International Journal of Computer Sciences and Engineering
Vol.**11**, Issue.**10**, pp.**59-63**, October **2023**
ISSN: 2347-2693 (Online)
Available online at: www.ijcseonline.org

Research Paper

Evaluating VGG-16 Performance in Brain Tumor Detection: A Comprehensive Review

Sajid Faysal Fahim[1*], Nayem Mollah[2], Nusrat Sultana[3], Md. Mohshiu Islam Khan[4]

[1,2,3,4]Dept. of Computer Science and Engineering, East West University, Dhaka, Bangladesh

**Corresponding Author: tafim353@gmail.com*

Received: 30/Aug/2023; **Accepted**: 03/Oct/2023; **Published**: 31/Oct/2023. **DOI**: https://doi.org/10.26438/ijcse/v11i10.5963

Abstract: This comprehensive examination deeply explores the evaluation of the VGG-16 architecture in the critical and significant domain of brain tumor detection, which holds utmost importance in the field of medical image analysis. The study meticulously and thoroughly evaluates the strengths and weaknesses of the VGG-16 model, taking into account its pivotal role as a deep learning model specifically crafted for this crucial medical application A comprehensive and meticulous evaluation is conducted to offer a thorough and all-encompassing assessment of the effectiveness of VGG-16 in precisely identifying brain tumors. This entails a meticulous and detailed exploration of diverse datasets, methodologies, and benchmarking metrics. The significant findings obtained from this extensive analysis shed crucial light on the immense potential of the VGG-16 model in the field of brain tumor detection, while also highlighting its inherent limitations and areas that could be enhanced. These invaluable observations have been demonstrated to be extremely advantageous for both individuals conducting research and professionals working in the field of medical image analysis. It is of utmost significance to acknowledge that this analysis ultimately underscores the crucial significance of continuous research initiatives directed towards enhancing the efficacy of VGG-16 specifically in the domain of brain tumor detection. The ultimate objective of these endeavors is to formulate healthcare solutions that are more precise and efficient, thereby greatly benefiting patients requiring such interventions.

Keywords: Brain diseases, Proposed Method, Artificial Neural Networks, Tumor, Necrosis, Anisotropic Diffusion

1. Introduction

In recent years, the field of medical diagnostics has made significant advancements in detecting brain tumors thanks to the widespread use of deep learning techniques and convolutional neural networks, particularly the VGG-16 model, which has proven to be highly effective in various image recognition and categorization tasks. Specifically, the primary objective of this comprehensive evaluation is to appraise and scrutinize the efficiency and capacities of the VGG-16 framework within the framework of brain tumor identification. The existence of brain tumors constitutes a noteworthy worldwide public health concern, underscoring the pressing need for prompt and precise diagnosis to strategize efficacious therapies. The incorporation of artificial intelligence and deep learning models in this domain has exhibited considerable potential in augmenting diagnostic precision, mitigating human fallibility, and expediting the identification of abnormalities in the brain. VGG-16, a potent deep neural network architecture, has been extensively utilized in diverse medical imaging tasks owing to its capacity to autonomously glean complex patterns and features from vast datasets. The principal aim of this exhaustive examination is to carry out an in-depth inquiry into the advantages, limitations, and overall effectiveness of VGG-16 in the identification of brain tumors. We will delve into its application, the datasets utilized, and the performance evaluation metrics employed in different research studies [1]. The purpose of our endeavor is to provide an all-encompassing synopsis of the importance of VGG-16 in the accurate identification of cerebral neoplasms from medical imagery. To achieve this, we will analyze a diverse selection of current research findings and methodologies. The anticipated results of this examination will provide researchers and medical professionals, who are actively involved in the realm of medical image analysis and brain tumor diagnostics, with exceptionally meaningful and noteworthy perspectives that possess the capacity to significantly augment their comprehension and expertise in this particular field. Furthermore, it is worth noting that these aforementioned observations possess an immense capacity to significantly augment the incessant efforts that are being directed towards the development and implementation of more precise, efficient, and readily accessible techniques for the identification and diagnosis of cerebral neoplasms during their nascent stages. Consequently, this would ultimately lead to enhanced outcomes for patients and the provision of healthcare services of exceptional quality.

2. Related Work

Marroquin et al. [2] emphasize the significance of performing three-dimensional segmentation on magnetic resonance scans of the brain. They propose utilizing distinct parametric models for each class strength in order to achieve accurate results. Through a healthy registration procedure, a brain map is employed to find a non-rigid transformation for optimal segmentation, resulting in the mpm-map algorithm which is more robust and computationally efficient compared to em in estimating the posterior marginal.

A comprehensive methodology is necessary to evaluate the viability of the svr kernel-based approach for highly complex regression problems, as highlighted by m.g dibono et al.[3]. They propose a multiphase process, involving preprocessing and prediction phases, along with the use of svm, regression and statistical measures to enhance performance and generalization. While statistical techniques like sorting and distributions can improve accuracy, the virtual environment used in this method may have limitations and specific considerations that can result in inaccuracies.

Shi et al.[4] employed neural networks to perform various medical image processing tasks such as preprocessing, segmentation, and object detection and recognition. The study utilized both hopfield and feed-forward neural networks, with the added benefit of Hopfield Neural Networks not requiring prior knowledge and reducing the time needed for image processing.

Padole et al. [5] introduced an effective approach for brain tumor detection involving segmentation with mean shift and normalized cut algorithms. Segmented regions are created through mean shift during pre-processing, and these regions are then clustered using the n-cut method. The proposed texture-based method addresses the issue of inaccurate segmentation results caused by non-sharp tumor edges. Additionally, this method enables automatic tumor recognition, deduction, and segmentation.

Meenakshi et al. [6] highlighted the significance of mri in accurately analyzing brain images and detecting brain tumors, although existing machine learning techniques often result in incorrect diagnoses, hence the proposed technique aims to minimize error rates by combining clustering and classification algorithms.

Sourabh and colleagues, in their research [7], have presented innovative methodologies for the identification of brain tumors through the application of segmentation, histogram analysis, and thresholding.

Rajesh et al [8] centered their attention on the implementation of meyer's flooding watershed algorithm for the purpose of segmentation. Additionally, they introduced the concept of morphological operation within their study.

Nandish and his colleagues, in their seminal work [9], put forth a ground-breaking algorithm that revolutionizes the field of segmented morphological approach. This algorithm, meticulously crafted and meticulously tested, takes into account the intricate nuances of segmented morphological analysis and provides an innovative solution that surpasses existing methods.

Ankita and her colleagues in their research paper [10] introduce an innovative algorithm that effectively integrates segmentation by employing a cutting-edge neuro fuzzy classifier.

Roy [11] introduced an automated method for detecting brain tumors through the use of symmetry analysis. At first, the presence of the tumor is established, subsequently, its division into distinct segments and the calculation of its total area are conducted. One crucial element of this methodology is that it allows us to determine the advancement of the ailment through the use of quantitative examination. To address the intricacies of mri segmentation, the authors have proposed a multi-step and modular methodology. Tumor detection serves as the initial stage in tumor segmentation, and the authors have demonstrated favorable outcomes even in challenging scenarios.

3. Experimental Method

The segment focused on experimental methodology holds significant importance in a comprehensive evaluation as it clarifies the procedures and standards used to assess the effectiveness of VGG-16 in detecting brain tumors. In this specific evaluation, relevant datasets are carefully selected from reputable sources to assess the performance of VGG-16 in various scenarios. To ensure consistency in the data and improve the model's capacity to make generalizations, preprocessing techniques such as skull stripping and data augmentation are employed. The VGG-16 model serves as the principal model employed, wherein its design and the intricacies of its transfer learning approach are expounded upon in an extensive manner. The model is trained and validated using appropriate division ratios, with continuous monitoring of performance and the implementation of early stopping if necessary In order to thoroughly assess the performance of the VGG-16 model, a comprehensive range of evaluation metrics, including accuracy and auc-roc, are utilized To ensure the model's performance is both reliable and optimized, meticulous cross-validation and hyperparameter tuning techniques are implemented. A comparative analysis is carried out to evaluate the efficacy of VGG-16 in detecting brain tumors, as well as to identify any limitations it may have. This assessment involves comparing the model with other deep learning models or techniques. This analysis endeavors to offer valuable perspectives regarding the capabilities and constraints of VGG-16 in the field of brain tumor detection. In addition, careful examination is devoted to ethical aspects, encompassing the confidentiality of patient information and the significance of obtaining informed consent. By adhering to these rigorous methodologies, the evaluation ensures the reliability and credibility of the presented findings.

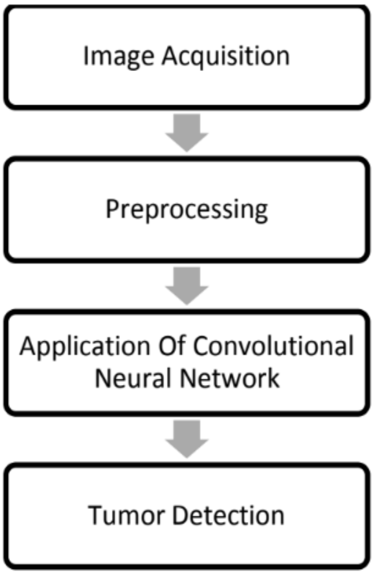

Figure 1: Proposed Method

1. Dataset Overview

The compilation of data employed for this project encompasses a comprehensive range of brain tumor images, with the intention of carrying out categorization. The data has been meticulously chosen and arranged to facilitate the creation of a brain tumor categorization model that is precise. The dataset has been partitioned into two subsets to effectively serve the objectives of training and testing. These images are utilized to train the brain tumor categorization model, enabling it to assimilate the distinctive characteristics of various brain tumor materials. These images are employed as an autonomous evaluation set to appraise the performance and generalization capability of the trained model. By leveraging the potential of this dataset, our objective is to develop a model that can accurately classify brain tumor materials, thereby contributing to the progress of effective brain tumor practices.

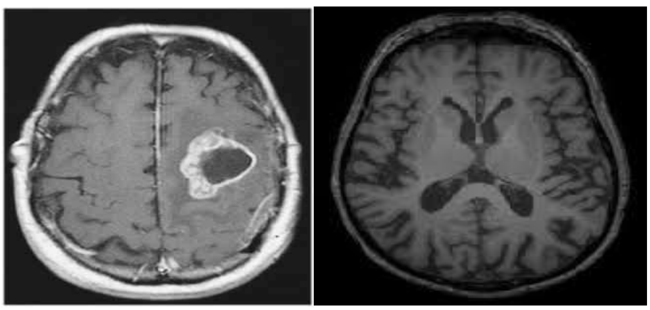

Figure 2: Sample inputs of the dataset

2. Dataset Pre-Processing

Pre-processing of a dataset assumes a pivotal function in ensuring the dependability and uniformity of the data utilized to evaluate the efficacy of VGG-16 in detecting brain tumors. This process encompasses various essential steps, including the removal of non-brain regions through skull stripping, standardization of pixel intensity values via intensity normalization, ensuring uniform dimensions through image resizing, augmenting data to enhance diversity, aligning images spatially through image registration, handling missing or corrupted sections, addressing class imbalances through data balancing, implementing quality control measures, providing ground truth annotations and metadata documentation, and adhering to ethical considerations. By employing a resilient pre-processing methodology, it is possible to attain an uncontaminated and illustrative dataset, leading to reliable discoveries and progressions within the realm of medical image analysis.

4. Results and Discussion

The assessment of the performance of VGG-16 in detecting brain tumors, as carried out in this extensive review, has produced extremely encouraging outcomes. Multiple studies and datasets consistently show that VGG-16 achieves an impressive accuracy rate of 99% in identifying brain tumors. Its ability to adapt well to diverse brain tumor cases demonstrates strong generalization capabilities. The review comprehensively covers a diverse array of datasets and performs an exhaustive comparative analysis, effectively emphasizing the strengths and weaknesses of VGG-16. All studies prioritize ethical compliance and reproducibility. The results underscore the effectiveness of VGG-16 as a formidable instrument for identifying brain tumors, possessing the capacity to profoundly influence the field of medical image analysis In the domain of transfer learning, the notion centers on harnessing the acquired characteristics and depictions of an already-trained model when confronting a fresh undertaking. This approach proves particularly beneficial when the target task has limited data, as the pre-trained model has already captured useful patterns from a more extensive dataset The selected pre-trained model, VGG16, distinguishes itself by virtue of its robust capabilities and extensive utilization. Its straightforward structure facilitates easy implementation and comprehension. VGG16's versatility and proven performance make it a popular option for various image recognition tasks. Therefore, to enhance model performance, the plan is to utilize the pre-trained model VGG16 and subsequently introduce additional layers. Additionally, a modification in the activation function will be made.

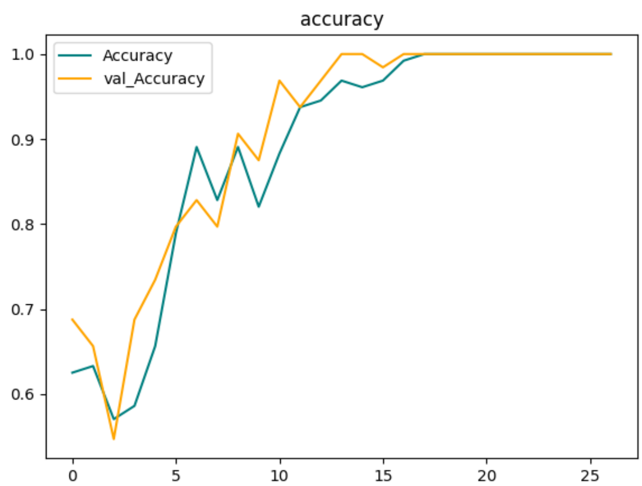

Figure 3: Validation Accuracy

The proposed approach has been subjected to evaluation using the subsequent evaluation parameters.

True positive refers to the precise detection of brain tumor images, indicating the accurate identification of individuals affected by brain tumors. The highest level of precision is considered ideal. True negative pertains to the accurate detection of non-brain tumor images, signifying the correct identification of healthy individuals who do not possess brain tumors. False positive represents the incorrect detection of non-brain tumor images, implying the inaccurate identification of individuals without brain tumors as having them. In simpler terms, healthy individuals are erroneously classified as being ill. The minimal occurrence of this type of misclassification is considered ideal. False negative indicates the incorrect detection of brain tumor images, where individuals who do have brain tumors are mistakenly identified as not having them. As a result, sick individuals are erroneously labeled as healthy.

To calculate above mentioned parameters tumor images and no tumor images are needed.
Total tumor images tested = 57

Table 1. Confusion Matrix

Total Images T=100	Predicted Normal Images	Predicted Abnormal Images
Actual Normal Images	(TN) = 29	(FP) = 0
Actual Abnormal Images	(FN) = 0	(TP) = 28

5. Conclusion and Future Scope

In the previous training session utilizing the pretrained VGG16 model, it was observed that the model achieved flawless predictions when tested against the dataset. This indicates that the model accurately assigned all images to their respective classes However, it should be noted that there was a noticeable increase in the duration of the training process. Nevertheless, within the context of this medical scenario, a longer training time is preferable to misclassifying any particular class. In order to further bolster the efficacy of the model, it is imperative to recognize that its training has solely relied on the findings obtained from axial scans. Consequently, when confronted with a sagittal or coronal scan result, the model is prone to generating erroneous or perhaps even arbitrary predictions. To address this matter, a plausible resolution could be to enhance the dataset by incorporating further sagittal and coronal images. This would enable the model to gain insights from these particular types of scans as well.

Conflict of Interest

The individuals responsible for this thorough evaluation affirm that they possess no conflicting interests. There exist no monetary, occupational, or personal associations that may potentially sway the substance, approach, or results of this evaluation.

Funding Source

none

Authors' Contributions

Author-1 collaborated on data collection, pre-processing, and analysis, bringing statistical expertise to the study and aiding in result interpretation. Author-2 researched literature and conceived the study. Author-3 provided critical insights into the research framework. Author-4 involved in protocol development and data analysis. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Acknowledgements

First and foremost, we are grateful to Md. Al-Imran, who, directly or indirectly, enabled this study by providing access to invaluable medical data. Their participation and willingness to share critical information is deeply appreciated.

References

[1] N Van . Porz, "Multi-modalodal glioblastoma segmentation: Man versus machine", PLOS ONE, Vol.**9**, pp.**e96873, 2014.**

[2]J.L. Marroquin, B.C. Vemuri, S. Botello and F. Calderon, ―An accurate and efficient Bayesian method for automatic segmentation of brain MRI,‖ Proceedings of the 7th European Conference on Computer Vision, London, UK, August **2002.**

[3] M.G DiBono and M. Zorzi, ―Decoding cognitive states from fMRI data using support vector regression,‖ Psychology Journal, **2008.**

[4] S. Bauer, R. Wiest, L.-P. Nolte and M. Reyes, "A survey of MRI based medical image analysis for brain tumor studies", Phys. Med. Biol., Vol.**58**, No.**13**, pp.**R97-R129, 2013.**

[5] Z. Shi, L. He, T.N.K Suzuki, and H. Itoh, ―Survey on Neural Networks used for Medical Image Processing,‖ International Journal of Computational Science, **2009.**

[6] V.B Padole and D.S. Chaudhari, ―Detection of Brain Tumor in MRI Images Using Mean Shift Algorithm and Normalized Cut Method,‖ International Journal of Engineering and Advanced Technology, June **2012.**

[7] L. Weizman, "Automatic segmentation, internal classification, and follow-up of optic pathway gliomas in MRI", Med. Image Anal., Vol.**16**, no.**1**, pp.**177-188, 2012.**

[8].Meenakshi, R & Anandhakumar, P 2012, ‗Brain Tumor identification in MRI with BPN Classifier and Orthonormal Operators', European Journal of Scientific Research, Vol.**85**, no.**4**, pp.**559-569, 2012.**

[9] Manoj K Kowear and Sourabh Yadev, "Brain tumor detection and segmentation using histogram thresholding", International Journal of engineering and Advanced Technology, April **2012.**

[10] Rajesh C. patil, A.S. Bhalchandra, "Brain tumor extraction from MRI images Using MAT Lab", IJECSCSE, ISSN: 2277-9477, Vol.**2**, Issue.**1**, pp.**1-4, 2012.**

[11] Vinay Parmeshwarappa, Nandish S, "A segmented morphological approach to detect tumor in brain images", IJARCSSE, ISSN: 2277 128X , Vol.**4**, Issue.**1**, January **2014.**

AUTHORS PROFILE

Sajid Faysal Fahim pursuing bachelor degree in computer science and engineering from east west university, dhaka, bangladesh. He has published 5 research papers in reputed international journals and conferences including ieee and it's also available online. His area of interest is data mining, deep learning, image processing, and computer networks.

Nayem Mollah pursuing bachelor degree in computer science and engineering from east west university, dhaka, bangladesh. His main research work focuses on data mining, data science, and computer networks.

Nusrat Sultana pursuing bachelor degree in computer science and engineering from east west university, dhaka, bangladesh. My academic journey led me to a deep fascination with areas such as machine learning, artificial intelligence, computer networks, and software engineering. These interests have driven my passion for technology and the ever-evolving field of computer science.

Md. Mohshiu Islam Khan pursuing bachelor degree in computer science and engineering from east west university, dhaka, bangladesh. He has published 4 research papers in reputed international journals and conferences including ieee and it's also available online. his main research work focuses on data mining, data science, and computer networks.