ORIGINAL ARTICLE

The Diagnostic Accuracy of Convolutional Neural Network Architectures for the Diagnosis of Brain Cancer

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ABSTRACT

Background: There is a rising trend in the number of malignant tumors along with an increase in world population growth. More than 0.29 million cases of central nervous system tumors were diagnosed in 2018. The utilization of artificial intelligence for the histological analysis of tumors is being explored for the purpose of better patient care.
Aim: The main purpose of the present research is to evaluate the diagnostic accuracy of two convolutional neural network architectures VGG 19 & ResNet18 for the histological examination of astrocytoma.
Methods: After the ethical approval, the study is conducted on 190 anonymized digital pathology images which included 115 images of astrocytoma and 75 images of normal brain tissue. These images have been acquired from the anonymized H & E stained slides. From the total 190 images, one hundred twenty-eight (128) images are employed for the training set, 24 images for validation while 38 images for the test set. The digital images are classified by applying CNN architectures VGG-19 and ResNet-18**.**
Results: The analysis of the test data revealed that the diagnostic accuracy and F1 score of ResNet-18 CNN architecture are 97% and 0.97 respectively while the diagnostic accuracy and F1 score of VGG-19 for the histological diagnosis of astrocytoma are 92% and 0.94 respectively**.**
Conclusion: The diagnostic accuracy (97%) of ResNet-18 CNN architecture for the histological diagnosis of astrocytoma is better than the diagnostic accuracy (94%) of VGG-19.
Keywords: Artificial Intelligence, VGG 19, ResNet 18, Brain Cancer

INTRODUCTION

After the better control of microbial infections, the challenge of cancer is rising. The mortality and morbidity associated with malignancy have been predicted to increase in future. The increase in the number of cases of cancer has been attributed to population growth and improvement in the average age. It has been estimated that more than 18 million new cases of malignancies occurred in 2018, which included 296851 cases of central nervous system tumors[1]. The brain neoplastic lesions are relatively more common in male as compared to female[2]. Astrocytoma is the most common primary malignant tumor of the brain[3-4]. Among the astrocytomas, glioblastoma multiforme (high-grade astrocytoma) is more common in adults while pilocytic astrocytoma (low-grade astrocytoma) is more prevalent in children[2,5].

The patients of astrocytoma usually present with the clinical features of headache, seizure and focal neurological deficits. Radiological imaging studies such as computerized axial tomography (CT Scan) and magnetic resonance imaging (MRI) are helpful in the assessment of brain tumors. The magnetic resonance spectroscopy has an excellent positive predictive value of 94.9% for the detection of brain cancer[6]. But the final diagnosis depends on the histological examination of the brain biopsy. The characteristic features of astrocytoma on microscopy include increased cellularity, pleomorphism, hyperchromasia, mitosis, endothelial proliferation and necrosis.

Histological examination of biopsies is a very sensitive task because a minor mistake may have a significant adverse impact on patient care. The job of histopathologist is quite a labour intensive as the thorough assessment of slides is vital for the final diagnosis of lesions. For the provision of assistance to the histopathologists in their task, the applications of convolutional neural network architectures are being tested for their effectiveness and usefulness in the field of histopathology.

The aim and purpose of the present study are to assess the usefulness of CNN architectures VGG-19 and ResNet-18 and compare their accuracy for the diagnosis of astrocytoma by analyzing the digital pathology images.

MATERIALS & METHODS

The ethical approval of this research has been taken from the University of Lahore - Islamabad Campus. The study is conducted on one hundred and ninety (190) digital anonymized images. These images are taken from the anonymized H & E stained slides. The dataset is comprised of 190 images which included 115 digital images of astrocytoma and 75 images of normal brain tissue. Two histopathologists have reviewed all of these images. The dataset has been split into two groups. The first group (A) is labelled as train dataset, which included 80% of the entire data. The other group (B) is named as the test data set, which is composed of 20% of the total dataset. CNN architectures VGG-19 and ResNet-18 have been used for

the analysis of pathology images. The number of datasets is limited; we applied the transfer learning approach on ImageNet data set[7]. To avoid the chances of selecting images from one class in a batch, we used FASTAI random approach to load and made the batches. For regulation, the data-augmentation technique is used.

For the validation, we used k-fold Cross-validation with 15% of the train data.

K = 5

24 images for validation

128 images for the training set

38 images for test set

To prevent the overfitting; we applied a 50% drop out and ran the code only for three epochs.

RESULTS

In the present study, 190 digital pathology images have been analyzed with the convolutional neural network architectures VGG-19 and ResNet-18. One hundred and fifty (152) images have been selected from both groups (A and B), which comprised 80% of total data. These (152) images have been used for training and validation. A total of thirty-eight (38) images from both groups have been used as test data. VGG-19 and ResNet-18 CNN architectures are used for the classification of pathology images. The diagnostic accuracy and F1 score of VGG-19 are 92% and 0.94 respectively while for ResNet-18 CNN architecture, diagnostic accuracy and F1 score are 97% and 0.97 respectively. The results are summarized in Table 1 and 2.

Table 1. The Comparison of Results of VGG-19 and ResNet – 18

	Train				Test			
VGG-19	**Actual**	Astrocytoma	**75**	1	**Actual**	Astrocytoma	**25**	1
		Normal	1	**51**		Normal	2	**10**
			Astrocytoma	Normal			Astrocytoma	Normal
			Predicted				**Predicted**	
ResNet-18	**Actual**	Astrocytoma	**79**	1	**Actual**	Astrocytoma	**22**	1
		Normal	0	**48**		Normal	0	**15**
			Astrocytoma	Normal			Astrocytoma	Normal
			Predicted				**Predicted**	

Table 2. Results of test data with Resnet 18 and VGG-19

Measure	**RESNET-18**	**VGG-19**
	Value	**Value**
Sensitivity	1	0.9259
Specificity	0.9375	0.9091
Precision	0.9565	0.9615
Negative predictive value	1	0.8333
False-positive rate	0.0625	0.0909
False discovery rate	0.0435	0.0385
False-negative rate	0	0.0741
Accuracy	0.9737	0.9211
F1 score	0.9778	0.9434
Matthews correlation coefficient	0.947	0.8147
Diagnostic Accuracy	**97%**	**92%**

DISCUSSION

The analysis of the results of VGG-19 and ResNet-18 CNN architecture unveiled the significant importance of artificial intelligence application in the diagnostic laboratories. Both convolutional neural network (CNN) architectures revealed the diagnostic accuracy of more than 90%, which is quite significant. The diagnostic accuracy (97%) of ResNet-18 CNN architecture is better than the diagnostic accuracy (94%) of VGG-19.

The defeat of world class chess player by the computer (deep blue) predicted a strong rise of artificial intelligence (AI) in digital technology. Recent advances in artificial intelligence have revealed the astonishing performance of AI in many domains where it has surpassed human being[8].

Artificial intelligence is being employed to aid in speech recognition, computer vision and natural language processing. The use of computer software in health care has facilitated the digitalization of data related to health care. Based on this data from the health care system, there would be an opportunity to develop computer programs for the analysis of the data which may be very helpful for the application of artificial intelligence in the health care[9-10].

The accurate histopathological diagnosis has a strong impact on the provision of better patient care. The histological assessment of biopsy tissue has got paramount importance in the management of malignant tumors over the past hundred years**.** After the processing of the surgical biopsy specimen, the processed tissue is embedded in the paraffin wax and tissue blocks are prepared. These tissue blocks are cut at three to four-micron thickness level. The slides are most frequently stained with hematoxylin and eosin stain. The changes in the color of cellular and extracellular structures stained with hematoxylin and eosin stain have been observed in different lesions. The identification of these alterations in the intensity and texture are very vital for the diagnosis of various lesions[11]. This procedure is being carried out for the last century with little modification as this process is very laborious and exerted a lot of stress on the histopathologists which may be attributed to the increase in the risk of human errors.

The recent advancement in digital technology has produced very beneficial results for the human being in various fields such as telecommunication, banking, marketing, trade, business, education, law enforcement and health care. The application of digital technology is associated with increased speed in the performance and reduced chance of errors. It turned out to be cost-effective as well in many fields. The digital technology has exerted a strong influence on the economic growth of the society as well.

In the present study, The application of artificial intelligence on the digitalized pathological lesions for the

histological diagnosis has revealed the bright future of this technology in the field of histopathology. A similar finding like our study has been reported by other researchers working on the application of artificial intelligence for the histological diagnosis of certain lesions such as cancers of prostate, skin, breast and lungs[12-15].
Further studies for the diagnosis of pathological lesions by applying different architectures of deep learning on a bigger dataset are suggested.

CONCLUSION

The application of artificial intelligence for the histological diagnosis has emerged as an efficient diagnostic tool. The diagnostic accuracy (97%) of ResNet-18 CNN architecture for the histological diagnosis of astrocytoma is better than the diagnostic accuracy (94%) of VGG-19.

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