Breast Cancer Histopathological Images Multi-classification using Deep Learning

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Abstract-In recent years, breast cancer classification can be considered a primary subject for biology and health care, given that cancer is the second leading cause of death in women. From there, the medical community has seen advances in the field of research in the use of various techniques to screen for and identify multifold threatening diseases, such as breast cancer. In this survey, the various deep learning (DL) approaches are analyzed for multi-classifying the breast cancer histopathological images. This survey discusses the significant assumptions, limitations, and advantages are analyzed in existing DL based techniques as segmentation and classification are used for multi-classification of breast cancer histopathological images. The existing method's performance was analyzed by using various performance measures such as accuracy, precision, recall, sensitivity, specificity and f1-score. This survey concludes that the various breast cancer histopathological image multi-classification over DL have feasible to overcome the drawbacks as inefficient supervised feature and enhance the efficiency.

Keywords: Breast Cancer, Deep Features, Deep Learning, Histopathological image, Multi-classification and Segmentation

1. INTRODUCTION

Breast cancer is a major health concern for women worldwide, accounting for the majority of female cancer deaths in many regions across the globe [1].Pathological analysis is widely recognized as the gold standard parameter for the diagnosis of breast cancer due to its unrivaled accuracy and specificity compared to other diagnostic methods [2].Although the quality of histopathological images is essential as one of the fundamental factors for the accuracy of pathological results in breast cancer, subjective aspects such as the experience and attention levels of physicians also play a significant role in the accuracy of pathological test results. Then, errors are likely to occur, causing unintended harm to the patient. Timely detection of breast cancer is the key to reducing mortality rates, which is closely related to early detection of the patient [3].Computer-aided systems can help clinicians to reach the right treatment for breast cancer more accurately and faster based on the increasing development in computer and artificial intelligence technologies[4].However, despite these facts, human expert image analysis is heterogeneous, time-consuming, and has potential challenges including interpretation bias [5].

Deep learning (DL) methods have recently gained widespread adoption by the computer vision (CV) community and are now almost ubiquitous in biomedical image processing, allowing automatic feature representation of complex and low-level image features [6].Widely used approaches based on deep learning to classify histopathological images of breast cancer mainly target two main categories [7].Similarly, some researchers have used the deep feature learning capability of CNN models to extract features from breast cancer histology images, which are then used in predictive models based on traditional machine learning to develop classifiers for classification purposes [8]. In the domain of elite breast cancer pathology image classification, convolutional neural networks had higher levels of performance compared to standard machine learning protocols relying on traditional classifiers [9]. Semi- or fully-automated methods for the analysis of breast pathology images help pathologists obtain more accurate diagnoses, thereby speeding up and simplifying the work. DL models use the complexity of an image to consume subjective knowledge and think about granular attributes given the data format [10].

The following section of this paper is discussed as follows: a review of related works of breast cancer multi-classification is represented in section 2. A taxonomy of breast cancer histopathology image classification is represented in section 3. Section 4 describes the comparative analysis of the taxonomy. Problem statement is represented in section 5 and summary of this paper is represented section 6, also concludes with references.

2. LITERATURE REVIEW

The various existing techniques were analyzed and developed for analyzing the multi-classification of breast cancer histopathology images to precise classification and diagnosis of breast cancer. But some existing approaches faced an issues for analyzing histopathology image classification. The related works about multi-classification of breast cancer histopathology images were presented along with its benefits and limitations.

Nouman Ahmad et al. [11] presented the transfer learning-assisted multi-resolution breast cancer histopathological image classification. The deep learning and transfer learning approach was developed for classifying the histopathological images for diagnosis of breast cancer. The adopted path selection technique was developed to classify breast histopathological images on fewer training images that applied TL without losing the performance. At first, the patches were extracted from whole slide images and fed into convolutional neural network (CNN) for feature extraction. The discriminative patches were selected and fed into Efficient-Net approach pre-trained on ImageNet dataset based on these features. Feature extracted from Efficient-Net approach were also utilized to train a support vector machine (SVM) classifier for whole slide histopathology image classification. The both Efficient-Net and SVM were accomplished the relatively good outcomes.

Chiagoziem C. Ukwuoma et al. [12] suggested the multi-classification of breast cancer lesions in histopathological images using DEEP_Pachi. This research was developed the DEEP_Pachi to classify the breast histopathological images at various magnifications. The suggested DEEP-Pachi was gathered global and regional features, which were significant for efficient breast histopathology image classification. The ensemble approach of DenseNet201 and VGG16 was the backbone of suggested model. Ensemble model extracts global features (general image information), whereas DEEP_Pachi extracts spatial information (regions of interest). This approach was also intend on extending DEEP-Pachi approach to other disease classification using histopathological or microscopic images such as oral cancer, skin cancer etc. However, the suggested approach was required to replace the MLPBlock with SGTM neural like structures for assessing the feasible best approach in this model.

David Clement et al. [13] developed the multi-class breast cancer histopathological image classification using multi-scale pooled image feature representation (MPIFR) and one versus one SVM. A group of four DCNN types were integrated with SVM classifiers to classify breast cancer histopathological images into eight subtype classes, four malignant and four benign. The developed approach harnessed the power of DCNNs to extract the most predictive MPIFR from 4 resolutions of BC images, which were then classified by SVM. Eight pre-trained DCNN architectures were trained individually and an ensemble of four best-performing models was used for feature extraction. However, an advanced approach to analysis with feasible pre-trained models was needed, especially since ConVNet has fewer connections to provide a lightweight gradient system for use in locations with limited access to computational resources.

Muhammad Junaid Umer et al.[14] introduced the multi-class classification of breast cancer using 6B-Net with deep feature fusion and selection approach. The introduced approach involves three phases; initially, a 35-layer deep CNN model was presented with a concurrent processing block. The introduced approach is initially pre-trained using the third-party CIFAR-100 dataset for feature learning. This model was further applied as a feature extraction tool and then successfully pre-trained the model developed for breast cancer multi-class classification problems. The extracted feature vector is passed as input to the PSO feature selection approach and then the feature extraction phase for optimal feature selection. The outputs of the introduced 6B-Net model selection vector and ResNet-50 selection vector were sequentially combined to improve the performance of breast cancer classification. However, the introduced approach was used to develop a unique feature selection approach with a new CNN model that also includes segmentation of tumors for high performance.

Yiping Zhou et al. [15] developed the classification of breast cancer from histopathological images using resolution adaptive network. A novel approach based on image processing method was developed to help pathologists effectively make accurate diagnosis, which consists of two modules called anomaly detection with SVM (ADSVM) approach and resolution adaptive network (RANet) model. The ADSVM approach segmented the mislabeled links to improve the training performance of the RANet model. Subnetworks with variable resolutions and depths were used in the RANet model to classify images according to classification difficulty. This analysis allows the classification approach to be conducted directly at the patient level and increases the efficiency of patient level classification. However, the developed approach needed to use a new feature extraction approach that can replicate the features obtained from the RANet model to improve the classification performance and computational efficiency.

3. TAXONOMY OF BREAST CANCER MULTI-CLASSIFICATION

In this section, breast cancer histopathological image multi-classification using DL are analyzed the various approaches as segmentation and classification. The various segmentation and classification are analyzed as taxonomy in this section. Figure 1 represents the taxonomy diagram of breast cancer histopathological image multi-classification.

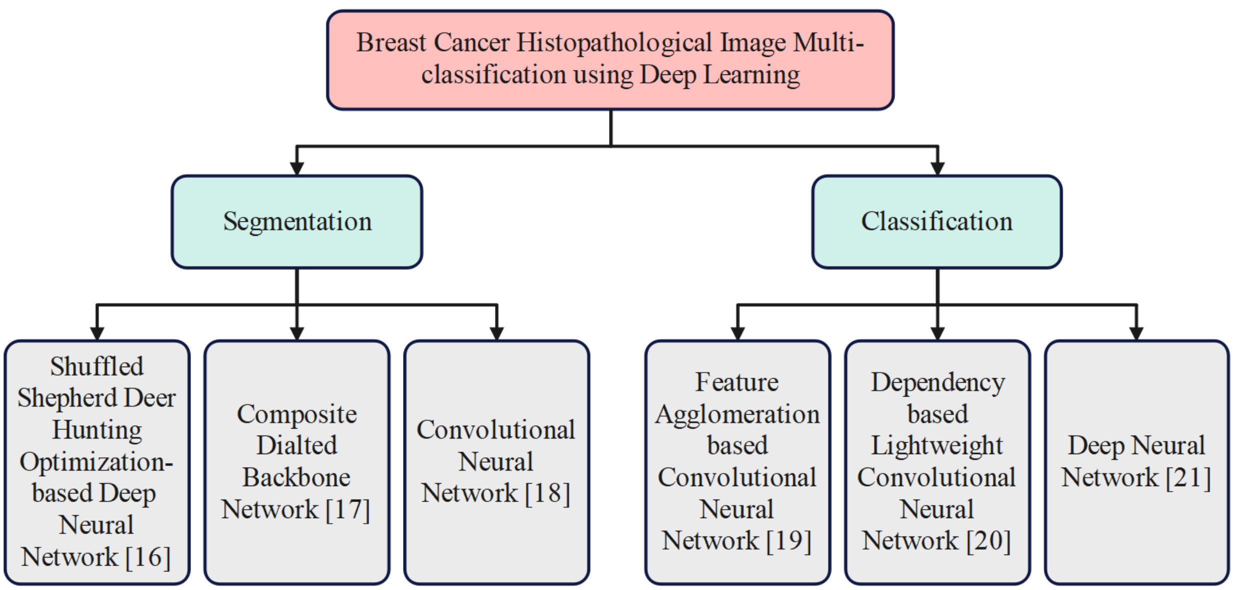

Figure 1 Taxonomy of Breast Cancer Histopathological Image Multi-Classification

3.1. Segmentation

The various segmentation techniques are analyzed in multi-classification of breast cancer histopathological image using DL and those brief explanations are described in this section. Deep Neural Network based on Shuffled Shepherd Deer Hunting Optimization (SSDHO-based DNN), are described below.

3.1.1. Shuffled Shepherd Deer Optimization Algorithm based Deep Neural Network

Deshmukh Pramod Bhausaheb and Kanchan Lata Kashyap [16] developed the Deep Neural Network based on Shuffled Shepherd Deer Hunting Optimization (SSDHO-based DNN)for Breast Cancer Classification by Breast Histopathology Images. The developed framework improves the performance of image data-assisted breast cancer classification by integrating optimization algorithms and deep learning.The method is based on Shuffled Shepherd Optimization Algorithm (SSOA) and Deer Hunting Optimization Algorithm (DHOA) in guiding the optimization process. Features such as statistical features, shape features and Convolutional Neural Network (CNN) features are effectively extracted from the classified blood cells. A DNN uses its hidden neurons for this purpose: classification, improved performance and accuracy are achieved this way. Convergence analysis demonstrates that the developed SSDHO method has a slightly increased convergence speed in contrast to other alternative optimization approaches, which also indicates its effectiveness in obtaining optimal results.

3.1.2. Composite Dilated Backbone Network

Vinodkumar Mohanakurup et al. [17] breast cancer detection on histopathological images using a composite dilated backbone network. The developed method introduces a composite expanded backbone network (CDPN) that integrates multiple similar backbones into a robust backbone for breast cancer detection in histopathological images. ResNet, dilated convolution and AlexNet was integrated to CDBN for enhancing detection performance and accuracy over existing CNN detector-based systems. With the ability to identify cells in breast tissue pathology images, the CNN algorithm will provide much-needed help in diagnosing breast cancer and other disorders. The CDBN model feeds high-level output features from previous vertebrae to the next vertebra in a hierarchy, which improves the identification of objects in histopathological images. CDBN does not require pre-training, saving time and resources compared to using pretrained models such as ResNet or ResNeXt.

3.1.3. Convolutional Neural Network

Felipe Andre Zeiser et al. [18] developed the hybrid deep learning model for interpretable diagnosis of breast cancer in whole-slide images (DeepBatch). The developed method is a two-part deep patch model that uses convolutional neural networks (CNN) to segment multiple and whole-slide breast cancer images into multiple tissues. DeepBatch includes four main modules: deep learning such as pre-processing, ROI detection, ROI sampling, and segmentation to efficiently encode key information in given images for pathologists. By using the U-Net convolutional architecture, WSIs are detected by the identification modules of suspicious expansions, occurring at low magnification, and a combination of ResNet50 and U-Net approach is used for high magnification. Therefore, deep patch is a method that ensures two important aspects of computational drug discovery, which are correct and consistent segmentation of WSI assessment in breast cancer diagnosis.

3.2. Classification

The various classification techniques are analyzed in multi-classification of breast cancer histopathological image using DL and those brief explanations are described in this section. The different classification techniques such as feature agglomeration based convolutional neural network (FabNet), dependency based lightweight convolutional neural network (DBLCNN) and deep neural network (DNN) are described below.

3.2.1. Feature Agglomeration based Convolutional Neural Network

Muhammad Sadiq Amin and Hyunsik Ahn [19] presented the feature agglomeration based convolutional neural network (FabNet) for multi-scale breast histopathology image classification. A FabNet model is developed to describe net-like structures and multi-level structures as stable structures of histopathological images using an accretive network framework. This approach uses a hierarchical structure by selectively combining layers of the hierarchy. Hierarchical feature mapping used in the deep layer modifies the feature hierarchies and does it in an iterative and hierarchical manner, thus leading to the inference of features with fewer parameters. Acquiring both slides and patches of cancer images through histopathological images, the end point of the proposed method is the identification of cancer tumors. Benchmarking the model with publicly available datasets are key additional features used to render FabNet.

3.2.2. Dependency based Lightweight Convolutional Neural Network

Chaoqing Wang et al. [20] developed the lightweight CNN based on dependency for multi-classification breast cancer histopathology images. A novel network was developed in that dependencies applied to guide sub-species features for superior recognition. The backbone MobileNet was redesigned for greatly diminishing the model parameters and computation while ensuring excellent performance of recognition. Subsequently, ImageNet based transfer learning (TL) was applied to the network of DBLCNN. The wide analysis on BreakHis dataset had exhibited that the

DBLCNN network in terms of utilization in performance and computation. The developed DBLCN approach was significantly fast in terms of computational scale and model parameters and most feasible and computation effective.

3.2.3. Deep Neural Network

Agaba Ameh Joseph et al. [21] suggested the enhanced multi-classification of breast cancer histopathological images using handcrafted features and deep neural network (DNN). The handcrafted feature extraction approaches as color histogram, Hu moment and Haralick textures were employed for breast cancer multi-classification using histopathological images on the BreakHis dataset. The extracted feature using handcrafted approaches are utilized for training the DNN classifiers with four dense layers and SoftMax. The data augmentation approach was employed to solve the overfitting difficulties. A learning approach with various magnification levels was applied to contrast handcrafted features and DNN classifier for multi-classifier for multi-classification of BC histopathology images. These outcomes illustrated the power of suggested solution in accuracy compared to other related approaches.

4. COMPARATIVE ANALYSIS

The various algorithms are developed for improved multi-classification of breast cancer histopathological images to attain the better performance of classification. The breast cancer multi-classification is compared with existing approaches for enhancing performance of model. The comparative analysis is significant for analyzing in development and effective enhancement of model's performance. These comparative analysis comprises the employed methodologies, performance measures, advantages and limitations are represented in Table 1.

Table 1 Comparative analysis of various techniques

Authors	Methodology Employed	Advantages	Limitations	Performance Measures
Deshmukh Pramod Bhausaheb and Kanchan Lata Kashyap [16]	Shuffled Shepherd Deer Hunting Optimization based Deep Neural Network for Breast Cancer Classification using Breast Histopathology Images	The proposed SSDHO-based DNN approach achieves accurate breast cancer classification by effectively mining features from segmented blood cells and using a DNN for classification	The precision value of the hybrid space approach used in the proposed method is low due to the extensive growth of false positives	Specificity, accuracy, sensitivity and precision
Vinodkumar Mohanakurup et al. [17]	Breast Cancer Detection on Histopathological Images Using a Composite Dilated Backbone Network	CDBN does not require pretraining, saving time and resources compared to using pretrained models like ResNet or ResNeXt.	The accuracy of the proposed method may be affected by the lack of label information in histopathological images of breast tumors, leading to potential inaccuracies in grouping and clustering	True positive rate and False positive rate
Felipe Andre Zeiser et al.[18]	A hybrid deep learning model for interpretable diagnosis of breast cancer in whole-slide images	The methodology used by DeepBatch allows for precise segmentations, improving the accuracy and consistency in the WSI evaluation of breast cancer	The developed method relies on the use of CNNs that attainslimitations in terms of generalizability and interpretability.	Specificity, accuracy, Intersection over union (IoU) sensitivity and F1-score
Muhammad Sadiq Amin and Hyunsik Ahn [19]	A Features Agglomeration-Based Convolutional Neural Network for	The proposed model achieves high sensitivity and accuracy, making it	The sources do not mention the specific strategies used to cope with the data	Accuracy, recall, precision, f1-score

	Multiscale Breast Cancer Histopathology Images Classification	useful for cancer detection and diagnostics using histological images	imbalance issue, which could limit the generalizability of the proposed model.	
Chaoqing Wang et al. [20]	Dependency-based lightweight convolutional neural network for multi-classification of breast histopathology images	The DBLCNN method achieves competitive performance by extracting features of images for classification through CNN, making it a reliable magnification-independent multi-classification method.	The proposed method is evaluated on the BreakHis dataset, and its performance may vary when applied to other datasets or real-world scenarios	Binary accuracy, precision, recall, f1-score, flops and params
Agaba Ameh Joseph et al. [21]	Improved multi-classification of breast cancer histopathological images using handcrafted features and deep neural network	The use of handcrafted feature extraction techniques and DNN classifiers resulted in better performance compared to other methods.	The proposed method focuses on multi-classification of breast cancer using histopathological images, but it does not address other important aspects of breast cancer diagnosis and treatment, such as molecular profiling or genetic markers	Precision, accuracy, f1-score, recall, confusion matrix

5. PROBLEM STATEMENT

- Variability within a class and consistency between classes can make classification very difficult, especially when dealing with multiple classes
- Deploying deep learning models in clinical settings requires scalability and real-time performance, and efficient inference is requires to consider on large whole-slide images.
- Training deep learning models on large histopathological datasets requires considerable computational resources.
- While deep learning models achieve high accuracy, understanding their decision-making process remains challenging.

6. CONCLUSION

Breast cancer ranks as the second most common cause of death in women, following closely behind lung cancer. Early detection can reduce the leading cause of death in women due to breast cancer. Due to the fact that mammographic diagnosis is challenging by its very nature and has to be done manually, accurate early cancer detection is actually problematic. This survey discusses the significant assumptions, limitations, and advantages are analyzed in existing DL based techniques as segmentation and classification are used for multi-classification of breast cancer histopathological images. The existing method's performance was analyzed by using various performance measures such as accuracy, precision, recall, sensitivity, specificity and f1-score. This survey concludes that the various breast cancer histopathological image multi-classification over DL have feasible to overcome the drawbacks as inefficient supervised feature and enhance the efficiency.

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