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A Review of AI in Breast Cancer Detection

Abhilasha[1], Ashima Narang[2], and Priyanka Vashisht[3]

[1] MCA Scholar, Department of Computer Application, Amity University, Gurugram, Haryana, India
[2] Assistant Professor, Department of Computer Science & Engineering, Amity University, Gurugram, Haryana, India
[3] Associate Professor, Department of Computer Science & Engineering, Amity University, Gurugram, Haryana, India

Correspondence should be addressed to Abhilasha; abhilashasheokand389@gmail.com

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ABSTRACT- Cancer stands out as one of the most pressing global health challenges, and over the past decade, significant advancements have been made in diagnostic tests and methodologies. These tests fall into categories such as imaging tests, and endoscopic procedures, generating substantial volumes of data. This data needs expert evaluation to distinguish between benign and malignant tumors. Enter artificial intelligence (AI), which offers improved accuracy in analyzing large quantities of diagnostic imaging, thereby enhancing the efficiency of healthcare systems. The integration of new AI algorithms, technical advances, and enhanced computer hardware enables the training of diagnostic neural networks. This allows machines to learn from a diverse range of scans, leading to a comprehensive understanding of cancer scanning data. AI software has been evaluated against conventional diagnostic tools used by cancer specialists, and the results show significantly increased precision, making it highly effective in early diagnosis and extended forecasting for various types of cancers.

In the realm of breast cancer prognosis, AI systems have demonstrated the potential to surpass human specialists, enabling much earlier diagnosis. Similarly, informatics has developed AI algorithms and deep learning techniques capable of predicting individuals' likelihood of developing lung cancer through low-dose CT analysis. The use of convolutional neural networks (CNNs) has been instrumental in diagnosing the invasion depth of gastric cancer based on gastric endoscopy.

KEYWORDS- Cancer, Diagnostic Tests, Artificial Intelligence, Deep Learning Techniques.

I. INTRODUCTION

It is an evolution that will have a significant impact on the medical field. It holds great promise for improving and enhancing many facets of medical practice. This could ultimately result in better patient outcomes, increased productivity, and revolutionary shifts in the way healthcare is provided. Artificial intelligence (AI) technologies, such as computer vision, natural language processing, and machine learning, allow the analysis of large datasets and provide insights that can guide treatment planning, diagnosis, and clinical decision-making. This promotes more efficient and individualized patient care in addition to quickening the rate of medical research and innovation.

Furthermore, the use of AI in healthcare has the potential to address persistent issues like the growing strain on healthcare systems

The simulation of human intelligence processes by machines is termed artificial intelligence. It is the theory and development of computer systems capable of performing tasks that require human intelligence, such as recognizing speech, making decisions, and identifying patterns. Artificial Intelligence is a general term that includes a broad range of technologies, including machine learning, deep learning, and natural language processing (NLP).

While each has unique strengths and weaknesses, humans and machines can work in tandem to provide and improve healthcare. According to a recent definition provided by the American Medical Association, artificial intelligence in healthcare will be utilized to augment human intelligence rather than to replace it. The American Medical Association's perspective, which has significant ramifications for the application of AI in healthcare, emphasizes the collaboration between humans and machines. Medical Imaging:

Algorithms for machine learning are capable of processing vast amounts of data rapidly. Clinical Decision Support (CDS): By giving physicians pertinent information, AI can assist medical professionals in making better decisions. Drug Development: AI can expedite and assist in the identification of new drugs and this saves a lot of time. Artificial Intelligence has the potential to enhance the accuracy of robot-assisted surgery that can make the operation more effective.

II. LITERATURE REVIEW

A. Digital mammography screening using Standalone AI was as effective as or better than radiologists[1]

Nine datasets from multi-reader, multi-case studies, previously utilized for diverse research purposes across seven countries, were gathered. Each dataset comprised digital mammography (DM) exams captured through systems from four different vendors. These exams underwent assessments by multiple radiologists, and the ground truth was established through histopathological analysis or follow-up. In total, there were 2,652 exams (653 malignant) and interpretations by 101 radiologists, resulting in 28,296 independent assessments. An artificial intelligence (AI) system analyzed these exams, providing a suspicion level of cancer presence on a scale from 1 to 10.

B. AI in imaging diagnosis offers a promising outlook for a more precise and efficient diagnostic model for breast cancer[2]

The progress in artificial intelligence (AI)-assisted tumor diagnosis based on imaging represents an effective strategy to enhance the efficiency and accuracy of diagnostic processes. Through the analysis of image data and the development of algorithmic models, AI can automatically recognize, segment, and diagnose tumor lesions, demonstrating encouraging prospects for application.

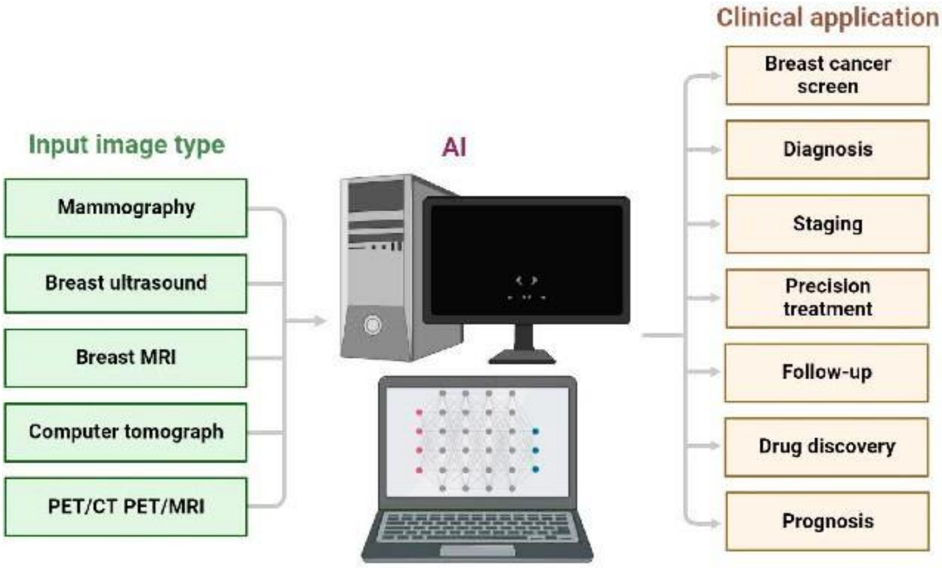

Figure 1: Application of AI in detection[2]

As an aspect of the breast cancer screen, a mammography image is captured, and AI diagnosis uses this type of image as an input. With the AI algorithms, the image is accurately diagnosed to identify the exact stage of breast cancer. For further examination and precise treatment strategy, breast MRIs and ultrasounds may also be used. PET/CT and PET/MRI imaging, as well as CT scans, are essential for prognosis and follow-up evaluations. In drug discovery, these imaging techniques play a very important role as they help with early detection.

C. Neural networks aid in identifying patterns within breast tissue images, enabling the early detection of potential signs[3]

With further research and development, the use of neural networks in the diagnosis of breast cancer may lead to earlier detection, better treatment outcomes, and higher patient survival rates.

D. Despite the level of experience of human readers, commercial AI software effectively assisted in the interpretation of mammography images[4]

A comparative analysis of the efficacy of two AI software, namely AI-1 and AI-2, involving two experienced and two novice readers reviewing 200 mammographic examinations (including 80 cancer cases). Two separate reading sessions took place within a 4-week timeframe. The readers provided ratings for the likelihood of malignancy on a scale of 1–7 and the percentage probability of malignancy on a scale of 0–100%, both with and without the assistance of AI. Our evaluation focused on differences in AUROC, sensitivity, and specificity.

E. Deep Learning Methods for Mammography Analysis and Breast Cancer Detection[5][8]

The studies under review are categorized into three groups based on their suggested methodologies: transfer learning and data augmentation, feature extraction, and multiple model-based architectures, as well as generative adversarial networks.

F. AI imaging algorithms, combined with evaluations of breast density, independently enhance the long-term prediction of invasive breast cancers, particularly advanced cases[6]

AI algorithms have demonstrated enhanced capabilities in improving breast cancer detection through mammography. However, the extent of their impact on long-term risk prediction for advanced and interval cancers remains unclear. It is imperative to delve into the nuanced aspects of AI's influence on these specific types of breast cancers to better understand its potential role in improving overall prognostic assessments. The exploration of AI's contribution to long-term risk prediction holds promise for refining our strategies in identifying and managing advanced and interval breast cancers, marking a crucial step forward in optimizing breast cancer screening and prevention efforts. Since 2020, a variety of deep learning (DL) approaches have been explored for the automated detection of microcalcifications (MCs), employing deep networks or convolutional neural networks (CNNs).

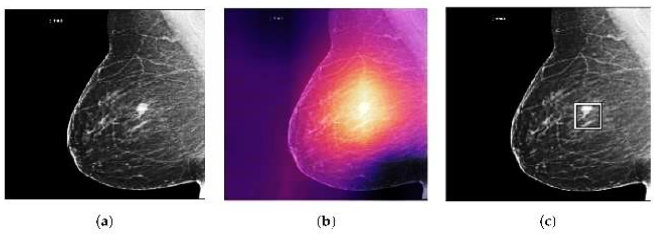

Figure 2: Cancer Detection[7]

(a) Initial image. (b) Using class activation maps on the image. (c) Adding a bounding box to the image.

These types of visualization provide information about how the deep learning model classifies images as positive or negative. They provide an improved understanding of the model's output by identifying the specific areas of the image that are influencing its decision (show in figure 2).

III. RESULTS AND DISCUSSION

Table 1: Comparison of different datasets for image classification.

Database	Type of Images	Dataset	Data Augmentation	Classify
Restricted	Digital	490 images 1044 images 72 images	YES	CNN
Restricted	Both	521 images 188 images	YES	CNN
Restricted	Both	521 images 188 images	YES	DNN
Open Access (MIAS)	Digitized	1288 images	NO	DNN
Restricted	Both	283 images	YES	CNN
Open Access (DDSM)	Digitized	2620 images	YES	CNN
Open Access (INbreast)	Digital	410 images	YES	CNN
Open Access (MIAS)	Digitized	322 images	YES	CNN
Open Access (INbreast)	Digital	354 images	YES	CNN
Both (INbreast)	Digital	410 images 141 images	YES	CNN

In the above table 1, it provides a detailed comparison between different datasets of medical imaging used for the detection of cancer in the breast. It highlights the metrics for the various ML models that are used with these datasets.

A specific dataset for this study was curated, comprising 1606 digital images, and data augmentation techniques were applied to expand the dataset. Augmentation involved flipping (horizontally and vertically) and rotating (90, 180, and 270 degrees) positive images. A CNN was initially trained on a smaller subset of the dataset and subsequently applied to the complete dataset to remove samples that were easier to classify. Following this, a second CNN was trained n a larger dataset, focusing on samples that were harder to categorize. The achieved sensitivity reached 70%, with an 80%–20% validation per image.

In recent years, various research groups have employed DL for MC detection with varying degrees of success. However, the outcomes of DL can exhibit marked variations when applied to different datasets, introducing challenges in cross-validation. While direct comparisons between studies may be challenging, certain DL approaches are worth further exploration. Notably, in 2022, a combination of a deep, fine-grained, cascade-enhanced network and a multi-scale, feature fusion algorithm achieved high accuracy (97.2%) in MC detection, utilizing the MIAS open-access database. Researchers like Anahita Sood et al. [9] and Dan Zheng et al. [2] utilized the INbreast open-access database, developing algorithms using CNNs for MC detection.

Jung, Hyun Yoon et al. [1] implemented an automated approach involving pre-processing to enhance image quality, segmentation network training, and a trained network. Hee Jeong Kim et al. [4] used an ensemble of CNNs to reduce false positives. Comparing the results, Jung, Hyun Yoon et al. [1] achieved higher sensitivity than Anahita Sood et al. [9] (88.1% vs. 83.5%). However, only the latter correctly divided the data into training and test sets by assigning patches belonging to the same image to the same set. Vachon et al. [6] employed a DL approach for MC detection using an open-access dataset (DDSM), reaching 98.2% accuracy with a modified U-net segmentation network. They allocated 60% of the dataset for training, 20% for validation, and the remaining 20% for testing, but on a per-image basis rather than per patient.

IV. CONCLUSION

This review exclusively focuses on mammography's role in detecting microcalcifications (MCs) and masses in the breast. However, for a more holistic examination of breast cancer detection and classification, it is imperative to consider other imaging modalities such as digital breast tomosynthesis (DBT), ultrasound, and magnetic resonance imaging (MRI). The sheer volume of published articles, particularly concerning the identification and classification of masses—deemed diagnostically more critical—precludes the incorporation of all available articles within a single review. Regrettably, some technical details from certain studies, such as the specifics of validation procedures or comprehensive metrics of success, are not included in this review due to their absence in all articles. From the current state of the art presented in this review, it is evident that computer-aided detection (CAD) algorithms warrant further investigation and validation using more extensive clinical data. This is crucial to unequivocally demonstrate their efficacy, value, and impact on breast cancer diagnosis.

Additionally, the research community needs to adopt best practices that promote consolidation, repeatability, and explainability if CAD systems for detecting breast abnormalities are to firmly establish themselves in clinical practice. Despite its limitations, this comprehensive review serves as both a thorough introduction to the field and provides indicative guidelines for the design and execution of future studies.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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ABOUT THE AUTHORS

Abhilasha is pursuing a Master's in Computer Applications. She has done B.Sc as her undergraduate course. She is currently working on a Machine Learning project. She is also very good in extracurricular activities, as she has an NCC(A) Certificate.

Dr. Ashima Narang has completed her Btech, Mtech and PhD in the field of computer Science from various prestigious institutes of India. Her areas of expertise include Cloud Computing, Security, Software Engineering and Virtualization. She has rich teaching experience of 12 years. She has authored numerous research papers in reputed international journals and conferences and has guided students for projects from undergraduate and graduate courses. She is also an active member in the various professional bodies like IAASSE, internet society, SCIEI etc. She is the reviewer to various journals from her expertise field.

Dr. Priyanka Vashisht has received her Ph.D from ThaparUniversity, Patiala, M.Tech from Banasthali Vidyapeeth, Rajsthan. She has 20 years of teaching and industry experience. Her areas of expertise include Cloud Computing, Fog Computing and Virtualization. She has authored numerous technical research papers and book chapters in international conferences and journals of repute. She has authored a book. She has 4 patents in her name. She is member of IETE, CSI and ACM.