzy Hough transformation and fuzzy clustering techniques with snake generalised gradient vector flow.
Chapter 1 is an overview of carcinoma and its types, scanning techniques for the cancer detection, overview of the proposed approaches, problem specification and objective of the research along with the methodology used in the system.

Chapter 2 describes the previous work done in the areas of speckle noise reduction, contrast enhancement techniques, segmentation procedures and boundary detection algorithms in detail and the various available techniques related to this research work.

Chapter 3 consists of a description of the Memetic Adaptive Neuro Fuzzy Inference System used for speckle noise reduction. The method of designing a noise reduction system is discussed critically to identify malignant carcinoma.

Chapter 4 is a detailed description of the Contrast Enhancement techniques. A detailed analysis on Fuzzy Hough Transformations is discussed to identify pre-malignant carcinoma. A comparison of the results obtained using Mean filter and Fuzzy Hough Transformation is presented.

Chapter 5 presents the results achieved by segmentation of the lesion by clustering. Various factors affecting the clustering process are investigated using fuzzy clustering systems. A comparison of the results obtained using Eliminating Particle Swarm Optimization and Modified Fuzzy Possibilistic C–Means with repulsion clustering is presented.

Chapter 6 discusses the border detection technique to determine the shape of the lesion. The border identified lesion is used to classify the stage of carcinoma as malignant, pre-malignant and benign by evaluating the size and intensity of the carcinoma. The usefulness of image information
derived from the coherence is discussed. This chapter contains a detailed consideration of the main approaches to identify the border of the lesion.

**Chapter 7** discusses the effects of sampling plan, analysis of the system and analysis of images. Results obtained using data at different scales, with different number of features with fixed numbers of training patterns as well as changing training patterns with fixed number of features are discussed.

**Chapter 8** discusses the overall conclusion drawn from the research. This chapter summarises the major findings of the research and provides a number of recommendations for future work using different methodologies.