



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 12, December 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.524

9940 572 462

6381 907 438

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Brain Tumor Detection from MRI Images Using Sequential Convolutional Neural Network Model

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ABSTRACT: Brain tumors are one of the most dangerous diseases, necessitating early and accurate detection methods; however, most detection and diagnosis methods now rely on neurosurgeons' and radiologists' decisions for image evaluation, which is subject to human error and time-consuming. MRI imaging plays an important role in brain tumor analysis, diagnosis, and treatment planning. It assists the doctor in determining the previous stages of the brain tumor. Brain tumor detection using MRI images is a challenging task because of the complex structure of the brain. A brain tumor is an abnormal cell growth in the brain. This study reviews and describes the processes and techniques used in the detection of brain tumors based on magnetic resonance imaging (MRI) and convolutional neural networks (CNN) techniques, which are executed in the different steps of a computer-aided detection system (CAD) after collecting the image data (MRI). In our work, CNN achieved an accuracy of 97%, which is very compelling. The main aim of this paper is to distinguish between normal and abnormal pixels based on texture-based and statistically-based features.

KEYWORDS: Brain Tumor, MRI Image, CNN, Data set

I. INTRODUCTION

The human body is composed of a variety of cell types. The brain is a delicate and highly specialized organ of the human body. A brain tumor is an extremely dangerous condition for people. The abnormal growth of tissue in or around the brain causes the intracranial mass known as a brain tumor. Brain tumor diagnosis is quite difficult because of diverse shape, size, location and appearance of tumor in brain. Early-stage brain tumor detection is highly challenging because it is impossible to determine the tumor's precise size. However, as soon as a brain tumor is diagnosed, the appropriate treatment can be started, and it may be treatable. Treatments including chemotherapy, radiation, and surgery are therefore dependent on the type of tumor [1].

There are roughly 130 different types of brain tumors. All of them range from benign to malignant, and from extremely rare to fairly common. 4 most common brain tumors are metastatic, meningioma, glioblastoma, and astrocytoma [2]. Few most common symptoms of brain tumors are: headaches, nausea and vomiting, change in speech, vision, or hearing, mood, personality, problems memory, balancing or walking, ability to concentrate, muscle jerking or twitching and numbness or tingling in the arms or legs [3].

In general, diagnosing a brain tumor usually begins with magnetic resonance imaging (MRI). Once MRI shows that there is a tumor in the brain, the most common way to determine the type of brain tumor is to look at the results from a sample of tissue after a biopsy or surgery. These tests and procedures are described below in more detail [4].

An MRI uses magnetic fields, not x-rays, to produce detailed images of the body. MRI can be used to measure the tumor's size. A special dye called a contrast medium is given before the scan to create a clearer picture. This dye can be

injected into a patient's vein or given as a pill or liquid to swallow. MRIs create more detailed pictures than CT scans (see below) and are the preferred way to diagnose a brain tumor. The MRI may be of the brain, spinal cord, or both, depending on the type of tumor suspected and the likelihood that it will spread in the CNS. There are different types of MRI. The results of a neuro-examination, done by the internist or neurologist, helps determine which type of MRI to use.

Deep Learning is becoming increasingly important in the medical field. It provides predictive behaviors that can accurately analyze complex medical data. With AI integration into many fields of medicine, it is important for healthcare providers to understand its capabilities and limitations. Its growing popularity and presence in healthcare has caused widespread media coverage, allowing a wider percentage of population to become aware of its great potential to help. Gaining knowledge and actionable insights from complex, high-dimensional biomedical data remains a key challenge in transforming health care. Various types of data have been emerging in modern biomedical research, including electronic health records, imaging, sensor data and text, which are complex, heterogeneous, poorly annotated & generally unstructured. Traditional data mining & statistical learning approaches typically need to first perform feature engineering to obtain effective and more robust features from those data, and then build prediction or clustering models on top of them. There are lots of challenges on both steps in a scenario of complicated data and lacking of sufficient domain knowledge. The latest advances in deep learning technologies provide new effective paradigms to obtain end-to-end learning models from complex data. The future of healthcare has never been more exciting. Not only do AI and ML present an opportunity to develop solutions that cater for very specific needs within the industry, but deep learning in healthcare can become incredibly powerful for supporting clinicians and transforming patient care [5].

II. RELATED WORKS

P Gokila Brindha, M Kavinraj, P Manivasakam and P Prasanth studied, a self-defined artificial neural network (ANN) and a convolution neural network (CNN) are used to detect the presence of brain tumors, and their performance is examined [6].

Tonmoy Hossain, Fairuz Shadmani Shishir, Mohsena Ashraf, MD Abdullah Al Nasim, Faisal Muhammad Shah studied by using CNN with Keras and TensorFlow implementation achieved an accuracy of 97.87% [7].

Asma Naseer, Tahreem Yasir, Arifah Azhar, Tanzeela Shakeel and Kashif Zafar studied and proposed CNN-based CAD system for brain tumor diagnosis performs better than other systems by achieving an average accuracy of around 98.8% [8].

Jainy Sachdeva, Vinod Kumar, Indra Gupta, Niranjana Khandelwal, and Chirag Kmal Ahuja studied and proposed a technique for classifying tumor focusing to make the CAD system more interactive. They used different datasets to check the accuracy of their proposed model. The first dataset contains five classes and the second dataset contains three classes of tumors. The technology used is modifying the SVM and ANN model by using them with a Genetic algorithm (GA) leading to proposing two models, namely, GA-SVM and GA-ANN. The suggested model was able to effectively increase the accuracy of the model from 79.3% to 91% for SVM and from 75.6% to 94.9% for ANN [9].

Ayesha Younis, Li Qiang, Charles Okanda Nyatega, Mohammed Jajere Adamu and Halima Bello Kawuwa studied, a CNN was built to detect brain tumors using MRI scans of the brain automatically. The network could be trained for faster and more convenient training using a pre-trained VGG 16 model. VGG 16 has sixteen layers and is a critical CNN model to evaluate if employing a commercial model for a task. This paper aimed to discover a brain tumor using the VGG 16, CNN model architecture, and weights to training data. The precision of the outcome was evaluated [10].

Tanzila Saba, Ahmed Sameh Mohamed, Mohamed El-Affendi, Javeria Amin Muhammad Sharif studied, brain tumor is detected by using both handcrafted features and the features extracted by the deep learner [11]. S. Deepak, P.M. Ameer studied, pretrained GoogLeNet is used to extract features. For classification, already proven classifiers are used. By using fivefold cross-validation, 98% accuracy is achieved. CNN is trained on augmentation of extensive data for brain tumor classification [12].

B. Devkota, Abeer Alsadoon, P.W.C. Prasad, A.K. Singh, A. Elchouemi studied, established the whole segmentation process based on Mathematical Morphological Operations and spatial FCM algorithm which improves the computation

time, but the proposed solution has not been tested up to the evaluation stage and outcomes as- Detects cancer with 92% and classifier has an accuracy of 86.6% [13].

Parnian Afshar, Arash Mohammadi, Konstantinos N. Plataniotis studied and proposed an improved CNN architecture for brain tumor classification dubbed member network capsule (CapsNet). CapsNet is a system that takes use of the tumor's spatial interaction with its surrounding tissues. The greatest accuracy achieved for the tumor that is segmented and that of unprocessed image of the brain was 86.56 percent and 72.13 percent, respectively [14].

Ramdas Vankdothu, Mohd Abdul Hameed studied, the proposed RCNN method is compared with the current classification methods of BP, U-Net, and RCNN. The proposed classifier obtained 95.17% accuracy in classifying brain tumor tissues from MRI images [15].

Hamza Rafiq Almadhoun and Samy S. Abu Naser studied, For testing, they had used their model which is created from scratch model, Inception, VGG16, MobileNet and ResNet models. The f-score accuracy we got for each model was as follows: Our model was 98.28, VGG16 was 99.86%, ResNet50 was 98.14%, MobileNet was 88,98%, and InceptionV3 was 99.88% [16].

III. EXPERIMENTAL METHODOLOGY

In this study, the Faster CNN algorithm was used to develop an automated technique for classifying and detecting brain tumors. Convolutional feature maps were created by Faster CNN using the VGG 16 architecture as its primary network. These maps were subsequently categorized to produce recommendations for tumor regions. Performance was measured by prediction accuracy.

To achieve our project goal, the proposed research effort chose to employ Python programming. The reasons the paper chose Python are:

- Python is free and open-source, with more datasets and graphical packages.
- Python provides greater control over implementation to achieve and better name visual-name visualsatial.
- We could easily manage a variety of classic library versions.

The dataset used in this study is a brain MRI image obtained from the Kaggle website. The dataset consists of 3000 images with two folders yes and no. The folder yes contains 1500 images are images with brain tumors. The folder no contains 1500 images are images with no brain tumors. The images collected were in .jpeg format [35].

Most have a bit depth of 24, but some have a bit depth of 8. Therefore, a conditional sentence is needed before gray scaling is done.

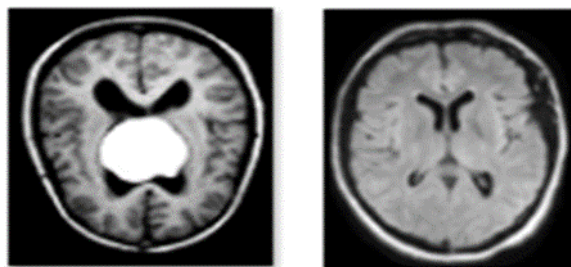


Fig. 1 MRI Images of Brain (a) with tumor and (b) no tumor [35]

In order to encourage the extraction of valuable insights from the data, data pre-processing is an essential stage in machine learning or neural networks. Preparing raw data (Cleaning and Organizing) for the creation and training of Machine Learning or Neural Network models is known as data pre-processing. Data pre-processing, to put it simply, is a data mining technique that turns raw data into a format that can be read and understood.

It will be demonstrated how to import Python libraries for data pre-processing in Machine Learning because Python is the library that Data Scientists worldwide use and prefer the most. Specific data pre-processing tasks can be carried out using the specified Python libraries. For this data pre-processing in machine learning, the three main Python libraries

are: NumPy, Pandas, Matplotlib.

Each dataset must be divided into a training set and a test set before being used in a machine learning model. The subset of a dataset used to train a machine learning model is referred to as the training set. In this case, the output has previously been known to the model. Contrarily, a test set is the portion of the dataset used to evaluate a machine learning model. The test set is used by the ML model to forecast results. The dataset is typically divided into 70:30 ratios or 80:20 ratios. This indicates that the model uses either 70% or 80% of the data for training while excluding the remaining 30% or 20%. Depending on the size and shape of the dataset under consideration, different splitting techniques are used. The data in this report has been divided using a 67:33 ratio.

The goal of machine learning and deep learning is to reduce the difference between the predicted output and the actual output. This is also called as a Cost function or Loss function. Cost functions are usually convex functions. The goal is to minimize this cost function by finding the optimized value for weights. The algorithms do this are known as Optimizers.

IV. RESULT AND DISCUSSION

The study’s results were examined using the metrics of precision, recall, f1-score and support. The confusion matrix was used to calculate these metrics’ values. Therefore, the parameters of the CNN model were true positive (TP), true negative (TN), false positive (FP), and false-negative (FN).

		Actual Values	
		Positive (1)	Negative (0)
Predicted Values	Positive (1)	TP	FP
	Negative (0)	FN	TN

Fig 2 Confusion Matrix Table

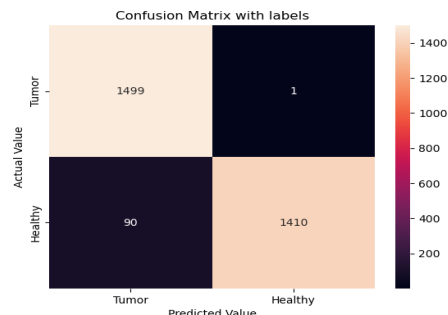


Fig 3 Confusion matrix of our model

One of the most effective machine learning techniques for predictive analysis is the confusion matrix. A confusion matrix compares correctly classed instances to incorrectly categorized examples to provide information on how well your machine classifier has performed. Confusion matrices are used to visualize important predictive analytics like recall, specificity, accuracy, and precision. Confusion matrices are useful because they give direct comparisons of values like True Positives, False Positives, True Negatives and False Negatives [36].

The Precision, Recall, F1-score of our model are 0.94, 1.00 and 0.97 for Tumor respectively and 1.00, 0.94 and 0.97 for Healthy respectively which are presented in the following table as classification report.

Classification	precision	recall	f1-score	support
Tumor	0.94	1.00	0.97	1500
Healthy	1.00	0.94	0.97	1500

Table1: Classification report of VGG16 with Adam

V. CONCLUSIONN AND FUTURE

In this paper, an efficient and effective model (i.e., VGG) has been developed for detecting brain tumor using CNN. VGG model are executing well in this dataset. The accuracy of this model is 97%.Its classification report is showing recall rates for ‘Tumor’ is 1.00 and for ‘Healthy’ is 0.94.Showing precision for ‘Tumor’ is 0.94 and for ‘Healthy’ is

1.00 .Showing f1 score for both ‘Tumor’ and ‘Healthy’ is 97%. The proposed system was able to detect tumor faster and accurately. This paper serves as a rudimentary manual for nascent biomedical researchers with an interest in deep learning or machine learning. It will provide insight into the use of pre-trained networks for medical image classification, as well as how to look at generate classification reports.

In the future work, the accuracy of CNN model can be increased by providing more image data. By using 3D brain imaging for detection of brain tumors in future can done more effectively.

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