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AI Smart Screening System for Early Detection of Breast Cancer Using Deep Learning

Mrs. U. Saritha[1], Ms.K.Bhargava Triveni Nandana[2]

[1]Assistant Professor, Department of CSE (AI & ML), CMR Technical Campus, Kandlakoya, Medchal, Telangana, India
sarithau.aiml@cmrtc.ac.in

[2] Assistant Professor, Department of CSE (AI & ML), CMR Technical Campus, Kandlakoya, Medchal, Telangana, India
bhargavanandana.aiml@cmrtc.ac.in

Abstract:
Breast cancer is one of the most important issues of health concern to women globally and early detection can be crucial in enhancing the survival rates. Conventional screening methods like mammography involve interpretation by experts and the interpretation process is time consuming and liable to human errors particularly in dense breast tissues. The proposed project introduces an AI Smart Screening System based on the deep learning methods to help with the early diagnosis of breast cancer. The offered one makes use of a Convolutional Neural Network (CNN) that is trained on the mammogram images to detect benign and malignant breast tissues and estimate the density of the breast tissues. The system offers both prediction outputs and a score of confidence and allows patients and doctors to access the information securely and through a web-based environment based on their roles. The system enhances the accuracy, efficiency, and ease of access of the mammogram analysis, report management, and aids the clinical decision-making process by automating mammogram analysis, incorporating digital report management.

Keywords: Breast Cancer Detection, Deep Learning, Convolutional Neural Networks, Mammogram Image Analysis, Medical Image Processing, AI-Based Screening System, Decision Support System.

1. Introduction

Breast cancer is a life threatening and one of the most widespread diseases in women all over the world, and it is a major cause of mortality in relation to cancer. Early and proper diagnosis has high success rates of treatment and survival. The most common method of screening is by mammography although interpretation of mammogram images is a complicated procedure considering that there is variation in density of breast tissues and the possibility of some delicate abnormalities that can hardly be detected using manual interpretation.

The recent Artificial Intelligence (AI) developments, especially the deep learning field, have demonstrated a tremendous promise in using medical images. Deep learning models will be able to automatically derive sophisticated patterns in mammogram images and help radiologists detect cancerous tissues with more precision and reliability. Project is a proposal of an AI-based smart screening system that will automate the process of identifying breast cancer, typing of tissue kinds and determine the breast density, thus,

acting as a solid decision support tool to medical practitioners.

2. Problem Statement

The breast cancer is among the most common causes of death among women across the globe especially because of late diagnosis and constraints with regard to conventional screening technologies. Despite the fact that mammography is the most popular diagnostic method, manual reading of mammographic images is time consuming, highly reliant on the expertise of the radiologists and subject to human error especially when dealing with dense breast tissue and minute abnormalities. Moreover, not all healthcare systems have digitized platforms that are secure in handling patient records and organic diagnostic reports besides being readily available to both the patients and physicians. With such challenges, there is a need to have an automated, precise, and safe AI-based screening system to aid in the early detection of breast cancer, enhance diagnostic accuracy, and streamline the report management process based on roles, allowing role controls.

3. Related Work

The Traditional breast cancer detection procedures are mostly based on medical imaging procedures including mammography, ultrasound, magnetic resonance imaging (MRI) and computed tomography (CT). The most popular of these, however, is mammography. Computer-Aided Diagnosis (CAD) systems were provided to help radiologists to identify suspicious areas in the mammogram images. CAD systems are more sensitive to detection but remain significantly reliant on manual interpretation and are generally plagued by a high false-positive rate and low consistency, especially in situations of dense breast tissue.

As machine learning has improved, there is a number of papers discussing the use of statistical and supervised learning approaches to classification of breast cancer. Earlier methods that were used included logistic regression, support vector machines, and k-nearest neighbors with handcrafted features on medical images. Though these methods proved to be of better performance in comparison to the traditional CAD systems, their performance was hampered by manual feature engineering and failure to capture complex patterns that could be found in mammogram images.

As recent studies have revealed, deep learning models, in particular, Convolutional Neural Networks (CNNs) perform considerably better in medical image analysis in comparison with traditional machine learning methods. CNN-based models learn hierarchical features automatically on mammogram raw images which lead to increased accuracy and robustness. Nonetheless, most existing deep learning solutions are limited to classification and do not offer secure user access, report management, and clinical workflow integration to end-to-end systems. To overcome these shortcomings, the given system will integrate CNN based breast cancer detection with a complete web stack, which allows patients and doctors to access the information based on their roles and improves both the diagnostic effectiveness and the practical functionality of the system.

4. System Overview

The proposed solution is an AI-based breast cancer detection system which will help in the early detection of abnormalities in the breast through mammogram images. Not only does the system

automatically classify breast tissue as either benign or malignant but also detects the degree of breast density which is vital in the assessment of risk of cancer. The system will combine the approach to deep learning and web-based interface to enhance the quality of the diagnostic process and decrease the reliance on the manual interpretation of radiologists.

The system allows various user roles including patients and doctors to use it securely via authentication and role-based access control. Patients will be able to post the mammogram images and access diagnostic reports, doctors may see the predictions provided by AI, analyze and manage patient records. This systematic access has guaranteed privacy of data, safe processing of medical data, and effective clinical workflow.

The system architecture is a combination of end-user-friendly frontend, back-end services powered by artificial intelligence, and a centralized database. Frontend gives an easy to use interface to upload images and view results and the backend reads images, does deep learning model executions and stores diagnostic results. This is a comprehensive design that can support efficient, reliable and scalable breast cancer screening.

5. Proposed Methodology

The suggested methodology starts with obtaining of mammogram images in the publicly available datasets and clinical sources. Preprocessing of these images is done by resizing, noise reduction, contrast enhancement and normalization of these images to maintain consistency and enhance model performance. The augmentation of data is used to deal with the imbalance in the classes and enhance enhancement of the learning process.

A Convolutional Neural Network (CNN) will be used in automated feature extraction and classification. The model is offered to be trained to differentiate between benign and malignant breast tissues and learn patterns of the categories of breast density. The dataset is segmented to training, validation and testing sets during training to compare the generalization performance. The effectiveness of models is evaluated by performance measures including accuracy, precision, recall and F1-score.

The model is then plugged into the back-end of the web application, after being trained. Upon uploading a mammogram image by a user, the system takes the input and gives the results of classification and confidence scores. These forecasts are safely placed in the database and reported out in role specific dashboards. This interdisciplinary approach guarantees a correct diagnosis, safe data management and clinical usefulness.

6. System Architecture

The system uses a client-server model with a combination of user interface, backend services and deep learning model. The frontend has interfaces with patients and doctors in terms of roles such as login pages, dashboards, and the ability to view reports. Frontend-backend communication is facilitated by secure HTTP request, the backend, which was developed based on Flask, takes care of authentication, authorization, report management, and inferential model. The CNN model that is created in TensorFlow

and Keras receives the mammogram images and provides the results of the predictions. The patient information, the user logins, and the screening reports are stored in a centralized MySQL/PostgreSQL database, which provides the security of patient data and scalability of the system.

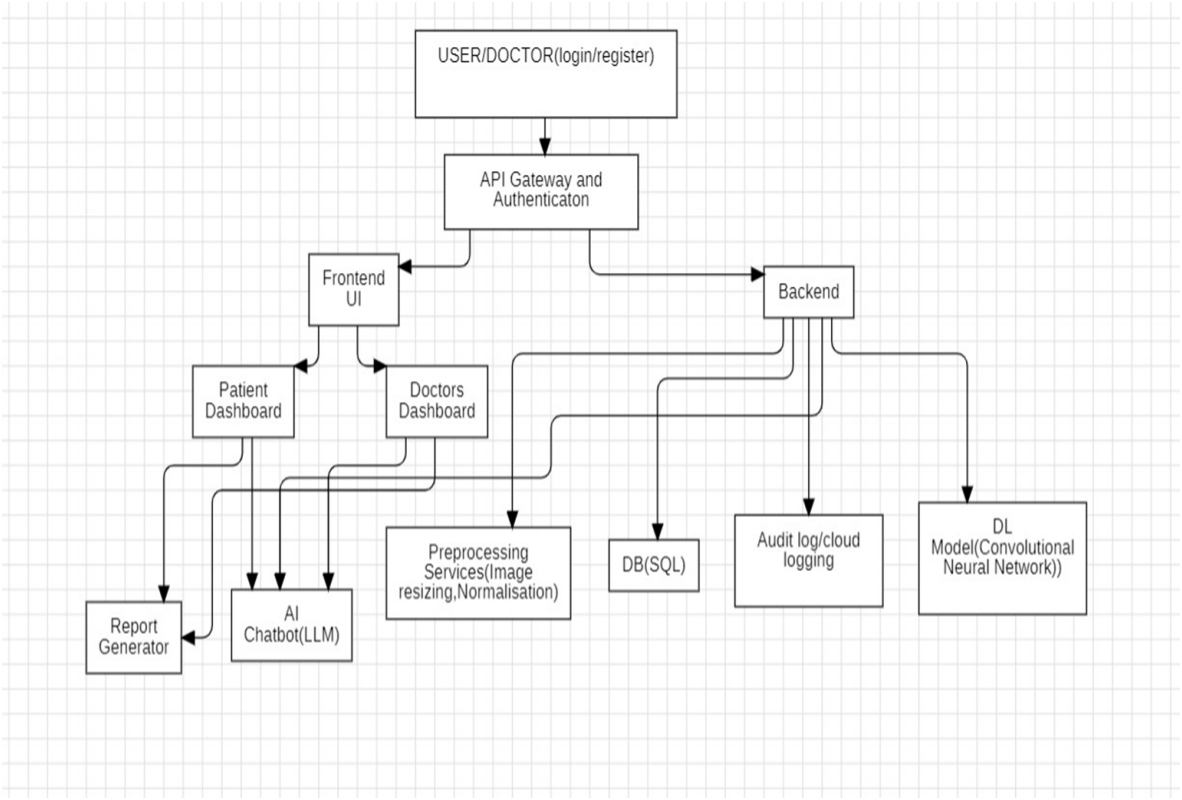

Fig. 1. AI smart screening system for early detection of breast cancer using Deep learning

7. Implementation Details

The system suggested is deployed based on the combination of deep learning and web technologies. Frontend interface is created in HTML, CSS and JavaScript to offer a user-friendly and responsive interface to the patients and doctors. The Python and Flask framework are used to build the backend where the user authentication, image uploading, and interaction with the trained AI model happen. Role-based access control is adopted to provide secure management of the medical information.

The deep learning module is constructed on the basis of TensorFlow and Keras. A Convolutional Neural Network (CNN) is trained on processed images of mammograms in order to classify mammogram tissue as benign or malignant and determine the degree of breast density. To enhance model performance and generalization, image normalization and data augmentation methods are used. The trained model is installed to the backend to use in real-time prediction.

The database contains user details, uploaded images, and results in a centralized database. Data of the images and the predictions are stored and accessed safely and retrieved when needed. Authenticated API endpoints provide a stable communication between components of the system. Such an implementation offers an effective and safe structure of AI-assisted breast cancer detection.

8. Deep Learning Models used

The breast cancer detection system proposed is supervised deep learning whose idea is to classify mammogram images as benign or malignant, as well as determining the level of breast density. The methodology will start with the collection of mammogram images out of publicly available datasets, and then undergo a preprocessing phase, including image resizing, image normalization, removal of noise, and enhancement of contrast to enhance image quality and consistency. Data augmentation methods are used to augment the diversity of the datasets and minimise overfitting. The trained deep learning models on the processed images are then applied to extract discriminative features of medical images automatically.

There are three deep learning models used to classify breast cancer:

1. Convolutional Neural Network (CNN)
2. VGG16
3. ResNet50

8.1 Convolutional Neural Network(CNN)

The models central to the proposed system of detecting breast cancer are the Convolutional Neural Networks (CNNs). CNNs are image-specific and they learn to extract spatial and hierarchical features based on mammogram images automatically. In this project, CNN model has convolutional layers that will extract features, pooling layers that will reduce the number of dimensions, and fully connected layers that will perform the classification of the features. The model predicts the benign or malignant nature of the breast tissue and helps in the classification of the breast density. The effectiveness of CNNs lies in their capacity to generate fine details of patterns and textures of medical images, but their success relies on the presence of adequate training data and the appropriate selection of parameters.

8.2 VGG16

VGG16 is a neural network model that is a deep convolutional neural network, unlike other models with a complex design, but it has good performance in image classification challenges. VGG16 (a transfer learning model) is proposed in the described system, fine-tuning with mammogram images in case of pre-trained weights of the ImageNet dataset. This will help the model to take advantage of the learnt low level and mid level features enhancing the accuracy of classification despite a small amount of medical data. VGG16 is capable of identifying complex patterns in mammograms due to its deep architecture, but the deep architecture is more computationally intensive than simple CNN models.

8.3 ResNet50

ResNet50 is a deep learning model with residual learning, which is proposed to solve the vanishing gradient problem by adding skip connections between layers. The ResNet50 is used in this project to

improve classification of breast cancer as it allows deeper learning in terms of features without degradation. The remaining connections enable the model to learn complex representations effectively that is why it is the most appropriate to use in identifying subtle abnormalities in mammogram images. Also, ResNet50 has a benefit of regularization which helps avoid overfitting and enhance generalization and is therefore useful with large and imbalanced medical images data.

9. Experimental Results and Discussion

The way the experimental trial of the proposed AI Smart Screening System on the prediction of breast cancer shows successful real-time operation and the high degree of diagnostic monitoring based on the role-based web platform. The system is effective in the management of various patients as it can run and store a number of patients as demonstrated in the doctor dashboard and even generate AI-based reports of breast cancer screening which can be securely accessed by authorised doctors. The trained deep learning model reliably processes uploaded mammogram images and makes comparable predictions, which allows doctors to view patient information and diagnostic outcome via a centralized interface. The well-organized reporting system and the smooth combination of AI predictions confirm the reliability, usability, and appropriateness of the system according to its use in the clinical decision-making process in breast cancer screening.

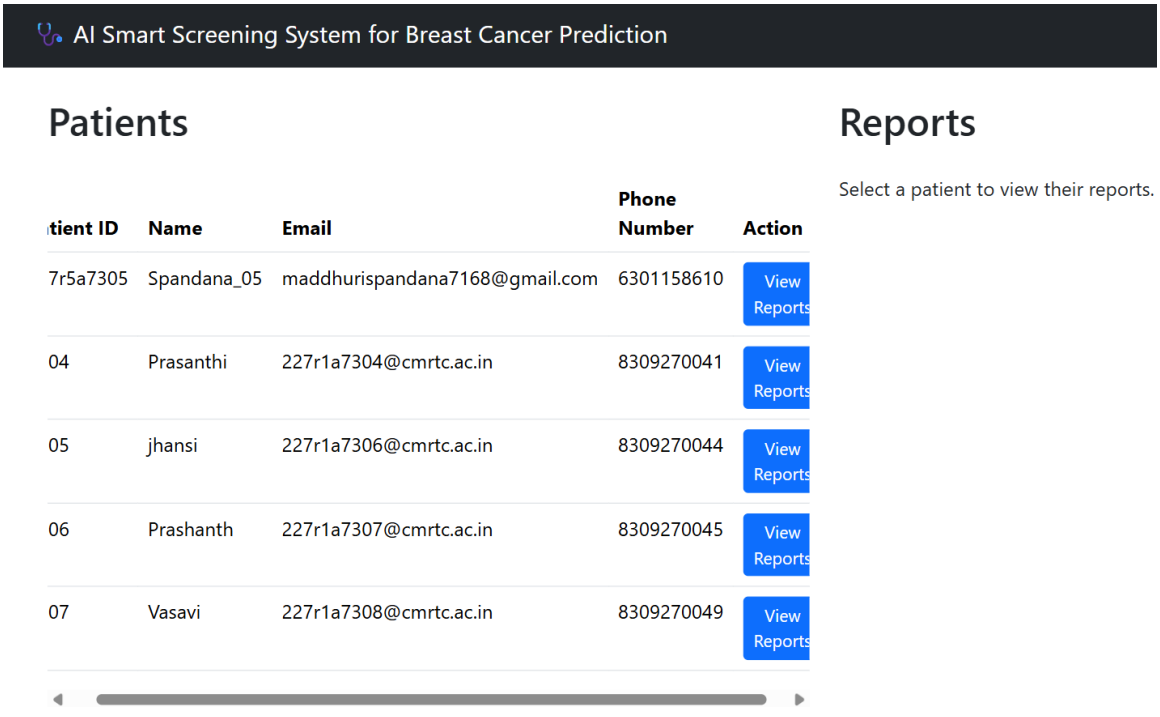

Fig 2. AI smart screening system for early detection of breast cancer using Deep Learning Result Interface

10. Advantages of Proposed System

The suggested AI Smart Screening System has multiple benefits in comparison to the conventional methods in breast cancer diagnostics because it integrates image-processing neural networks based on deep learning and a secure web environment with a role-based system. The system improves automated and correct classification of mammogram images thereby decreasing the reliance of manual interpretation and eliminates human error. Patient and physician access control guarantees privacy of crucial medical information whereas the centralized report management enhances efficiency in clinical workflow. The option to create real-time diagnostic reports, as well as downloadable ones, helps to increase accessibility and usability. Moreover, the scalable system design ensures that the future improvement can be integrated without any issues with ease, which makes the platform applicable to the implementation in the various healthcare settings.

11. Conclusion

The proposed project will introduce a breast cancer screening system that utilizes AI-based technology and provides an easy-to-use and safe web application as a user-friendly one. Through the application of convolutional neural networks to automated mammogram detection, the application is effective in identifying breast cancer and aiding the early cancer diagnosis. Patient and doctor role-based dashboards provide an effective access to reports and clinical review to enhance transparency and diagnostic reliability. The feasibility, practicality, and clinical relevance of the proposed approach can be confirmed by results of the experiments and outputs of the system. On the whole, the system has a high potential of being a decision-support tool to enhance the process of breast cancer screening and diagnostic.

12. Future Scope

The improvement of the system can be made by incorporating bigger and varied mammograms data in order to better the accuracy of the prediction. Transformers and multimodal learning can be provided as advanced models to integrate clinical data and imaging to improve the diagnosis. Also, live cloud architecture and mobile-application connection can widen access of remote and rural medical care sites.

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