Integration of Artificial Intelligence in Medical Imaging for Breast Cancer Detection and Diagnosis

Tanay Goyal, Puneet Singh
Department of Computer Science and Engineering, Chandigarh University, Punjab, India
19BCS1165@gmail.com, 19BCS1167@gmail.com

Abstract- This paper explores the role of artificial intelligence (AI) in medical imaging for breast cancer detection and diagnosis. AI algorithms have shown promising results in improving the accuracy and efficiency of breast cancer diagnosis and detection. This paper discusses various AI techniques used in medical imaging, such as convolutional neural networks (CNNs) and deep learning methods. It also examines the challenges involved in applying AI to medical imaging, such as data quality and ethical concerns. The paper concludes that AI has the potential to revolutionize breast cancer detection and diagnosis, but further research is needed to ensure its safe and effective implementation in medical practice.

Keywords- Mammogram, Surgery, Cancer, Magnetic Resonance Images, Breast Cancer, ML model, CT Imaging.

1. Introduction

Breast cancer is a serious health problem that affects people all over the world. Reduced morbidity and mortality rates are among the benefits of early diagnosis and detection of breast cancer for patients. Breast cancer detection, diagnosis, and treatment all depend heavily on medical imaging. Different imaging methods have been created and improved over time to increase their sensitivity and specificity in identifying breast cancer. These procedures include computed tomography [1]. (CT), MRI, PET, MRI with positron emission tomography (PET), and mammography. Medical imaging for breast cancer has been transformed by recent technology developments, providing better detection, improved diagnosis, and individualised treatment. Breast cancer is the most common malignancy in women worldwide, predicted to be discovered in 2.3 million new cases in 2020 alone [2]. Early identification continues to be the most efficient strategy to lower mortality rates, even when improvements in therapy have increased survival rates. Mammography is the gold standard screening tool for breast cancer and has been used extensively in the detection and diagnosis of the disease for many years. Traditional mammography, though, has its limitations, especially for women with dense breast tissue or those who are at a high risk of breast cancer. Numerous medical imaging techniques have been created and improved in order to get around these restrictions and increase the precision of breast cancer detection and diagnosis. Ultrasound, MRI, PET, CT, and more recent technologies like Digital Breast Tomosynthesis (DBT) and Contrast-Enhanced Spectral Mammography (CESM) are some of the techniques used. Artificial intelligence (AI) and molecular breast imaging (MBI), two recent developments in medical imaging technology, have increased the sensitivity and specificity of breast cancer detection and diagnosis [3]. An overview of the state of medical imaging for breast cancer, including the benefits and drawbacks of each imaging modalities, is what this review paper seeks to do. The paper will also discuss recent advancements in imaging technology and how they may impact the management of breast cancer. This study aims to provide academics and healthcare professionals with a comprehensive understanding of the role of medical imaging in the management of breast cancer. One of the most prevalent malignancies in women, accounting for 12.5% of all new cancer cases worldwide, is breast cancer. According to projections from the International Agency for Research on Cancer (IARC), there would be around 2.26 million new cases of breast cancer and, deaths globally in 2021. Late discovery, which significantly lowers survival chances, is one of the main issues with this complaint. Women with locally advanced disease have a median survival rate of 97.5 years, compared to an estimated 29 years for breast cancer that has progressed to distant body regions. Lately, emphasis has been placed on reducing mortality by early identification using innovative clinical evaluation methods. In situations of asymptomatic breast cancer, the main imaging technique is mammography, which has been proven to reduce mortality by 30 to 70 percent. A radiologist interprets mammograms and assigns them a clinical classification. The breast imaging reporting and data system (BI-RADS) evaluation of the results is used to report the findings. Fresh tests, similar as a special type of mammogram or ultrasound, are demanded to find abnormal areas on a mammogram. However, fresh vivisection testing is considered, if these findings suggest cancer [4]. Still, it’s delicate to dissect these images due to the different types of lesions and differences between lesions and thick breast towel. thick towel can also cover nasty excrescences, reducing the perceptivity of mammography. Computer- backed opinion (CAD), a useful and necessary CT imaging fashion for breast cancer discovery, can give a alternate opinion to ameliorate breast cancer discovery and help radiologists in lesion discovery and individual decision- timber. He can also assess the liability that the lesion is benign or nasty. CAD systems are grounded on several processes similar as pre-processing, image completion, point birth, point selection and model bracket [5]. The application of statistics and information and communication technology (ICT) to scientific imaging for the force of healthcare services is covered by scientific imaging informatics. Over the past 30 years, a vast array of multidisciplinary scientific imaging immolations have developed, spanning from everyday scientific exercise to advanced mortal body structure and disease. First, it was described as follows by the Society for Imaging Informatics in Medicine (SIIM) The term "imaging informatics" refers to the study of all aspects of the imaging chain, including snap preface and accession, snap distribution and control, picture storage and reclamation, image processing, analysis, and comprehension, as well as visualisation and data navigation, as well as print interpretation, reporting, and dispatches. The industry acts as an integrative catalyst for those procedures and bureaucracy, laying the foundation for imaging and various clinical specialties. According to SIIM, the goal of medical imaging informatics is to increase the effectiveness, sensitivity, and trustworthiness of services provided by the medical industry with regard to the use and modification of medical images in sophisticated healthcare systems [6]. A new technology is emerging for clinical imaging informatics in this environment, defining the path towards the perfection of medical medicine. This is related to the abettor technological advances in massive- data imaging, omics and digital fitness data (EHR) analytics, dynamic workflow optimisation, environment-knowledge, and visualisation. This paper presents a top position view of winning generalities, highlights demanding situations and possibilities, and discusses fortune traits.

A review of the pertinent literature revealed that experimenters focused solely on one DL or ML model for categorising breast photos and that numerous research incorporated danger factors and clinical evaluations into the discovery model. Nevertheless, combining breast pictures with clinical features may improve a discovery system's effectiveness and resilience. Additionally, to our knowledge, no previous works have mentioned the development of an ML-DL model trained on a dataset of linked mammograms and health records. As a result, we created a hybrid model to investigate this issue [7]. Our research may help refine the art of cancer discovery, and we think it would be beneficial to employ this model as an alternative option.

2. Background Study

Breast cancer detection, diagnosis, and treatment all heavily rely on medical imaging. A projected 2.3 million new cases and 685,000 fatalities from breast cancer will occur in women globally year 2020. Since breast cancer is more curable in its early stages, early identification is essential for improving patient outcomes. Mammography, digital breast tomosynthesis, ultrasound, magnetic resonance imaging (MRI), and nuclear medicine imaging methods like molecular breast imaging (MBI) and positron emission tomography (PET) are just a few of the imaging modalities used in the diagnosis and treatment of breast cancer. The choice of imaging modality is influenced by a number of variables, including the patient's age, breast density, and clinical history. Each modality has advantages and disadvantages. By identifying malignancies at an earlier stage, mammography, the most widely used imaging modality for breast cancer screening, has been demonstrated to lower breast cancer mortality [8]. A more recent imaging technique called digital breast tomosynthesis gives a 3D picture of the breast, potentially increasing sensitivity and lowering false-positive rates. With dense breast tissue or when examining palpable lumps, ultrasound is frequently employed as an additional imaging technique to mammography. MRI is a highly sensitive imaging technique that is frequently employed in high-risk patients or for staging breast cancer. It can detect small breast lesions. By measuring metabolic activity or metabolic changes, nuclear medicine imaging techniques like MBI and PET can identify breast cancer at an early stage. A number of new imaging modalities and approaches have been created as a result of developments in medical imaging technology, including computer-aided detection (CAD) software, automated breast ultrasound (ABUS), and contrast-enhanced spectral mammography (CESM) [6]. These developments may increase the accuracy of breast cancer detection and diagnosis, which would result in earlier and more efficient treatment. In conclusion, breast cancer detection, diagnosis, and treatment all rely heavily on medical imaging. A number of new imaging modalities and procedures have been created as a result of advances in imaging technology, each having unique advantages and disadvantages. The improvement of breast cancer outcomes and decrease in mortality rates will depend heavily on ongoing research and innovation in medical imaging.

3. Methodology Used

We investigated five machine literacy algorithms for the detection of breast cancer via model comparison [9]. Decision trees, kernel styles, and neural networks were some of the model complexity options that served as the foundation for our selection models. We selected an introductory bracket system that is comparable to K- NN to gauge the problem's complexity. Because it can manage data noise and nonlinearity, the radial base function (RBF) Gaussian kernel SVM was chosen for the kernel method. Additionally, we took into account neural network models, which are a significant class of nonlinear prophetic models. Since RF and GBM are well-known ensemble-based decision tree algorithms, we took them into consideration. A lazy literacy system, the k- closest neighbour (KNN) only learns when testing data that needs to be categorised. To determine the classification of the new data, it calculates the similarity or closest distance between each piece of testing data and every piece of training data. The k-closest data (k-nearest neighbours) are likewise selected based on the minimal distance with unlabeled testing data and assigned to the class that was the most popular class among the k-nearest neighbours during the training phase. The distance function, which can be computed by Euclidean, Minkowski, and cosine-distance criteria, is a crucial component of the KNN model. A supervised literacy model for bracket and retrogression issues is the Support Vector Machine (SVM). SVMs do calculations based on the stylish hyperplane's chance to divide features into various categories. A p-dimensional space can be split into (p-1)-dimensional hyperplanes in double bracket, which separates data points into implicit classes. The support vectors are the data points that are closest to the stylish hyperplane, which is the biggest boundary between the two classes (38). The foundation of an artificial neural network (ANN) is a basic multilayer perceptron model with connected bumps. At each knot, inputs are transformed into labours and transferred as inputs to the following subcaste. A 3-subcaste feedforward is used to construct the ANN model. The layers consist of an affair subcaste with a single knot, a retired subcaste, and an input subcaste. The model's weights (a decay hyperparameter) were adjusted throughout the training phase by increasing or decreasing their value. The hidden units were connected by a sigmoid function. Values of 0 and 1 from the exit bumps indicated a bad outcome. A well-liked machine learning algorithm for bracket problems is Random Forest (RF). By employing arbitrary subsamples of the training set, one can generate a huge number of decision trees, each of which is composed of randomly changing characteristics. To deal with decision trees' perceptivity, RF prioritises them using ensemble styles. The final calculation is made by adding the outcomes for each tree in the forest. A direct ensemble learning method for retrogression and bracket issues is grade Boosting Machine (GBM). As the main classifier for training input, use decision trees. This method creates a strong prophetic model by combining all of the weak base classifiers. also calculate the loss function based on the difference between the prognosticated and factual data. Depending on the error value, the hyperparameters of each base classifier are rated higher or lower. In the end, this procedure chooses the fashionable model with the least amount of training loss.

Mammography A webbing system that uses low- curex-rays to produce images of breast towel. It's the most generally used system for breast cancer webbing and detects excrescences that are too small to be felt on a physical examination. Vivisection. This is a procedure in which a small piece of breast towel is removed and examined under a microscope to see if it's cancerous. There are numerous types of vivisection procedures including fine needle aspiration vivisection, core vivisection, and surgical vivisection. Surgery is frequently used to remove breast cancer. The type of surgery depends on the size and position of the excrescence and the stage of the cancer. Common surgical procedures for breast cancer include mastectomy, mastectomy, and lymph knot junking. Radiation Therapy This treatment uses high- energy radiation to kill cancer cells. Radiation remedy is frequently used after surgery to kill any remaining cancer cells and reduce the threat of the cancer returning. Chemotherapy This treatment uses medicines to kill cancer cells [10] Chemotherapy is frequently used along with surgery and radiation remedy and may be given before or after surgery. Hormone remedy This treatment is used for hormone receptor positive breast cancer. That is, they grow in response to hormones similar as estragon. Hormone remedy works by blocking the action of hormones or lowering the situations of hormones in the body. Targeted remedy This remedy is used for breast cancers with specific inheritable mutations or proteins that promote cancer growth. Targeted curatives work by blocking these specific targets and precluding the cancer from growing.

Digital breast tomosynthesis (DBT) is a more recent type of mammography that creates a 3D picture by stitching together several low-dose X-ray images taken at various angles. Small tumours that might be concealed on conventional 2D mammography can be found with this.

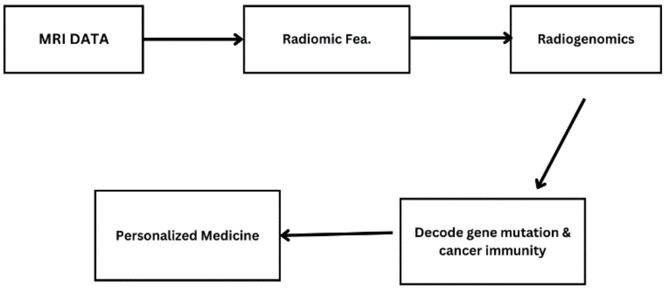

Fig 1. MRI Processing

Magnetic resonance imaging (MRI): Breast MRI produces precise pictures of the breast using a magnetic field and radio waves. For women with a high risk of breast cancer or to assess the scope of the disease in those who have recently been diagnosed, it is frequently used in conjunction with mammography. Contrast-enhanced spectral mammography (CESM): A contrast agent is used in CESM to make regions of abnormal blood flow in the breast more visible. For women with dense breast tissue, this can be especially helpful in identifying benign from malignant tumours [11]. Positron emission mammography (PEM) uses a tiny quantity of radioactive material to identify breast cancer. PEM is a type of nuclear medicine imaging. It can be used to aid in the direction of biopsies and is especially sensitive for spotting small cancers [12]. Automated breast ultrasound (ABUS): ABUS creates 3D ultrasound images of the breast using an automated scanning device. For women with dense breast tissue or to assess abnormalities, it is frequently used in combination with mammography.

4. Experimental Result Analysis

Images created by imaging tools display differences in contrast as a result of changes in physical characteristics. In contrast to X-ray-based procedures, digital imaging technologies are receiving a lot of interest in the field of cancer imaging. Cancer is staged, detected, evaluated for treatment response, and guided during biopsy procedures using a magnetic resonance system.

A. Digital Imaging Technology

A typical screening method is mammography. Malignancy screening mammography is frequently used to find the illness. It has been claimed by numerous studies to aid in lowering cancer death rates. Mammography can be used to image young, compact breasts, but because the surrounding fibro glandular tissue masks abnormalities, its sensitivity is insufficient to find them. The "gold standard" for identifying breast cancer is mammography on film. Although it can be used to detect tumours early and monitor their progression, screen-film mammography has certain intrinsic drawbacks, such as poor contrast features. A valuable imaging technique for breast screening, full-field digital mammography (FFDM) has a number of advantages over conventional film-based procedures. Tomosynthesis, softcopy review, telemedicine, reduced dose, and digital archiving are only a fewof the benefits. It's important to remember that classic film-screen mammography has advantages in terms of cost and accessibility.

Skaane and Skjennald (2004) found that mammography had superior cancer [13] detection results than screen-film mammography in the 50-69 age group. Their study was titled "Screen-Film Mammography versus Full-Field Digital Mammography with Soft-Copy Reading". The detection rates for the two systems were nearly identical in the 45–49 age group. In a study, Obenauer and associates found that digital mammography offers better image quality than screen film. The potential for normal tissues, such as glandular tissue, to cover and disguise cancers is one of the potential downsides of 2D mammography. Breast tightness could be reduced with the use of X-ray equipment. In contrast-enhanced mammography, iodinated compounds are utilized as a provocation method. This experimental technology is predicated on the notion that angiogenesis-mediated enhanced blood supply is required for fast tumor growth. In the absence of the compression tool, contrast must be provided. In sites where angiogenesis occurs, the contrast agent will build up. For both detecting primary and secondary lesions and for keeping track of treatment, tomosynthesis may be helpful.

B. Ultrasonography

Ultrasonography, a common imaging technique, is used to diagnose breast cancer. It has developed to the point that breast imaging is now possible in recent years. To clarify ambiguous findings, ultrasound is a tool that is utilised as a follow-up examination. Ultrasonography can be utilised to evaluate the orientation and shape in breasts that are predominantly dense and fatty. Using expanded field of view imaging, a high-resolution, sweeping image of the breast is produced. When utilising ultrasound to find breast lesions, elastic sonography is a common procedure [13]. Contrast-enhanced ultrasound is used to detect and track the effectiveness of local treatment. In this method, gas microbubbles are intravenously administered. 3D ultrasonography can be used to determine a lesion's volume. Despite the fact that some studies thought that employing ultrasonography to find cases that mammography missed might lead to more false-positive masses. Berg and colleagues (2008) discovered that using ultrasonography in addition to mammography increased the accuracy of diagnosis. One study found that mammography is advised for breast cancer when comparing mammography with ultrasound results. According to a 2008 study, screening ultrasound can find small, node-negative breast tumours.

Finally, the researchers discovered that breast neoplasm may be predicted by clinical diagnosis, ultrasonography, and mammography. Devolli-Disha and colleagues looked at 546 women who had breast complaints in a different trial and discovered that ultrasonography was statistically superior to mammography in those people.

C. Magnetic resonance imaging (MRI)

Breast MRI is used as an aid in conjunction with mammography. Breast neoplasm was examined with MRI in 1982 by Ross and colleagues. Breast MR is becoming more widely used as a complement. MRI is less frequently used as a breast cancer surveillance diagnostic due to high rates of false positives and high costs, while having more sensitivity than mammography. Breast MRI is a useful screening tool for women with thick breast tissue. The ability of MRI to identify contralateral breast neoplasm extension has been confirmed by the American Cancer Society. These problems suggest that MRI should be used instead of mammography.

This disparity implies that magnetic resonance imaging may be useful in determining whether to have surgery or a breast-conserving mastectomy. More precise cancer detection and anatomical delineation are now possible because to recent improvements in MRI technology [14]. Some research suggests using a combination of techniques to detect breast cancer early. According to a study, mammography alone, as well as mammography and ultrasonography, is insufficient for early diagnosis [15]. In Table 1, the sensitivity and specificity values of imaging techniques are displayed and compared.

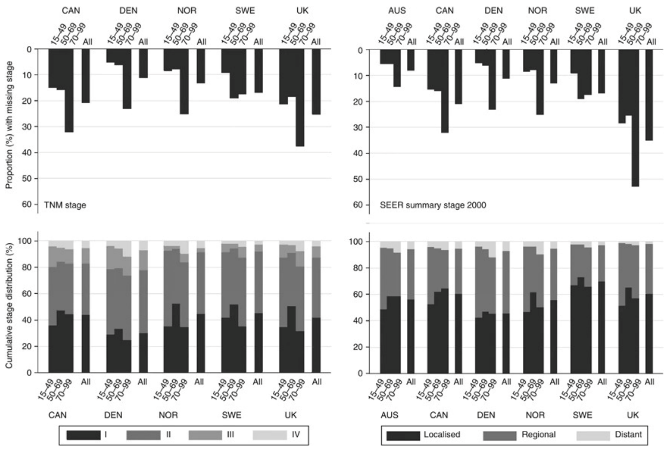

Fig 2. Breast cancer analysis on the basis of stages.

Missing stage prevalence among breast cancer patients (upper figure) and cumulative stage distribution among patients who have been staged (bottom figure). Results are shown by diagnosis age and nation: SEER Summary Stage 2000 (right) and TNM (left). Notes: National data for Denmark and Norway; New South Wales in Australia; British Columbia and Manitoba in Canada; Uppsala-rebro and Stockholm-Gotland health regions in Sweden; Northern Ireland, Wales, and the Northern and Yorkshire Cancer. Registry and Information Service; Oxford Cancer Intelligence Unit; West Midlands Cancer Intelligence Unit in England; UK (TNM analysis); and Northern Ireland and Wales in the UK (SEER SS2000 analysis). We examined women diagnosed in Denmark between 2004 and 2007.

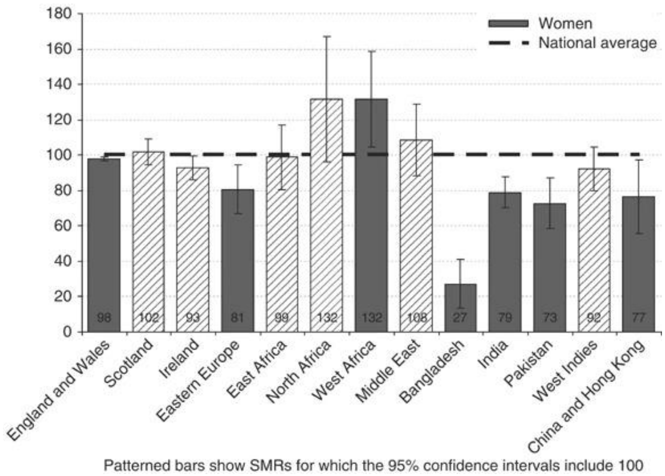

Fig 3. Analysis of breast cancer among other cancers

Over the course of the study period, there were roughly as many deaths among women from breast cancer (33 291) as there were from lung cancer (33 311). The number of breast cancer fatalities was either comparable to (for women born in England and Wales, Eastern Europe, or Bangladesh) or greater than the number of female lung cancer deaths for the majority of subgroups by country of birth, with the exception of Scotland and Ireland as indicated above. Women born in North and West Africa had a high breast cancer death rate, albeit the difference was only statistically significant for the latter group. Women born in Bangladesh, India, Pakistan, China, Hong Kong, and Eastern Europe have low SMRs.

Table 1. Sensitivity and specificity values of imaging techniques

Imaging Modality	Sensitivity	Advantages	Specificity	Limitations
Mammography	80-90%	Widely available, low cost	90-95%	Limited sensitivity in dense breast tissue, high false positive rate
Digital Breast Tomosynthesis (DBT)	90-95%	Improved sensitivity, 3D imaging	80-90%	Higher radiation dose than mammography, longer exam time
Contrast-Enhanced Spectral Mammography (CESM)	90-95%	Improved sensitivity in dense breast tissue, 3D imaging	90-95%	Higher radiation dose than mammography, limited availability
Magnetic Resonance Imaging (MRI)	90-95%	Improved sensitivity, no radiation exposure	90-95%	Expensive, time-consuming, limited availability
Molecular Breast Imaging (MBI)	80-90%	Improved sensitivity in dense breast tissue, no radiation exposure	90-95%	Expensive, limited availability, longer exam time
Automated Breast Ultrasound (ABUS)	80-90%	Improved sensitivity in dense breast tissue, no radiation exposure	80-90%	Limited availability, longer exam time

5. Conclusion and Future Scope

Medical imaging in the fight against breast cancer has a bright future. The application of artificial intelligence (AI) algorithms to the study of medical imaging is one area of progress. AI has demonstrated promising improvements in breast cancer detection and diagnostic efficiency and accuracy. Additionally, the incorporation of AI in medical imaging analysis can result in customised treatment strategies depending on the features of each patient and the biology of the tumour. The development of molecular imaging technologies, like MBI, which can identify biological indicators of breast cancer and support therapy choice, is another area of progress. Furthermore, improvements in imaging methods, such MRI and PET, can offer a more accurate staging of breast cancer, enabling a more focused and efficient course of treatment. Last but not least, the application of mobile and portable imaging technologies can enhance access to medical imaging in underprivileged areas and communities, perhaps resulting in early detection and treatment of breast cancer. Improving imaging modalities' sensitivity and specificity is one area of research, especially for women with thick breast tissue or those who are at high risk of developing breast cancer. This can be accomplished by creating sophisticated imaging methods or incorporating AI algorithms that can increase the precision of image interpretation.

Finally, it should be noted that medical imaging is essential for the early detection, diagnosis, and management of breast cancer. Although modern imaging modalities like DBT, CESM, and MRI have improved the accuracy of breast cancer detection and diagnosis, particularly in women with thick breast tissue or those at high risk of acquiring the disease, traditional mammography continues to be the gold standard for breast cancer screening. Additionally, recent developments in imaging technologies, including AI and MBI, have demonstrated significant promise for enhancing the precision of the diagnosis of breast cancer and directing personalised treatment. This review paper seeks to direct clinical decision-making and future research initiatives by giving healthcare practitioners and researchers a thorough overview of the present status of medical imaging in breast cancer.

References

[1] Agarwal, R. Kumar, and M. Gupta, "Review on Deep Learning based Medical Image Processing," *In 2022 IEEE International Conference on Current Development in Engineering and Technology (CCET)* (pp. 1-5). IEEE, 2022.

[2] S. Kour, R. Kumar, and M. Gupta, "Study on detection of breast cancer using Machine Learning," *In 2021 International Conference in Advances in Power, Signal, and Information Technology (APSIT)* (pp. 1-9). IEEE, 2021.

[3] R. Kaur, R. Kumar, and M. Gupta, "Review on Transfer Learning for Convolutional Neural Network," In *2021 3rd International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)* (pp. 922-926). IEEE, 2021.

[4] M. Mayer, "Treatment and Outcomes for High-risk and Metastatic Breast Cancer in California: An Inquiry into Disparities and Research Needs," California Breast Cancer Research Program, 2004.

[5] M. Hehenberger, A. Chatterjee, U. Reddy, J. Hernandez, and J. Sprengel, "IT solutions for imaging biomarkers in biopharmaceutical research and development," IBM Systems Journal, vol. 46, no. 1, pp. 183-198, Jan. 2007.

[6] M. J. Masrour, A. Shafaie, L. Yoonesi, H. Aerabsheibani, and S. J. Masrour, "Evaluating endometrial thickness and vascular ultrasound pattern and pregnancy outcomes in intrauterine insemination cycle," Asian Journal of Pharmaceutical Research and Health Care, pp. 24-29, Jan. 2016.

[7] S. Ergin and O. Kilinc, "A new feature extraction framework based on wavelets for breast cancer diagnosis," Computers in Biology and Medicine, vol. 51, pp. 171-182, Dec. 2014.

[8] S. Walters, C. Maringe, J. Butler, B. Rachet, P. Barrett-Lee, J.P.W.V.D. Bergh, et al., "Breast cancer survival and stage at diagnosis in Australia, Canada, Denmark, Norway, Sweden and the UK, 2000-2007: a population-based study," British Journal of Cancer, vol. 108, no. 5, pp. 1195-1208, Mar. 2013.

[9] D. J. Yang, L. Pham, M. H. Liao, F. L. Kong, H. Uemura, and Y. Y. I. Shih, "Advances in molecular pathway-directed cancer systems imaging and therapy," BioMed Research International, vol. 2014, 2014.

[10] J. W. Bai, S. Q. Qiu, and G. J. Zhang, "Molecular and functional imaging in cancer-targeted therapy: current applications and future directions," Signal Transduction and Targeted Therapy, vol. 8, no. 1, article no. 89, Jan. 2023.

[11] S. P. Poplack, T. D. Tosteson, W. A. Wells, B. W. Pogue, P. M. Meaney, A. Hartov, et al., "Electromagnetic breast imaging: results of a pilot study in women with abnormal mammograms," Radiology, vol. 243, no. 2, pp. 350-359, Nov. 2007.

[12] K. Brindle, "New approaches for imaging tumour responses to treatment," Nature Reviews Cancer, vol. 8, no. 2, pp. N/A, Feb. 2008.

[13] D. Robinson, J. Bell, H. Møller, and A. Salman, "A 13-year follow-up of patients with breast cancer presenting to a District General Hospital breast unit in southeast England," The Breast, vol. 15, no. 2, pp. 173-180, Apr. 2006.

[14] H. Uemura and Y. Y. I. Shih, "Advances in Molecular Pathway-Directed Cancer Systems Imaging and Therapy," in Proceedings of IEEE Engineering in Medicine and Biology Society Conference, 2013, pp. 1353-1356.
[15] S. H. Wild, C. M. Fischbacher, A. Brock, C. Griffiths and R. Bhopal, "Mortality from all cancers and lung, colorectal, breast and prostate cancer by country of birth in England and Wales, 2001–2003," in British Journal of Cancer, vol. 94, no. 7, pp. 1079-1085, Apr. 2006.