# DETECTION AND ANALYSIS OF BREAST CANCER USING MAMMOGRAM IMAGING

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF DEGREE

OF

MASTER OF TECHNOLOGY

IN

**SOFTWARE ENGINEERING**

SUBMITTED BY:
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AUGUST, 2020

# CANDIDATE'S DECLARATION

I, Pravaritti Kaushik Roll No. 2K18/SWE/13 student of M.Tech (Software Engineering), hereby declare that the project Dissertation titled **"**Detection and Analysis of Breast Cancer using Mammogram Imaging**"** which is submitted by me to the Department of Computer Science and Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of and Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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Pravaritti Kaushik

# CERTIFICATE

I hereby certify that the Project Dissertation titled **"Detection and Analysis of Breast Cancer using Mammogram Imaging"** which is submitted by Pravaritti Kaushik, 2K18/SWE/13 Department of Computer Science Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Master of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

SONIKA DAHIYA

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# ACKNOWLEDGEMENT

The success of a Major II project requires help and contribution from numerous individuals and the organization. Writing the report of this project work gives me an opportunity to express my gratitude to everyone who has helped in shaping up the outcome of the project.

I express my heartfelt gratitude to my project guide **Mrs. Sonika Dahiya** for giving me an opportunity to do my Major II project work under his guidance. Her constant support and encouragement has made me realize that it is the process of learning which weighs more than the end result. I am highly indebted to the panel faculties during all the progress evaluations for their guidance, constant supervision and for motivating me to complete my work. They helped me through out by giving new ideas, providing necessary information and pushing me forward to complete the work.

I also reveal my thanks to all my classmates and my family for constant support.

**PRAVARITTI KAUSHIK**

# ABSTRACT

Breast cancer is the second most common cancer in women after skin cancer. Early discovery and determination is the best methodology to control the tumor movement. Mammograms can detect breast cancer early, possibly before it has spread. Mammogram pictures are observed to be hard to decipher so a CAD is turning into an undeniable essential device to help radiologists in the mammographic lesion interpretation. In this dissertation we explore an automated technique for mammogram segmentation. From comparing different Digitization Noise Removal techniques in light of parameters, for example, PSNR, MSE and SNR, comparing different direct and indirect image enhancement techniques, Background Separation, Edge Detection and finally Segmentation of Breast ROI all are analyzed. Therefore the dissertation leaves us with the best techniques which make tumor detection easy for radiologists.

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# CHAPTER 1
# INTRODUCTION

Breast cancer statistics are gruesome compared to other known cancers. In India, more and more patients are  being identified with breast cancer. Irrespective of age, religion or gender, breast cancer is everywhere. It is the most ordinary cancer in Indian women. It has been observed that breast cancer develops in one in 22 women in India. Out of two who develops it, one dies.

Breast cancer in India is different from the West. Here, it is impairing younger women and more than half of them submit themselves in advanced stages.
By 2030, it is estimated that breast cancer will result in maximum deaths among women in India than any other cancer.

Beforehand spotting is the most victorious tactic of coping with this plaguey. Presently, the best approach for early spotting is mammography which stays the proven method. A fall has been observed in both critical breast cancer and fatality in patients who go through routine mammography, due to beforehand spotting and treatment . However, routine examination programs provide the examining radiologist with a stackload of exams, raising the probability of incorrect diagnosis.Also, mammograms are very difficult to read and interpret as is. Mammograms are low energy X-ray examination of the breasts that helps in early detection of cancer. Digital mammography provides breast's electronic images. The machine is equipped to detect the smallest of the lumps and helps in detecting the presence of cancerous cells.

With this research, we aim to develop a reliable tool to detect tumor or any malignancy in breast using mammogram images. Various Image Processing methods are used as the framework of this thesis. This chapter starts with the introduction to breast cancer and issues and challenges encountered during breast cancer detection. We then describe the research motivation, objectives, contributions and an outline of the proposed framework of this thesis is presented.

## 1.1. Motivation

Reasons for cancer in India are similar to the other regions of the world i.e. biological, chemical and other environmental identities cause uncontrolled and unorganized proliferation of cells, known as carcinogens. Under extraordinary conditions, carcinogens engage with DNA of the regular cells triggering a sequence of complex processes composed of multiple steps causing uncontrolled cell proliferation or tumors. Both external as well as internal variables may result in cancer. External variables involve environmental variables such as diet, tobacco, radiations or other infectious agents whereas internal variables involve hormones and immune conditions. A considerable deviation has been observed and recorded as a result of life choices, styles and food habits.

It is very crucial to locate the malignancy for the formulation of most efficient treatment. Breast Cancer is first detected with the subjective signs or superficial symptoms like an unusual lump around breast tissue or unusual discharge from breasts. After the manual screening, further tests are taken to ensure the possibility of cancer cells existence. Mammography and clinical breast examinations by a trained medical practitioner are used for the confirmation of malignancy, although other techniques exist but these are considered with the most successful detection rate. But it still does not provide a 100% success rate. These types of misdiagnosis are called false positive and these false positives mean more diagnostic procedures and more tests which could be stressful for the patients.
Thus we need better techniques with better and more accurate results which are effective for cancer cell detections.

### 1.2. Objectives

Determining breast cancer from mammograms with the help of preexisting systems only covers the display of upper outline detection schemes. Objectives of this thesis include:

- To remove all kinds of noises from the mammography images, usually caused by external factors.
- To preprocess the image for further analysis by the image enhancement techniques.
- To differentiate the breast tumor candidates from other regions of higher gray scale value such as various kinds of noise, dense tissue and calcification and.
- To obtain quantitative features such as shape and area of tumor.
- To improve the low contrast image quality which is expected to contain abnormal regions.
- To provide radiologists, a “second pair of eyes,” with good repeatability and consistency.

### 1.3. Report organization

This thesis comprises seven chapters along with introduction. Chapter 2 discusses briefly about types of breasts, breast tissues and breast composition, breast cancer detection, digital mammography, other cancer detection methods, common breast diseases etc. Next it discusses various imaging mechanisms such as Ultrasound imaging (US), Magnetic Resonance Imaging (MRI), X-ray . Chapter 3 gives the literature review which talks about the past and present research works related to breast cancer. This chapter has extensively covered the research work done in Mammography. Chapter 4 presents the preprocessing of the mammogram images. Preprocessing consists of filtering and image enhancement techniques. This chapter intensively discusses different filters and their impact on mammograms. Similarly with the various enhancement techniques and how they improve the mammograms for better. Chapter 5 discusses the post processing of the mammograms for early breast cancer tumor detection. Chapter 6 includes the references used for this dissertation.

# CHAPTER 2
# BREAST AND MAMMOGRAPHY

## 2.1. Anatomy of Breast

Breast cancer is caused by the corrupt cellular division. Therefore it is basically a malignancy which is the result of inefficient cellular division. In order to understand breast cancer, it is necessary to have basic knowledge of breasts and their structure.

Every breast consists of 15 to 20 sections called lobes which encircle the nippular region in spokes on a wheel like structure or a radial manner. These lobes comprise smaller sections known as lobules. At the end of these lobules, there are tiny "bulbs" to produce milk. These bulbs are connected together by small tubes called ducts, that carry milk to nipples. The spaces between the lobes and ducts are filled with fat.

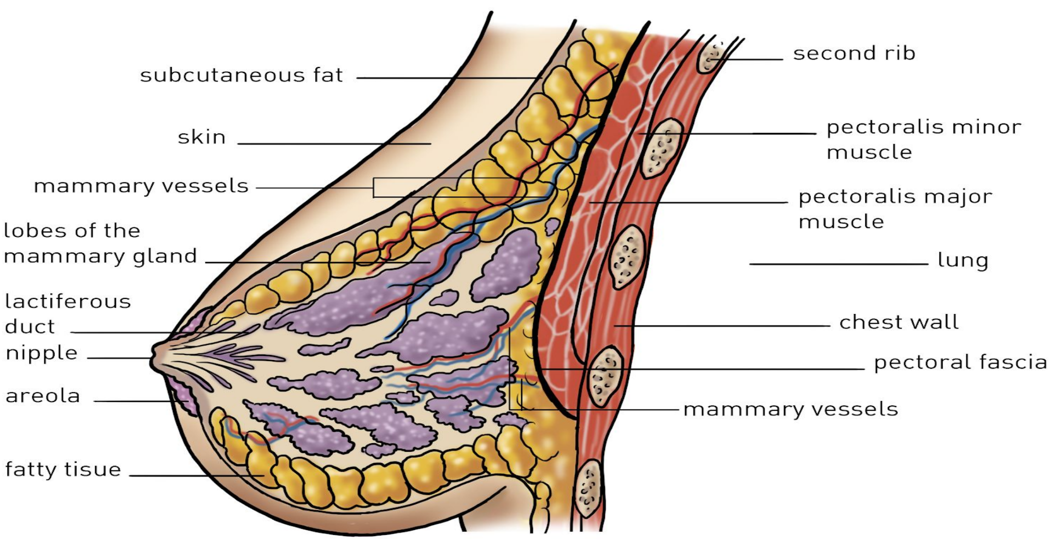


**Figure 1. Anatomy of breast**

### A. Mammary Glands

Mammary glands are sweat glands that have been modified and they comprise of 15 to 20 series of secretory lobules and ducts.

### B. Lactiferous duct

Lactiferous duct is a single tube-like structure or duct which drains many alveoli.

C. **Connective Tissue Stroma**

A supportive structure around mammary glands is called Connective Tissue Stroma. It mainly has fatty and fibrous components. The fibrous stroma later forms suspensory ligaments which connect the breasts with pectoral fascia and separate the secretory lobules of the breasts.

D. **Pectoral Fascia**

A sheet of connective tissue which connects breasts with pectoralis major muscles is called Pectoral Fascia. It is the attachment point for suspensory ligaments.

E. **Fatty Tissue**

### 2.2. Breast Conditions

There are many breast conditions that may affect breasts. Few are mentioned below:

- Breast Cancer:
  - Cancer happens in breasts when malignant cells or cells with some kind of defects multiply abnormally and spread throughout the body. Men and women both can be affected by breast cancer, although it is more prominent in women. Breast cancer can be superficially detected with bloody nipple discharge, changes in skin or lump detection.

- Breast Calcification:
  - Microcalcification is small deposits of calcium which are challenging to detect in mammograms due to their small size and low contrast. These calcium deposits can be as small as 0.33 to 0.7 mm in size. Isolated microcalcifications are not as easily detectable as cluster microcalcification due to their small size. Cluster microcalcification comprises three or more microcacification with an area of 1cm. Microcalcification detection is very crucial for early stage cancer detection. It is important to be able to differentiate between malignant and benign microcalcification as it could result in cancer.

- Simple Breast cyst:
  - This is a non cancerous or benign tumor with sac like structure and usually is filled with fluid. It is usually seen in women in their 30s or 40s. Tenderness can be caused by Breast cysts and fluid can be drained from the cyst.

- Phyllodes tumor:
    - This is a rare, rapidly growing tumor which can be benign or malignant, commonly developed in women in their 40’s. The tumor looks like fibroadenoma on ultrasound and is usually large in size.

- Breast fibroadenoma:
    - It is a common noncancerous solid tumor which creates a painless but movable lump in the breast.

- Fibrocystic breast disease:
    - A noncancerous breast lump which changes size throughout the menstrual cycle and causes discomfort.

**2.3. Types of cancer**

**Benign**

These are the tumors that are not life threatening to the patient. They are non cancerous. A benign tumor can easily be removed with less chances of it growing back. This is because of the fact that cells in benign tumors do not spread.

**Malignant**

In contrast to benign tumors malignant are cancerous. The cells of malignant tumor are abnormal and they split abruptly. Malignant tumor cells can move to other parts of the body and form new tumors. These cells conduct aggressive behaviour and attack the tissues around them.

**2.4. Stages of cancer**

Cancer tumors are classified in Stages. A tumor stage is determined with the way tumor cells look under a microscope. A stage helps determine the type of cancer, body is suffering from and lay out treatment for the patient. It determines how far advanced cancer has grown and spread across the body. There are numerous staging systems. Most common system is the TNM. The "T" stands for the size of the tumor, "N" states the number of lymph nodes involved and "M" gives the metastases i.e. how much the cancer has spread to other body organs though the circulatory system or lymphatic system. The lower the stage the better as it indicates less advanced cancer which is more likely to not have spread in the body and better results can be achieved by the treatment.

Stages of cancer:
Stage 4 = cancer in a different organ from where it started.
Stage 3 = larger cancer that is also in the lymph nodes.
Stage 2 = larger cancer that may or may not have spread to the lymph nodes.
Stage 1 = small cancer found only in the organ where it started.
Stage 0 = precancer.

**2.5. Breast Cancer**

Breast cancer is differentiated on the basis of the way cells look under the microscope. Most breast cancers are carcinomas. Carcinoma is a type of cancer. In this type of cancer, the cells that line organs and tissues like the breast. There is no cure for cancer and no effective way to stop it from happening. Breast cancer statistics are gruesome compared to other known cancers. In India, more and more patients are being identified with breast cancer. Irrespective of age, religion or gender, breast cancer is everywhere. It is the most ordinary cancer in Indian women. It is observed that breast cancer is developed by one in 22 Indian women. Out of two who develops it, one dies.

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### 2.6. Breast cancer lesions

Bilateral asymmetry, Microcalcifications (MCs), architectural distortions and masses are few breast cancer lesions.

a) Microcalcifications

Microcalcification is small deposits of calcium which are challenging to detect in mammograms due to their small size and low contrast. These calcium deposits can be as small as 0.33 to 0.7 mm in size. Isolated microcalcifications are not as easily detectable as cluster microcalcification due to their small size. Cluster microcalcification comprises three or more microcacification with an area of 1cm. Microcalcification detection is very crucial for early stage cancer detection. It is important to be able to differentiate between malignant and benign microcalcification as it could result in cancer.

b) Masses

Masses resemble the normal breast parenchyma which makes them more difficult to detect in mammograms than microcalcification. There could be different mass shapes like round, oval, lobular or irregular as shown in the figure below:

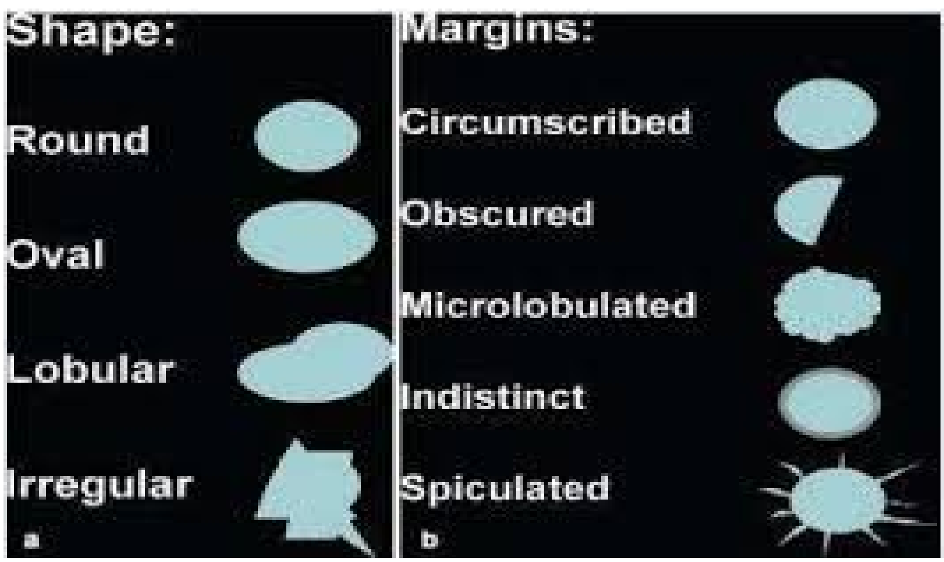


**Figure 2. BI-RADS standardized description of masses**

Mass is also of either benign or malignant category and it is challenging to distinguish among them. The differences are in characteristics of texture and shape of the mass. Benign masses are round in shape with smooth and distinct texture. Whereas, malignant masses are irregular with blurry boundaries.

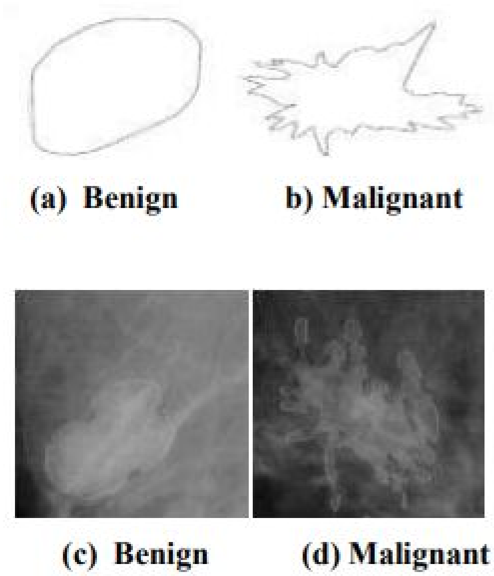


**Figure 3. Benign and malignant tumors.**

**2.7. Methods to detect breast cancer**

**2.7.1. X -ray**

Early detection of breast cancer tumors is very crucial for better treatment as there is no cure to it. Beforehand spotting is the most victorious tactic of coping with this plaguey. Presently, the best approach for early spotting is mammography which stays the proven method. A fall has been observed in both critical breast cancer and fatality in patients who go through routine mammography, due to beforehand spotting and treatment . However, routine examination programs provide the examining radiologist with a stackload of exams, raising the probability of incorrect diagnosis. Also, mammograms are very difficult to read and interpret as is.

Mammography is a low energy X-ray examination of the breasts that helps in early detection of cancer. To detect breast diseases in women ,who are showing symptoms like nipple discharge or lump, diagnostic mammogram is taken and read by the radiologist. Mammogram includes more images of the concerned area.

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A diagnostic mammogram can show:

1. The abnormality is not to be concerned about and the patient can get routine yearly mammograms. They do not need to go for further tests.

2. The abnormal tissue or lesion has more possibility of being benign or not cancerous. In such cases, patients get their mammograms every 4 to 6 months.
3. The tissue is suspected to be malignant or cancerous and whether a biopsy is needed to make sure if it is cancer.

### 2.7.2. Ultrasound

Ultrasonography, or commonly known as Ultrasound, is an imaging technique which emits high frequency sound waves. These sound waves bounce off tissues and internal organs, and their echo produces an image called a sonogram. These sound waves can not be heard by human ears.

Ultrasound is equipped with a transducer which is a handheld instrument and to obtain a sonogram, a special gel is applied on the interested area. Then with the help of a transducer, sonogram is obtained by pressing it over the gel against the skin. Sounds waves are emitted which bounces off body tissue and an echo is produced which is picked up by the machine to produce a bacl and white image on the computer screen. This image is then analysed by the radiologist. This is a radiationless and painless test.

Uses of Ultrasound:

- Ultrasounds are helpful to use along with mammograms while scanning high risk women with dense breasts.
- Ultrasound comes in practice to direct radiologists for invasion therapies for different cancers like prostat, liver and others..
- Useful in evaluation of lumps that are hard to catch on mammograms.
- It is also used as part of other Medical Imaging Technologies.

### 2.7.3. Magnetic Resonance Imaging

MRI which stands for Magnetic resonance imaging, has also proved itself very helpful in detection of breast cancer in high risk women. Strong magnets and radio waves are used for MRI scans rather than using x-rays. Gadolinium, a contrast liquid, is injected into a vein during or before the breast MRI. It helps show better details.Using MRIs along with Mammograms for high risk women is proven to be helpful for close observations and better examination. It can be used for better examination of the suspicious areas in the mammograms. It is also used to detect the actual size of the tumor in the breast.

### 2.7.4. Positron Emission Mammography Detection

Beforehand spotting is the most victorious tactic of coping with this plaguey. Presently, the best approach for early spotting is mammography which stays the proven method. Studies have indicated a fall in both critical breast cancer and fatality in women who go through routine mammography, due to beforehand spotting and treatment . However, routine examination programs provide the examining radiologist with a stackload of exams, raising the probability of incorrect diagnosis. Also, mammograms are very difficult to read and interpret as is.

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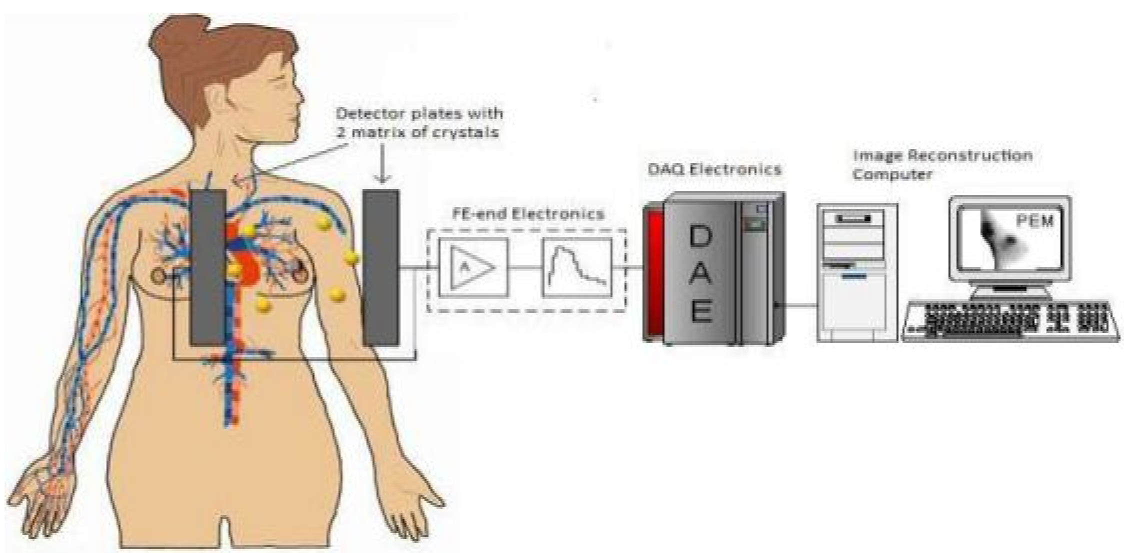


**Figure 4. PEM architecture**

**2.8. Digital mammography equipment**

### 2.8.1. Introduction to mammography equipment

In case of any type of cancer it is a crucial step to detect the cancer before any symptoms start showing. In breast cancer especially, mammography is the most common method which is used for the detection before symptoms surface. Once symptoms develop, it indicates that cancer has already spread and prognosis is less favorable. This research helps the radiologists to detect missed out breast lesions and hence prevent cancer from reaching advanced stages.

### 2.8.2. Working principle of mammography equipment

The Mammography is the most efficient system to detect clinically occult illness, being the only image based method recommended for breast cancer screening. An application of Hough transform to Identify Breast Cancer in Images. Mammography can greatly reduce breast cancer mortality in a well- organized screening program over the population, being the breast cancer detection technique that most reduces mortality . The performance of the mammography decreases as the density of the breast increases. Mammography is a diagnosis exam that uses low amplitude and high current X-rays to examine the human breast. X ray is an electromagnetic radiation with high energy: wavelength in the range of objects and bodies. The main X-ray photons interactions with the tissue are photoelectric effect and Compton scattering . The photoelectric effect occurs when an X-ray photon of short wave length interacts with the electric field of an atom nucleus and ejects off its electrons. The free electron becomes an ionizing particle. In Compton scattering, the X-ray photon intersects with an external electron and becomes free. The incident photon transfers energy to the scattering electron, which is ejected and becomes ionized. The photon changes direction. The photoelectric effect is the primary responsible for the radiologic image contrast, while Compton scattering is the primary mechanism for the image resolution limit. Currently, Mammography 39 equipment has an X-ray tube which produces X-rays. This radiation crosses a metal filter and a collimator, which narrows the beam wave. The radiation is transmitted to the breast, which transmits a portion to an anti-scatter grid, passing to the image receptor. There, the photons interact and deposit their energy locally, allowing the image formation. A fraction of x- rays passes through the receiver without interaction, reaching a sensor, which is used to activate the mechanism of automatic exposure control . The image formation will depend on the structures' densities when penetrated with the X-rays, as its absorption is dependent on the structures' densities. The image must have high spatial resolution to delineate the edges of structures of reduced dimension, as microcalcifications. Usually, there are two standard image projections: craniocaudal (CC), which is a view from top, allowing a better imaging of the central and inner breast sectors; and mediolateral oblique , which is lateral view from a central angle, having an enhanced perspective of the glands .

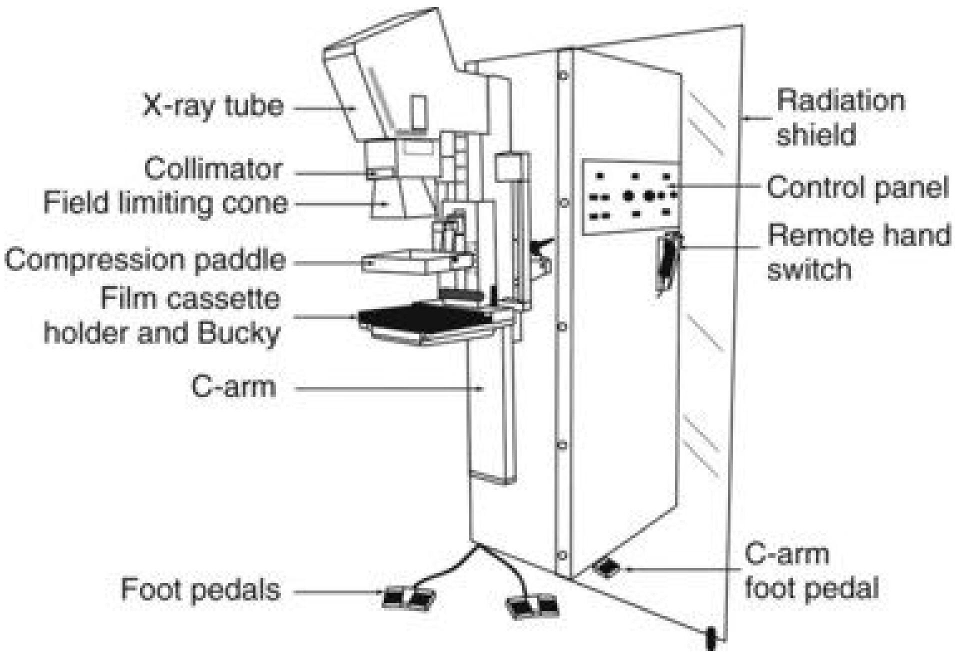


**Figure 5. Diagram of digital mammography equipment**

This permits some indication of three dimensions and an understanding of overlapping structures. High-quality mammograms with high spatial resolution and adequate contrast separation allows radiologists to observe fine structures.

Drawbacks of mammography:

- Abnormalities might get masked by complex structures.
- False positive and false negative due to misinterpretation.
- Inter-intra observer variability is high.
- Overdiagnosis and overtreatment due to misinterpretation.
- Unnecessary challenges are created by superimposed tissues.
- In case of dense breasts, cancerous lesions may stay hidden by normal breast structure.

## 2.9. Introduction of breast cancer detection

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Generally, a typical digital mammogram system includes two steps:

1. Mammogram image pre processing
    a. Noise Removal
    b. Image Enhancement
2. Mammogram image post processing
    a. Edge Detection
    b. Segmentation
    c. Bilateral Asymmetry

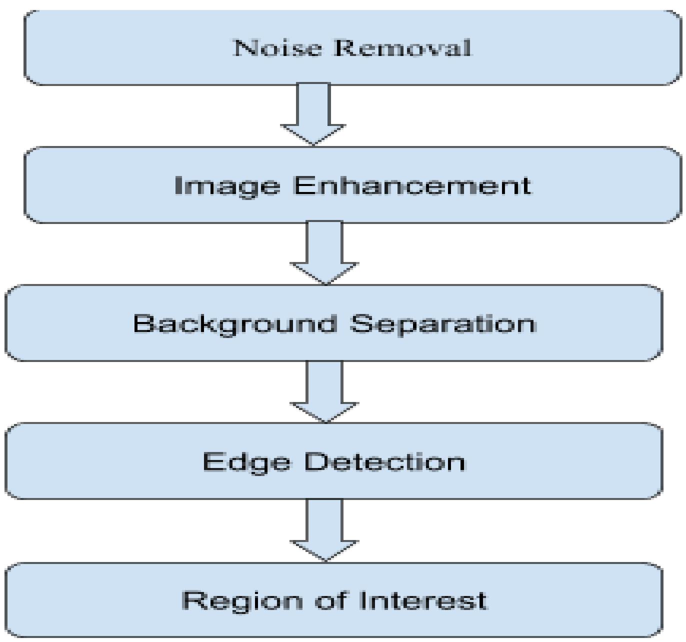


**Figure 6. Steps of Image Processing of Mammogram Image.**

# CHAPTER 3
# REVIEW OF LITERATURE

## 3.1 INTRODUCTION

Breast cancer is differentiated on the basis of the way cells look under the microscope. Most breast cancers are carcinomas. Carcinoma is a type of cancer. In this type of cancer, the cells that line organs and tissues like the breast. There is no cure for cancer and no effective way to stop it from happening. Breast cancer statistics are gruesome compared to other known cancers. In India, more and more patients are being identified with breast cancer. Irrespective of age, religion or gender, breast cancer is everywhere. It is the most ordinary cancer in Indian women. It is observed that breast cancer is developed by one in 22 Indian women. Out of two who develops it, one dies.

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## 3.2 PREPROCESSING

Our ultimate aim for this research is the betterment of the image characters with the help of computer aid and this is achieved by alterations of digital information collected. All this is included in DIP or Digital Image Processing. The preprocessing helps prepare the image for further detection of the region of interest by maximising the sharpness, clarity and details of features of interest towards in format ion extraction and further analysis. It was in 1972 that the digital image data became available for the land remote sensing applications, although it was the 1960s when this type of remote sensing preprocessing first started. In today's time, computer hardware and software are available for access at low costs and are common, although the source of digital image data is many and varied. The unprocessed digital data when observed makes it challenging to distinguish between fine characteristics of that image. To selectively work on those fine features, the digital image is preprocessed, making it ready for further work. The preprocessing includes two major steps of noise removal and image enhancement discussed below.

Steps involved in preprocessing of mammograms:

- Noise Removal
- Image Enhancement

### 3.2.1. Noise and it's removal

Image noise can be defined as the random and unexplainable difference in color or brightness information of the image captured. It is considered a degradation in image signal triggered by external sources. In other words, noise pixels show different intensity values instead of true pixel values that are obtained from the image.

We can compare image noise in digital photography to the film grain for analogue cameras. Noise usually demonstrates itself as spontaneous speckles on a smooth surface which can result in serious degradation in the image quality. Although it is not always harmful. Increasing the sharpness of the digital image might be proved as helpful.

Following factors cause noise:

- Electric Electrical glitch
- Dust particles
- Long exposure may result in more noise
- physical temperature
- sensitivity setting of camera

The noise level usually rises depending on sensitivity of camera, physical temperature and length of exposure. Noise plays a very important part in digital processing of images and it is in fact the parameter that specifies success or failure of any enhancement scheme. We must take that into account how much of the discovered signal can be registered as true and how much of it is related to the random background events that happen from either the transmission or detection process. These random events are taken under the general topic of noise. As discussed above, this noise can be generated from a variety of factors, including variation in detector sensitivity, the discrete nature of radiation, data transmission errors, photo- graphic grain effects, properties of imaging systems such as image quantization errors and water droplets or air turbulence. In every instance, the characteristics of the noise vary and thus the image processing operations that can be applied to reduce their effects.

### 3.2.2. Enhancement and analysis of mammograms

Enhancement in mammograms is done to achieve better contrast, especially when it comes to mammograms of dense breasts. The basic enhancement required in mammograms is a step-up in contrast, particularly for dense breasts. On mammograms of dense breasts, Contrast amongst normal dense tissue and malignant tissue might persist, but beneath human perceiving. Besides, calcifications in an adequately dense mass might be hard to read because of low contrast, thus identifying calcifications is challenging. To enhance the mammographic images

Photographic unsharp masking , digital unsharp masking, and spatial bandpass filtering have been used for mammogram enhancements.

Although a lot of work has been done for identification of image features and analysis of mammograms that indicate cancer, little effort has been put on enhancement of mammographic images. In this research the approach is to enhance tricky mammograms to decent standards to enable the radiologist to establish his diagnosis with more credibility.

#### 3.2.2.1 Enhancement by Histogram Equalization and Specification

Histogram equalization technique is employed to enhance the image contrast by many application fields. We use cumulative density function to perform histogram flattening along with stretching the dynamic range of gray levels. This contrast enhancement technique is not advisable as level of brightness gets manipulated significantly which may result in harsh view in the altered contrast and brightness levels.

#### 3.2.2.2 Enhancement by Contrast Stretching

Contrast can be described as the difference between the intensity values of brighter pixels and darker pixels. The thought behind enhancement by contrast stretching is to raise the dynamic range of the image under observation. Contrast stretching broadens the intensity level range in an image. In order to produce a higher contrast image than the original image,two things could be done. Either we brighten the levels above (say) m in the original image or we darken the levels below m. Thus, being a simple enhancement that contrast stretching it, it simply increases the range of desired intensity values. It uses a linear function. Contrast stretching also known as normalization.

#### 3.2.2.3 Local and Global Contrast Stretching (LCS)

For enhancement of the image different elements are modified in LCS to boost the view of the whole image consisting of both dark and light components through operations executed simultaneously. The element situated at the center is modified and windows slide across the whole input image.

#### 3.2.2.4 Brightness Bi-Histogram Equalization (BBHE)

Bi-histogram equalization techniques autonomously equalize the two sub-histograms obtained by dividing histograms. This method is better used to lessen the diversity in mean image brightness after histogram equalization. In order to partition the histogram, several image characteristics such as mean gray level, median or some sort of automatically selected grayscale threshold are used. This technique based on Bi-HE (BBHE) was introduced to overcome the drawbacks of Histogram Equalization that triggered changed brightness levels with modified contrast.

#### 3.2.2.5 Convolution Mask Enhancement

Convolution Mask Enhancement Convolution masking uses unsharp masking as enhancement operation. Originally unsharp masking was practiced photographically. Although in this technique an indistinct negative of the photograph is arranged in the register along with its positive image. We obtain the difference image that contains all the details in the image. This image that has only the details, is then accentuated so that it can be added to the blurred image and a print is obtained. As low-frequency details are reduced in intensity and the high-frequency information is magnified, this results in a sharper end print. Here we use a 3x3 mask for digital unsharp masking. This makes convolution mask enhancement one of the most used technique for image enhancement purposes. This procedure is avoided for the mammograms as it alters the appearing image too significantly whereas the total subjective image appearance is vital for diagnosis.

#### 3.2.2.6 Enhancement by Background Removal

The background removal enhancement technique uses the image's low-pass filtered version to subtract it from the image itself. We have used two methods, gray-scale morphological processing and spline filtering, to estimate image background. Unsharp masking is a simpler version of enhancement by background removal. Background subtraction is considered a direct technique to reduce slowly varying portions of an image thus allowing an increase in gray level variation in image details.

### 3.3. Postprocessing of mammograms

Once the mammogram image is preprocessed, they are ready for further examination and evaluation. Purpose of post processing methodology is to make it easy for the radiologist to detect and examine the tumor easily. Post processing includes two steps:

1. Segmentation
2. Bilateral Asymmetry

### 3.3.1. Segmentation

Region growing technique is used for the segmentation of masses, whereas border is extracted using Canny edge detection. Grayscale erosion by gray scale is used to process the border.

### 3.3.2. BILATERAL ASYMMETRY

Bilateral asymmetry is done to calculate the fluctuating asymmetry using volumes of left and right breasts. Phenotype-based deformation is a useful predictor and it is measured with the help of fluctuating asymmetry. Low fluctuating asymmetry indicates lower morbidity.

# CHAPTER 4
# METHODS AND IMPLEMENTATIONS OF PREPROCESSING OF MAMMOGRAMS

**Preprocessing of an image**

Our ultimate aim for this research is the betterment of the image characters with the help of computer aid and this is achieved by alterations of digital information collected. All this is included in DIP or Digital Image Processing. The preprocessing helps prepare the image for further detection of the region of interest by maximising the sharpness, clarity and details of features of interest towards in format ion extraction and further analysis. It was in 1972 that the digital image data became available for the land remote sensing applications, although it was the 1960s when this type of remote sensing preprocessing first started. In today's time, computer hardware and software are available for access at low costs and are common, although the source of digital image data is many and varied. The unprocessed digital data when observed makes it challenging to distinguish between fine characteristics of that image. To selectively work on those fine features, the digital image is preprocessed, making it ready for further work. The preprocessing includes two major steps of noise removal and image enhancement discussed below.
Steps involved in preprocessing of mammograms:

- Noise Removal
- Image Enhancement

## 4.1. Noise and it's removal

Image noise can be defined as the random and unexplainable difference in color or brightness information of the image captured. It is considered a degradation in image signal triggered by external sources. In other words, noise pixels show different intensity values instead of true pixel values that are obtained from the image.

We can compare image noise in digital photography to the film grain for analogue cameras. Noise usually demonstrates itself as spontaneous speckles on a smooth surface which can result in serious degradation in the image quality. Although it is not always harmful. Increasing the sharpness of the digital image might be proved as helpful.

Following factors cause noise:

- Electric Electrical glitch
- Dust particles

- increases depending on the length of exposure
- physical temperature
- sensitivity setting of the camera

The noise level usually rises depending on the physical temperature, sensitivity of camera and the length of exposure. Noise plays a very important part in digital processing of images and it is in fact the parameter that specifies success or failure of any enhancement scheme. We must take that into account how much of the discovered signal can be registered as true and how much of it is related to the random background events that happen from either the transmission or detection process. These random events are taken under the general topic of noise. As discussed above, this noise can be generated from a variety of factors, including variation in detector sensitivity, the discrete nature of radiation, data transmission errors, photo- graphic grain effects, properties of imaging systems such as image quantization errors and water droplets or air turbulence. In every instance, the characteristics of the noise vary and thus the image processing operations that can be applied to reduce their effects.

### 4.1.1. Salt and pepper noise

Salt-and-pepper noise can be seen in digital images when there is a significant amount of pixels that are black or white. Usually a significant amount is taken as a considerable amount. Taking r as the likelihood of a pixel to be tainted or corrupt, we can take r/2 randomly selected pixelsas white and other r/2 as black and this is how salt-and-pepper noise is introduced in an image. In order to de-noise digital images, passing the images through low-pass filters has not been proven the best to achieve the desired results.

Now we consider using salt-and-pepper noise to deblur this problem. Take the practical situation where the recorded picture is later corrupted. The given model first creates a blurred image represented by bexact = A x. Now salt-and-pepper noise is added to the image as discussed above, which results in noisy image b. Gaussian blurring is added to the image using psfGauss with sigma = 2, and then corrupt 0.2 % of the pixels (i.e., r = 0.002) with salt-and-pepper noise. Now, the image is reconstructed using Tikhonov regularization and/or TSVD with regularization parameter alpha about 0.01and threshold tol.

Salt and pepper noise refers to a wide variety of processes that result in the same basic image degradation: only a few pixels are noisy, but they are very noisy. The outcome is similar to salt and pepper or black and white dots spattered on the image.

When we transmit images over a noisy digital link, this can be considered as an example which results in salt and pepper noise. Consider each pixel is quantized to B bits in the usual fashion. $X=\sum_{i=0}^{B-1} b_i 2^i$ describes the value of the pixel. Assuming the channel has a crossover probability of $\in$ and is a binary symmetric channel. Now flip each bit with probability $\in$. Taking the received value, Y. Now, assume that these bit flips are independent, (7.33) Pr [|X−Y|=2i]= (1− )B−1 ε ε

for i=0,1,...,B−1. The MSE becomes 4B−1instead of ε (4B−1−1)/3 ε for all the other bits combined because of the most significant bit. In conclusion, the most significant but now contributes to the MSE as much as three times as compared to all the other bits. Pixels with changed most significant bits are likely to appear as black or white dots. Salt and pepper noise is a (very) heavy tailed noise.

A simple model is the following: Say f(x,y) be the original image and **q**(x,y) be the image after it has been altered by salt and pepper noise.

(7.34) $Pr[q=f]=1-\alpha$

(7.35) $Pr[q=MAX]=\alpha/2$

(7.36) $Pr[q=MIN]=\alpha/2$,

Where MIN and MAX are the minimum and maximum values of the image, respectively. Take MIN=0 and MAX = 255 for 8 bit images. The idea behind this is that with the probability αth pixels are changed to smallest or largest values whereas with the probability 1 - α, the pixels are untouched or unaltered. The pixels that get altered look like whiate and black dots spattered over the image. Salt and pepper noise can be easily removed by using statistic filters in different orders. These filters include the LUM filter and center weighted median filter.

### 4.1.2. Speckle noise

Speckle noise has a granular pattern and is multiplicative in nature. Speckle noise can be described as a feature effect usually observed in ultrasound images that add to the visual noise. The image of a relatively uniform object with many scattering sources within a resolution cell will have pixel values that vary randomly with position due to constructive and destructive interference.there are many types of noises and the reason for their existence are the factors like transforming images acquiring images, capturing images,compressing images etc. Due to their different causing factors, it is important to treat every noise with different techniques. Speckle noise consists of high frequency components which is usually the result of temporal organ movement. Some examples that have been used to deal with this type of noise are Gamma MAP filters, Wiener, Lee, Kuan, Frost, Median, Mean etc.

## 4.2 Various Noise removal techniques

Image noise is degradation of image signals usually caused by external sources or factors. It is often spontaneous fluctuations in color or brightness information in the captured images. Noise is taken as a false signal and in all processing systems we must consider how much of the detected signal can be taken as true and how much is related to the random background events. We consider many image processing operations to deal with these and reduce their effects.

### 4.2.1 Mean Filter

Mean filter, or average filter, is a windowed filter of linear class and it smoothes image signals. The elementary foundation behind this filter is for any element of the image signal to take average across its neighborhood. The arithmetic mean filtering process finds the average value using the pixels in the region and thus restore the false detected value.

### 4.2.2 Median Filter

There are linear and nonlinear types of filters. Median filter comes under the category of nonlinear filters. Median filter has proved itself the best to remove impulse noises, such as salt-and- pepper noise, in images. Unlike mean filter, median filter changes gray level of each pixel with the median of gray level in a neighborhood of the pixels, instead of using the average operation. For median filtering, kernel size is specified and pixel values that cover the kernel are listed to determine the median value. If even numbers of pixels are covered by the kernel, the average of two median values is used. Edge distortion is introduced at the image boundary by padding the row and column with zeros.

Median filtering does not use convolution to process the image with a kernel of coefficient. This is a common nonlinear method used to suppress noise that has unique characters. Instead of using each position of the kernel frame, a pixel of the input image is chosen to become the output pixel. After we center the kernel frame on each pixel(m,n) of the original image, we compute the median value of each pixel within the kernel frame. The pixel at coordinates (m,n) is set to the computed median value. Median filter does not have the same smoothing characteristic as the mean filter has. Features or characteristics which are half the size of the median filter are completely removed from the output image by the filter. Although large changes in the intensities of the image or large discontinuities as edges are observed to stay unaffected by the median filter in terms of gray level intensity. This nonlinear operation of the median filter allows significant reduction of specific types of noise. For example, "pepper-and-salt noise" may be removed completely from an image without attenuation of significant edges or image characteristics.

### 4.2.3 Wiener Filter

Wiener filter can be described as the original image's linear estimation which is based on a stochastic framework.This filtering technique is an inverse filtering which restores for the deconvolution later. In other words, the image is blurred using a lowpass filter and then the image is recovered by generalized inverse filtering and inverse filtering. Although, inverse filtering is sensitive to additive noise. This approach in which we reduce one degradation at a time makes us capable of developing a restoration algorithm for other types of degradation and later combine them.

Wiener filtering minimizes overall mean squared error or MSE during the process of noise smoothing and inverse filtering. Thus it is optimal to get desired results in MSE.

### 4.2.4 Gaussian Filter

Gaussian filter is a linear filter and it is often used to reduce noise and blur the image. It can be used for “unsharp masking” i.e. edge detection as it will reduce contrast and blur the edges, if we use two of them and then subtract.

One of the most simple methods to reduce noise, especially salt-and-pepper in an image, is median filter. Median filter claims to keep the edges relatively sharp in comparison with Gausian filters for noise reduction. This is one benefit that the median filter provides us over the gaussian filter but Gaussian filter is faster as multiplying and adding is faster than sorting.

### 4.2.5 Adaptive Median Technique

Median filter is proved to be an important technique for noise removal which even keeps the edges relatively intact. Thus with few adjustments in the median filter, we can achieve an advanced and better version of it. In adaptive median filtering technique, pixels are classified as noise by comparing every pixel to its surrounding pixels in the neighborhood. Threshold as well as the size of the neighborhood is adjustable in this technique. The pixels that are not structurally aligned with its neighboring pixels or those that have majority difference from their neighborhood, these pixels are adjustable. Thus adaptive median filter processes the input image spatially to find whether a pixel from input image is affected by the impulse noise. The pixels that do not align with their neighborhood, are replaced by the median pixel value from the neighborhood that has passed the noise labeling test.

**Purpose**

1). To minimize distortion like excessive thickening or thinning of image or object boundary.
2). To remove impulse noise like salt-and-pepper.
3). For smoothing of other noises

### 4.3. Comparison Images and Tables

### 4.3.1. Salt and Pepper Noise Comparison at different densities

#### 4.3.1.1. Comparison at density 0.02

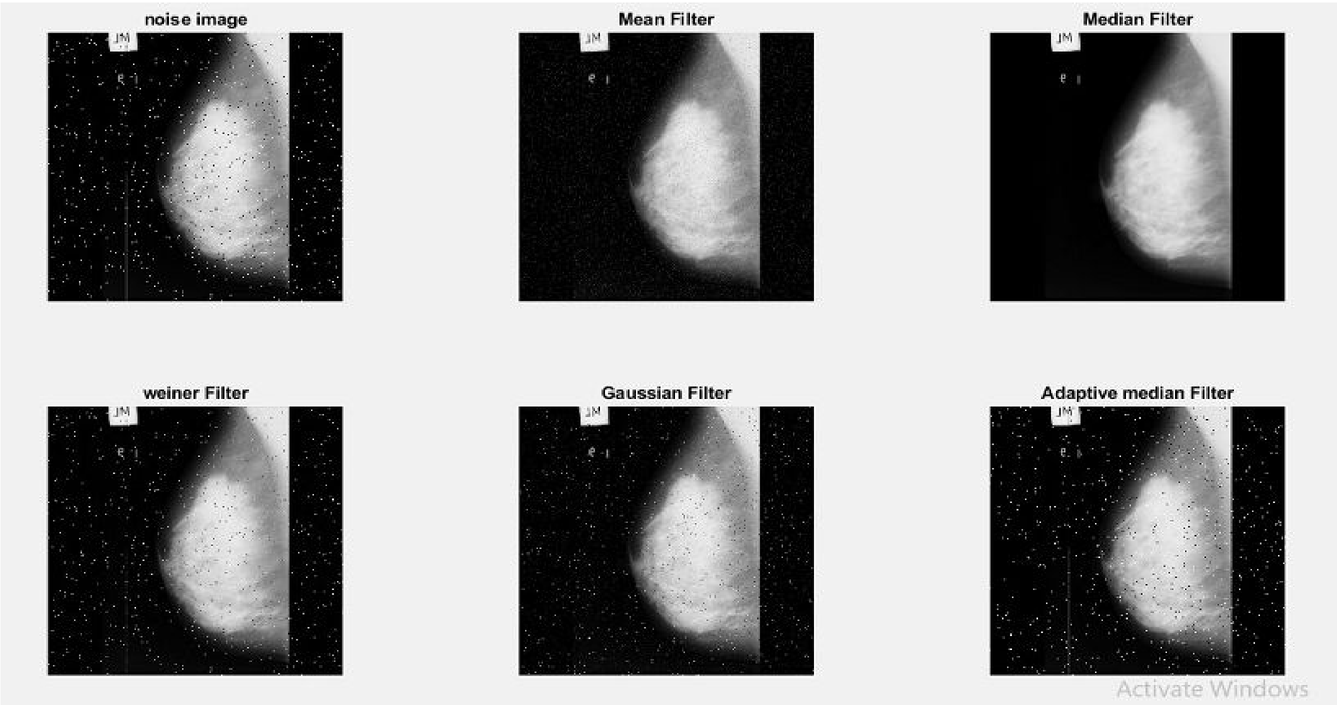


**Figure 7. Comparison at density 0.02**

| PARAMETER<br>FILTER | MSE | PSNR | SNR |
|---|---|---|---|
| NOISE | 557.3818 | 20.6693 | 12.3478 |
| MEAN | 502.9086 | 21.1159 | 17.3402 |
| MEDIAN | 569.0977 | 20.5789 | 17.1316 |
| ADAPTIVE MEDIAN | 1112.5223 | 17.6677 | 9.3470 |
| GAUSSIAN | 96.9933 | 28.2634 | 19.7860 |
| WEINER | 51.0315 | 31.0524 | 22.6189 |

**Table 1. Comparison at density 0.02**

### 4.3.1.2. Comparison at density 0.04

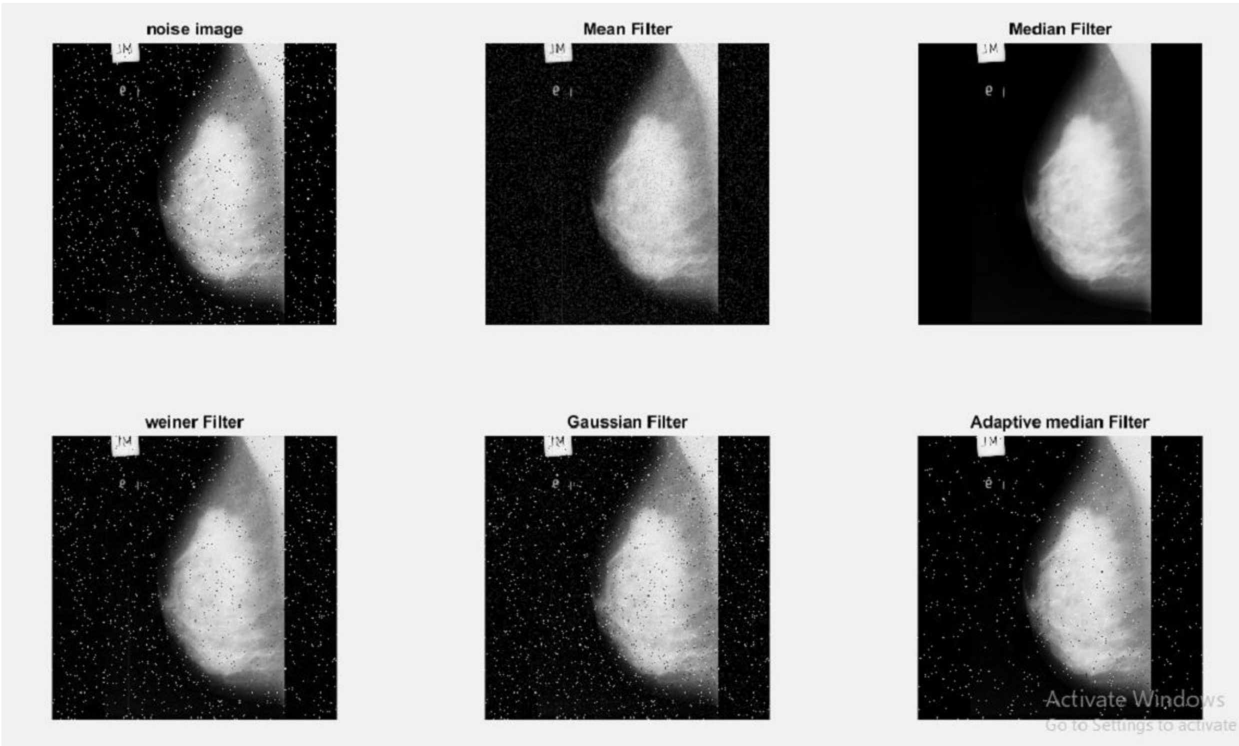


**Figure 8. Comparison at density 0.04**

| PARAMETER<br>FILTER | MSE | PSNR | SNR |
|---|---|---|---|
| NOISE | 1134.9358 | 17.5811 | 9.4668 |
| MEAN | 1000.4900 | 18.1287 | 9.5487 |
| MEDIAN | 1145.8205 | 17.5396 | 8.9969 |
| WEINER | 232.4522 | 24.4675 | 16.0424 |
| GAUSSIAN | 193.6118 | 23.2615 | 16.8488 |
| ADAPTIVE MEDIAN | 1682.0098 | 15.8725 | 7.5504 |

**Table 2. Comparison at density 0.04**

#### 4.3.1.3. Comparison at density 0.06

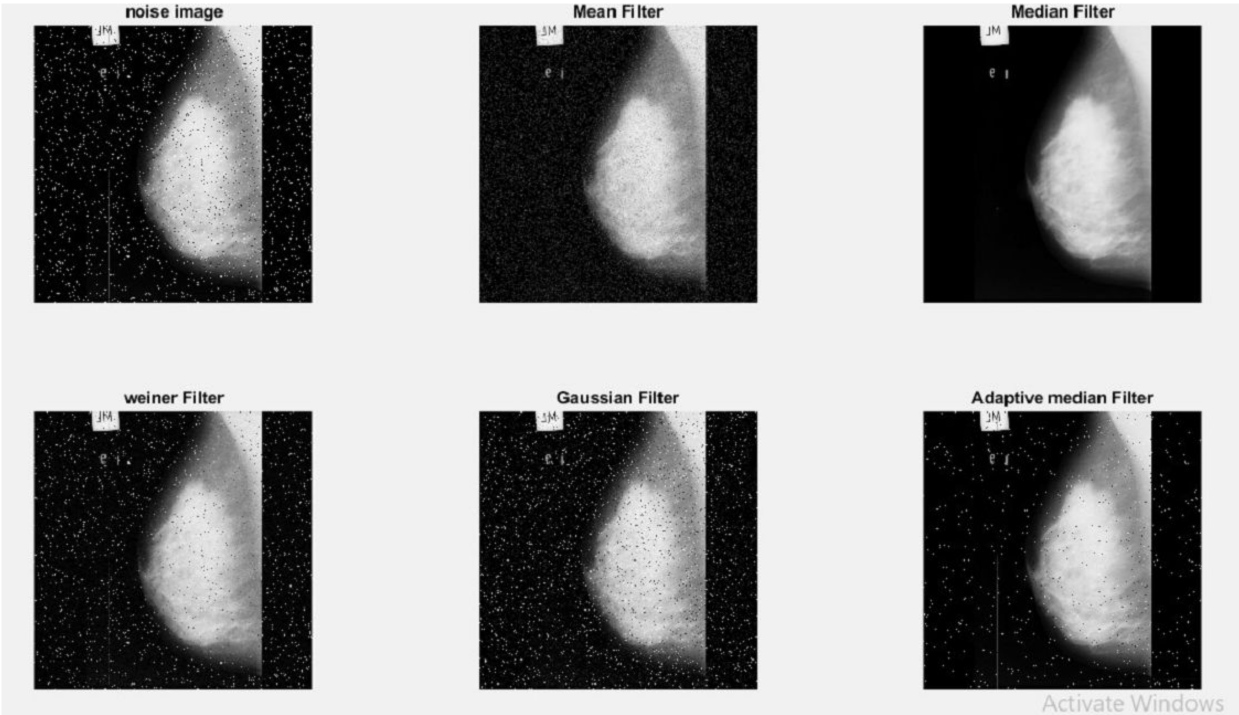


**Figure 9. Comparison at density 0.06**

| PARAMETER<br>FILTER | MSE | PSNR | SNR |
|---|---|---|---|
| NOISE | 1698.1546 | 15.8310 | 7.9204 |
| MEAN | 1483.7373 | 16.4172 | 7.8332 |
| MEDIAN | 1712.6478 | 15.7941 | 7.2517 |
| WEINER | 549.5581 | 20.7307 | 12.2925 |
| GAUSSIAN | 287.9738 | 23.5373 | 15.1956 |
| ADAPTIVE MEDIAN | 2248.5070 | 14.6119 | 6.2947 |

**Table 3. Comparison at density 0.06**

### 4.3.1.4. Comparison at density 0.08

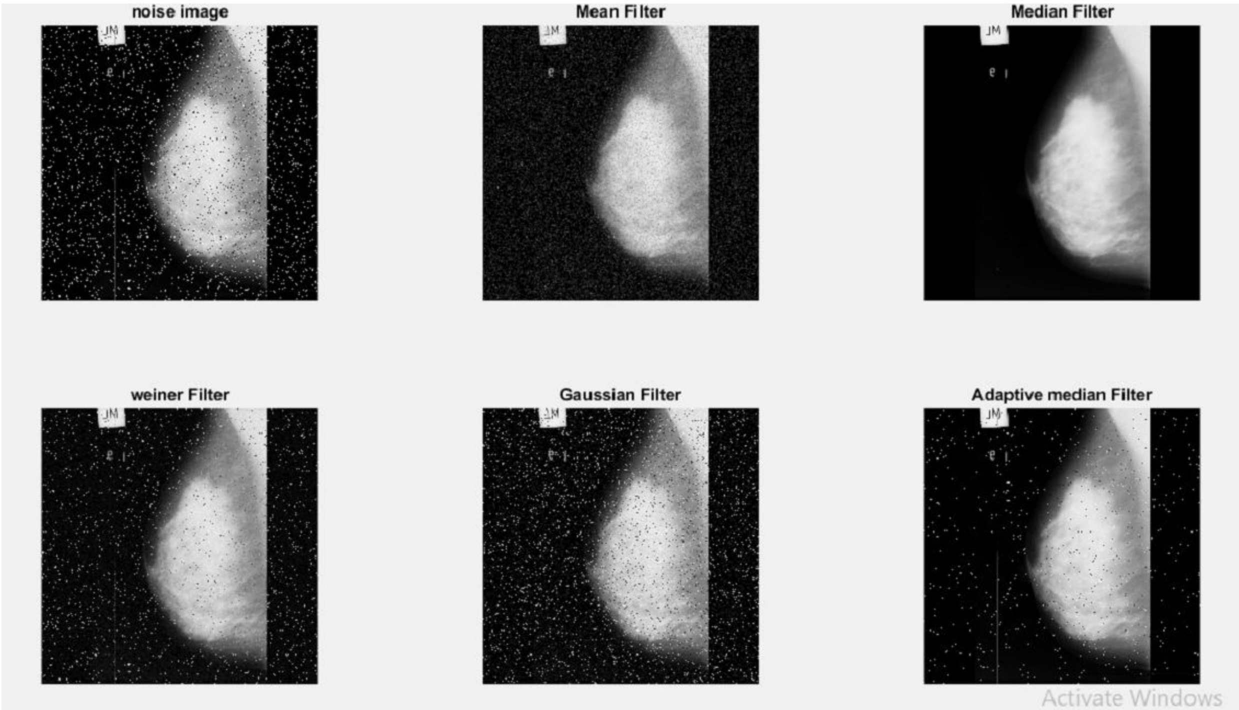


**Figure 10. Comparison at density 0.08**

| PARAMETER<br>FILTER | MSE | PSNR | SNR |
|---|---|---|---|
| NOISE | 2256.8146 | 14.5958 | 6.8669 |
| MEAN | 1945.8043 | 15.2398 | 6.6531 |
| MEDIAN | 2265.2291 | 14.5797 | 6.0372 |
| WEINER | 955.9704 | 18.3264 | 9.8722 |
| GAUSSIAN | 377.5166 | 22.3614 | 14.0882 |
| ADAPTIVE MEDIAN | 2779.8890 | 13.6905 | 5.3687 |

**Table 4. Comparison at density 0.08**

### 4.3.1.5. Comparison at density 0.10

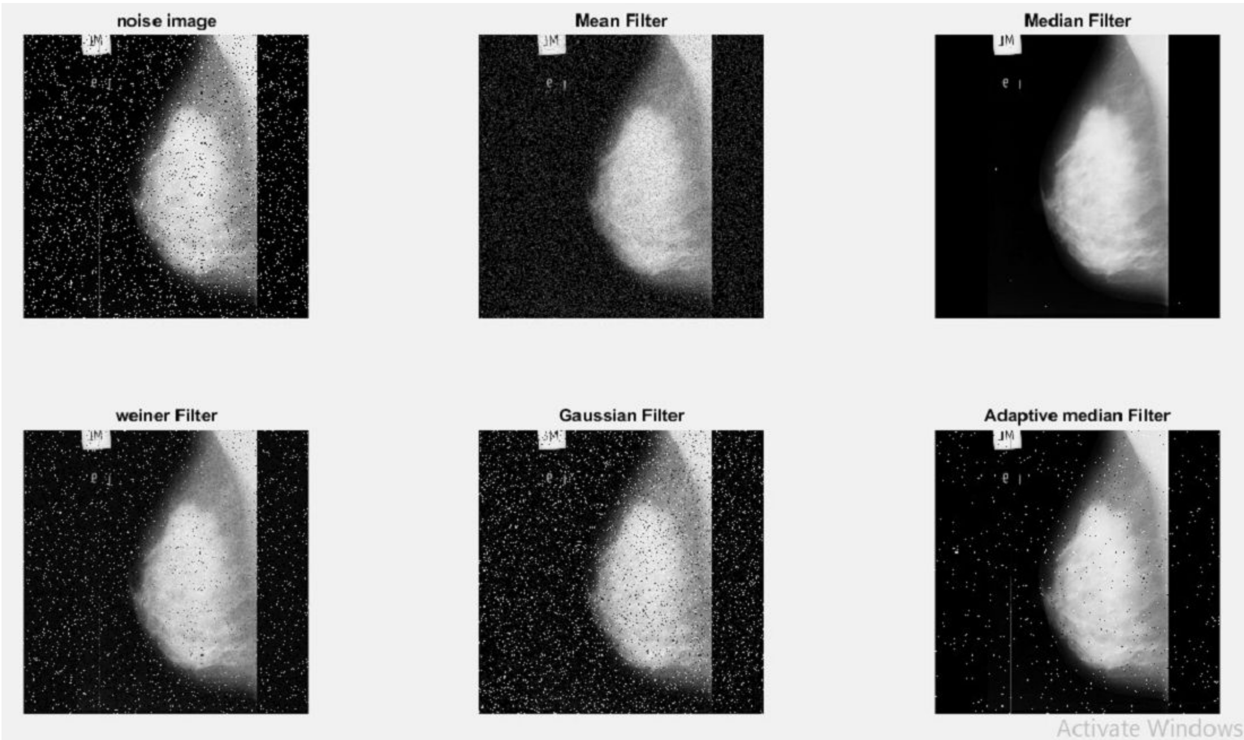


**Figure 11. Comparison at density 0.02**

| PARAMETER FILTER | MSE | PSNR | SNR |
|---|---|---|---|
| NOISE | 2823.0933 | 13.6236 | 6.0833 |
| MEAN | 2413.9116 | 14.3036 | 5.7272 |
| MEDIAN | 2831.1984 | 13.6111 | 5.0693 |
| WEINER | 1360.1423 | 16.7950 | 8.3445 |
| GAUSSIAN | 469.3961 | 21.4154 | 13.2211 |
| ADAPTIVE MEDIAN | 3349.6920 | 12.8808 | 4.5662 |

**Table 5. Comparison at density 0.10**

### 4.3.2. Speckle Noise Comparison at different densities

#### 4.3.2.1. Comparison at density 0.02

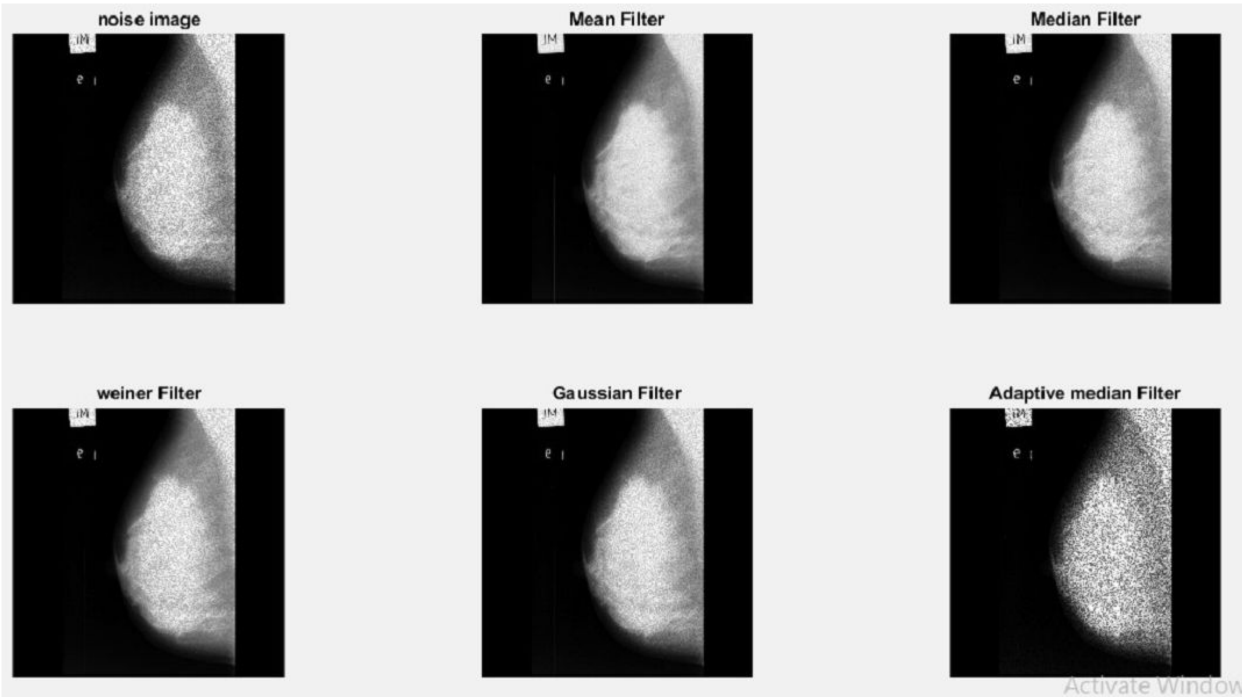


**Figure 12. Comparison at density 0.02**

| PARAMETER<br>FILTER | MSE | PSNR | SNR |
|---|---|---|---|
| NOISE | 168.6852 | 25.8600 | 17.3594 |
| MEAN | 161.4989 | 26.0491 | 17.4627 |
| MEDIAN | 177.2648 | 25.6446 | 17.057 |
| WEINER | 26.7463 | 33.8582 | 25.3126 |
| GAUSSIAN | 30.4564 | 33.2940 | 24.7405 |
| ADAPTIVE MEDIAN | 863.0106 | 18.7706 | 10.2336 |

**Table 6. Comparison at density 0.02**

### 4.3.2.2. Comparison at density 0.04

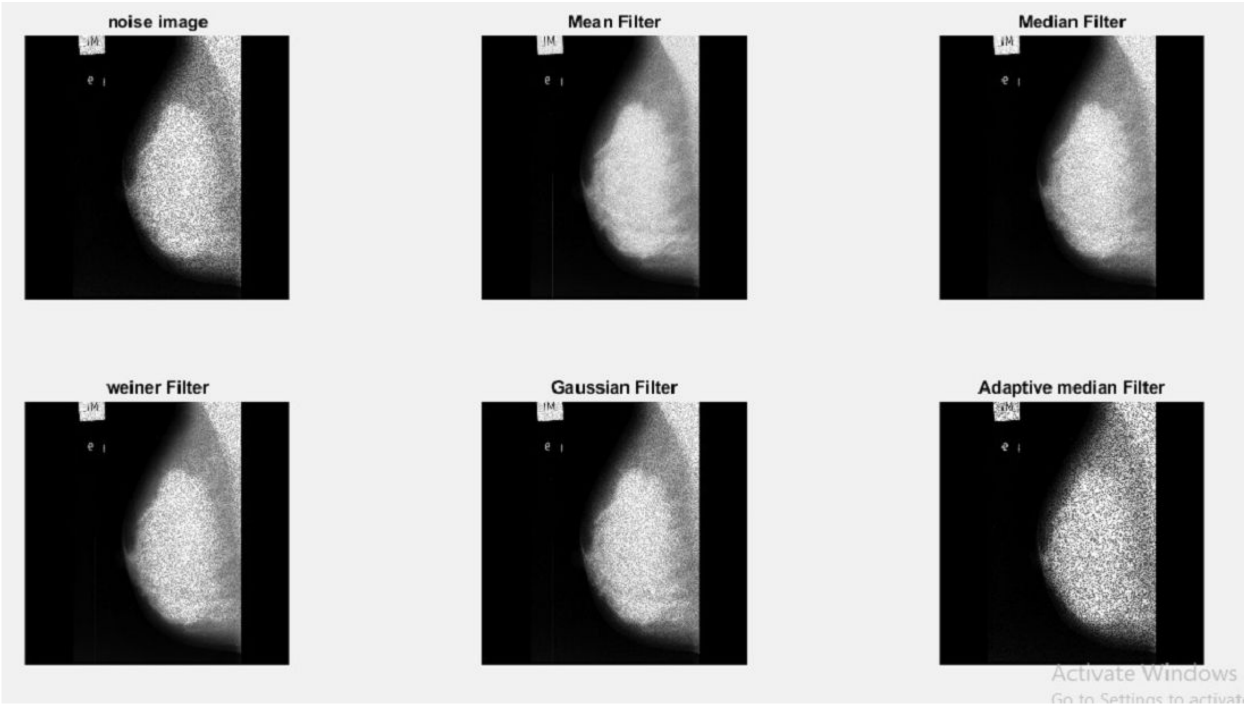


**Figure 13. Comparison at density 0.04**

| PARAMETER<br>FILTER | MSE | PSNR | SNR |
|---|---|---|---|
| NOISE | 313.6456 | 23.1664 | 14.6627 |
| MEAN | 287.4408 | 23.5453 | 14.8945 |
| MEDIAN | 320.3582 | 23.0744 | 14.5494 |
| WEINER | 41.6974 | 31.9297 | 23.3484 |
| GAUSSIAN | 55.1306 | 30.7169 | 22.1202 |
| ADAPTIVE MEDIAN | 1000.2139 | 18.1299 | 9.5874 |

**Table 7. Comparison at density 0.04**

### 4.3.2.3. Comparison at density 0.06

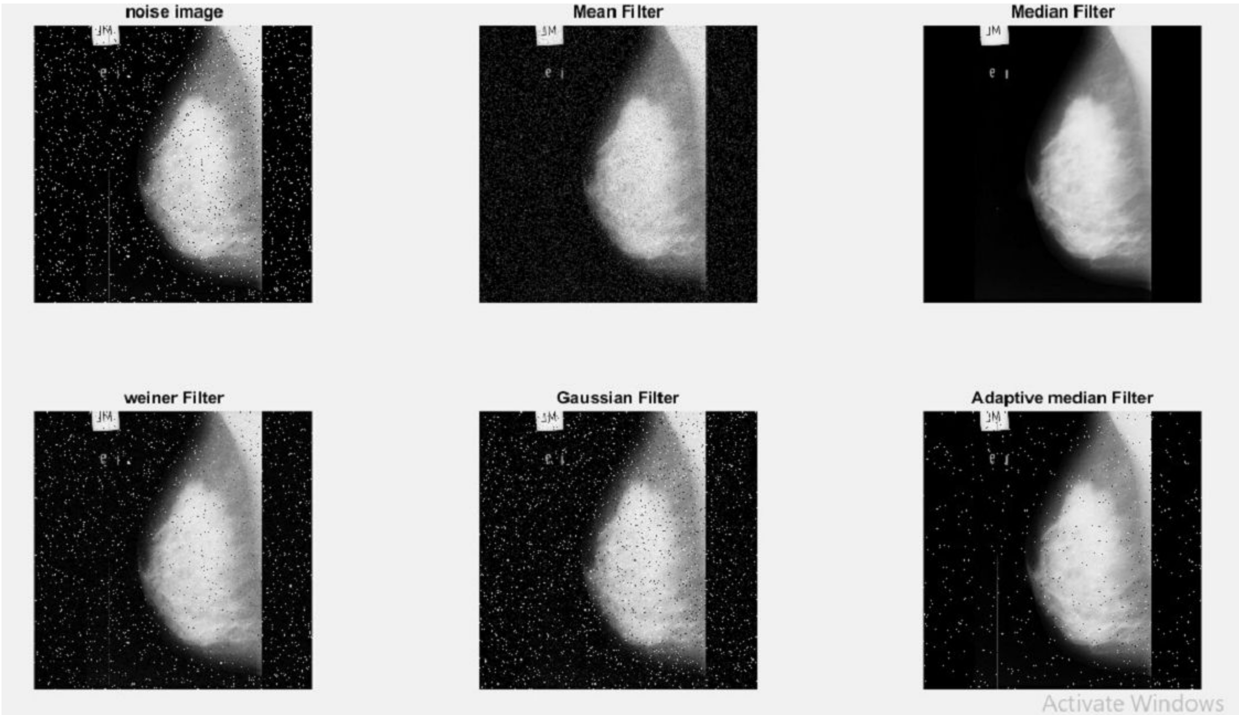


**Figure 14. Comparison at density 0.06**

| PARAMETER<br>FILTER | MSE | PSNR | SNR |
|---|---|---|---|
| NOISE | 447.2984 | 21.6248 | 13.1117 |
| MEAN | 401.1740 | 22.0975 | 13.3807 |
| MEDIAN | 449.4986 | 21.6035 | 13.0814 |
| WEINER | 55.0711 | 30.7216 | 22.1005 |
| GAUSSIAN | 77.4831 | 29.2387 | 20.5956 |
| ADAPTIVE MEDIAN | 1122.2974 | 17.6297 | 9.0852 |

**Table 7. Comparison at density 0.06**

#### 4.3.2.4. Comparison at density 0.08

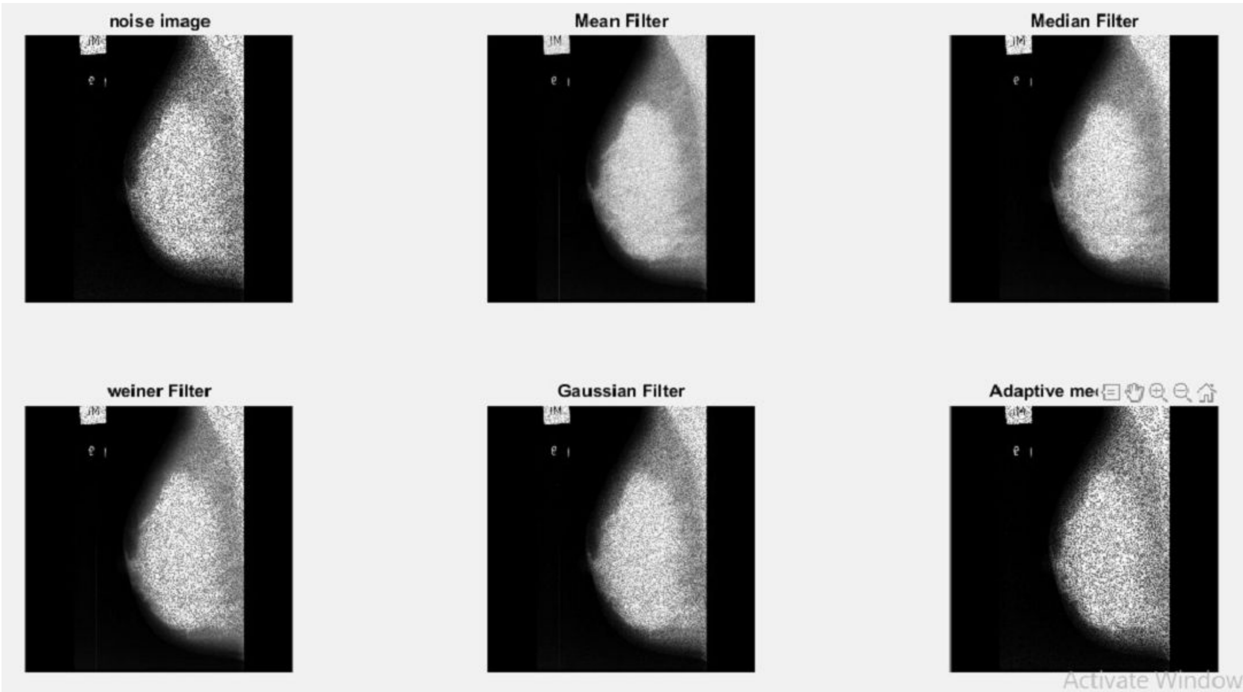


**Figure 15. Comparison at density 0.08**

| PARAMETER FILTER | MSE | PSNR | SNR |
|---|---|---|---|
| NOISE | 576.3588 | 20.5239 | 11.9954 |
| MEAN | 510.5726 | 21.0502 | 12.2629 |
| MEDIAN | 577.7896 | 20.5131 | 11.9896 |
| WEINER | 67.9551 | 29.8086 | 21.14131 |
| GAUSSIAN | 98.7159 | 28.1869 | 19.4926 |
| ADAPTIVE MEDIAN | 1239.1758 | 17.1995 | 8.6582 |

**Table 9. Comparison at density 0.08**

#### 4.3.2.5. Comparison at density 0.10

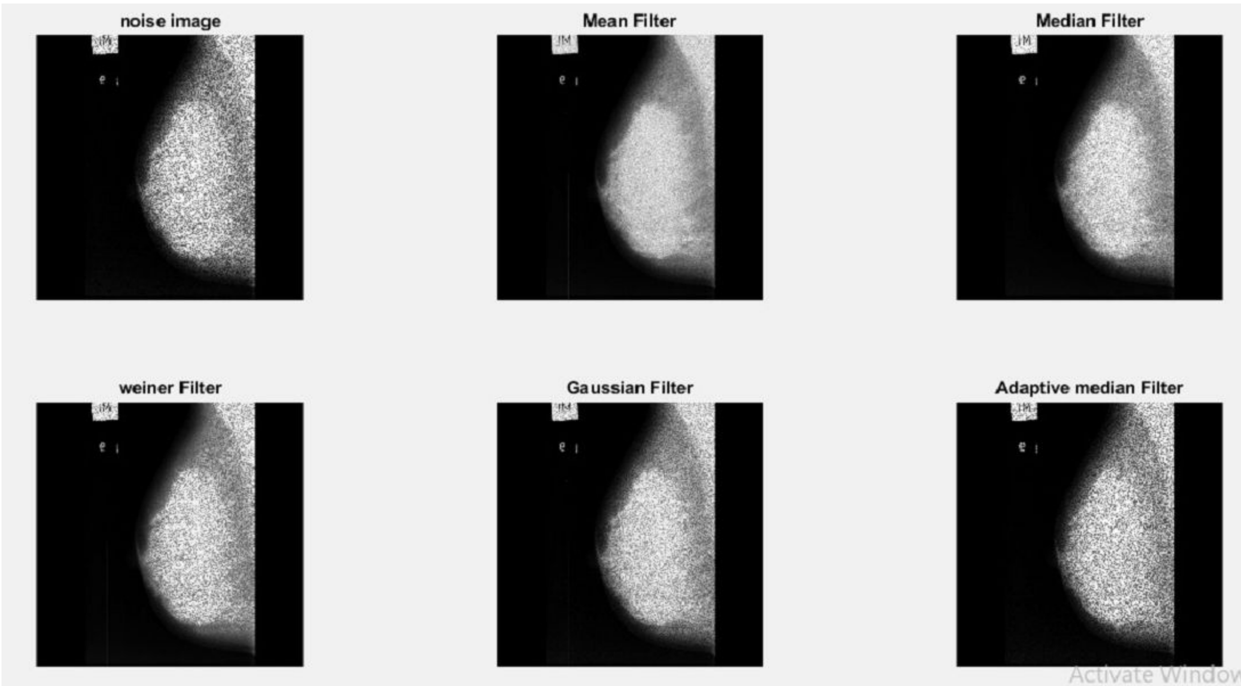


**Figure 16. Comparison at density 0.10**

| PARAMETER<br>FILTER | MSE | PSNR | SNR |
|---|---|---|---|
| NOISE | 699.5723 | 19.6825 | 11.1445 |
| MEAN | 613.9978 | 20.2491 | 11.4000 |
| MEDIAN | 697.0939 | 19.6979 | 11.1798 |
| ADAPTIVE MEDIAN | 80.0824 | 29.0954 | 20.3930 |
| GAUSSIAN | 18.6149 | 27.3894 | 18.6416 |
| WEINER | 1352.6762 | 16.8189 | 8.2805 |

**Table 10. Comparison at density 0.10**

### 4.4. Image Enhancement

Mammograms are low contrast images of breasts which are difficult to analyze as is. In order to make them easy to analyse, mammograms images are enhanced using image enhancement techniques. Image enhancement techniques basically improve the quality and information content of the original image and make the output image more sharp and bright. Commonly contrast enhancement, density slicing, FCC and spatial filtering are used to improve the quality before processing it.Contrast enhancement also known as stretching is done by increasing the original range of gray level. This is a linear transformation of an image. Density slicing changes the continuous gray tone range into a series of density intervals marked by symbol or separate color to represent different features whereas spatial filtering revolves around the improvement of naturally occurring features such as lineaments, fault and shear zones.

Thus to summarize it all, image enhancement is a process that manipulates an image digitally and stores the output image using software. The tools that are used for image enhancement consist of many other operations like filters, image editors etc. to change different properties of the original image.

### 4.5. Performance Parameters

The main motive for any image enhancement technique is to optimize the quality of the image to make it better for further processing. The performance and effect of an enhancement technique on the image can be evaluated visually which can be differ subjectively. Thus to evaluate and compare the effects fairly, some performance parameters are taken into consideration. This research work uses few parameters to evaluate the enhancement algorithms fairly and helps in choosing the best results given by enhancement techniques. The performance parameters used for the evaluation in this work include signal to noise (SNR), Effective Measure of Enhancement (EME) and Peak Signal to Noise Ratio (PSNR).

#### 4.5.1. Effective Measure of Enhancement (EME)

EME is derived by splitting the image into a number of blocks and using the equation,

$$EME = \frac{1}{K_1 K_2} \sum \sum 20 log \left( \frac{I_{max}(k,l)}{I_{min}(k,l)} \right)$$

Where $K_1$ is the number of horizontal blocks, $K_2$ is the number of vertical blocks in the image, $I_{max}(k.l)$ is the maximum pixel value in a given block and $I_{min}(k.l)$ is the minimum pixel values in a given block.

EME is considered as the qualitative measure of image enhancement.

#### 4.5.2. Signal to Noise ratio (SNR)

Signal to Noise ratio is calculated by taking the ratios of difference between intensities of foreground signal and background noise to the standard deviation of the noise. The higher the value of SNR, the more desired the algorithm becomes.

$$SNR = \left| \frac{\mu_{signal} - \mu_{noise}}{\sqrt{2}\sigma_{noise}} \right|$$

#### 4.5.3. Contrast to Noise Ratio (CNR)

When the ratio of difference between intensities of foreground signal and background noise to the standard deviation of the noiseis squared, it is called CNR. Formula is given below:

$$CNR = \left( \frac{\mu_{signal} - \mu_{noise}}{\sigma_{noise}} \right)^2$$

#### 4.5.4. Mean Squared Error (MSE)

MSE gives us the mean squared difference between the distorted and original images. It evaluates the similarity among the images by determining the average energy of signal's error. MSE is extensively used for measuring the quality of full reference images. Minimum the value of MSE, more similarities the processed image shows.

$$MSE = \frac{\sum_{M,N} \left[ I_1(m,n) - I_2(m,n) \right]^2}{M*N}$$

#### 4.5.5. Peak Signal to Noise ratio (PSNR)

A ratio among two images. It is often used as a quality measurement among the actual image and compressed image is called Peak Signal to Noise Ratio. The higher the value, the improved the quality of the compressed image.

$$PSNR = 10\, log_{10} \left( \frac{R^2}{MSE} \right)$$

### 4.6. Enhancement and analysis of mammograms

Enhancement in mammograms is done to achieve better contrast, especially when it comes to mammograms of dense breasts. The basic enhancement required in mammograms is a step-up in contrast, particularly for dense breasts. On mammograms of dense breasts, Contrast amongst normal dense tissue and malignant tissue might persist, but beneath human perceiving. Besides, calcifications in an adequately dense mass might be hard to read because of low contrast, thus identifying calcifications is challenging. To enhance the mammographic images

Photographic unsharp masking , digital unsharp masking, and spatial bandpass filtering have been used for mammogram enhancements.

Although a lot of work has been done for identification of image features and analysis of mammograms that indicate cancer, little effort has been put on enhancement of mammographic images. In this research the approach is to enhance tricky mammograms to decent standards to enable the radiologist to establish his diagnosis with more credibility.

**Figure 17. Original**

### 4.6.1 Enhancement by Histogram Equalization and Specification

Histogram equalization technique is employed to enhance the image contrast by many application fields. We use cumulative density function to perform histogram flattening along with stretching the dynamic range of gray levels. This contrast enhancement technique is not advisable as level of brightness gets manipulated significantly which may result in harsh view in the altered contrast and brightness levels.

### 4.6.2 Enhancement by Contrast Stretching

Contrast can be described as the difference between the intensity values of brighter pixels and darker pixels. The thought behind enhancement by contrast stretching is to raise the dynamic range of the image under observation. Contrast stretching broadens the intensity level range in an image. In order to produce a higher contrast image than the original image,two things could be done. Either we brighten the levels above (say) m in the original image or we darken the levels below m. Thus, being a simple enhancement that contrast stretching it, it simply increases the range of desired intensity values. It uses a linear function. Contrast stretching also known as normalization.

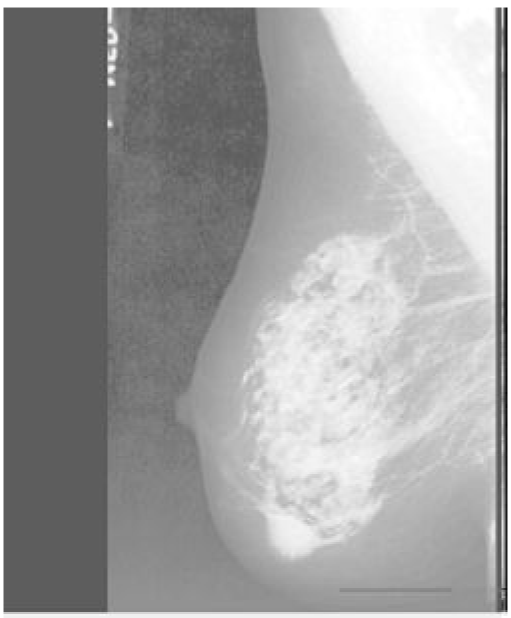

**Figure 18. Contrast Stretching**

### 4.6.3 Local and Global Contrast Stretching (LCS)

For enhancement of the image different elements are modified in LCS to boost the view of the whole image consisting of both dark and light components through operations executed simultaneously. The element situated at the center is modified and windows slide across the whole input image.

**Figure 19. Local and Global Contrast Stretching (LCS)**

### 4.6.4 Brightness Bi-Histogram Equalization (BBHE)

Bi-histogram equalization techniques autonomously equalize the two sub-histograms obtained by dividing histograms. This method is better used to lessen the diversity in mean image brightness after histogram equalization. In order to partition the histogram, several image characteristics such as mean gray level, median or some sort of automatically selected grayscale threshold are used. This technique based on Bi-HE (BBHE) was introduced to overcome the drawbacks of Histogram Equalization that triggered changed brightness levels with modified contrast.

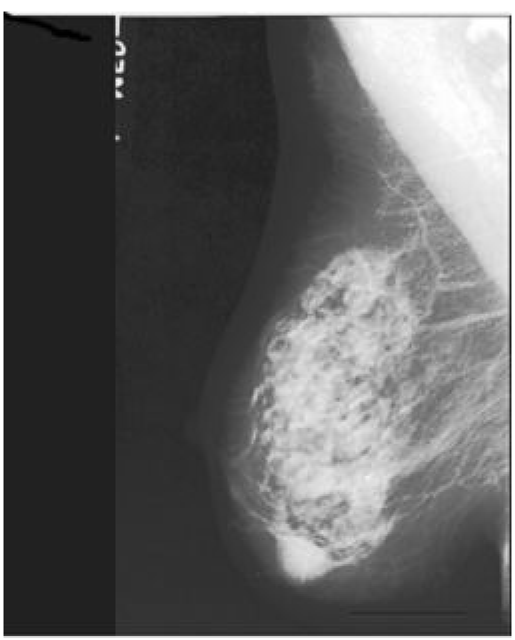

**Figure 20. Brightness Bi-Histogram Equalization (BBHE)**

### 4.6.5 Convolution Mask Enhancement

Convolution Mask Enhancement Convolution masking uses unsharp masking as enhancement operation. Originally unsharp masking was practiced photographically. Although in this technique an indistinct negative of the photograph is arranged in the register along with its positive image. We obtain the difference image that contains all the details in the image. This image that has only the details, is then accentuated so that it can be added to the blurred image and a print is obtained. As low-frequency details are reduced in intensity and the high-frequency information is magnified, this results in a sharper end print. Here we use a 3x3 mask for digital unsharp masking. This makes convolution mask enhancement one of the most used technique for image enhancement purposes. This procedure is avoided for the mammograms as it alters the appearing image too significantly whereas the total subjective image appearance is vital for diagnosis.

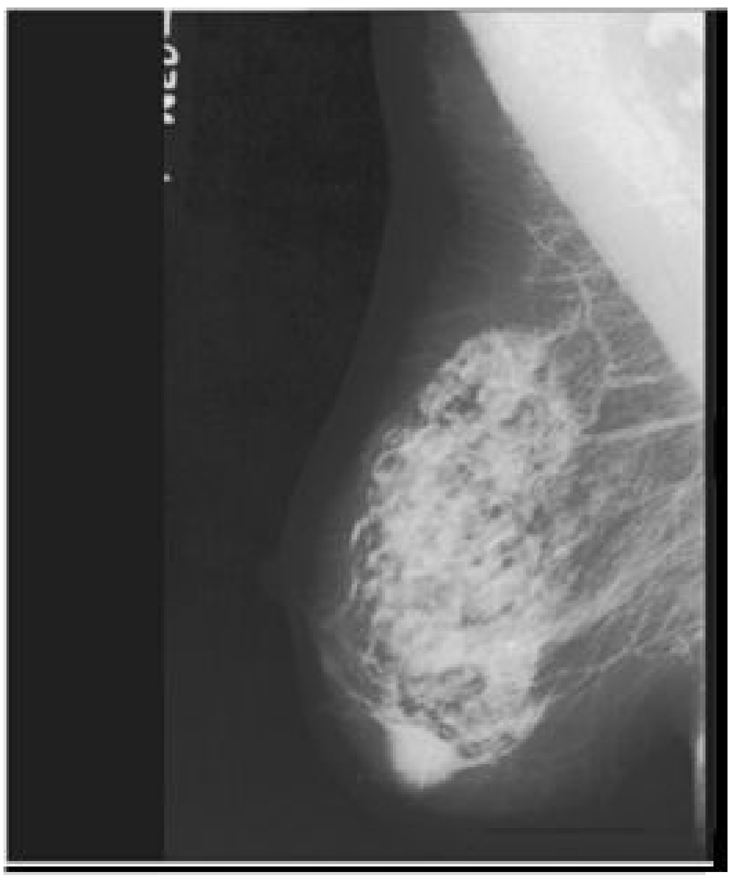

**Figure 21. Convolution Mask Enhancement**

### 4.6.6 Enhancement by Background Removal

The background removal enhancement technique uses the image's low-pass filtered version to subtract it from the image itself. We have used two methods, gray-scale morphological processing and spline filtering, to estimate image background. Unsharp masking is a simpler version of enhancement by background removal. Background subtraction is considered a direct technique to reduce slowly varying portions of an image thus allowing an increase in gray level variation in image details.

**Figure 22. Enhancement by Background Removal**

### 4.6.7 Region-based Enhancement

The methods discussed above are whether global techniques or fixed- neighborhood.

They may adjust to local features within a neighborhood, but do not embrace the size of the neighborhood to local characteristics. Thus, they modify the image using global properties that may not be representing  a small region of interest in the image. Numerous images, including mammograms, have isolated regions which are the essential features of interest. These features can differ in shapes and sizes, and often cannot be improved by global methods or fixed-neighbourhood.
We have modified the adaptive-neighborhood technique which grows by region and enhance every region by their local background.

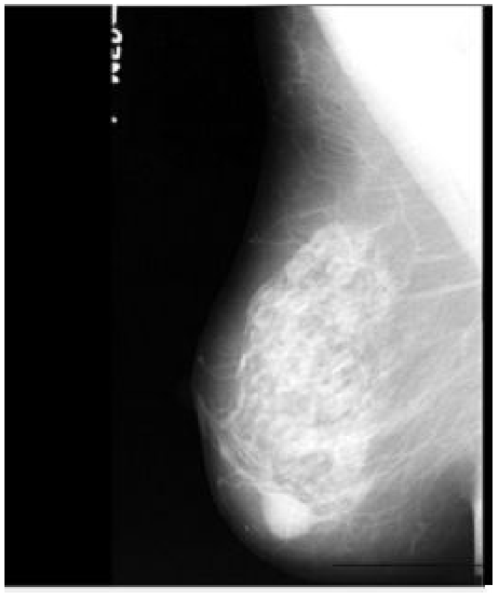

**Figure 23. Region-based Enhancement**

**4.7. Region Based Image Processing**

Conventional enhancement methods used for image enhancement are not capable of evolving to the changing characteristics of the image. Therefore by using fixed operators or global characteristics, we cannot achieve good results for a neighbourhood that is changing. A neighbourhood can be defined as the extent of which is dependent on the features of the image in which that pixel is present. This neighbourhood of similar pixels in region-based enhancement is given a term called region. During image segmentation, the groups of pixels with similar properties like gray level are used to specify separate image regions known as segments. To perform a region-based process on an image, we can start by segmenting the image and then dealing with each segment one by one. Otherwise we could face overlapping regions for every pixel and deal with each of these regions independently. If regions are characterized properly, they would represent features of the image.Thus, image features are treated as individual blocks instead of treating the pixels using random neighboring pixel groups. Now we process to implement image processing operations based on image features instead of doing it pixel by pixel.

This research work uses terms like region-based processing or adaptive region- based image processing. Establishing the image regions is the most basic step in all region based image processing algorithms. There can be two types of regions: non overlapping regions obtained during the image segmentation and overlapping regions obtained through the region growing techniques.

### 4.8. Proposed Method

Taking the shortcoming of these above ready-made methods, a modified algorithm is proposed using adaptive region growing method of image enhancement. The proposed technique consists of seed selection and 8-connected neighborhood approach.This algorithm depends upon the seed point to a great extent. This algorithm is divided into five major steps. a) Seed-Fill Region Growing. b) Region Growing Parameter c) Foreground enhancement done using Adaptive Histogram Equalization d) Combine Foreground and Background. e) Gradient of original image is then added to the image obtained.

#### 4.8.1. Seed-Fill Region Growing

A pixel in the original image is chosen which seems to be needing enhancement. This start pixel is called a seed pixel. Pixel aggregation is used here as the region growing method. The basis of this method is a simple graphical seed-fill algorithm in which regions include connected pixels that lie within a specified gray-level deviation from the starting or seed pixel. In this work we are using 4-connected regions for accurate region growing for high resolution mammogram images, whereas 8-connected was found more adequate for small features. The algorithm begins with the seed pixel which is our start pixel or given pixel. This start pixel is put in an empty queue. This queue will later hold pixels to be evaluated for whether the pixel will later be included or excluded from the growing region. Here the main loop is started. The loop is exited when the queue gets emptied which indicates all the pixels have been processed. If not, the start pixel is taken from the queue. A pixel to be considered as a foreground pixel, the gray level value of the current pixel into consideration should lie within a specific range from seed. If the contiguous pixels to the start pixel are not included in the queue due to the previous connection from the observed pixels, it is added to the queue as it is also possibly a foreground pixel.A pixel under consideration that does not fall inside the permitted gray level range is added as background pixel. This is how border pixels are obtained. There could be two types of borders, both internal and external borders. A region may possess both internal as well as external borders. Thus this clears that the background comprises more than one set of pixels and each set is disconnected from the other sets. Once all the neighbor pixels of the current pixel are observed, the command is returned back to the loop beginning to check the queue for succeeding pixels. By completing the background, we aim to discover the regions of the image. Once this is achieved, neighbours are investigated if they fall in line as foreground or background of the image. Otherwise they become part of the next layer of the background. This new layer starts a chain of discovering other layers on after the other until known background width is achieved. An inefficiency of a single pixel getting visited and observed more than one time, is faced by this region growing method. But this inefficiency can be overcomed by using other complicated algorithms applied along with line segments for region growing. There are the region's redundant seed pixels in the connected foreground that give us foreground and background based on the pixels with the same gray level. It was observed that region seed pixels improve the resolution of the mammogram by

7.5% which is a significant improve.Moreover percentage of the redundant pixel depends on the growth tolerance applied during the region growing. Images that have large uniform regions, they could have a higher percentage of redundant seed pixels.

### 4.8.2.Region Growing Parameters

Region growing parameters help us decide if a particular pixel is to be added to the foreground region or not. The most significant region growing parameter in applying seed-fill region growing is the growth tolerance. The growth tolerance parameter helps us determine whether a pixel is to be added in the foreground region or to be excluded from it. Growth tolerance suggests the deviation, be it positive or negative, regarding the gray levels of the seed which is permitted within the foreground region. The main reason behind using this particular type of growth tolerance is that the seed-fill region growing leads to the regions that have contrast higher than a decided minimum contrast. The results of the enhancement are desired to be independent of a multiplicative transformation of the image. For this purpose, this minimum contrast requires to be independent of region gray level.

### 4.8.3. Contrast Enhancement of Foreground

Here we have considered using clipped Adaptive histogram equalization (ahe) because Adaptive histogram equalization (ahe) is a contrast enhancement method designed to establish effectiveness. Moreover, if we over enhance noise using ahe, it creates two problems: a) ahe generates relatively homogenous regions and slow speed. The proposed algorithm is configured to remove these concerns. Thus we figured that clipped ahe should be prefered in medical imaging and clipped Adaptive histogram equalization might be made fast enough so that it can be regularly used in normal display sequence.

### 4.8.4.Combining Foreground and Background

After all the above steps, we add the background region to the already enhanced foreground. Thus to achieve the final enhanced image, pixels in foreground and background buffer are combined.

### 4.8.5.Gradient of original image

Eventually the gradient of the original image is included in the enhanced image achieved from step 3 and the final image is obtained.

### 4.9. Experiment & Result

The main motive for any image enhancement technique is to optimize the quality of the image to make it better for further processing. The performance and effect of an enhancement technique on the image can be evaluated visually which can be differ subjectively. Thus to evaluate and compare the effects fairly, some performance parameters are taken into consideration. This research work uses few parameters to evaluate the enhancement algorithms fairly and helps in choosing the best results given by enhancement techniques.

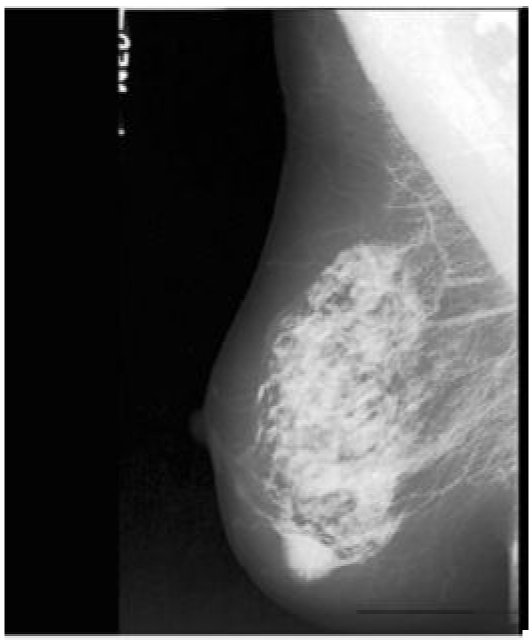

**Figure 24. Region-based adaptive contrast enhancement**

#### 4.9.1.Evaluation Parameters

In this research work Signal to noise(SNR), Effective Measure of Enhancement (EME), Contrast to Noise Ratio (CNR), Mean Squared Error (MSE) and Peak Signal to Noise Ratio (PSNR) are the evaluation parameters used for performance comparison of different algorithms. They are discussed briefly as below:

**a. Signal to Noise ratio (SNR)**

Signal to Noise ratio is calculated by taking the ratios of difference between intensities of foreground signal and background noise to the standard deviation of the noise. The higher the value of SNR, the more desired the algorithm becomes.

$$SNR = \left| \frac{\mu_{signal} - \mu_{noise}}{\sqrt{2}\sigma_{noise}} \right|$$

**b. Effective Measure of Enhancement (EME)**

EME is derived by splitting the image into a number of blocks and using the equation,

$$EME = \frac{1}{K_1 K_2} \sum \sum 20 log \left( \frac{I_{max}(k,l)}{I_{min}(k,l)} \right)$$

Where $K_1$ is the number of horizontal blocks, $K_2$ is the number of vertical blocks in the image, $I_{max}(k.l)$ is the maximum pixel value in a given block and $I_{min}(k.l)$ is the minimum pixel values in a given block.

EME is considered as the qualitative measure of image enhancement.

**c. Contrast to Noise Ratio (CNR)**

When the ratio of difference between intensities of foreground signal and background noise to the standard deviation of the noiseis squared, it is called CNR. Formula is given below:

$$CNR = \left( \frac{\mu_{signal} - \mu_{noise}}{\sigma_{noise}} \right)^2$$

**d. Mean Squared Error (MSE)**

MSE gives us the mean squared difference between the distorted and original images. It evaluates the similarity among the images by determining the average energy of signal's error. MSE is extensively used for measuring the quality of full reference images. Minimum the value of MSE, more similarities the processed image shows.

$$MSE = \frac{\sum_{M,N} \left[ I_1(m,n) - I_2(m,n) \right]^2}{M*N}$$

**e. Peak Signal to Noise ratio (PSNR)**

A ratio among two images. It is often used as a quality measurement among the actual image and compressed image is called Peak Signal to Noise Ratio. The higher the value, the improved the quality of the compressed image.

$$PSNR = 10\ log_{10} \left( \frac{R^2}{MSE} \right)$$

### 4.9.2.Evaluation of algorithm vs other techniques

The evaluation images are enhanced using proposed algorithm and other techniques. The above mentioned enhancement methods are used to produce the results for the valuation of the proposed algorithm and other techniques. The following results are produced by the mentioned enhancement methods: Figure 1, represents visual results for the test image. While analysing visually, we observed that the proposed algorithm produced a more precise and better enhanced image when compared to other techniques. Human visualization can not be considered a reliable criterion for image quality and performance evaluation of the proposed algorithm. Thus the values of SNR, MSE and PSNR are measured with the purpose of evaluation and then comparison of original image vs the resultant image. The results from the evaluation parameter concludes that the proposed enhancement algorithm improves the quality of the image.

| | HE | Contrast Stretching | LCS | Convolution Masking |
|---|---|---|---|---|
| MSE | 8126.14 | 496.1570 | 958.0308 | 892.3173 |
| PSNR | 9.0320 | 21.1746 | 18.3170 | 18.6256 |
| SNR | 0.7476 | 14.6568 | 10.6243 | 10.2510 |

| | Background Removal | Region Based | Proposed Algorithm |
|---|---|---|---|
| MSE | 2715.6478 | 541.4066 | 181.4657 |
| PSNR | 13.7921 | 20.7956 | 25.5429 |
| SNR | 8.4787 | 12.5112 | 17.7382 |

**Table 11. Comparison of different enhancement methods**

# CHAPTER 5
# POST PROCESSING OF MAMMOGRAMS

## 5.1. POST PROCESSING METHODOLOGY

Once the mammogram image is preprocessed, they are ready for further examination and evaluation. Purpose of post processing methodology is to make it easy for the radiologist to detect and examine the tumor easily. Post processing includes two steps:

1. Segmentation
2. Bilateral Asymmetry

## 5.2. SEGMENTATION

Region growing technique is used for the segmentation of masses, whereas border is extracted using Canny edge detection. Grayscale erosion by gray scale is used to process the border.
Later we process the border with grayscale erosion and then by grayscale dilation.

Procedure described as follows:

1. Region growing technique is used for the segmentation of masses. A highest intensity value for pixels is chosen as seed point S and threshold value T is also taken by observing histogram. Difference between location of the first major valley to the left of histogram and maximum mass value helps determine the value decided as threshold.

2. To extract the border, a Canny edge detection operator is used in matlab.

3. Grayscale dilation using a 5×5 kernel as a structuring element is done.

4. Grayscale erosion using a 5×5 kernel as a structuring element is done labview. Magic wand tool is used to find the margin of standard deviation, area, mass, mean, by utilizing magic wand tool.

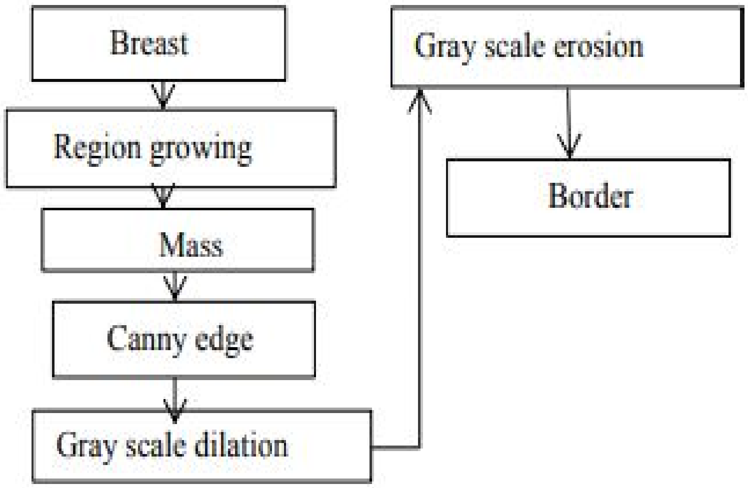


**Figure 25. Flowchart of Segmentation**

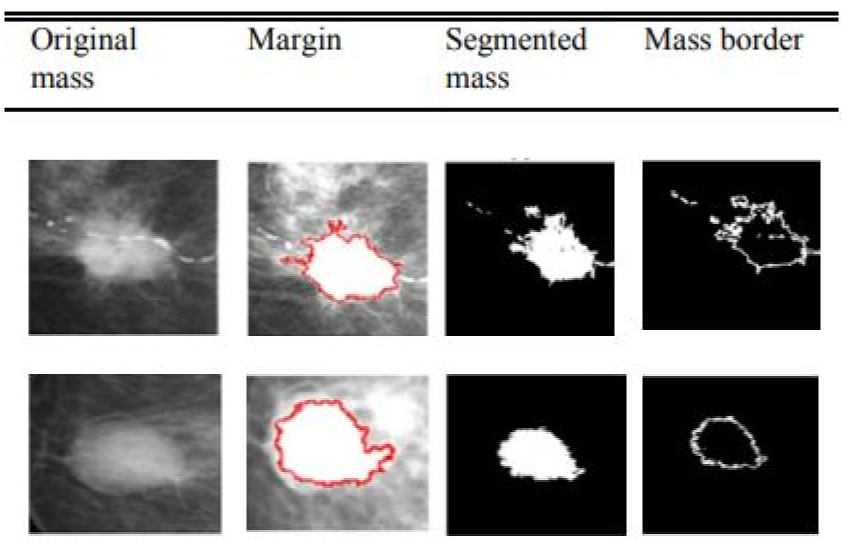


**Figure 26. Segmentation**

### 5.3. BILATERAL ASYMMETRY

Bilateral asymmetry is done to calculate the fluctuating asymmetry using volumes of left and right breasts. Phenotype-based deformation is a useful predictor and it is measured with the help of fluctuating asymmetry. Low fluctuating asymmetry indicates lower morbidity.

Volume V = $\pi \times w^2 \times h/12$

Fluctuating Asymmetry FA = $V^L + V^R/2 \mid V^L - V^R \mid$

$V^L$ = left breast volume

$V^R$: = right breast volume

Vdiff = volume difference

Procedure described as follows:

1. Use measure tool to get the height of the breast.
2. Use measure tool to get the width of the breast.
3. Calculate volume of right and left breasts with the help of above formula. The result is obtained in terms of pixels.

**Figure 27. Patient 1**

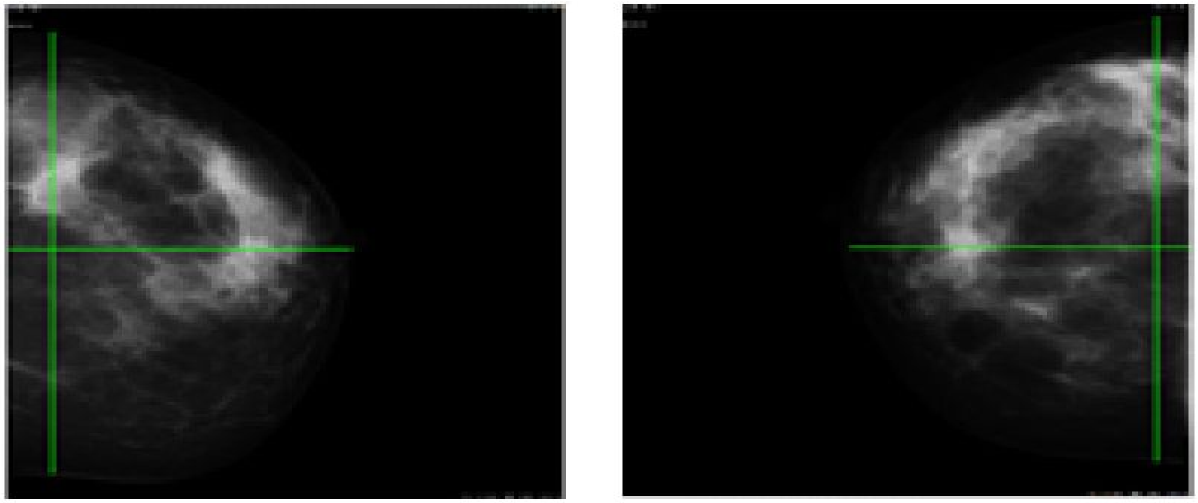

Figure 28. Patient 2

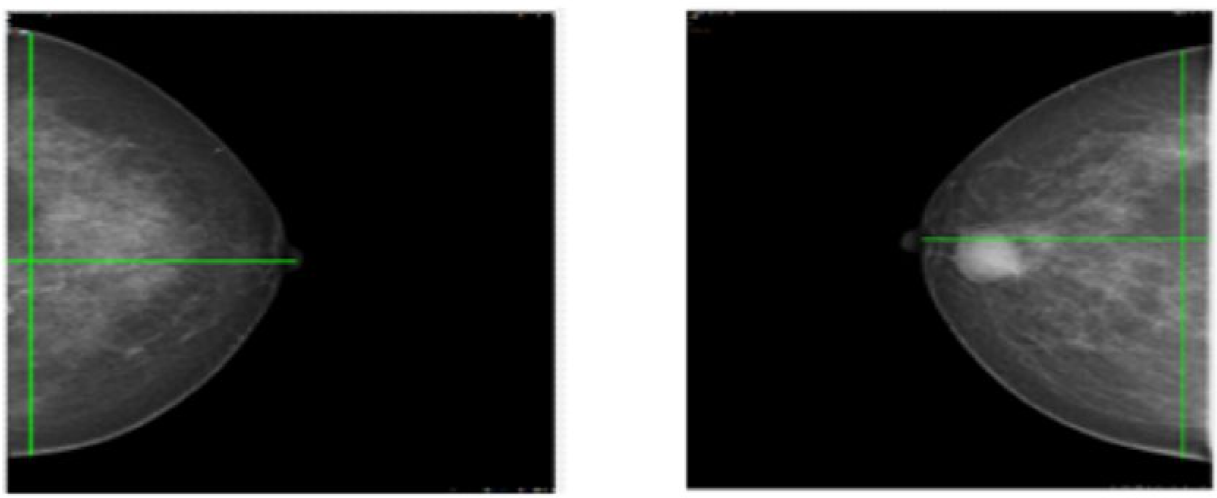

Figure 29. Patient 3

**Figure 30. Patient 4**

| Image | Masses | MC | Vdiff | FA | BA | A |
|---|---|---|---|---|---|---|
| 1 | SM | NP | 2359 | .0527 | P | M |
| 2 | NP | NP | 690.5 | .0070 | NP | N |
| 3 | CM | NP | 180.5 | .0025 | NP | B |
| 4 | NP | NP | 4910.2 | .03199 | P | EI |

**Table 12. P:Present, NP: Not Present, SM: Spiculated mass, CM: Circumscribed mass, MC: Micro calcification, FA: Fluctuation Asymmetry, BA: Bilateral Asymmetry, M: MAlignant, B:Benign, EI: Early Detection, A: Assessment**

## 5.4. CONCLUSION

It is observed that patients with high fluctuating asymmetry have high risks of breast cancer. So if a patient has benign cancer but fluctuating asymmetry is high, it can be considered as early detection of breast cancer. When we compare standard deviations, it is observed that the spiculated masses have less standard deviation in comparison to circumscribed masses. Along with this, high fluctuation asymmetry is observed which clearly indicates the presence of bilateral asymmetry that further encourages the investigation for early detection of breast cancer by the radiologist or doctor.

# CHAPTER 6
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