http://www.jctjournals.com ISSN(ONLINE):2278 - 3814

Volume-12, Issue-08, August 2023
JOURNAL OF COMPUTING TECHNOLOGIES (JCT)
International Journal
Page Number: 01-07

A Literature Survey of Brain Tumor Detection Using Different Deep Learning and Machine Learning Techniques: A Review

[1]Gajanan Jadhav, [2]Prof. Swati A. Jaipurkar
[1]M.Tech Scholar, [2]Assistant Professor,
[1,2]Department of Computer Science and Engineering (CSE)
[1,2]Marathwada Institute of Technology, Aurangabad,
[1,2]Dr. B.A.T.U., Lonere, Raigad, Maharashtra, INDIA
[1]gajananj10@gmail.com, [2]swati.kulkarni@mit.asia

Abstract— **Many people suffer from brain tumors, which are a serious health issue. If malignant cells are not detected in time, this type of tumor, which is either benign or malignant, can be fatal. In the most recent human health care analysis, brain tumors have risen dramatically and are now the tenth most common cause of death. Therefore, identifying brain tumors timely and accurately helps to improve the patient's recovery. In this paper, we present a comprehensive approach to brain tumor detection using advanced medical imaging and machine learning techniques. The power of medical imaging modalities, such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT), and Positron Emission Tomography (PET) scans are helps to obtain detailed structural and functional information about the brain. A brain tumor can be detected, located, sized, and characterized through these imaging techniques. Deep learning might increase the accuracy of brain tumor classification at early stage and may lead to decrease the mortality rate when treated at early stage.**

***Keywords*— Brain Tumor, Detection, Medical Imaging, Machine Learning, Deep Learning, Convolutional Neural Networks, MRI, CT, PET.**

1. INTRODUCTION

In this technological age, people are running for money and living without caring about their body. Brain tumours' among the people increasing day after day. It become the tenth most common cause of death in the world [1]. The National Cancer Institute (United States government) is predicted that 24k+ new cases with 18K+ deaths will be recorded by 2023 [2]. Firstly, we explore brain, brain tumours', and MRI brain imaging in the following subsections:

A. Overview of Brain and Brain Tumor:

The brain is the main component of the human neurological system. It is situated in the human head, and the skull protects it [3-5]. All of the body's components are controlled by the human brain. It is a specific sort of organ that enables people to adapt to and tolerate any environmental condition. Humans can behave and communicate their thoughts and feelings thanks to their brains [6]. In this section, we go through how the brain is organized to comprehend the most fundamental concepts. Fig. 1: Basic Morphology of the Human Brain Primary brain tumors (benign tumors) and secondary brain tumors (malignant tumors) are the two basic categories into which brain tumors are divided [7].

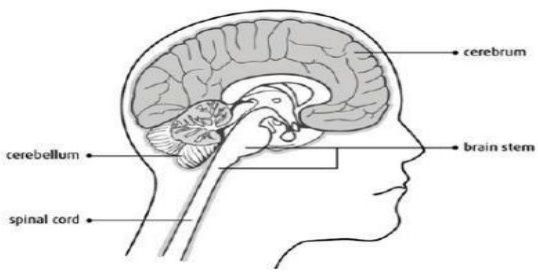

Fig. 1.1: Basic Structure of Human Brain

Gliomas are a form of brain tumor that is benign tumor and develops slowly in the brain. It comes from atrocities, which are brain cells that are not neurons. Primary tumors

ISSN(ONLINE):2278 – 3814

are often less aggressive, but because of the strain they put on the brain, the brain becomes dysfunctional [8]. The secondary tumors are more aggressive and spread into adjacent tissues more quickly. Secondary brain tumors develop from other body parts [10]. These tumors are caused by metastatic cancer cells that have travelled to various bodily parts, such as the brain and lungs. A secondary brain tumor is extremely cancerous. Lung, kidney, and bladder cancers are the primary causes of secondary brain tumor [11] .

B. MRI Brain Imaging

Thoughts are one of the leading causes of increased infant and adult mortality globally, which is not at all unique. A tissue that develops out of control of the typical forcedly regulating growth can also be a tumor [12]. The majority of research from top-tier nations reveals that the number of people who get brain tumors and pass away as a result of them has likely increased by 300 over more than three decades. the commander Favored brain tumors occur 11–12 times per 100,000 people annually in the US, whereas the rate for the most common malignant brain tumors is 6–7 instances per 100,000 people. Because of the synergistic impacts of several radiologists and the computer's scientific image assessment and device mastery techniques, radiologists predict that cad structures can improve their diagnostic skills [13][14]. A Current-day approach to reading the human mind is neuron imaging which lets scientists check the structural or realistic factors of the gadget a fearful. There are factors to take into account at the same time as using practical measurements that are accessible for neuroscience investigations, including spatial selection. It is the precise localization and temporal selection of the sign supply, which is essentially the length of the crucial size. Due to the fact that a musical melody is processed in terms of lovely one-based total connections, it is frequently defined in this way [16-20].

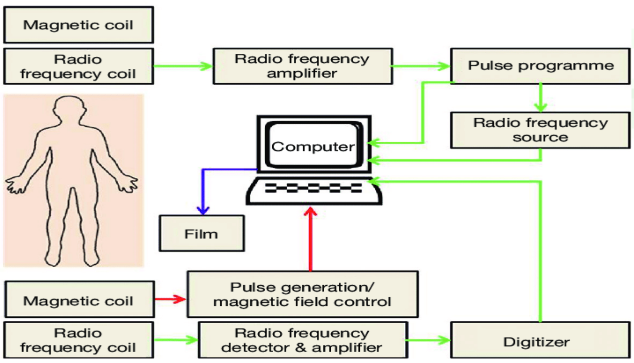

Fig 2 MRI Brain Imaging [21]

Because of this, the melody idea emphasizes the active role of the human mind, demonstrating how it depends on the listener's conviction to require a succession of sounds and transform them properly into a full intellectual experience [22]. The varied aspects of melody even simple songs in this manner employ several sophisticated techniques for identifying tonal family members. In order to "tap into the on-the-spot-to-2d statistics of intellectual interaction with the track," the neuroscience of melody seeks to elicit. In addition to analyzing melodic concept deficiencies in people with localized brain damage, the harem dynamic methodology supplemented by methods like magnetic resonance imaging is a recommended method to identify the brain regions involved in melody notion [24].
Unfortunately, due to the spatial extending of bioelectric current caused by the skull and Scalp, the mental contents are difficult to localize [25]. The terrible spatial yearning makes localization incorrect, not like. The example above shows how specific brain imaging techniques can result in focused studies on particular regions of the brain. The assessment tested how different brain regions responded to complete tone sequences while also using and examining temporal records of brain reactions to individual tones [26].
Brain tumor detection using machine learning is an emerging field of research that focuses on developing computer algorithms capable of accurately detecting brain tumors from medical images. This is done by training machine learning models on a large dataset of brain scans, which enables the models to identify patterns and features that are indicative of tumors [30].

II. LITERATURE REVIEW

In this section, we have discuss a literature review of different Brain tumor detection techniques using machine learning and deep learning.

M.O. Khairandish, et. al., (2022) one of the world's non-death-causing diseases is brain tumor identification and categorization owing to aberrant cell proliferation or portable progression across the body. This research work has applied a hybrid technique on brain MRI images to identify and categorize the tumor utilizing the BRATS database. The system in place uses supervised hybrid CNN and SVM algorithms to categorize brain pictures as benign or malignant tumors. The input pictures were first normalized using the main preprocessing processes, and then relevant features were extracted using the maximum stable extremely regions (MSER) approach and segmented using a threshold-based segmentation algorithm. To categorize brain MRI images, labeled segmentation features are supplied as input to hybrid CNN and SVM algorithms. [01].

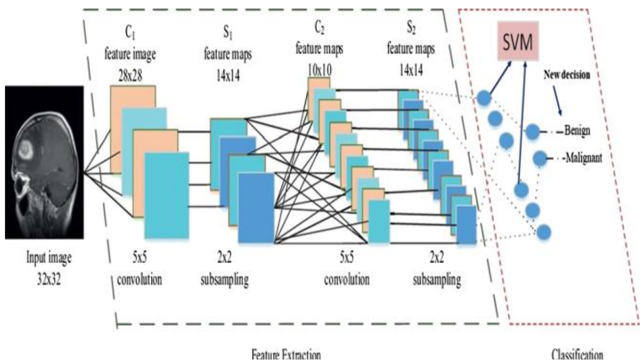

Fig. 3: A Hybrid CNN-SVM Threshold Segmentation [01]

Overall, it achieved 98.4959% properly categorized the hybrid model, compared to 72.5536% for SVM alone and 97.4394% for CNN. The result showed the highest correctly classified with PPV and the lowest of FPV. A quick glance revealed that the hybrid model proposed offers improved and more efficient categorization procedures. Future research can demonstrate the overall improvement in decision-making using the quicker CNN with SVM and other optimization techniques (bio inspired algorithms) [01].

Vinayak Singh, et. al., (2022) Humans develop brain tumors when a normal cell in the brain develops into an abnormal cell. In general, benign tumors and malignant tumors are the two main categories of brain tumors in Homo sapiens. Magnetic resonance imaging (MRI) is crucial in the identification of brain tumors because it demands great precision and accuracy; otherwise, a small inaccuracy might have serious repercussions. In order to assess whether or not a person has a brain tumor, multiple configurable convolution neural network (CNN) paradigms were used for brain tumor MRI data in this study. This study focuses on objective function values (OFV) obtained by different CNN paradigms with the least validation cross-entropy loss (LVCEL), maximum validation accuracy (MVA), and training time (TT) in seconds. These values can be used as a workable tool by clinicians and the medical community to precisely identify tumor patients. A total of 2189 brain MRI images were used for the experimentation and assessment, and the best architecture had the greatest accuracy (0.8275), maximum objective function value (1.84), and area under the ROC (AUC-ROC) curve (0.737) for correctly identifying and categorizing whether or not a person was conscious [02].

Shko M. Qader, et. al., (2022) The primary goal of the DCNN-G-HHO described was to offer an automated brain tumor detection model. As a result, a CNN based on deep learning was taken into consideration and improved by using a hybrid optimization method that combines GWO and HHO approaches. Additionally, segmentation is crucial in the detection of tumors. As a result, an Otsu thresholding method is used. As a consequence, more accurate segmentation and classification were accomplished. On massive augmented MRI images, the performance of the new technique was evaluated by comparison with the old technique in terms of accuracy, precision, recall, f-measure, execution time, and memory consumption. The performance comparison initially showed that the proposed DCNN-G-HHO was significantly more effective than the existing methods. The suggested DCNN-G-HHO technique exceeded existing methods for brain tumor diagnosis, with 0.97 accuracy. This indicates the precision and efficacy of the method. The preceding approaches have lower recalls than the new strategy, which had a recall of 0.95. Finally, 0.96 is the Measure for the method described. Therefore, in terms of accuracy, precision, recall, and F-measure, the presented methodology is more effective than the current methods. On the enhanced MRI image dataset, the overall effectiveness of the authors' presented position was benchmarked in terms of execution time and memory use. On the MR images, the proposed DCNN-G-HHO was quicker at classifying and identifying brain tumor cancers. Similarly to this, the author's approach consumed less RAM than its rivals. Unexpectedly, KNN used more time than the other techniques, although SVM used the most memory. Compared to other classifiers, the DCNN-G-HHO technique was speedier and consumed less memory [03].

P Gokila Brindha, et. al., (2021) one of the greatest methods for analyzing picture collection is CNN. CNN performs the prediction by cropping the image to the desired size while preserving the necessary data. By giving more picture data, the testing accuracy of the ANN model created here, which is 65.21%, may be improved. Applying image augmentation techniques and examining ANN and CNN performance can achieve the same results. This model was created using the trial and error methodology. The number of layers and filters that may be employed in a model will eventually be decided using optimization approaches. The CNN currently shows to be the best option for the supplied dataset [04].

Manav Sharma, et. al., (2021) The aim of this paper is to create a model with high accuracy to determine brain tumors from the MRI images. The dataset used consists of 253 brain MRI images and was sufficient to check the performance of the model. The model is based on the machine learning algorithm CNN (Convolutional Neural Network). It helps to predict just by reducing and resizing the image without losing any important information that will be used for predicting. The created model achieves an accuracy of 97.79% when applied to the training set and an accuracy of 82.86% when applied to the validation set. The loss gradually starts decreasing with the increase in the number of epochs. The model loss is very less when applied to the training set whereas it is high when applied to the validation set [05].

Marcin Woz´niak, et. al., (2021) the presented CLM model is fast learning from the data. Authors can see that all statistics show the ability of fast and efficient learning. The system gives a novel and easy idea of CNN composition. The palette can be composed from the variety of filters to modify the image and number of grids to extract the most important features. In presented research tests, Authors have used those which gave the best results in brain tumor detection, but the CLM can be also applied to other purposes. Due to parallel implementation, the CLM can evaluate many incoming palettes (configuration of the CNN architecture) in each iteration. The model can be run on various number of threads, so that as a result researchers receive flexible system composition with possibility to examine broad spectrum of CNN configurations whose performance actually depends only on the type of used cpu. Construction of the system does not limit it only to biomedical research domain but makes it useful model in most image processing and object detection tasks which is another advantage of author’s idea. Presented training model was originally tested on brain images; however, it could be easily implemented in other medical fields like lung analysis, sarcoidos is detection and others [06].

Muhammad Yaqub, et. al, (2020) A comparative analysis of different optimization algorithms used by authors presented CNN architecture to measure the performance for brain tumor segmentation. The comparison is made on a publicly available MRI brain image data set, i.e., BraTS2015. Both quantitative and graphical results show that all optimizers perform consistently but that Adam performs much better. Among the 10 optimizers for authors' architecture, Adam has the smallest error rate and the highest accuracy rate when it reaches the minimum on a particular epoch. The NAG and RMS Prop optimizers failed badly. Due to limited resources to run several architectures, AdaDelta and Adam ax should be used to provide minimal risk. The performances of the momentum and SGD optimizers were inferior to that of Adam. The adapted pipeline of the CNN optimizer comparison concludes that the performance of Adam is comparable with the latest research [07].

Zhiguan Huang, et.al. (2020) The diagnosis of brain tumor types generally depends on the clinical experience of doctors, and computer-assisted diagnosis improves the accuracy of diagnosing tumor types. Therefore, a convolutional neural network based on complex networks (CNNBCN) with a modified activation function for the magnetic resonance imaging classification of brain tumors is presented. The network structure is not manually designed and optimized, but is generated by randomly generated graph algorithms. These randomly generated graphs are mapped into a computable neural network by a network generator. The accuracy of the modified CNNBCN model for brain tumor classification reaches 95.49%, which is higher than several models presented by other works. In addition, the test loss of brain tumor classification of the modified CNNBCN model is lower than those of the Res-Net, Dense-Net and Mobile Net models in the experiments. The modified CNNBCN model not only achieves satisfactory results in brain tumor image classification, but also enriches the methodology of neural network design [08].

Ghazanfar Latif et.al. (2020) - The agriculture industry is of great importance in many countries and plays a considerable role in the national budget. Also, there is an increased interest in plantation and its effect on the environment. With vast areas suitable for farming, countries are always encouraging farmers through various programs to increase national farming production. However, the vast areas and large farms make it difficult for farmers and workers to continually monitor these broad areas to protect the plants from diseases and various weather conditions. A new concept dubbed Precision Farming has recently surfaced in which the latest technologies play an integral role in the farming process. In this paper, we propose a SMART Drone system equipped with high precision cameras, high computing power with proposed image processing methodologies, and connectivity for precision farming. The SMART system will automatically monitor vast farming areas with precision, identify infected plants, decide on the chemical and exact amount To Spray [09].

Siraj Khan et.al. (2020) In computer vision, traditional machine learning (TML) and deep learning (DL) methods have significantly contributed to the advancements of medical image analysis (MIA) by enhancing prediction accuracy, leading to appropriate planning and diagnosis. These methods substantially improved the diagnoses of automatic brain tumor and leukemia/blood cancer detection and can assist the hematologist and doctors by providing a second opinion. This review provides an in-depth analysis of available TML and DL techniques for MIA with a significant focus on leukocytes classification in blood smear images and other medical imaging domains, i.e., magnetic resonance imaging (MRI), CT images, X-ray, and ultrasounds. The proposed review's main impact is to find the most suitable TML and DL techniques in MIA, especially for leukocyte classification in blood smear images. The advanced DL techniques, particularly the evolving convolutional neural networks-based models in the MIA domain, are deeply investigated in this review article [10].

III. PROBLEM FORMULATION

Healthcare sector is totally different from other industry. It is on high priority sector and people expect highest level of care and services regardless of cost. After the success of deep learning in other real-world application, it is also providing exciting solutions with good accuracy for medical imaging and is a key method for future applications in health sector. Brain is an organ that controls activities of all the parts of the body. Recognition of automated brain tumor in Magnetic resonance imaging (MRI) is a difficult task due to complexity of size and location variability. In this research statistical analysis morphological and thresholding techniques are proposed to process the images obtained by MRI for Tumor Detection from Brain MRI Images. Feed-forward back prop neural network will be used to classify the performance of tumors part of the image. The results produced by this approach will increase the accuracy and reduce the number of iterations.

IV. MRI DATASET

We have used open-source (freely available) brain MRI images that include tumor and non-tumor images in various sizes and formats such as JPG, JPEG, and PNG. The MRI dataset used in this study has been manually labeled and collected by radiologists, researchers, medical experts, and doctors and several researches have also been published on this dataset. In this dataset, there are a total of 253 brain MRI images from two categories with and without tumor segments of varying sizes and shapes. The dataset is further classified into two parts, 155 images with tumor segments and 98 images without tumors. This dataset also includes both types of MR images T1 and T2 weighted with non-uniform picture resolution. We presented the images in such a way that tumor images are labeled as "yes" and normal images (without tumors) are labeled as "no", as shown in Fig. 4.

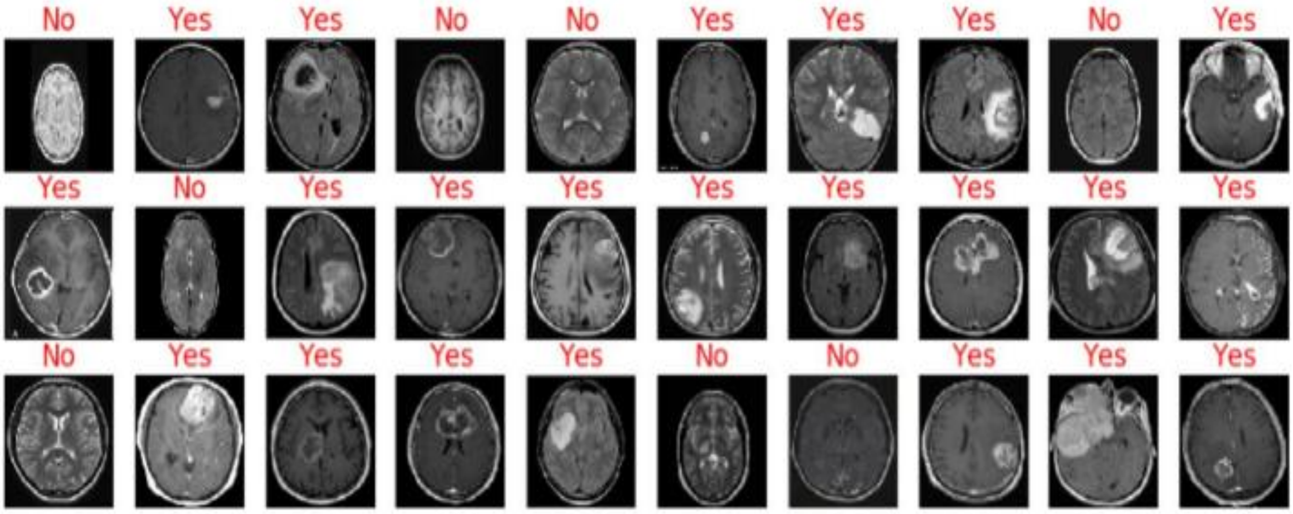

Fig. 4: images of the brain MR image dataset [31]

A. MRI DATA PRE-PROCESSING

Refining or capturing useful information before processing the data is known as preprocessing. This is an important function of an image or signals analysis where useful information is obtained or data is cleaned before the processing stage. This stage has its importance because the wrong information, noisy data, or uncategorized data may provide poor analysis results even with a very efficient classifier. In this stage, we have fetched the size, shape, and pixel information of the MRI image dataset by finding the image ration distribution graph. Since the dataset used for this work is heterogeneous in nature that means each image has a different size, shape, pixel information, and image formats. Hence by dividing each image's width by its height we get the image ratios distribution data. This image ratio distribution data is plotted against the image count to visualize the image size in the dataset, shown in Fig. 3.2. it can be seen that about 90 image ratio of width and height is equal to one which is of the same height and width, remaining images widths and height ratio are different. Therefore, before preparing these images for training, it is necessary to resize it so that it is homogenous. There are various preprocessing techniques used before feeding the raw MR images for classification, such as cropping, resizing, data augmentation (DA), and data distribution [32].

V. CONCLUSION FROM LITRATURE SURVEY

Deep learning has proven to be a valuable tool in the field of brain tumor detection. By leveraging deep neural networks and advanced image processing techniques, researchers and medical professionals have developed accurate and efficient methods for detecting and classifying brain tumors from medical imaging data.Deep learning libraries, such as TensorFlow, PyTorch, and Keras, have played a crucial role in facilitating the development and deployment of these models. These libraries provide a wide range of tools, algorithms, and resources that simplify the implementation and training of deep neural networks.The use of deep learning in brain tumor detection has several benefits. It enables automated and objective analysis of medical images, reducing human error and variability. Deep learning models can process large amounts of data quickly, allowing for faster and more efficient diagnoses. They can also handle complex features and patterns in the images, leading to improved accuracy in tumor detection.

REFERENCES

[1] Khairandish, Mohammad Omid, Meenakshi Sharma, Vishal Jain, Jyotir Moy Chatterjee, and N. Z. Jhanjhi. "A hybrid CNN-SVM threshold segmentation approach for tumor detection and classification of MRI brain images." *Irbm* 43, no. 4 (2022): 290-299.

[2] Singh, Vinayak, Mahendra Kumar Gourisaria, Harshvardhan GM, Siddharth Swarup Rautaray, Manjusha Pandey, Manoj Sahni, Ernesto Leon-Castro, and Luis F. Espinoza-Audelo. "Diagnosis of intracranial tumors via the selective cnn data modeling technique." *Applied Sciences* 12, no. 6 (2022): 2900.

[3] Qader, Shko M., Bryar A. Hassan, and Tarik A. Rashid. "An improved deep convolutional neural network by using hybrid optimization algorithms to detect and classify brain tumor using augmented MRI images." *Multimedia Tools and Applications* (2022): 1-28.

[4] Brindha, P. Gokila, M. Kavinraj, P. Manivasakam, and P. Prasanth. "Brain tumor detection from MRI images using deep learning techniques." In *IOP conference series: materials science and engineering*, vol. 1055, no. 1, p. 012115. IOP Publishing, 2021.

[5] Sharma, Manav, Pramanshu Sharma, Ritik Mittal, and Kamakshi Gupta. "Brain tumour detection using machine learning." *Journal of Electronics* 3, no. 4 (2021): 298-308.

[6] Woźniak, Marcin, Jakub Siłka, and Michał Wieczorek. "Deep neural network correlation learning mechanism for CT brain tumor detection." *Neural Computing and Applications* (2021): 1-16.

[7] Yaqub, Muhammad, Jinchao Feng, M. Sultan Zia, Kaleem Arshid, Kebin Jia, Zaka Ur Rehman, and Atif Mehmood. "State-of-the-art CNN optimizer for brain tumor segmentation in magnetic resonance images." *Brain Sciences* 10, no. 7 (2020): 427.

[8] Zhiguan Huang; Xiaohao Du; Liangming Chen; Yuhe Li; Mei Liu; Yao Chou "Convolutional Neural Network Based on Complex Networks for Brain Tumor Image Classification With a Modified Activation Function" Volume: 8,2020.

[9] Ghazanfar Latif , Jaafar Alghazo , R. Maheswar V. Vijayakumar c , Mohsin Butt "Deep Learning based Intelligence Cognitive Vision Drone for Automatic Plant Diseases Identification and Spraying" 2020.

[10] Siraj Khan, Muhammad Sajjad, Tanveer Hussain , Amin Ullah , And Ali Shariq Imran "A Review on Traditional Machine Learning and Deep Learning Models for "WBCs Classification in Blood Smear Images" November 27, 2020.

[11] Roy, Sanjiban Sekhar, Nishant Rodrigues, and Yh Taguchi. "Incremental dilations using CNN for brain tumor classification." *Applied Sciences* 10, no. 14 (2020): 4915.

[12] Sajjad, Muhammad, Salman Khan, Khan Muhammad, Wanqing Wu, Amin Ullah, and Sung Wook Baik. "Multi-grade brain tumor classification using deep CNN with extensive data augmentation." *Journal of computational science* 30 (2019): 174-182.

[13] Amin, Javaria, Muhammad Sharif, Mudassar Raza, Tanzila Saba, and Muhammad Almas Anjum. "Brain tumor detection using statistical and machine learning method." *Computer methods and programs in biomedicine* 177 (2019): 69-79.

[14] Kaldera, H. N. T. K., Shanaka Ramesh Gunasekara, and Maheshi B. Dissanayake. "Brain tumor classification and segmentation using faster R-CNN." In *2019 Advances in Science and Engineering Technology International Conferences (ASET)*, pp. 1-6. IEEE, 2019.

[15] Khan, Muhammad A., Ikram U. Lali, Amjad Rehman, Mubashar Ishaq, Muhammad Sharif, Tanzila Saba, Saliha Zahoor, and Tallha Akram. "Brain tumor detection and classification: A framework of marker-based watershed algorithm and multilevel priority features selection." *Microscopy research and technique* 82, no. 6 (2019): 909-922.

[16] Özyurt, Fatih, Eser Sert, Engin Avci, and Esin Dogantekin. "Brain tumor detection based on Convolutional Neural Network with neutrosophic expert maximum fuzzy sure entropy." *Measurement* 147 (2019): 106830.

[17] Myronenko, A. (2019). 3D MRI brain tumor segmentation using autoencoder regularization. In Brainlesion: Glioma, Multiple Sclerosis, Stroke and Traumatic Brain Injuries: 4th International Workshop, BrainLes 2018, Held in Conjunction with MICCAI 2018, Granada, Spain, September 16, 2018, Revised Selected Papers, Part II 4 (pp. 311-320). Springer International Publishing.

[18] Chandra, Saroj Kumar, and Manish Kumar Bajpai. "Effective algorithm for benign brain tumor detection using fractional calculus." In *TENCON 2018-2018 IEEE Region 10 Conference*, pp. 2408-2413. IEEE, 2018.

[19] Rashid, M. H. O., M. A. Mamun, M. A. Hossain, and M. P. Uddin. "Brain tumor detection using anisotropic filtering, SVM classifier and morphological operation from MR images." In 2018 international conference on computer, communication, chemical, material and electronic engineering (IC4ME2), pp. 1-4. IEEE, 2018.

[20] Bahadure, Nilesh Bhaskarrao, Arun Kumar Ray, and Har Pal Thethi. "Image analysis for MRI based brain tumor detection and feature extraction using biologically inspired BWT and SVM." *International journal of biomedical imaging* 2017 (2017).

[21] ShanmugaPriya, S., and A. Valarmathi. "Efficient fuzzy c-means based multilevel image segmentation for brain tumor detection in MR images." *Design Automation for Embedded Systems* 22 (2018): 81-93.

[22] Rao, C. Hemasundara, P. V. Naganjaneyulu, and K. Satya Prasad. "Brain tumor detection and segmentation using conditional random field." In *2017 IEEE 7th International Advance Computing Conference (IACC)*, pp. 807-810. IEEE, 2017.

[23] Dong, Hao, Guang Yang, Fangde Liu, Yuanhan Mo, and Yike Guo. "Automatic brain tumor detection and segmentation using U-Net based fully convolutional networks." In *Medical Image Understanding and Analysis: 21st Annual Conference, MIUA 2017, Edinburgh, UK, July 11–13, 2017, Proceedings 21*, pp. 506-517. Springer International Publishing, 2017.

[24] Haritha, D. "Comparative study on brain tumor detection techniques." In 2016 International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES), pp. 1387-1392. IEEE, 2016.

[25] Somwanshi, Devendra, Ashutosh Kumar, Pratima Sharma, and Deepika Joshi. "An efficient brain tumor detection from MRI images using entropy measures." In *2016 international conference on recent advances and Innovations in engineering (ICRAIE)*, pp. 1-5. IEEE, 2016.

[26] Shanthakumar, P., and P. Ganeshkumar. "Performance analysis of classifier for brain tumor detection and diagnosis." *Computers & Electrical Engineering* 45 (2015): 302-311.

[27] Kanade, Pranita Balaji, and P. P. Gumaste. "Brain tumor detection using MRI images." *Brain* 3, no. 2 (2015): 146-150.

[28] Saba, Tanzila, Ahmed Sameh Mohamed, Mohammad El-Affendi, Javeria Amin, and Muhammad Sharif. "Brain tumor detection using fusion of hand crafted and deep learning features." *Cognitive Systems Research* 59 (2020): 221-230.

[29] Dipu, Nadim Mahmud, Sifatul Alam Shohan, and K. M. A. Salam. "Deep learning based brain tumor detection and classification." In *2021 International*

Conference on Intelligent Technologies (CONIT), pp. 1-6. IEEE, 2021.

[30] Arif, Muhammad, F. Ajesh, Shermin Shamsudheen, Oana Geman, Diana Izdrui, and Dragos Vicoveanu. "Brain tumor detection and classification by MRI using biologically inspired orthogonal wavelet transform and deep learning techniques." *Journal of Healthcare Engineering* 2022 (2022).

[31] https://www.kaggle.com/datasets/masoudnickparvar/brain-tumor-mri-dataset

[32] https://www.kaggle.com/datasets/ahmedhamada0/brain-tumor-detection

