IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

AI REVOLUTION IN HEALTHCARE: A CRITICAL REVIEW OF ITS IMPACT ON DISEASE DIAGNOSIS AND PERSONALIZED MEDICINE

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Abstract : Artificial intelligence (AI) is increasingly influencing modern healthcare by enhancing disease diagnosis and supporting the advancement of personalized medicine. This review discusses the application of AI-based technologies, particularly machine learning and deep learning, in the analysis of complex medical data such as clinical records, medical imaging, and genomic information. These approaches improve diagnostic precision, facilitate early disease detection, and assist healthcare professionals in making timely and accurate clinical decisions. AI-driven techniques have demonstrated notable success in cancer diagnosis, especially in skin cancer, through automated image processing and pattern recognition methods. Furthermore, AI-enabled personalized medicine allows treatment strategies to be customized according to individual genetic profiles, biomarkers, lifestyle factors, and disease characteristics, thereby reducing unnecessary interventions and treatment-related adverse effects. Although challenges related to data quality, ethical concerns, and clinical implementation persist, ongoing research and technological progress are expected to overcome these limitations. Overall, AI has strong potential to reshape healthcare by enabling more accurate diagnosis and patient-specific therapeutic approaches.

Keywords: Artificial intelligence, Disease Diagnosis, Skin Cancer, Machine Learning, Deep learning, Personalized Medicine

1. INTRODUCTION

Artificial intelligence has become an integral component of healthcare innovation, offering advanced computational approaches for managing and interpreting complex medical information. Rather than replacing clinical expertise, AI functions as an assistive technology that enhances the ability of healthcare professionals to analyse data, reduce diagnostic variability, and improve decision-making accuracy. The expansion of digital health records, advanced imaging systems, and high-throughput genomic technologies has created an environment in which AI can significantly contribute to improved healthcare efficiency and quality.

In pharmaceutical research and clinical development, AI is increasingly utilized to streamline drug discovery processes, optimize clinical trial methodologies, and improve success rates. Conventional drug development pathways are often resource-intensive and associated with substantial financial and time-related challenges. AI-based predictive models assist in identifying viable drug candidates, anticipating safety concerns, and refining patient selection criteria, ultimately contributing to more effective and safer therapeutic development.

Key applications of AI in healthcare include predictive analytics, drug discovery, and personalized medicine. Predictive analytics enables forecasting of disease progression and therapeutic response, while AI-assisted drug discovery supports target identification and molecular optimization. Personalized medicine leverages AI to integrate genetic, clinical, and lifestyle data, allowing treatments to be tailored according to individual patient characteristics. Collectively, these applications highlight the expanding role of AI in enhancing diagnostic precision and therapeutic personalization. (1,2,3)

2. Diagnosis

The diagnosis process includes the four steps to identify the disease.

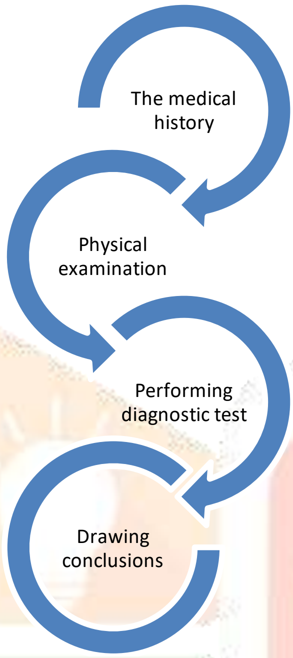

Figure 1: Steps for the diagnosis process

Diagnosis represents a structured clinical process aimed at identifying diseases or medical conditions through the evaluation of patient history, physical examination, diagnostic testing, and clinical interpretation. AI-based diagnostic systems enhance this process by supporting the analysis of large and complex datasets, thereby assisting clinicians in reaching accurate and timely conclusions

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3. Detection of cancer through AI

Artificial intelligence in cancer detection refers to the use of computer algorithms and machine learning models to analyse medical data (i.e., images, pathology slides, genetic data, or clinical records) in order to identify signs of cancer at an early stage, assist doctors in diagnosis and improve accuracy and speed compared to traditional methods.

AI detects:

- Skin cancer
- Breast cancer
- Lung cancer
- Liver cancer
- Brain cancer
- Pancreatic cancer

4. AI in the detection of skin cancer

Skin cancer cause due to the damage of the DNA in skin cells which causes them to grow uncontrollably. The most common cause of the DNA damage is because of the exposure to ultraviolet radiation. AI can detect skin cancer from dermoscopy images. The FDA has approved Derma sensor the first AI-powered tool to diagnose skin cancer.

4.1 How skin cancer is diagnosed with help of AI

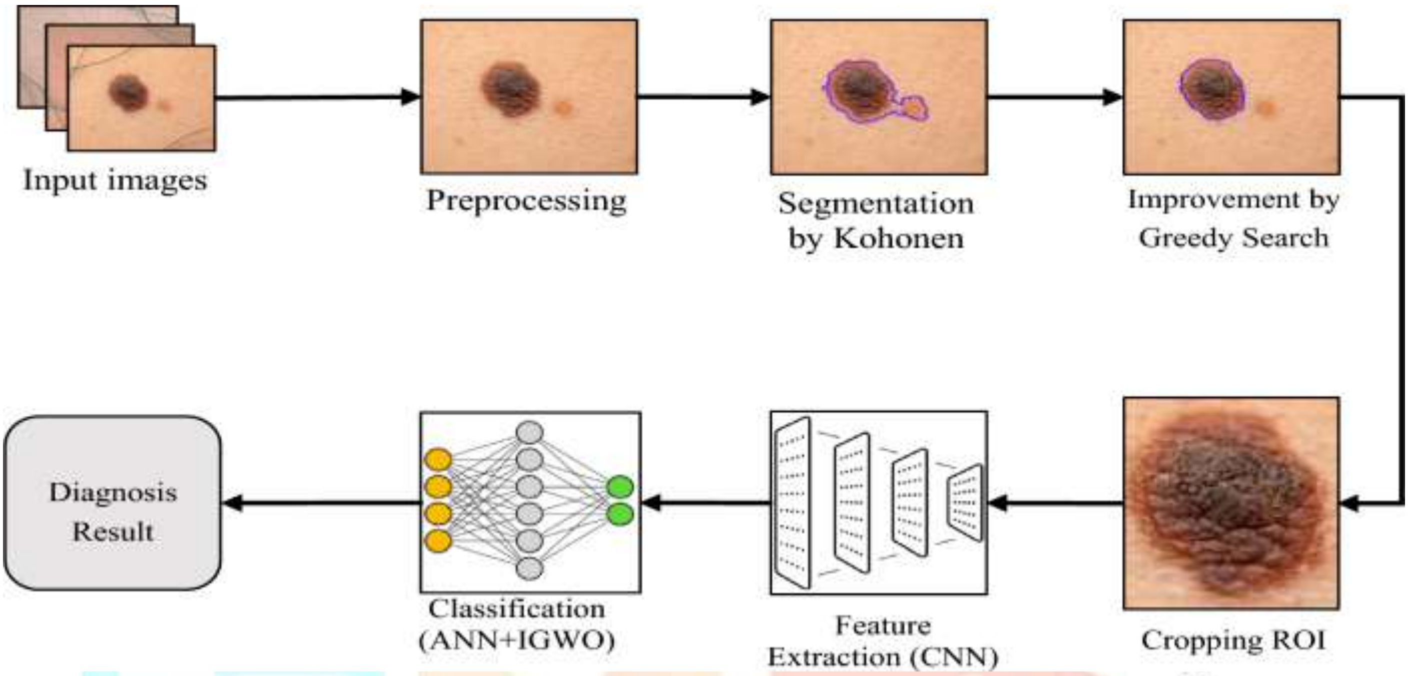


Figure 2 : Steps for diagnosis

Input images- There is an input of skin images or dermoscopic images from public datasets. The images may have artifacts such as hair, thin blood vessels which interface with segmentation.
Preprocessing- The goal of preprocessing is to cleanup the images, removing or reducing noise, hair, and small distracting structures that may mislead segmentation. Morphological closing operator is used to remove this hair or thin vessels, after this morphological closing operator some blur is introduced. To counter this unsharp filter is used to sharpen edges and restore clarity.
Segmentation by kohonen neural network- In this the images are segmented into regions such that plixers forming a region are similar. This are used for initial segmentation each pixel is grouped into clusters.
Improved by greed search algorithm- The segmentation from kohonen network is refined using a greedy search algorithm, in the paper sometimes referred to as a greedy search or GSA. The idea is to correct boundary errors, fill holes, or remove small false positives.
Cropping ROI- The images are cropped to the bounding box of that region after the lesion region is segmented, before feeding into CNN, the cropped region is resized to a fixed size so that CNN input is consistent.
Feature extraction- The cropped ROI is passed through CNN while in this framework it is not used to classify directly but to extract features.
Classification- The 100 dimensional feature vector (from the CNN) is then used as input to an artificial neural network (ANN) classifier. They optimize the both the structure and the weight vector of the ANN using the improved gray wolf optimization algorithm.
Diagnosis- Finally the ANN provides the class label for lesion. (6,7)

4.1.1 Types of skin cancer

After the complete process of diagnosis the different types of skin cancer detected are:

Figure 3: Basal cell carcinoma

Figure 4: Squamous cell carcinoma

Figure 5: Melanoma (8,9)

4.2 Current Trend, Challenges and Future aspects in Skin cancer

The use of AI in skin cancer diagnosis is changing dermatology in a positive way, with the help of machine learning, deep learning, computer vision and mobile technologies, AI is improving the accuracy, speed, and availability of skin cancer detection. These tools support early diagnosis, better treatment planning and improved patient outcomes. However continued research and careful use in clinical practice are necessary to ensure AI is safe, reliable and effective

While AI has the potential to significantly improve skin cancer management its successful integration faces several challenges related to data quality, bias, transparency, ethics, regulation, and clinical adoption. Addressing these issue through better data practices, clear regulations, and close collaboration between technologists and healthcare professionals is essentials for the safe and effective use of AI in dermatology

The future of AI in skin cancer management is highly promising. AI systems are expected to become more accurate and reliable with access to larger and more diverse datasets. Advances in deep learning and computer vision will further improve early detection especially for melanoma. Ai is also likely to support personalised treatment by combining image data with genetic and clinical information. The use of mobile applications and wearable devices will expand, allowing continuous skin monitoring and early warning for high risk individuals. In the future, AI will mainly act as a supportive tool for dermatologist, improving decision making, reducing diagnostic errors and enhancing patient outcomes through faster and more accessible care. (10)

5.Personalized medicine

Personalized medicine, often described as precision medicine, represents a modern approach to healthcare that emphasizes the customization of prevention strategies, diagnostic procedures, and treatment plans based on individual patient characteristics. This approach acknowledges that genetic variability, molecular biomarkers, lifestyle behaviors, and environmental exposures significantly influence disease progression and therapeutic outcomes. (11)

A key component of personalized medicine is genetic testing, in which a patient's DNA is examined to identify mutations or molecular alterations associated with disease risk or therapeutic response. Based on this information, targeted therapies are selected to match the biological profile of the patient, thereby improving treatment effectiveness while reducing unnecessary toxicity. Continuous monitoring further allows clinicians to modify treatment strategies as the disease or patient condition changes over time.

Artificial intelligence plays a critical role in advancing personalized medicine by interpreting large and complex datasets that are difficult to analyse using traditional methods. In genomics and pharmacogenomics, AI systems evaluate genetic information to predict disease susceptibility and determine how patients are likely to respond to specific medications. Machine learning models also assist in drug development by predicting interactions between compounds and biological systems, accelerating the creation of more precise therapies.

By integrating genetic data with clinical records and lifestyle information, AI supports the development of individualized treatment plans that maximize therapeutic benefits and minimize adverse effects. Additionally, predictive modeling enables early intervention by forecasting disease progression, while digital patient twins allow virtual testing of treatment options before real-world application. (12,13)

5.1 Personalized medicine in skin cancer

Customizing care based on a persons unique genetics, skin type, lifestyle and environment, using genomic data, molecular markers and AI algorithms to make precise treatment decision.

Area	Role of AI	Benefits to the patients
Genomic Analysis	AI rapidly analyses gene mutations (e.g., BRAF, NRAS in melanoma)	Selects targeted therapies like BRAF inhibitors
Early Detection & Imaging	AI models (e.g., deep learning) detect skin lesions from images (like dermoscopy or mobile apps)	Faster, accurate diagnosis even in the remote areas
Biomarker Identification	AI finds patterns in blood, tissue, or DNA that predict cancer type or treatment response	Enables custom therapies based on tumor profile
Drug Matching	AI matches the right drug to the patients specific profile mutation or risk profile	Reduces trial and error in treatments
Risk Prediction	AI combines personal and environmental data (UV exposure, skin type, family history)	Identifies high risk individuals early for prevention
Treatment Monitoring	AI tracks progress using imaging and medical records to adjust treatment in real time	Enables dynamics, adaptive care

Table 1 : Clinical applications and benefits of AI in skin cancer (14,15)

5.2 Process for personalized medicine in skin cancer

First the Person has to be diagnosed after getting the result that it has skin cancer AI analyses patient genomic data, imaging and clinical data and on the basis of this analyses AI will give the best therapy and recommends personalized medicine like vemurafenib for BRAF mutated melanoma or pembrolizumab for PD-L1 positive and melanoma after this process the patient is continuously monitored and the responses are taken.(16)

5.2.1 AI powered personalized medicine treatment plans

Surgical method- the primary treatment for melanoma is wide local excision, a surgical procedure in which tumor is removed along with a margin of healthy surrounding tissue. The size of the margin depends on the thickness and stage of the melanoma, ensuring complete removal of cancer cells while preserving as much normal tissue as possible

Radiation therapy- used after surgery to reduce the risk of cancer recurrence, it is also applied in advanced stages for palliative care to help relieve symptoms such as pain. In certain cases, such as lentigo maligna melanoma, radiation therapy can serve as the main treatment option.

Immunotherapy method- supercharges the patient immune system, particularly activating T cells to identify and destroy melanoma cells. This approach is especially beneficial when melanoma has spread to other parts of the body or cannot be completely removed through surgery, common immunotherapy drugs include pembrolizumab, nivolumab and atezolizumab

Targeted therapy- focuses on specific genetic mutations present in melanoma cells, allowing for more precise treatment. These drugs interfere with cancer promoting pathways while minimizing damage to normal cells. Examples include vemurafenib and dabrafenib, which are effective in patients with BRAF mutated melanoma

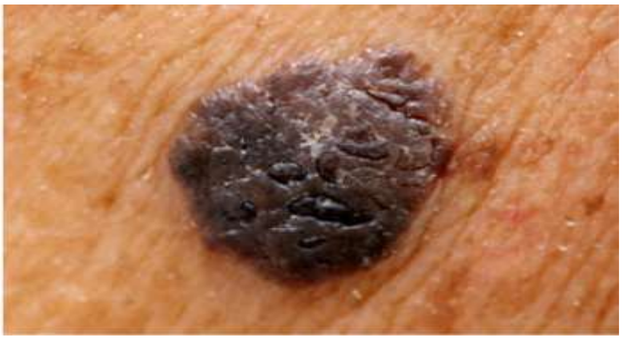
Combination therapy- this involves using two or more treatment strategies together to improve outcomes. This may include combining targeted therapies, immunotherapy agents or both. Common approaches involve BRAF and MEJ inhibitors for BRAF-mutated melanoma, or combining immune checkpoint inhibition such as anti-PD-1 and anti-CTLA-4 antibodies for other melanoma types. (17)

5.2.2 Case study on pembrolizumab (Immunotherapy method)

How Pembrolizumab is given to the patient (18)

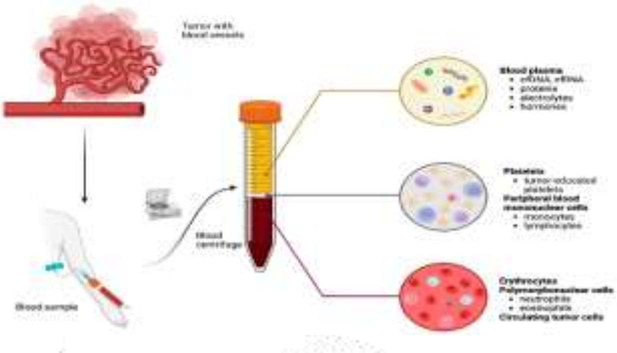
Diagnosed by Melanoma

The first step is the diagnosis in which the doctor confirms that the person has the skin cancer with the help of biopsy (taking a small sample of skin) and image scans, the types and stages are identified.



Biomarker Testing

In this step the cancer tissue are tested for special markers (PD-L1, BRAF mutation or MSI-H) with this result it can be decide that the pembrolizumab is right or not for the patient, it is given after the surgery so that to lower the chance of recurrence, in some advance cases it is the first treatment option.



Pembrolizumab Infusion

It is given through a drip into the vein (IV infusion), takes around 30 minutes, usually the schedule for this is once every 3 weeks (200mg) or once every 6 weeks (400mg). this is usually given for up to 2 years.

Monitoring & side effect management

After the completion of the treatment doctors will monitor the patient for that do the blood test before giving the dose and asks for the symptoms and also watch the immune side effects such as cough, diarrhea, fatigue, rash, yellow eyes/skin.
Every 2-3 months scans are done to see that the treatment is properly working or not. Some side effects like thyroid or adrenal problems may be lifelong and needed daily medication.

Treatment outcomes

After the completion of the all dose we can see the clear result shown in the figure that the reaction which has cause due to the cancer have been disappear

5.2.3 Targeted therapy for melanoma patient

- Diagnosis- confirms melanoma with biopsy and histopathology and determine the type and stage.
- Molecular/Genetic testing- performs tumor profiling and identify mutation offers mainly if BRAF mutation is positive.
- Treatment selection- in this there is an combination of two class for that BRAF inhibitor and MEK inhibitor the example of this are dabrafenib and trametinib, encorafenib and binimetinib.
- Initiation of therapy- Oral targeted therapy for that tablets and are taken daily
- Monitoring- Clinical visits every few weeks and CT scan / MRI at a gap of 6-12 weeks and the side effects are observe.(19)

6.Conclusion

Artificial intelligence is playing an increasingly important role in transforming healthcare by improving disease diagnosis and enabling more precise and individualized treatment strategies. This review highlights the contribution of AI technologies, particularly machine learning and deep learning, in enhancing diagnostic accuracy, minimizing human error, and supporting clinical decision-making across various medical disciplines. In cancer care, especially skin cancer, AI-based image analysis has demonstrated significant potential for early detection, leading to timely diagnosis and improved patient outcomes.

The combination of AI with personalized medicine represents a major shift from conventional treatment approaches toward patient-specific care. In skin cancer management, AI-assisted analysis of genomic mutations and biomarkers enables clinicians to select targeted therapies and immunotherapies that are both effective and less harmful. Continuous monitoring through AI systems further supports treatment optimization by evaluating patient response and adapting therapeutic strategies over time.

Despite these advancements, challenges such as data reliability, algorithms bias, ethical considerations and clinical implementation remain. Addressing these issues through high-quality datasets, transparent AI models, appropriate regulatory frameworks, and collaboration between healthcare professionals and technologists is essential. Overall, AI is expected to function as a supportive tool rather than a replacement for clinicians, contributing to improved diagnostic precision, personalized treatment, and enhanced patient care in the future of healthcare.

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