DETECTION OF BREAST CANCER AND SEGMENTATION OF ABNORMALITIES USING DEEP LEARNING AND IMAGE PROCESSING TECHNIQUES: A SURVEY

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Abstract : In recent years, Ministry of Health under Government of India has ranked Breast cancer as the number one cancer diagnosed among Indian women [1], followed by Cervical Cancer. India has witnessed an increase in the number of young women diagnosed with Breast cancer. In order to address this public health problem, there is a need of improving the diagnostic techniques in detection of breast cancer. Various imaging modalities used in the detection of breast cancer are Mammography, X-Ray, MRI (Magnetic Resonance Image), Computed Tomography (CT) etc. In this paper, we discuss Imaging modalities for detection of cancer, Computer aided diagnosis systems, and present a survey of Techniques used for Detection of breast cancer using Deep Learning and Segmentation of abnormalities from medical imaging using Image processing. These computer aided methods may improve interpretation of imaging results, thus helping doctors make better decisions in the treatment and management of breast cancer.

***Index Terms* - Cancer, Radiology, Imaging Modalities, Deep Learning, Image processing, Classification, Segmentation.**

I. INTRODUCTION

Breast Cancer is a common cancer found among women in India, and has overtaken cervical cancer lately. Breast cancer is generally diagnosed in women between the age group of 50-64, but has now been found to affect younger women. According to the latest report [1], it was found that 1 in 2 women diagnosed with breast cancer dies in India. Breast cancer accounts for 14% of all cancers in women. In 2018, around 1,62,468 new cases of breast cancer were registered, out of which 87,090 died. Overall, 1 in 28 women is likely to develop breast cancer in her lifetime. In urban areas, 1 in 22 women and in rural areas, 1 in 60 women is likely to develop breast cancer in her lifetime. Breast cancer poses a serious public health problem, these observations indicate the need for improving diagnostic techniques to detect breast cancer.

Cancer is a complex and multifactorial disease which is caused due to variety of genetic and environmental factors. There are more than 100 types of cancer presents in all, among which breast cancer is more common among women. Breast cancer most often begins in the milk ducts of the breast, and starts when cells present in breast tissue begin growing in an uncontrolled way, and form a tumor which may be felt as a lump. This tumor may be malignant or benign. Malignant tumor is cancerous and is the one to be worried about. The cells of malignant tumor can spread to other parts of the body through blood or lymph system. Benign tumors on the other hand are non-cancerous and they do not spread.

According to the Ministry of Health and Family Welfare under Government of India , India has low survival rate for breast cancer, with only 66.1% women diagnosed with the disease between 2010 to 2014 surviving compared to other countries such as the US and Australia where survival rate is about 90%. Survival rate can be improved if cancer gets diagnosed early. According to WHO, 50% of diagnosed cancer in India are in Stage III or Stage IV where treatment of cancer becomes very difficult which contributes to high mortality rates. Moreover, Doctor-patient ratio and lack of awareness among people leads to delay in treatment which adds to mortality rate.

Doctors who detect cancer are called as Radiologists and those who treat cancer are called Oncologists. Radiologists detect cancer using various imaging modalities such as Mammography, X-ray, Magnetic Resonance Image (MRI), Computed Tomography (CT) etc. Mammography and X-Rays are widely used as they are easily available and are less expensive. These scans identify the abnormal area, but do not differentiate cancerous cells from non-cancerous cells. To know about possibility of malignancy in the cells, doctors recommend a biopsy. Biopsy is a painful process and may result in false positive results. Therefore, there is a need to have a computer aided system to help doctors make precise diagnosis, resulting in possible reduction in biopsies, and enabling detection even when tissues in the breast are denser than normal.

The paper is organized as follows: In section II we have discussed imaging modalities used in detection of Cancer, in section III Computer Aided Diagnosis systems are discussed, in section IV Survey of Techniques used for Classification of breast cancer using Deep learning, and Segmentation of abnormalities from breast scans using Image processing are presented, in section V we have drawn conclusion and identified future work based on techniques discussed in section IV.

II. IMAGING MODALITIES FOR DETECTION OF CANCER

There are several imaging modalities used by doctors for detection of Breast Cancer. In this section, imaging modalities widely used in breast cancer detection are discussed, and are summarized in Table 1.

2.1. Mammography

Mammography is a medical imaging technique which uses low dose X-ray to examine human breast tissue. It is used for screening, early detection and diagnosis of breast cancer.

Mammography is widely used for detection of breast cancer as it is easily available and also not expensive. But it has limitations in terms of accuracy of results in diagnosis of breast tissue with high density. As a result, radiologists fail to detect 10-30% of breast cancers [4]. Moreover it has been shown that 17-34% of cancer foci visible on breast MRI (BMRI) are not detected by Mammography [28].

2.2. Ultrasound

Ultrasound is a beneficial tool to evaluate breast issues as a patient-follow–up tool to find abnormality in physical exam or mammography, for biopsy guidance and locating the tumour. Studies indicate that ultrasound is able to detect and discriminate benign and malignant tumours with high accuracy and sensitivity, specially invasive cancer in dense breast tissue. However, it is an operator-dependent modality and the interpretation of its images requires expertise of the radiologist.

2.3. Computed Tomography (CT)

Computed Tomography is a diagnostic imaging technique that uses X-ray to build cross-sectional images of the body. It is based on the principle that density of tissue passed by the X-ray beam can be measured from calculation of attenuation coefficient [6]. CT images generally have non-contrast enhanced CT images. Thus in order to improve visualization of lesion, images are acquired by injecting iodinated contrast agent intravenously, known as contrast enhanced CT images.

CT imaging has some advantages and some disadvantages. It is quick, tolerable and informative, has excellent temporal resolution in the contrast enhanced dynamic phases, and has good soft tissue information. CT has improved quality of imaging for detection as compared to ultrasound, but has some contraindications making it unsuitable for some patients. These contraindications include allergy to the injection of contrast agent (iodine), renal failure, diabetes, multiple myeloma, thyroid disease being treated with iodine [6].

2.4. Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging uses non-ionising radiation to create useful diagnostic images. MRI makes use of magnetic properties of human body and hydrogen nucleus to produce detailed images of body parts. The hydrogen nucleus is used as it is abundant in fat and water. MR imaging is beneficial for patients who are allergic to iodine-based CT contrast agents, or suffer from renal conditions (transplantation/ insufficiency). MRI is widely suggested for screening high risk patients of breast cancer.

Like other imaging modalities MRI also has some advantages and disadvantages. The advantage of MRI is its ability to perform imaging without using any radiation, in contrast to CT. With MRI, images can be obtained in multiple planes without repositioning the patient. The main advantage of MRI over CT is its superior soft tissue contrast compared to CT. On the negative side, MRI is expensive compared to other modalities, and is contraindicated in patients having cardiac pacemaker, surgical and vascular clips, small ferromagnetic foreign bodies, etc.

Table 1. Review of Imaging modalities used for detection of breast cancer

	Mammography	Ultrasound	Magnetic Resonance Imaging	Computed Tomography
Techniques used	Low dose X-ray is used	High frequency sound waves	MRI uses magnetic property of human body	X-rays are used
Radiation Risk	Radiation in involved	No radiation is involved	No radiation involved	Moderate radiation in involved
Contrast Agent used	Contrasting agent contains iodine	Micro bubbles are used as contrasting agents in ultrasound	Gadolinium is used.	iodinated contrast agent is used
Cost Involved	medium	Low	High	Medium
Tumor detection	Moderate	Difficult	Easy	Easy
Treatment planning	Used in guiding for biopsy and surgery	Supports in guiding surgery	Supports in guiding for biopsy, in follow up patient's treatment	Supports in guiding for biopsy, in follow up patient's treatment
Unsuitable Cases	When tissues are very dense	When high resolution is required	When metal is present inside the body	Patient is allergic to contrasting agent
Advantages	Used for diagnosing abnormality in breast.	Less expensive, Easily available, less time required for screening	No exposure to radiation, thus is safe	Contrast enhanced images produce good results
Disadvantages	It is not suitable to the patients whose breast has very dense tissues. It can also damage DNA cells.	It depends on operators experience and contains not-uniformity	Not suitable for patients containing cardiac pacemaker, surgical and vascular clips, small ferromagnetic foreign bodies	Not recommended for patient who are allergic to contrasting agent, diabetic patients, and kidney failure.

III. Computer Aided Diagnosis System

3.1. Objective of Computer Aided Diagnosis Systems

Radiologists are challenged by issues related to image quality and human error in diagnosis of cancer. Computer Aided Diagnosis (CAD) systems are being designed to overcome these challenges by automating breast cancer detection and classification into benign/ malignant lesions. Radiologists can use CAD system as decision support system, to aid in the final diagnosis/ classification/ staging. CAD systems have been developed for assisting physicians in screening of chest, breast, and colon cancer [3].

The main objective of Computer aided-diagnosis systems is to provide accurate and reliable results to decrease misdiagnosis and assist in decision making, thus improving the accuracy and efficiency of the Radiologist. CAD systems use Deep learning and Image processing techniques.

3.2. Deep learning for classification

Deep learning is the technology which resembles the way human brain works. It is a class of machine learning that consists of network of interconnected simple units. These units form multiple layers which are capable of extracting information and patterns from given input data.

In traditional classification using Machine learning, there are two main phases: Training phase and Prediction phase. In the Training phase, Machine learning model is trained using a dataset comprising of images and their corresponding labels, and in Prediction phase, the trained model is used to predict unseen images. Training phase consists of two steps: the first is Feature extraction and second is Model training. In Feature extraction we find important characteristics of an image which can be used for classification such as Histogram of oriented gradients (HoG), Scale-Invariant Feature Transform (SIFT), Speeded up robust features (SURF), blobs, edges, etc. This requires deep domain knowledge. In Model training step, Classification model is trained using cleaned dataset which consists of features extracted from first step with corresponding labels. Refer Figure 1.In Deep learning Features are extracted automatically by algorithm itself. Deep learning has the potential of assessing a large number of features, and arrive at results in minimal amount of time. Convolutional neural network (CNN) is one of the common Deep learning methods used in computer vision, object detection, classification, etc. CNN uses two phases in classification: Training phase and Classification phase. In Training phase, CNN is trained by adjusting the weights of the individual neurons, till the error (difference between actual and predicted value) is minimized. In Classification phase the trained model is used for classification. Unlike Classification through machine learning, features in CNN are extracted automatically by algorithm. Fig 1 shows the difference between classification through Machine Learning and Deep Learning.

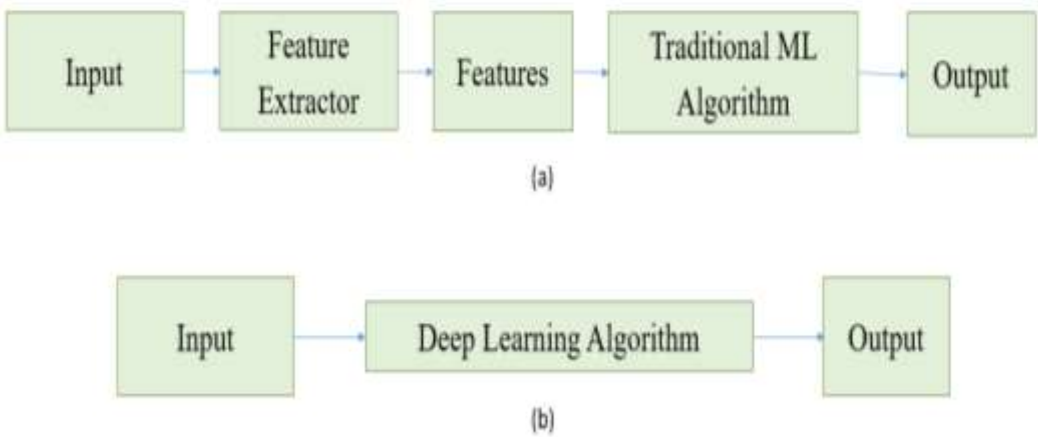

Figure 1: classification flow: (a) using machine learning, (b) using deep learning

In medical field, large data sets required in training the model are not easily available resulting in over fitting the network. To overcome this problem, Data augmentation and Transfer learning may be used. In Transfer learning **[11, 13]**, the network is first trained using different datasets. Then, the network is fined-tuned through additional training with dataset specific to the problem being addressed.

3.3. Image processing for Segmentation:

In medical imaging, image segmentation plays an important role, and in case of breast cancer, helps in locating the abnormal or malignant lesion, which can in turn guide cases referred for biopsy. There are different approaches for segmentation using image processing, as shown in figure 2 and are discussed below:

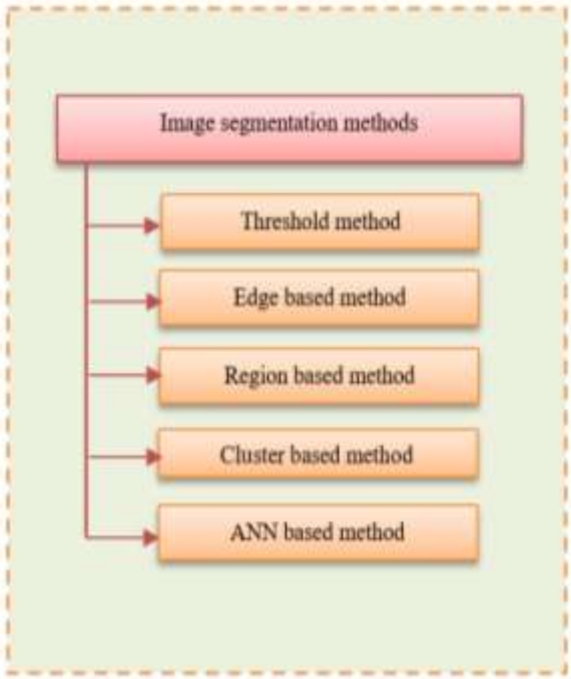

Figure 2. Image segmentation techniques

i. Thresholding method: This is a popular and commonly used method for image segmentation. This method is mainly used to distinguish the foreground objects from background images. Threshold values are chosen based on prior knowledge. Thresholding methods are broadly divided into three categories: Global Thresholding, Variable Thresholding and Multiple Thresholding.

ii. Edge Based Method: The connected pixel along the boundary of regions are called edges. The edges are determined to know the discontinuity of objects present in image. There are various types of edge detectors such as Canny edge detector, Prewitt edge detector, Sobel edge detector filter etc. Edge detection methods fall under structural technique.

iii. Region Based Segmentation Method: This algorithm starts with a set of seed pixels (i.e. region) defined by the user, sequentially adding a pixel to the region provided the pixel has not been assigned to any other region, and is a neighbour of that region. It operates on iteratively grouping together pixel which are neighbours having similar values and splitting groups of pixels having dissimilar values. Region growing [22], Region merging and Split & merge are region-based segmentation algorithms.

iv. Clustering based segmentation method: In clustering based techniques an image is segmented into clusters having pixels with similar characteristics. There are two basic categories of clustering methods: Hard Clustering (e.g. K-means clustering) and Soft clustering (e.g. Fuzzy C-means clustering) [31].

v. Artificial Neural Network (ANN) Based Segmentation method: This method is now popularly used, separates image from background in two steps: Feature extraction and Segmentation by neural network.

IV. Survey Of Computational Methods For Classification Of Breast Cancer And Segmentation Of Abnormalities Using Medical Imaging

In this section a survey of papers using Computational methods in Detection of Breast Cancer (refer Table 2) and Segmentation of Abnormalities (refer Table 3) used in medical imaging have been described.

4.1. Classification of Breast Cancer:

Detection of breast cancer uses Classification techniques. In machine learning, Classification is the problem of identifying the category to which a given object belongs. Classification is used in medical imaging to determine the presence or absence of abnormality in the image and classifying this abnormality as malignant or benign [1,12,13]. Classification process depends on the extraction of features from images. There are two ways of extracting features from images: handcrafted and automatic. Automatic feature extraction can be done with Deep learning algorithms specifically CNN [11]. Different CNN models are used in breast cancer detection such as VGGNet [14,18], Alexnet [19], ResNet [19], UNET [19]. Transfer learning [17,18] is used for training when dataset is small. We came across usage of machine learning algorithms for classification such as Support vector machine (SVM), K-nearest neighbour (KNN) [15], Random forest which use handcrafted features.

In [24], Rasti, R., proposed Mixture Ensemble of Convolutional neural network (ME-CNN) model which can be used as effective tool by radiologists to analyse breast dynamic contrast enhanced magnetic resonance imaging (DCE-MRI) images. DCE-MRI is more sensitive in detecting breast cancer compared to mammography and ultrasound. This system uses two steps: i) Tumor Segmentation based on the intensity and morphological information of masses in image, using local active contours for finding the region of interest from a breast MR image; ii) Tumor Classification based on deep learning ensemble of CNN called ME-CNN, for classification of benign versus malignant breast tumors.

Sanket Agrawal in [25] detected the probability of early stage breast cancer using mammography images. The mammography images are pre-processed using Contrast Limited Adaptive Histogram Equalization (CLAHE) technique. In order to detect masses from mammograms, a hybrid approach has been used. The author combined neural network with linear classifier. Author has used Visual Geometry Group (VGG-16) CNN model for feature extraction. These features are then fed to linear classifiers. Linear classifiers used are Decision trees, K-nearest neighbour, Gradient boosting. It was observed that none of the classifiers gave good results. So, they were used as an ensemble in a voting Classifier. This method was successful in classifying images into normal or abnormal, and gave about 85 % accuracy.

In [26], Al-masni proposed a CAD system based on regional deep learning techniques: You Only Look Once (YOLO). The system consists of four steps: pre-processing, feature extraction, mass detection and mass classification using fully connected network (FCN). Trained YOLO model is used to classify mass as benign or malignant. Author achieved overall accuracy of detection of mass was 96.33% and of classification was 85.52%.

Syed Jamal in [27] has applied Deep CNN VGG-16 for classification of normal and abnormal mammograms Region of interest (ROI). Features extracted from VGG-16 is then given to four different classifiers i.e. Simple logistic classifier, Binary decision tree classifier, Support vector machine classifier, K-nearest neighbour. For each case 10 folds cross validation is applied. Using SVM, KNN, Binary decision tree the author observed the accuracy to be 100% and using Simple logistic accuracy was 99.8%.

In [28], Arbach, L., presented the system for classification of significant lesion into malignant or benign. First the difference between the pre-contrast and post-contrast image is found to know the enhanced region. Then the ROI is marked by experts. Region shape feature is used to characterise the enhanced region. Then Perimeter length is found by measuring the number of boundary pixels. Using these features the back propagation neural network (BNN) is trained against biopsy results. They used three layers containing three neurons in hidden layer and one neuron in output layer.

4.2. Segmentation of Abnormalities

Once cancer is detected, the next step is evaluation of the extent of spread, also referred to as Segmentation. Image segmentation is the method of dividing an image into different regions in order to view them separately. In medical imaging, Segmentation is used for finding extent of abnormality and its exact location in the scan.

Dong Yin in [29], proposed a method of 3D reconstruction on segmentation of breast and tumor. Author first found the area of interest from chest film to find breast cancer. For this breast contour was detected using combination of Otsu and region growing method. From segmented image he found tumor region by calculating mean and variance on either side of mammogram in scan. The part with value greater than the threshold is considered as lesion area.

Yanli Tan in [30], presented the algorithm for automatic breast tissue segmentation of sagittal dynamic contrast enhanced magnetic resonance imaging (DCE-MRI) sequences. The method has two steps: i) generate first mask to remove the pectoral muscle. ii) the second mask is created to mask out air region and breast wall. The masks were applied on each slice to eliminate chest region. To separate the background, images were converted into binary images. Multiple morphological operations were then applied to remove the undesired noise.

Ali Qusay Al-Faris in [31], presented an automatic CAD system for breast MRI tumour segmentation. The study focuses on tumor segmentation using modified automatic seeded region growing algorithm with variation of the automated initial seed and threshold selection methodologies. Before applying of main method author pre-processed each image. The image is split into two sub-images by finding centre of x-coordinate and splitting. Then median filter is applied for removing noise from image. The breast skin is then detected and deleted using level-set active contour algorithm.

Table 2. Techniques for Classification

Title	Author	Preprocessing / Features	Classification Technique	Imaging Modality	Remark
Breast Cancer Diagnosis in DCE-MRI using Mixture ensemble of Convolutional Neural Networks **[2017]**	Rasti, R., Teshnehlab, M. and Phung, S.L	Contrast enhancement, global Otsu thresholding, morphological filtering, radius based filtering, active contour segmentation, ROI selection	Ensemble of Convolutional Neural Network as experts.	MRI	• MRI have high sensitivity and high resolution in dense breast tissues. • Accuracy achieved by this technique is 96.39%, a sensitivity of 97.73% and a specificity of 94.87%.
Detection of Breast Cancer from Mammograms using a Hybrid Approach of Deep Learning and Linear Classification. **[2018]**	Sanket Agrawal, Rucha Rangnekar, Divye Gala, Sheryl Paul and Dr. Dhananjay Kalbande	CLAHE histogram, flipping of images and downsizing, image enhancement using histogram	CNN for feature extraction. Decision tree, KNN, Gradient descent for classification.	Mammography	• The main purpose of this paper is to detect the probability of early stage breast cancer detection using mammography images. • This method provided 85% accuracy. • Future scope include better contrast enhancement would help achieve a better classification accuracy

Detection and classification of the breast abnormalities in digital mammograms via regional convolutional neural network. **[2017]**	Al-masni, M.A., Al-antari, M.A., Park, J.M., Gi, G., Kim, T.Y., Rivera, P., Valarezo, E., Han, S.M. and Kim, T.S.,	Multi-thresholding peripheral equalization technique. Resizing in 448*488.	You Only Look Once (YOLO)	Mammography	• The system contains four steps: pre-processing, feature extraction, mass detection and mass classification using fully connected network (FCN). • Author achieved overall accuracy of detection of mass was 96.33% and of classification was 85.52%. • This method only classifies the density, it does not classify the image into malignant or benign.
Mammogram classification using Deep learning Features**[2017]**	Syed Jamal Safdar Gardezi, Muhammad Awais, Ibrahima Faye, Fabrice Meriaudeau	___	VGG-16 CNN, Simple logistic classifier, Binary decision tree classifier, SVM, KNN	Mammography	• This paper presents a method for classification • of normal and abnormal tissues in mammograms using a deep learning approach. • Featured extracted from VGG-16 are given to classifiers explicitly. • VGG-16 involve many parameters which makes it heavy and also faces Vanishing gradient problem.

Table 3. Techniques for Segmentation

Title	Author	Preprocessing	Segmentation Technique	Imaging Modality	Remark
A Method of Breast Tumour MRI Segmentation and 3D Reconstruction**[2015]**	Dong Yin, Ren-wei Lu	Segmenting lower and upper part.	Otsu in combination with region growing	MRI	• Proposed a method of 3D reconstruction on the Segmentation of breast and tumor. • Segmentation involve two parts: breast contour and tumor. • It provides doctors richer details of human organs and more lesion location information which can't be obtained by 2D image so as to facilitate the surgical procedure • Otsu method considers the image to be of binary class due to which it divides histogram in two parts. But in MRI images the can be pixels in ROI which can have same value as background.
Automatic Breast DCE-MRI Segmentation Using Compound Morphological Operations**[2011]**	Yanli Tan, Li Liu, Qingqing Liu, Jian Wang , Xueyun Ma, Hairi Ni	Images are converted into binary images	Morphological operation is used.	Sagittal DCE-MRI	• Automatic segmentation method based on morphological operations was proposed. • Binary image is used to separate background. • Multiple morphological operations are used to remove noise. • To separate breast contour from chest, chest contour mask was generated.
Computer-Aided Segmentation System for Breast MRI Tumour using Modified Automatic	Ali Qusay Al-Faris & Umi Kalthum Ngah & Nor Ashidi Mat Isa	Splitting image into two halves. Median filter to reduce salt and pepper noise	Seeded region growing algorithm	MRI	• Study mainly focused on tumor segmentation using modified automatic seeded region growing algorithm with variation of automated initial seed and threshold methods. • The study is limited to segmentation.it is not able to type the tumor i.e.in benign or malignant.

Seeded Region Growing**[2014]**	& Ibrahim Lutfi Shuaib				

V. CONCLUSION

In this paper we have discussed Imaging modalities used in detection of cancer and observed that MRI has high sensitivity, high resolution and is emerging as new modality to help in detection of cancer in dense tissues. We have described computer aided diagnosis methods like Deep learning and Image processing.

We have presented a survey of computational techniques for Classification of breast cancer using Deep Learning like - BNN, VGG-16, YOLO, etc. The limitation of BNN is premature convergence[28], VGG-16 is used in **[27]** only for feature extraction, having many learning parameters, making it heavy for computation and has vanishing gradient problem, Yolo in [26] provides less accuracy and is not suitable for medical use.

We also reviewed the techniques for Segmentation using Image processing which helps in detecting the abnormal areas and can provide guidance for further decisions such as biopsy and surgery by knowing the size of tumor, from segmented images. Segmentation methods Otsu method – which has limitation in detecting small abnormal lesions, Region growing algorithm - found to segment abnormalities fast but requiring initial seed values.

Future work requires the development of the hybrid system using classification and segmentation to improve accuracy. The hybrid system can augment the process of diagnosis by doctors in detection of cancer in terms of accuracy and speed, resulting in qualitative improvement in both biopsy and surgery.

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