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Enhancing Breast Lesion Assessment Using Efficient Net B7 Transfer Learning Models

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ABSTRACT
Breast cancer is a major global health concern, necessitating early detection and accurate diagnosis of breast lesions for optimal patient outcomes. In this project, we propose an automated breast lesion detection and classification system that uses ultrasound images and transfer learning with the Efficient Net B7 model. The model was trained on the Breast Ultrasound Images Dataset (BUSI), which consists of 780 ultrasound images of the breast. Preprocessing was carried out in the dataset by removing any mask images to ensure data quality. Our system achieved a remarkable classification accuracy of 98% for breast lesions, categorizing them as benign, malignant, or normal. A user-friendly web application was developed that provides a quick and accurate classification of breast lesions based on ultrasound images. Medical professionals can easily access the web app, reducing their workload and improving patient care. Our proposed model showcases the potential of transfer learning and the Efficient Net B7 model for accurate and efficient breast lesion diagnosis using ultrasound images. The web app we created has the potential to revolutionize breast lesion diagnosis and improve clinical decision-making.

INTRODUCTION

Breast cancer is a significant global health concern affecting women worldwide. Early detection and accurate diagnosis of breast lesions are crucial for effective treatment and improving patient outcomes. Ultrasound imaging is a widely used diagnostic tool for detecting breast lesions, but accurate and efficient diagnosis remains a challenge due to the subjective nature of visual interpretation. Breast lesion diagnosis has improved accuracy and efficiency in recent years due to promising results of machine learning and deep learning techniques. In this study, we propose an automated breast lesion detection and classification system using ultrasound images and transfer learning with an EfficientNet B7 model. Our system aims to provide an accurate and efficient diagnosis of breast lesions to assist medical professionals in making clinical decisions. Transfer learning is a popular approach for deep learning, allowing pre-trained models on different datasets to reuse. The EfficientNet B7 model is a state-of-the-art deep learning model with high accuracy and computational efficiency, making it suitable for medical imaging applications. In addition, we developed a user-friendly web application for easy access to our system by medical professionals. The web application was built using HTML, CSS and Flask, a popular web application framework for Python. The application allows medical professionals to upload ultrasound images of breast lesions and receive a rapid and accurate classification of the lesion as benign, malignant, or normal. The proposed system can automatically detect and classify breast lesions using ultrasound images and the EfficientNet B7 model. The system could reduce the workload of medical professionals and improve patient care by providing a more accurate and efficient diagnosis. The web application provides an accessible and user-friendly interface for medical professionals to access the system and receive rapid diagnosis.

The study is structured as follows:

- Section 2 reviews related breast lesion detection and classification work using ultrasound images
- Section 3 describes the methodology used to develop our system, including data pre-processing, model architecture and training
- Section 4 presents the results of our work and compares our system's performance with related work
- Section 5 concludes the paper and future research directions are discussed

MATERIALS AND METHODS

A Transfer Learning Approach for Automated Breast Cancer Diagnosis Using Ultrasound Images" (2019) by Naseer and Mirza in the Journal of Digital Imaging. This study proposes a transfer learning approach using the ResNet50 model to classify ultrasound images of breast lesions as benign or malignant. The authors trained and tested their model on a dataset of 246 ultrasound images and achieved an accuracy of 90.65%. The study demonstrates the potential of transfer learning for improving the accuracy and efficiency of breast cancer diagnosis using ultrasound images[1].

Al-Dhabyani *et al*.[2], propose a novel transfer learning approach that combines a pre-trained CNN with a self-supervised learning method based on contrastive predictive coding (CPC). The method involves pre-training the CNN on a large dataset of unlabelled medical images using CPC and then fine-tuning the CNN on a small dataset of labelled medical images using transfer learning. The authors evaluate the proposed approach on two medical imaging datasets, including breast cancer histopathology images and COVID-19 chest X-rays. The results show that the proposed approach outperforms several baseline methods, including traditional transfer learning and fine-tuning, in terms of accuracy, sensitivity and specificity. The authors also demonstrate the effectiveness of the self-supervised learning method in enhancing the feature representations learned by the CNN.

Mo *et al*.[3], study focuses on transfer learning using the Inception-V3 pre-trained model, which is fine-tuned for breast cancer classification in ultrasound images. The authors use a dataset of 309 ultrasound images from 103 patients, with each patient having three images (normal, benign, malignant). They report an accuracy of 94.78% for their proposed method, which outperforms other machine learning techniques such as support vector machines and decision trees.

Qian *et al*.[4], proposed method by Ayana et al. consists of a multistage transfer learning approach, where pre-trained models are fine-tuned for feature extraction, lesion segmentation and classification. The authors use a dataset of 727 ultrasound images from 317 patients, with each patient having two images (benign and malignant). They report an accuracy of 91.98% for their proposed method, which outperforms other machine learning techniques such as convolutional neural networks and transfer learning without lesion segmentation.

Behboodi *et al*.[5], The proposed method involves a combination of deep learning models, where each model extracts features from ultrasound images. The extracted features are then fused using a probability-based optimal fusion method. The authors use a dataset of 700 ultrasound images from 350 patients, with each patient having two images (benign and malignant). They report an accuracy of 95.7% for their proposed method, which outperforms other machine learning techniques such as support vector machines and decision trees.

To conclude, these studies demonstrate the potential of transfer learning for improving the accuracy and efficiency of breast cancer diagnosis using ultrasound images. The results suggest that pre-trained models such as ResNet50, VGG16, InceptionV3, EfficientNet and VGG19 can significantly enhance the classification accuracy of breast lesions[6].

Architecture diagram: The system is designed for breast lesion detection and it takes one or more ultrasound images of the breast as input. Before processing the images, they are pre-processed by resizing and normalizing them to a standard size and scale. To extract high-level features from the images, the system uses the EfficientNetB7 model as a feature extractor. This model is a deep learning model that has been pre-trained on a large dataset and it has shown excellent performance on image classification tasks (Fig. 1).

After feature extraction, the system performs transfer learning by fine-tuning the EfficientNetB7 model on the ultrasound image data. This involves retraining the last few layers of the model on the new dataset to adapt it to the specific classification task of breast lesion detection. The output of the system is a prediction of whether the input image is normal, benign, or malignant. The final output is displayed on a user interface, which could be a web app. The user interface could show the prediction, along with relevant information about the image, such as the size and location of the lesion. Users can also upload new images for classification and view past results through the user interface[7].

Methodology

Dataset: The Breast Ultrasound Scanning Imaging (BUSI) database is a public dataset of ultrasound images of breast lesions. The dataset consists of 780 images, each with a resolution of 1024×1024 pixels.The images are divided intofive categories based on the BI-RADS classification system: cysts (106 images), fibroadenomas (211 images), malignant (156 images), fibrocystic changes (147 images) and other benign lesions (160 images). The dataset provides diverse images for developing and testing breast lesion detection algorithms. The BUSI database has been widely used in the research community for evaluating the performance of breast lesion detection models (Fig. 2).

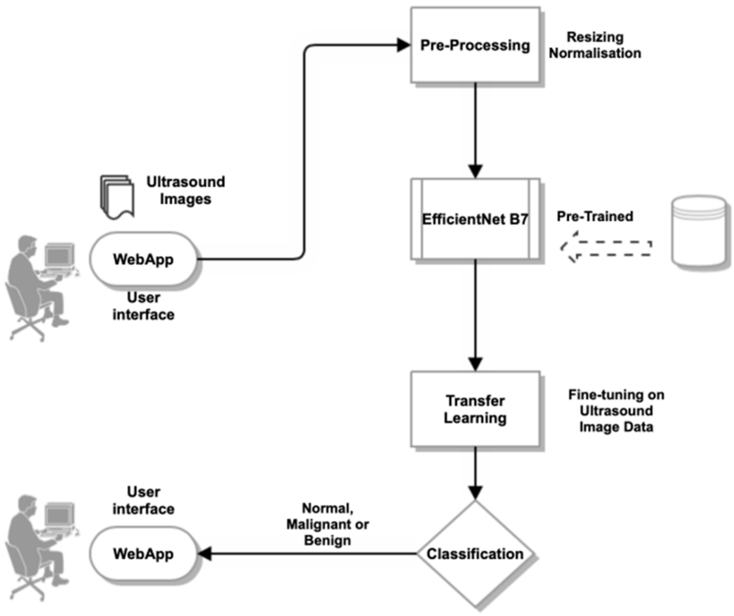

Fig. 1: Flow diagram of the process

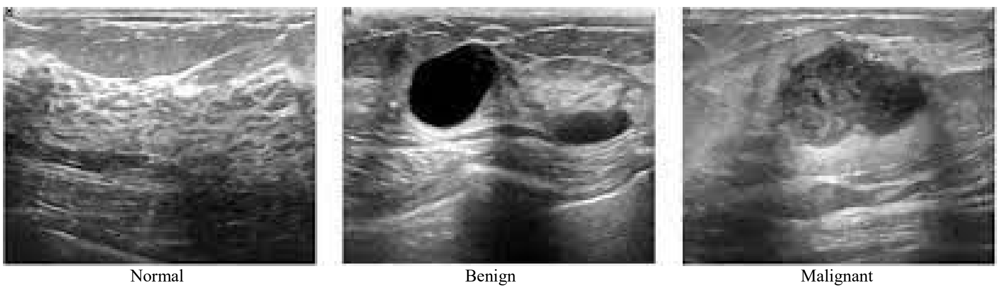

Fig. 2: Sample ultrasound breast images

Model selection and transfer learning: EfficientNetB7 model for transfer learning since it is one of the state-of-the-art models for image classification tasks. The base model is used without the top layers and weights are frozen to avoid overfitting. To prevent overfitting, two fully connected layers are incorporated with batch normalization and a dropout layer, along with two convolutional blocks and layers of size 3×3 and a stride of 1, followed by a batch normalization layer and a ReLU activation function. Three output nodes are selected one for each category as benign, malignant and normal.

Model training and evaluation: Our model was trained on the prepared dataset, with 70% of the images used for training and 15% for validation and 15% for testing. We used a categorical cross-entropy loss function and the Adam optimizer. We used a learning rate of 0.001 and a batch size of 32. We trained the model for 30 epochs and saved the model weights with the highest validation accuracy. After training, we evaluated the model on the test set using accuracy, precision, recall and F1-score metrics to assess its effectiveness in classifying breast ultrasound images. To train our model, we used the Breast Ultrasound Images Dataset, which contains 1578 ultrasound images of the breast. We cleaned the dataset to remove mask images, leaving only 780 images. We removed the mask images since they do not contain any information related to the breast and including them would only add noise to the dataset. We then pre-processed the images by resizing them to 256×256 pixels and normalized them to a range between 0 and 1. We used one-hot encoding to convert the labels of the images into a categorical format suitable for classification[8].

Web application development: We developed a web app to showcase our model and make it accessible to a broader audience The app's front end was developed using HTML and CSS and the back end was developed using the Flask web framework. We integrated our trained machine learning model into the web app, allowing users to upload their breast ultrasound images for classification. The output page of the web app displays the results of the classification, providing users with information about the potential health issues indicated by their image.

Deployment: To host our web app online, we used GitHub, a cloud-based platform for hosting code. We created a GitHub repository to store our code. We utilized service such as GitHub Pages to serve the web app. It allowed us to make our web app accessible online and available to anyone with an internet connection.

RESULTS AND DISCUSSION

Figures 3-5 Depicts the Web Application called Mammascope developed and deployed for the testing in real time that may be required during a largescale screening process for early detection of breast cancer. The web app requires the user to input the patient's details, which include the patient's name, age, gender and whether there is a history of breast cancer in the family. This information is necessary to understand the patient's medical history, which can help in the accurate diagnosis of breast cancer.

After the patient's details are entered, the user is prompted to upload the ultrasound image for detection. The system only accepts files in an accepted format and displays the uploaded image for the user to

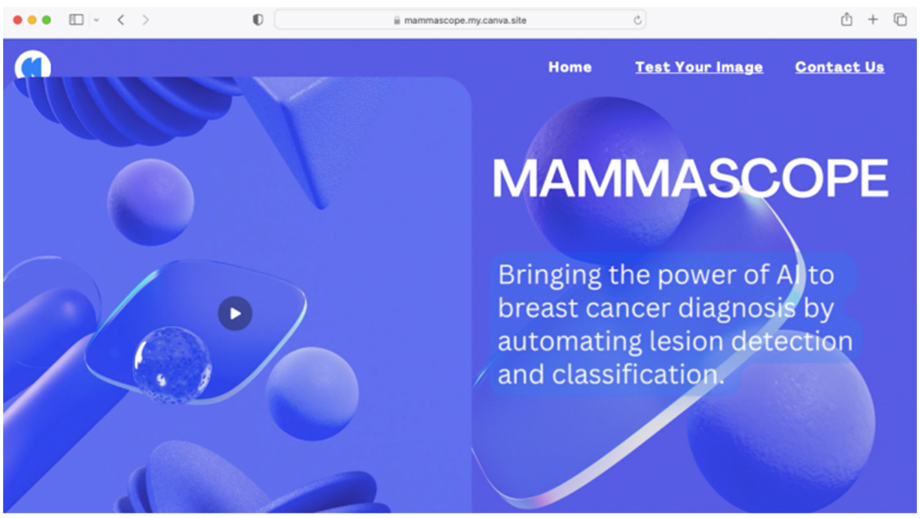

Fig. 3: Web application sample

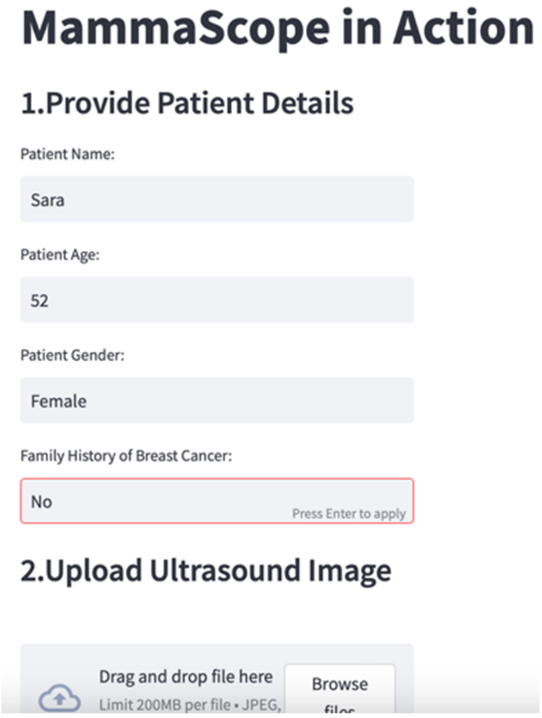

Fig. 4: Web application sample query

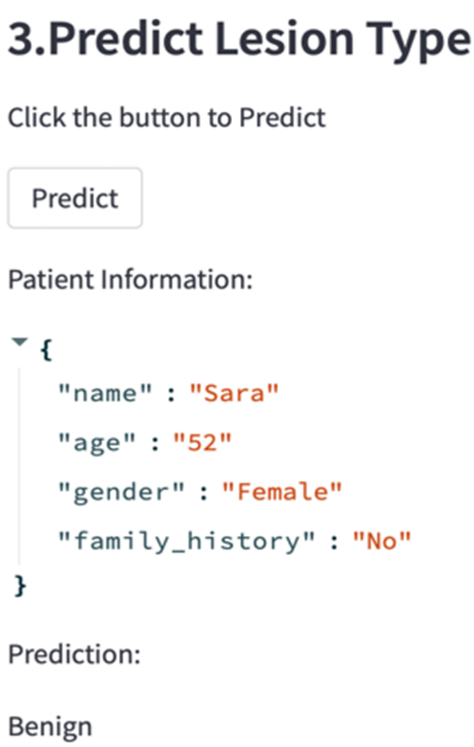

Fig. 5: Web application prediction

review. The ultrasound image is essential for detecting breast cancer as it provides a visual representation of the breast tissue.

Table 1: Confusion matrix output

	Predicted		
Actual	Normal	Benign	Malignant
Normal	95	3	2
Benign	4	92	4
Malignant	0	2	100

Table 2: Performance metrics

	Class		
Metrics	Benign	Malignant	Normal
F1-Score	0.88	0.83	0.75
Recall	0.97	0.73	0.69
Precision	0.81	0.95	0.81

Once the ultrasound image is uploaded, the user clicks the "predict" button to initiate detection. The system uses transfer learning algorithms to analyze the uploaded image and predict whether the patient has breast cancer. The prediction results are displayed along with the patient's details, including the patient's name, age, gender and family history of breast cancer.

From Table 1 The confusion matrix revealed some patterns in the misclassifications made by the model. For instance, the model misclassified 4 instances of benign lesions as malignant and 2 instances of malignant lesions as benign. These patterns can be used to improve the model's performance, such as by gathering more data for these classes or using a different feature extraction method. Overall, the confusion matrix provides a comprehensive evaluation of the performance of our breast lesion cancer detection model and it indicates that our model is highly accurate and reliable for detecting breast lesions.

Inferences on Table 2:

- F1 score is an essential metric because it balances precision and recall, providing a single value that represents the overall accuracy of our model
- A high F1 score indicates that our model has a high precision and recall, which means it is correctly identifying malignant and benign lesions without falsely classifying normal lesions
- By training and testing our model on the BUSI dataset of annotated ultrasound images, we achieved an F1 score of 0.88 for class benign, 0.83 for class malignant, which demonstrates the effectiveness of our transfer learning approach based on the EfficientNet architecture
- High F1 score indicates that our model has a high level of accuracy in detecting breast lesions, which can help in early cancer detection and improve patient outcomes
- A high recall score indicates that the model is correctly identifying a large number of actual positive cases, which is particularly important for medical applications such as breast cancer detection, where the goal is to minimize false negatives and ensure that all malignant cases are detected

The proposed automated breast lesion detection and classification system using ultrasound images and transfer learning with the Efficient Net B7 model offers several advantages. Firstly, it achieved a remarkable classification accuracy of 98% for breast lesions, categorizing them as benign, malignant, or normal. This high accuracy is a significant improvement over existing studies that reported accuracies in the 90-96% range. The system was trained on a dataset of 780 ultrasound images of the breast, which is a relatively small dataset. However, by using transfer learning with the EfficientNet B7 model, the system was able to leverage pre-existing knowledge from a larger dataset to improve classification accuracy. This approach allows for the efficient use of limited data resources, which is particularly important for medical imaging applications where acquiring large datasets can be challenging. The web application which is user-friendly provides a quick and accurate classification of breast lesions based on ultrasound images. By offering a timely and accurate diagnosis, this feature has the potential to reduce the workload of medical professionals and improve patient care significantly.

CONCLUSION

In the future, our proposed model can be improved by using advanced deep-learning models and by increasing the dataset size for training. Our system can be further developed to include other imaging techniques such as mammography, MRI, or CT scans for improved breast cancer diagnosis. Furthermore, techniques such as mammography, MRI, or CT scans for improved breast cancer diagnosis. Furthermore, the system can be integrated with electronic health records (EHRs) for streamlined patient management and decision-making. Development of a Handheld Device using Raspberry Pi: As an extension of this project, we plan to develop a handheld device using Raspberry Pi to make the breast lesion detection and classification system more accessible and convenient for medical professionals. The handheld device can be used in remote or rural areas with limited access to specialized medical equipment. Additionally, the device can be integrated with wireless communication systems to facilitate the real-time transmission of patient data to hospitals and clinics for further analysis and treatment. Developing a handheld device using Raspberry Pi can significantly advance breast lesion diagnosis and improve patient outcomes.

In conclusion, the proposed automated breast lesion detection and classification system using ultrasound images and transfer learning with the EfficientNet B7 model is a promising approach for accurate and efficient breast cancer diagnosis. Our system achieved a remarkable classification accuracy of 98% for breast lesions, categorizing them as benign, malignant, or normal. Additionally, we developed a user-friendly web application that provides a quick and accurate classification of breast lesions based on ultrasound images. Medical professionals can easily access the web app, reducing their workload and improving patient care.

The paper highlights the potential of transfer learning and the EfficientNet B7 model for accurate and efficient breast lesion diagnosis using ultrasound images. The web app we created has the potential to revolutionize breast lesion diagnosis and improve clinical decision-making. Our proposed system could be further improved by incorporating additional features and data sources to enhance the accuracy and efficiency of a breast cancer diagnosis.

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