Role of Artificial Intelligence in Early Detection of Cancer: A Review Focused on Breast, Lung, and Skin Cancer

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Abstract:

In the area of medical diagnostics, artificial intelligence (AI) has become a game-changing tool, especially for the early diagnosis of cancer. This review investigates the use of AI technology for early detection and prognostication of skin, lung, and breast cancers. AI algorithms have proven remarkably accurate and efficient by using imaging and histopathology data to recognize patterns. The article outlines AI-based diagnostic systems' recent developments, present drawbacks, and prospective future developments. The objective is to provide a thorough yet targeted summary of how AI is changing cancer diagnosis, enhancing patient outcomes, and assisting medical professionals.

1. Introduction:

Worldwide, one of the biggest causes of illness and mortality is still cancer.[1,2] The possibility of a successful course of treatment and survival is greatly increased by early identification.[3] Even though they work well, traditional diagnostic techniques have drawbacks such inter-observer variability, time commitment, and dependence on expert interpretation.[4,5] Early cancer detection is undergoing a hopeful change because of the introduction of Artificial Intelligence (AI), especially in the areas of image recognition and data analysis.[6,7,8] This review focuses on the significance of AI in the early diagnosis of three of the most common forms of cancer worldwide: skin, lung, and breast cancer. [6]

2. Relevance to Basic Science:

The application of AI to cancer diagnosis touches on fundamental scientific fields such as pathology, bioinformatics, and molecular biology.[5,6,8] AI can help generate and validate hypotheses in molecular profiling, cellular classification, and early carcinogenesis.[17,23] This makes AI a research accelerator for comprehending cancer biology in addition to a diagnosis tool.[17,24]

3. Overview of AI in Biomedical Research:

Artificial Intelligence (AI), which includes machine learning (ML), deep learning (DL), and natural language processing (NLP), has become more and more prevalent in the fundamental biomedical sciences.[8,9] AI systems can analyze vast amounts of intricate biomedical data, such as genetic sequences, imaging, and histopathological samples.[7,23] Convolutional neural networks, or CNNs, are especially good at diagnosing problems based on images because they can learn spatial hierarchies from data.[4,6] Moreover, artificial intelligence facilitates personalized care, patient classification, and predictive modeling.[17,18]

4. Breast Cancer Detection Using AI:

In order to diagnose breast cancer, mammography, ultrasound, and biopsy are frequently used.[3,11] Artificial intelligence (AI) applications improve these methods by seeing minute patterns that the human eye might overlook.[18] Artificial intelligence (AI) systems trained on mammography datasets have demonstrated near-human or superior performance, with an Area Under Curve (AUC) as high as 0.97. IBM Watson Health and Google Health AI provide solutions that speed up diagnosis, decrease false positives, and enhance the diagnostic process.[12,15] According to research, AI-assisted mammography screening can fill in the shortage of radiologists in places with low resources, such as India.[22,24]

5. AI in Lung Cancer Detection:

For early lung cancer screening, low-dose computed tomography (LDCT) is now the gold standard.[10] AI technologies that have demonstrated potential in improving the precision of pulmonary nodule diagnosis include Samsung Auto Lung and DeepLR. Using CNNs and Recurrent Neural Networks (RNNs), radiological images are analyzed for early-stage abnormalities.[14] In India, where late-stage diagnosis is prevalent, AI-assisted techniques can be extremely helpful in boosting early detection rates and directing additional imaging or biopsy.[21,22]

6. Skin Cancer Detection with AI:

Melanoma and other skin cancers can now be diagnosed with greater accuracy thanks to AI-driven picture categorization.[12,16,19] Artificial intelligence (AI) systems like SkinVision and MoleScope have shown accuracy on par with dermatologists when analyzing dermatoscopy images. The robustness of lesion classification has been enhanced using deep learning frameworks like as ResNet and EfficientNet.[13] These resources are especially helpful in rural and isolated locations with limited access to dermatological care.[16,20]

7. Comparative Summary and Platforms:

AI systems vary according to the type of cancer, the way data is entered, and performance indicators. Tables 1 and 2 provide an overview of the main AI platforms and diagnostic applications, respectively.

Table 1: Comparative Summary of AI Use in Cancer Types

Cancer Type	Diagnostic Tools	AI Methods Used	Reported Accuracy (AUC)	Key Benefits
Breast	Mammography, USG	CNN, Transfer Learning	Up to 0.97	Early identification, reduced false positives
Lung	X-ray, CT	RCNN, DeepLR	High sensitivity	Workflow assistance and nodule detection
Skin	Dermoscopy, Apps	CNN, ResNet	Comparable to experts	High scalability and remote accessibility

Table 2: AI Tools and Platforms in Cancer Detection

AI Platform	Cancer Type	Technique	Advantages	Challenges
Google Health AI	Breast	CNN, Transfer Learning	High precision	Requires a lot of training data.
IBM Watson Health	Multiple	NLP, ML, DL	Multimodal integration	Cost, technical complexity
DeepLR	Lung	Deep Learning	CT scan enhancement	Needs imaging standardization

AI Platform	Cancer Type	Technique	Advantages	Challenges
SkinVision	Skin	CNN, Image Analysis	Mobile use, real-time diagnostics	Varying accuracy by skin tone
DermaCompare	Skin	3D Imaging + AI	Mole tracking over time	Historical data requirement

8. Benefits of AI in Early Cancer Detection:

Enhances physician decision-making, decreases diagnostic inequalities in underserved areas, increases diagnostic accuracy and reproducibility, facilitates quicker screening and triage, and integrates imaging and genetic data.[19,23,24]

9. Limitations and Challenges:

Lack of representative and varied training datasets - Privacy and informed consent are ethical issues - Inadequate regulatory requirements for AI use - Clinical validation is required for various demographic groups - In rural areas, deficits in infrastructure and technological literacy.

10. Future Directions in Basic Cancer Research with AI:

Early cancer diagnosis may be completely transformed by combining AI with transcriptomics, proteomics, and genomes. AI-powered radiogenomics and pathology models will improve risk stratification and tumor characterisation. Increasing clinical acceptance will be facilitated by the development of explainable AI (XAI) models. Additionally, training on decentralized datasets could be possible with federated learning, enhancing data privacy.

11. Conclusion:

One interesting addition to the early cancer detection toolkit is artificial intelligence. With promising outcomes, its use in a variety of imaging modalities and cancer types—particularly skin, lung, and breast cancer—has been extensively described. Even if there are still obstacles to overcome, research is continuing, particularly in India and other developing nations, and suggests that artificial intelligence will eventually improve and supplement conventional diagnoses. The application of AI to fundamental cancer research may lead to important developments in precision oncology.

Keywords:

Artificial Intelligence, Breast Cancer, Lung Cancer, Skin Cancer, Early Detection, Deep Learning, Radiomics, Basic Science

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