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BREAST CANCER PREDICTION USING CONVOLUTION NEURAL NETWORK (CNN) WITH EXPLAINABLE AI(XAI)

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ABSTRACT

Breast cancer is one of the most common and life-threatening diseases affecting women worldwide. Early detection plays a crucial role in improving survival rates and enabling timely medical intervention. However, traditional diagnostic methods rely heavily on manual examination of medical images by radiologists, which can be time-consuming and prone to human error. With the advancement of Artificial Intelligence (AI) and deep learning technologies, automated medical image analysis has become an effective approach for supporting accurate and faster diagnosis.

This project proposes an intelligent breast cancer prediction system using a Convolutional Neural Network (CNN) integrated with Explainable Artificial Intelligence (XAI) techniques. The CNN model is trained to analyze breast medical images and classify them into benign or malignant categories. To enhance transparency and interpretability of the deep learning model, Grad-CAM (Gradient-weighted Class Activation Mapping) is incorporated to visualize the regions of the image that influence the model's prediction. This enables medical professionals and usersto better understand how the AI model reaches its decision.

Can a system that analyses histopathological images truly replace the burden of uncertainty that a medical professional carries when making a diagnosis alone? Does making such a tool accessible through a simple web interface bring us closer to a future where no case of breast cancer goes undetected simply because the right expertise was not available at the right time? This research attempts to answer these questions, asking whether intelligent detection systems, when designed with transparency and accessibility in mind, can become a genuine bridge between patients and the timely diagnosis that could save their lives.

Keywords: Breast Cancer Detection, Convolutional Neural Network (CNN), Explainable Artificial Intelligence (XAI), Grad-CAM, Deep Learning, Medical Image Analysis, Tumor Classification, Risk Assessment, Healthcare AI, Flask Web Application.

1.INTRODUCTION

Breast cancer is one of the most common and life-threatening diseases affecting women worldwide Early detection and accurate diagnosis play a crucial role in reducing mortality rates and improving treatment outcomes. Traditionally, diagnosis is performed by radiologists and oncologists who analyze medical images such as mammograms, ultrasound scans, and histopathology slides. However, this manual process can be time-consuming, subjective, and sometimes prone to human error, especially with the growing volume of medical data.With the rapid advancement of Artificial Intelligence (AI) and Machine Learning (ML), healthcare systems are increasingly adopting automated solutions for disease detection. Deep learning models, particularly Convolutional Neural Networks (CNNs), have shown excellent performance in image classification tasks. These models can automatically extract complex features from medical images and identify patterns associated

with cancer, enabling faster and more accurate detection.

Despite their high accuracy, CNN models often function as "black boxes," meaning their decision-making process is not easily understandable. This lack of transparency can reduce trust among medical professionals. To overcome this challenge, Explainable Artificial Intelligence (XAI) techniques such as Grad-CAM are used to provide visual explanations by highlighting the important regions in an image that influence the prediction. the proposed system integrates CNN based breast cancer prediction with XAI to create a reliable and transparent diagnostic support tool. It analyzes breast images, classifies them into benign or malignant categories, and generates heatmaps to explain the model's predictions. Additionally, the system provides risk level assessment, simple medical interpretations, and suggestions for further consultation.

To ensure accessibility, a web-based application is developed using Flask along with HTML, CSS, and JavaScript. Users can upload images, view AI-generated results, visualize explanations, and download detailed medical reports. An admin dashboard is also included to monitor system usage and performance. Overall, this system demonstrates how the integration of deep learning and explainable AI can enhance diagnostic accuracy, reduce the workload of healthcare professionals, and support early detection of breast cancer, ultimately contributing to better patient care.

2.LITERATURE SURVEY

Breast cancer is a major health concern worldwide, and early detection is essential for improving survival rates. Traditional diagnostic methods like mammography and biopsy depend on expert analysis, which can be time-consuming and prone to human error. With the growth of medical data, manual analysis becomes difficult. Advancements in Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) have enabled automated systems for disease detection. Convolutional Neural Networks (CNNs) are widely used for analyzing medical images, but they lack interpretability, leading to the use of Explainable AI (XAI).

- **Machine Learning Approaches**

Early systems used algorithms like SVM, Decision Trees, Naïve Bayes, and KNN for classification. These models relied on manually extracted features and datasets such as the Wisconsin Breast Cancer Dataset.

Although useful, they required domain expertise and could not effectively handle complex image patterns.

- **Deep Learning in Medical Imaging**

Deep learning, especially CNNs, enables automatic feature extraction and accurate image classification. CNNs learn hierarchical patterns and outperform traditional methods in detecting subtle features in medical images.

However, they require high computational power and lack transparency.

- **CNN-Based Breast Cancer Detection**

CNN models are widely used to classify breast cancer images into benign and malignant categories. Transfer learning with models like VGG16, ResNet, and Inception improves accuracy, even with limited data.

Some models also perform tumor localization, but most lack explainability.

- **Explainable AI (XAI) in Healthcare**

XAI techniques improve transparency by explaining AI predictions. Methods like LIME, SHAP, and Grad-CAM highlight important features or regions influencing the decision.

This helps doctors understand and trust AI-based systems.

- **Grad-CAM for Interpretation**

Grad-CAM generates heatmaps that highlight important regions in medical images. It helps identify tumor-related areas and provides visual explanations for model predictions.

This improves interpretability and supports clinical decision-making.

The workflow of the breast cancer prediction system using CNN and Explainable AI. It begins with the input of medical images such as mammograms or histopathology slides uploaded by the user. These images undergo preprocessing steps like resizing and normalization to improve quality.The processed images are then passed to the CNN model, which extracts important features and classifies them as benign or malignant. After prediction, Grad-CAM is applied to generate

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heatmaps that highlight the regions influencing the model's decision.

Finally, the system displays the prediction results along with visual explanations, risk level, and a generated medical report through a web-based interface, making it easy for users and doctors to interpret the results.

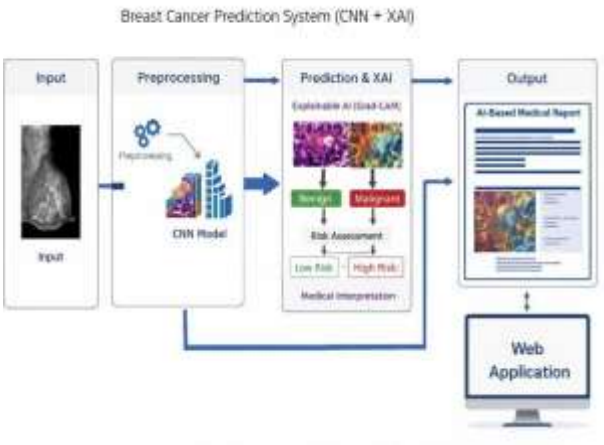

Figure 1:Breast Cancer Prediction System.

3.PROPOSED SYSTEM

The proposed system develops an intelligent breast cancer prediction platform using deep learning and Explainable AI. It uses a Convolutional Neural Network (CNN) to analyze medical images and classify them as benign or malignant. CNN automatically extracts features from images, improving accuracy compared to traditional methods.

To enhance transparency, the system integrates Explainable AI using Grad-CAM, which generates heatmaps highlighting important regions influencing the prediction. This helps medical professionals understand the model's decision.

The system also provides additional features such as tumor region detection, risk level estimation, and simple medical explanations. It can generate downloadable reports containing prediction results and visualizations.

A web-based application is developed using Flask, with HTML, CSS, and JavaScript for the frontend. Users can upload images, view predictions, and download reports easily. An admin dashboard is included to monitor system performance and usage.

3.1 Architecture diagram

The system architecture diagram illustrates the overall structure of the system and how different components interact with each other. The proposed architecture follows a **client-server architecture** where the frontend interface communicates with the backend server that processes AI predictions.

The architecture mainly consists of the following components:

User Interface (Web Application), Flask Backend Server, CNN Prediction Model, Explainable AI (Grad-CAM) Module, Database (MySQL), and Report Generation System.

3.2Architecture Flow

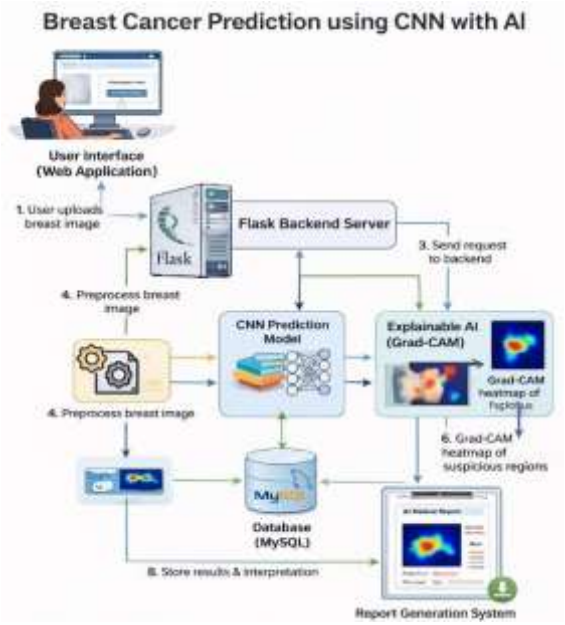

Figure 2:Proposed system architecture of breast cancer classification.

1. The user accesses the web interface through a browser.
2. The user uploads a breast image for analysis.
3. The request is sent to the Flask backend server.
4. The backend preprocesses the image.
5. The CNN model analyzes the image and predicts whether it is benign or malignant.
6. Grad-CAM generates a heatmap to highlight suspicious regions.

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7. The system calculates the risk level and generates medical interpretation.
8. Results are stored in the MySQL database.
9. The prediction results and visualizations are displayed to the user.
10. The system generates a downloadable AI medical report.

4.RESULT DISCRIPTION

The proposed breast cancer prediction system was tested using standard medical image datasets such as mammograms, ultrasound, and histopathology images. The CNN model successfully classifies images into benign and malignant categories and performs the complete workflow, including preprocessing, prediction, and result display through a web interface.

The model shows strong performance based on evaluation metrics like accuracy, precision, recall, and F1-score. These metrics indicate that the system can reliably detect cancer patterns and distinguish between cancerous and non-cancerous tissues. CNN improves performance by automatically learning important image features without manual extraction.

The confusion matrix analysis shows that most samples are correctly classified, with very few errors. The system maintains high true positives and true negatives while minimizing false positives and false negatives, which is important for safe medical diagnosis.

Explainable AI using Grad-CAM is a key feature of the system. It generates heatmaps that highlight important regions influencing the prediction. In malignant cases, strong highlighted regions indicate tumor areas, while benign cases show weaker or scattered activation. This improves transparency and helps doctors trust the model's decisions.

The system also provides risk level assessment, medical interpretation, and recommendations. It generates reports and displays results through a web interface, making it user-friendly and practical for healthcare use.

Overall, the system combines high accuracy with interpretability, making it a useful AI-assisted tool for breast cancer detection, though it supports—not replaces—medical professionals.

Figure 3: Web Interface for Breast Cancer Classification System

The web-based interface of the system where users can upload breast medical images and view prediction results. It provides an easy and user-friendly platform to interact with the AI model, display outputs, and download reports. The Grad-CAM visualization for a malignant case. The highlighted red and yellow regions indicates areas of high importance, showing where the CNN model detected abnormal or cancerous tissues.

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Figure 4: Malignant Grad-CAM Heatmap

The Grad-CAM visualization for a malignant case. The highlighted red and yellow regions indicates areas of high importance, showing where the CNN model detected abnormal or cancerous tissues. The

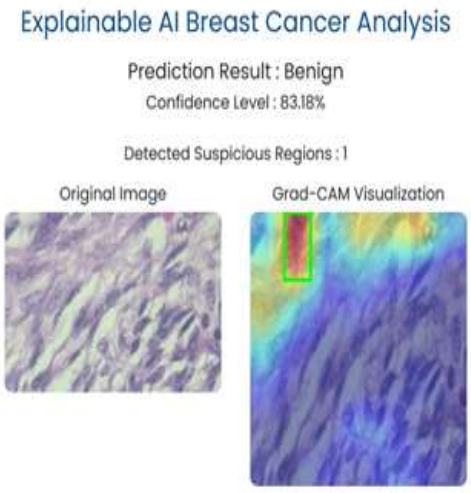

Figure 5: Benign Grad-CAM Heatmap

Grad-CAM output for a benign case. The heatmap contains weaker and scattered regions, indicating the absence of strong tumor-related patterns and supporting the non-cancerous prediction.

Over all result discussion:

The result demonstrate that the proposed CNN with explainable AI system is effective and practical for breast cancer prediction.It integrates image image upload preprocessing, prediction, Grad-CAM visualization, and report generation into a single application.

The CNN model provides accurate classification of benign and malignant cases, while Grad-CAM improves transparency by highlighting important regions influencing the system combines accuracy and interpretability making it a useful AI-assisted diagnostic tool that supports doctors with fast and reliable analysis, though it does not replace medical expertise.

5. CONCLUSION

breast cancer is a major cause of death for effective treatment. Traditional diagnosis relies on manual image analysis, which can be time-consuming and prone to errors. This project developed an intelligent breast cancer prediction system using Convolutional Neural Networks (CNN) with Explainable AI (XAI). The CNN model automatically extracts features from medical images and accurately classifies them as benign or malignant.

To improve transparency, Grad-CAM is used to generate heatmaps that highlight important regions influencing the prediction. This helps medical professionals understand and trust the model's decisions. The system is implemented as a web-based application using Flask, allowing users to upload images, view predictions, and generate reports. It performs efficiently and provides reliable results. Overall, the system combines accuracy and interpretability, making it a useful tool for early breast cancer detection and supporting AI-assisted medical diagnosis.

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