Benign-Malignant Breast Histology Classification using MobileNet Variants: An Analysis

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Abstract. Automatic analysis of the medical data is one of the common practices followed to detect diseases with better accuracy. Deep Learning (DL) tool-based medical image examination is one of the approved clinical practices, and the outcome of this process supports the treatment planning and execution. This work proposes a DL tool based on the ConvNeXt (CN) scheme to classify the chosen Breast Histology Images (BHI) into benign and malignant classes. The various phases of the proposed DL-tool include: image collection from the database and resizing it to 224x224x3 pixels, feature extraction using the chosen CN-model, feature reduction using 50% dropout, and serial features fusion to get fused-features-vector (FFV), and binary classification with 5-fold cross-validation. The merit of the developed scheme is confirmed using the classification executed with the chosen CN-feature and the FFV. The outcome of this study confirms that the FFV-based classification provides a detection result upto 99% when the SoftMax-based classification is executed. This confirms that the proposed DL-tool provides a better result on the chosen image database.

1 Introduction

The recent outcome from the report of Globocan-2022 verifies that the number of people getting cancer has increased globally due to various reasons. To reduce the global burden imposed by cancer, it is essential to develop effective methods for its early diagnosis and treatment. This method could also make it much easier to lower the date of death, which could be a big benefit. The death rate has also gone up because so many more people are being diagnosed with cancer around the world. This seems to be the case, even though a lot of programs to raise awareness have been done. Because of this, a number of clinical protocols have been put in place to find the cancer and figure out how bad it is using a variety of methods. One of these strategies is gathering medical images using a certain type of imaging [1,2]. The doctor, who is an expert in the disease, then looks at the medical photos of the cancer patient. This person is in charge of making sure that the right treatment is planned for the condition. Because the tissue and cells involved are so complex, it takes a long time to look at the cancer data by hand. There is also a chance that mistakes will be made during this study. Because of this, most of the newest processes use AI techniques like machine learning and deep-learning (DL) models [3]. These DL-models will help find cancer more accurately by using the data that is being looked at to find the disease. There are two types of deep learning models: custom models and standard models. Both kinds of models use the transfer learning method to work. The usual models are very hard to work with because of the need for appropriate planning of the architecture, developing the schemes using the right tool (software or hardware), testing the model's performance with the right data, and final verification of its performance and deployment. Given these considerations, transfer learning-based DL-approaches are often employed in research to attain more favourable results on the analyzed image database.

This study examined the DL-scheme to create a method for distinguishing between benign and malignant subtypes of breast-cancer (BC) in females [4]. Breast cancer is a disease that affects a lot of women and kills a lot of them, so finding and treating it is very important. Using medical imaging to check for cancer is a common method. In this study, histopathology image data from both benign and malignant classes were analyzed. The goal is to get a more accurate detection result by using the models that are being studied, which are based on the DTL process. This method is much simpler than the custom models, and it helps a lot in achieving a lot of success in the study. This study proposes a DL-framework for data analysis. This methodology includes the following steps: gathering and processing data, using the model to find deep features, using the SoftMax classifier to classify the data, and checking how well the system works by using a three-fold cross-validation method. This study also looked at the fused features (FF) that were made from the best model characteristics. The most accurate results from the model being used can be used to check if the plan that has been put into action is working. To evaluate the effectiveness of the system, the best-performing result obtained from the cross-validation process is considered [5-7].

This work examines a DL-based technique to analyze the image database utilizing SoftMax. This method helped figure out the BC categories, like the benign and malignant, which are important for figuring out the right treatment to control the disease. The results show that the proposed method offered better accuracy on the image database.

The main contribution of this research includes;

(i) Development of the DL-model for analysing the benign and malignant BC-histology image data,
(ii) Analysis of the performance of the considered DL-model using SoftMax, using the conventional and FF.

2 Literature review

Medical imaging-based disease detection is prevalent in hospitals; thus, a number of technologies, including invasive and non-invasive procedures, are routinely advocated in hospitals with the purpose of identifying diseases with greater precision. Approaches that do not involve any invasive procedures are typically considered for the initial diagnosis, whereas invasive methods might be utilized for the purpose of assessing the severity of the condition. Because cancer is such a severe illness, it is necessary to perform screenings at an earlier stage to save the patient from its severity. The histopathology image-based examination of cancer is one of the techniques that is commonly used in clinics. This approach helps in the detection of the disease and its severity of the disease. Following the collection of the sample tissue through the use of the biopsy technique, the tissue is then subjected to clinical processing and inspected through the use of a digital microscope at the recommended magnification threshold. After that, the image is pre-processed, which includes cropping and resizing, and then it is inspected using the methodology that was chosen. Because manual examination takes a significant amount of time, the majority of contemporary approaches make use of the DL-scheme in order to analyze the picture database that is being considered. The results of this work contribute to the improvement of the accuracy achieved with the DL-scheme by utilizing the FF [8,9].

Due to its significance, several image-based BC-detection approaches are widely considered by researchers to analyse the condition of the breast based on the histology data collected with a suitable procedure. The images are then resized and labelled for better examination. To effectively find an examination of the benign and malignant breast cancer data in the published literature, and the majority of these works utilized the DL-scheme to get a higher level of accuracy. In some of the earlier research, the DL-model was implemented. This model is simple and effective in terms of getting the desired result for the database that was being evaluated. During the course of this study, the DL-technique was utilized to categorize the histological data of breast cancer into the benign and malignant categories. The outcomes generated using this method were analyzed to assess and confirm the effectiveness of the proposed approach. During the course of this investigation, the FF-based detection was essential in achieving an accuracy of more than 97% using SoftMax [10].

3 Methodology

The design and implementation of the workflow used to analyze the image dataset play a crucial role in determining the overall performance of the digital data evaluation process. The suggested method aids in putting the deep-learning scheme for data analysis into practice, and the results are subsequently validated to validate the system's significance. In order to get a more accurate detection result, this research presented DL-model based detection. The image-based analysis of the malignancy from histopathology data is an essential technique. As shown in Figure 1, the architecture was designed for identifying the BC from the data that was taken into consideration. In the beginning, the process of collecting data connected to cancer can be carried out in a hospital by following the protocol that is advised. This procedure must be carried out in a controlled environment and by a laboratory technician who has previous experience. After the photos that were acquired from the patient have been pre-processed in accordance with the suggested protocol, the doctor will label them, and then they will be assessed for the purpose of identifying the disease. When it is finally finished, it is put away in a data repository so that it can be examined further.

The histology database that was accessible through the data repository was taken into consideration for the investigation in this work. Following the resizing of these photographs to the desired pixel dimension, they are then taken into consideration for the extraction of the details. When the features-based classification is carried out, SoftMax is utilized in conjunction with a desired deep learning model, and the performance values that are achieved are then documented. This approach helps in identifying the best two DL-models, whose features are used for producing FF using 50% dropout and serial fusion. The significance of the DL-technique is proven based on the accuracy that was attained, and this procedure also helps in identifying the best two DL-models. Afterwards, this feature vector is taken into consideration in order to authenticate the merit of the system by utilizing essential metrics such as the ROC-value and the CM value in order to validate the quality of this system. The entire framework of this method is illustrated in Figure 1, which may be found here.

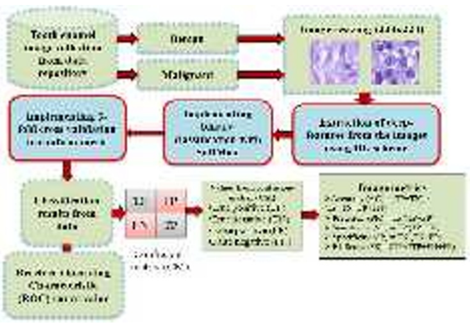

Fig. 1. Proposed architecture to detect the BC from the histology database

3.1 Histology image database

To test how well the DL-scheme works and to make sure it is useful with the real photographs taken with a certain imaging scheme, it is important to use standard images that work well for both the academic task and the real-time evaluation procedure. Because of the significance of the BC detection techniques, the researchers suggest a variety of these techniques be applied to the breast histology image dataset. The results that are obtained are then taken into consideration in order to validate the effectiveness of the DL-scheme. In this work, the image database that was identified in [11] was taken into consideration. Within this database, there are 2000 images accessible for each class, each of which has a pixel resolution of 512x512. In order to create the DL-model, these images were reduced to 224x224 pixels. The number of photos that were taken into consideration for this study is shown in Table 1, and the sample data for both classes are represented in Figure 2.

Table 1. Histology BC image database for the examination

Image class	Histology image slices			
	Total	**Train**	**Validate**	**Test**
Benign	2000	1600	200	200
Malignant	2000	1600	200	200

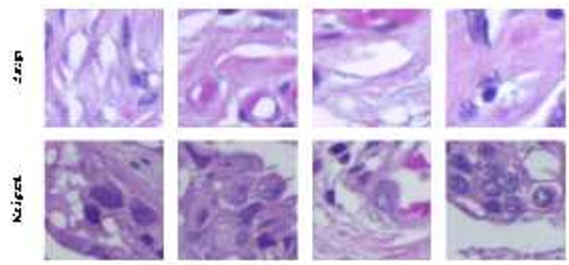

Fig. 2. Sample images from the histology database

3.2 Deep learning scheme

The selection of an appropriate computer algorithm is required in order to validate the effectiveness of the system that has been constructed, and this work took into consideration the pre-trained deep learning models that are typically utilized in current research efforts. Following the identification of a suitable scheme, it is required to verify the model's merit based on the classification result. This is necessary to verify the model's merit. The common deep learning scheme, also known as the ConvNeXt-models (CNT, CNS, CNB, CNL, and CNX), was taken into consideration in this research in order to accomplish this goal. The performance of these models was evaluated through the use of binary classification. When it comes to these models, the following settings have been assigned to produce a better outcome from this scheme: monitoring values equal to accuracy and loss, activation equal to ReLU, optimizer equal to Adam, pooling equal to max, learning rate equal to 1e-3, batch size equal to 8, and classifier equal to SoftMax [12,13].

3.3 Features fusion and classification

In the majority of the data examination jobs that are performed using the DL-scheme, the study of individual features may not produce a better outcome. As a result, modified features such as fused features and ensemble features are typically evaluated in order to reach a better conclusion. The FF-based examination that is frequently mentioned in the literature was taken into consideration in this work.

During the process of developing the FF, the first step is to identify the best deep learning models based on the accuracy that was achieved during the SoftMax classification task. After that, the features of these models are ranked and then reduced to fifty percent. Finally, the features of these two models are serially combined to form a single FF, which is then considered to classify the image data that is being considered. When compared to the individual features-based detection that is typically used in the implementation of the traditional DL-scheme, this FF is effective in achieving a better detection result on the image data, and its outcome is superior to that of it [14-16].

3.4 Performance verification

According to the findings of the study carried out with the Python software, the constructed DL-scheme proved to be beneficial for the photo database that was brought in. It was done to obtain additional information. The machine that is capable of doing this has a processor that is an Intel Core i7, 16 GB of RAM, and 4GB of VRAM. During the process of verification, the data on image performance that was obtained by CM and the ROC curve are utilized. The findings of the study demonstrate that the approach that was utilized is effective in enhancing the outcomes of cancer detection through the utilization of histopathology databases. These pieces of evidence were presented by the findings of the experiment.

4 Result and Discussion

This section presents and analyzes the experimental study conducted to evaluate the performance of the proposed deep learning–based approach. Following the installation of individual feature-based detection, the next phase in this study is the development of DL-based classification. Both of these steps are necessary to complete this investigation. The results of the experimental research that were acquired using the DL-tool that was proposed are provided and discussed in this part. Beginning with the implementation of the individual features-based detection, this study then moves on to the implementation of the FF-based categorization.

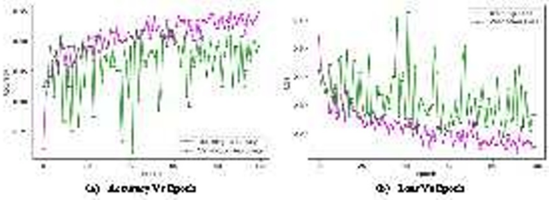

Fig. 3. Initial training outcome with VGG16

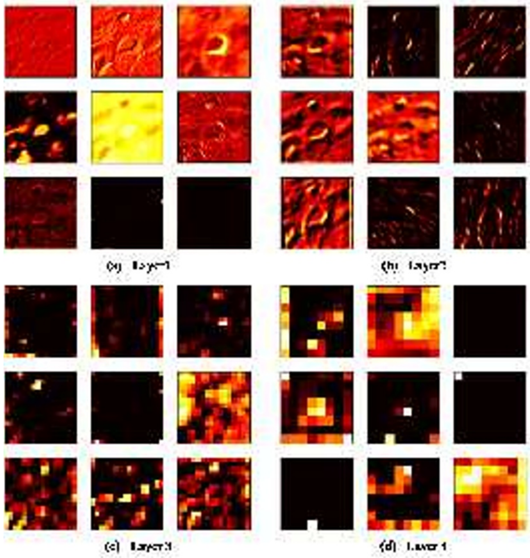

Fig. 4. Different layer results with VGG16

At the outset, the CN-tiny (CNT) model is taken into consideration for the classification of the image database by means of SoftMax. The job is carried out with the utilization of 100 epochs, and the results that were accomplished for training and validation can be found in Figure 3, which demonstrates both the training/validation values for the considered epochs. Figure. 3 (a) and (b) illustrate the accuracy and loss that were achieved using this approach. After that, the transformation of image pixels into features is validated by using an image that is taken into consideration, and the results of this process for several convolution layers (CL) are displayed in Figure 4. When this method was carried out, the results that were obtained for CL1 to CL4 are depicted in Figure 4(a) to (d). The outcome of the model is illustrated in Figure 5, which presents the ROC curve to demonstrate the effectiveness of the developed system. After verifying the performance with the CNT, a similar approach is taken into consideration in order to validate the performance of the DL-model with individual features. The findings that were obtained are presented in Table 2. It is possible to deduce from this table that the best CN-model features with better outcomes are considered to generate the FF, and its performance is verified with SoftMax classification.

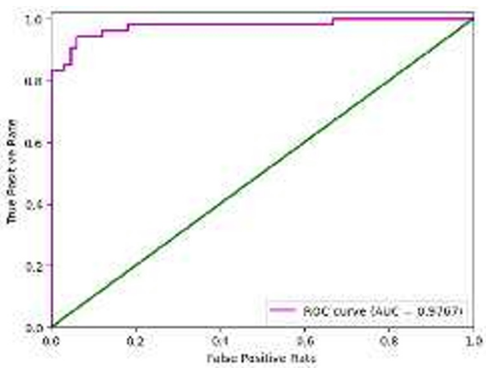

Figure 5. The achieved ROC-value to verify the merit of the DL-scheme

Table 2. Achieved classification results with SoftMax classification

Model	TP	FN	TN	FP	AC	PR	SE	SP	FS
CNT	181	19	180	20	90.2500	90.04975	90.5000	90.0000	90.27431
CNS	185	16	181	19	91.2718	90.68627	92.0398	90.5000	91.35802
CNB	184	16	182	18	91.5000	91.08911	92.0000	91.0000	91.54229
CNL	182	18	185	15	91.7500	92.38579	91.0000	92.5000	91.68766
CNX	183	17	182	18	91.2500	91.04478	91.5000	91.0000	91.27182
FF	196	4	198	2	98.5000	98.9899	98.0000	99.0000	98.49246

This approach which was executed to classify the images into benign/malignant based on the SoftMax help to attain better classification outcome wih both the individual-fetaures on CN-model and then the FF-based examination. This approach confirms that the developed system worked well on the histopathology BC-data and this approach will be considered in the future to evaluate the clinically collected image database.

To demonstrate the merit, a bar-chart is then constructed as in Figure 6 and this confirms that the experimental outcome with the FF-is better (98.50%), which confirms the merit of the developed system. In the future, this system can be considered to evaluate the BC-data collected from the hospitals. Further, this tool can be used as an aiding system for the doctors for analysing the histology data accurately, which is essential for planning and executing necessary treatment process.

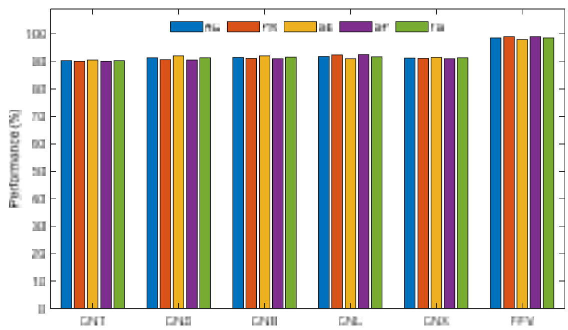

Fig. 6. Overall performance verification using a bar chart for Table 2 values

5 Conclusion

For the purpose of assessing the BC histological database that contains the benign/malignant class, this research developed a DL-tool that is both straightforward and efficient. The end goal is to acquire a better result on the histology data by utilizing the default SoftMax classifier, and the outcome that is achieved can be taken into consideration to validate the disease recognition task. The DTL-scheme is utilized in this work, and the categorization is carried out by utilizing the individual features and the filter function.

The result that was obtained demonstrates that the FF-based detection method has an accuracy of more than 98%. It is clear from this that the system that was designed delivers a major outcome on the database that was taken into consideration. It has been demonstrated through these findings that the FF-based detection approach produces superior results when compared to the histological database-based BC identification process.

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