Symptomatically Brain Tumor Detection Using Convolutional Neural Networks

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Abstract. In the human body, the most important and the complex organs work with billions of cells in the brain. The abnormal growth or uncontrolled division of cells around the brain will cause a brain tumor. These group of cells which affect the functioning of the brain and also destroys the human cells. In the olden days, the detection of brain tumors is way much harder than nowadays. The usage of modern computer vision techniques has made the detection to be more accurate and easy. In this paper, firstly the detection of tumor in the brain was performed using a Sequential Neural Network (SNN) model which classifies the symptoms, as the brain tumor and then Magnetic Resonance Images (MRI) Scans are used for the further confirmation. The SNN model has an accuracy of 99.36% whereas the Convolutional Neural Network (CNN) Model used in this paper is 99.89% accurate.

Keywords. Artificial Neural Networks, Computer Vision, Convolutional Neural Network, Symptoms, Brain Tumor.

1. Introduction
Medical imaging plays a prominent role in the diagnosis of diseases, planning of treatment, and clinical monitoring. The identification of the segments in the medical image is the fundamental problem in medical image analysis. The image segmentation deals with the identification of the boundaries of human organs or tumor cells which tends to be the abnormal increase of cells in a particular area. The various methods of medical imaging like MRI, ultrasound or, CT scans will help in the easy identification of the tumor cells or any abnormal thing that has happened in the human body, but the variations in those methods will lead to making complex challenges in the classification. Performing of the classification manually was said to be very time-consuming and subjective which can even lead to the inappropriate treatment, but by using an accurate classification algorithm based on different medical images the prediction accuracy can be improved, and even efficiency can be enhanced, this could lead to assist in accurate treatment planning. The usage of the MRI images is an extensively used technique throughout the medical research field which helps in the diagnosis and prognosis of many neurological diseases and can even detect the conditions of those diseases.

Computer Vision (CV) is one of the areas of Artificial Intelligence (AI) where the usage of image data will be high for feature extraction from those images. And due to its accuracy and easy usage, many innovations are rising and the people are expecting more. Many papers were published in that field, especially related to Deep Learning (DL), and Convolutional Neural Networks (CNN). The CNN
algorithm is exploited in various fields to get accurate results like image processing, video analysis, and much more. Research and development in the field of CV and more precisely CV using DL lead to many discoveries and practical applications in different domains. And thus in the medical field, the design and the development of fully autonomous medical image processing became easy by using CV.

There are two AI models which have been proposed in this paper for the accurate classification of brain tumor. An SNN model for the symptom classification and a CNN model which takes the input of the MRI scans of the brain and gives a classified output.

2. Literature Survey
In the paper published by Gurbin et al. [1], the classification and the detection system of the brain tumor are implemented using CWT (Continues wavelet transform), DWT (Discrete wavelet transform) and (Support Vector Machines) SVMs. They have used different levels for wavelets in their paper, the system with high accuracy was achieved using CWT. They have mentioned that the CWT method will prevent the loss of edges in the segmentation part. The result of their proposed methodology shows that SVM can differentiate abnormal and normal regions of tumors and also able to classify them accurately as a benign tumor, malign tumor, or a healthy brain. At last, they have mentioned that a hybrid approach is required in solving the problem of proper detection and classification of brain tumors.

Mina et al. [2], have published a paper related to Brain tumor segmentation using Multitask CNN. They have described an automated network that is able to multitask and learn simultaneously for segmentation of the brain tumor, and they have developed a CNN which was trained on the entire volume of medical images and also developed a new bounding box detection technique.

Harshini et al. [3] have proposed a paper on brain tumor detection which was the best technique for MRI-based brain tumor division. They have also mentioned about the working of cerebrum tumor division strategies.

In the paper published by Bramarambika et al. [4], they have mentioned about the histogram method and many other methods for the segmentation of MR images and has concluded that the histogram method was very efficient in segmentation.

Tonmoy et al. [5] have mentioned in their paper about the Fuzzy C – Means clustering algorithm which was used in the segmentation and the detection of brain tumors. But after comparing with various techniques they have mentioned that the SVM has given 92.42% accuracy which is efficient from the mentioned algorithms.

In the paper published by Malathi et al. [7], they have mentioned about the brain tumor segmentation which was implemented using CNN architecture. They have proposed an algorithm that relates both local and global features, because of the reason that the process of segmentation will be performed accurately.

Usman et al. [9], they have mentioned about their proposed method improved the MR image and also segmentation of the brain tumor using global thresholding. By using the morphological operations and also by applying windowing technique false segmented pixels are removed.

A CNN network was built in the paper published by Varun et Al. [10] for the recognition of the animal moods from the voice. The voice is converted into images as the sound wave and then the CNN model is used to predict the mood of the animals. The accuracy of the model is given to be 80% in the testing phase although in the training phase it was 100% accurate.
Some of the results of the previous methods which are mentioned in the papers published by the above-mentioned authors are displayed in table - 1. The table consists of the three columns from which the authors, their proposed model name along with the accuracies of their proposed models are displayed.

Table 1. Comparison of results of the previous methods.

| Paper             | Model Name                        | Accuracy   |
|-------------------|-----------------------------------|------------|
| Gurbin et al. [1] | Support Vector Machine            | Avg. 92%   |
| Seetha et al. [8] | Fuzzy C Means                     | 97.5%      |
| Usman et al. [9]  | Detection using Segmentation      | 97%        |
| Hossain et al. [5]| Convolutional Neural Network      | 97.87%     |

3. Problem Statement
The modern equipment and the Computer vision is helping the people in many ways, their usage in the medical field. The main problem of the existing methods in the medical field is although they possess high accuracy in classification of the images, it is not an efficient way to take the CT/MRI scans for everyone who visits a hospital which may cause the heavy cost for the patients. So, to reduce the cost spent by the patients in making the scans an SNN model is described in this paper which suggests the patient make the MRI scan or not. And further, make the correct decision the MRI scans of the patient who is suspected by the proposed SNN model will be given as the Input to the CNN model to classify and give the accurate result.

The details of the proposed SNN model and the CNN model is mentioned in the proposed methodology part of this paper. In addition to the description of the models used, the details about the system architecture, and the symptoms of the Brain Tumor is also mentioned.

4. Proposed Methodology
As mentioned in the literature survey, the present methodologies deal with the MRI Scan images directly which may become a cost-ineffective way as the patients need to take an MRI scan of their brain to know whether the tumor is present or not. To avoid such a waste of cost the proposed methodology helps in proposing the next steps to the patient, first the symptoms or the sufferings of the patient need to give as the input to the SNN model. As mentioned in the previous papers the types of brain tumors are above 100 in number which will lead to the differences in the symptoms of brain tumors depending on the type of tumor and its location. Common symptoms of brain tumors may include:

1. Persistent headaches.
2. Problems with vision.
3. Nausea, vomiting, and general drowsiness.
4. Seizures.
5. Issues with short term memory.
6. Speech problems.
7. Coordination issues.
8. Personality changes

From the above-mentioned issues or symptoms, a person is identified whether he/she has a brain tumor or not using the proposed SNN model. The SNN model will predict the symptoms as per the trained data and will be able to classify whether there is any chance of having a tumor the patient or
the patient is just suffering from any other chronic disease. If the prediction is classified as the symptomatic tumor, then the patient is suggested to take an MRI Scan where by using the proposed CNN model the MRI scan can be classified to give the absolute output with high accuracy. The entire proposed methodology can be shown in figure-1.

The Convolutional Neural Networks are the game changers to obtain the best solutions. They have wide usage in providing solutions to the problems related to computer vision. The training or test images which are given as the input to the proposed CNN model need to pass through the pre-processing phase where the given MRI scan image is taken first, then the filters like Canny, erode, dilute are applied on the images then saved in an array format. The saved array format will be given to the CNN model for the training purpose. The CNN used in this paper is as shown in Figure -2.

The sample of the input data given to the SNN model is as shown in figure – 3. Once if the SNN model classifies the given input as the patient may have a brain tumor according to the symptoms then the further prediction is performed by the proposed CNN model. The input MRI Scan for the CNN model is as shown in figure - 4. The two-class dataset, one with the MRI scan images of the brain which does not have a tumor and another set of images with the tumor is given as the input to the proposed CNN model after the pre-processing phase which is as shown in figure - 5.
The details about the pre-processing phase are described in the following steps.

1. The Primary step is to take all the images at once and put them in a folder.
2. A multi-dimensional array is defined to store the images and their respective classes.
3. Read the images using OpenCV.
4. The images or the MRI scans which are read has to pass through the Canny, Erode, Dilute filters. The filters will help the CNN model to achieve greater accuracy in predicting the output.
5. A NumPy file is been saved by combining the [image_array, class].
6. The images with the classes are in a symmetrical order. This may impact the efficiency of the model, hence the NumPy file is shuffled to make the confusing order is saved with (.npy) extension, which helps the CNN model to train in a complex way to provide better results.

After the pre-processing phase, the saved images are given to the CNN model for the training process which will undergo as shown in figure 6.

![Figure 6. Training phase of the CNN model.](image)

After certain iterations or epochs, the CNN model will learn, and stores the weights in a file, and using those weights the prediction of the test data is performed. In this paper, python is used as the platform to develop the CNN model for providing the solution for the problems mentioned in the problem statement phase. The model with the weights is stored in a file with the extension (.model) for future usage.

The details of the proposed CNN model are described in the following steps.

1. The Numpy file which is created above is imported and size adjustment is done from multidimensional array to single dimensional array.
2. A Convolutional neural network of 3 layers which is Conv2D is built with 2 pooling layers.
3. After a dropout weights of 25%, the sequential layers are built. The first layer is known as the flatten layer, this layer used to resize the data.
4. The second layer, which is the first hidden layer, is with neural network nodes and rectified linear activation function.
5. The third layer, which is the second hidden layer, is built with 512 neural network nodes and a relu activation function.
6. The fourth layer (third hidden layer) with 256 nodes neural network and a relu as the activation function.
7. The last layer is the layer with the same number of nodes as the classes that are available and the activation function is softmax (normalized exponential function to normalizes k real numbers into a probability distribution consisting of K probabilities).
8. The model is compiled using Adam Optimizer.
9. The loss in the network is calculated with sparse categorical cross-entropy.
The constructed model is trained with 15 epochs and the weights of the trained model are saved which has produced an accuracy of 99.89%. After the training phase, the CNN model is tested with real-time MRI Scan images which have produced good results.

5. Results Discussion
The proposed SNN model has produced an accuracy of over 99.36% with the data of the symptoms. The specification of the proposed SNN model is shown in figure – 7. The accuracy of the model is shown in figure - 8. As we can see that accuracy of the SNN model has started from 20% and raised to almost 100% in 60 iterations or epochs and the loss have reached to almost 0% by the end of the epochs in figure – 8.

![Figure 7. Test accuracy and Specifications of the CNN model.](image)

![Figure 8. SNN Model Accuracy](image)

The proposed CNN model has produced an accuracy of 99.89% over 15 epochs which is helpful to produce better results. The accuracy of the CNN model is represented in figure – 9, which consists of the test accuracy and the specifications of the model. The graph of the accuracy along with the loss percentage is shown in figure - 10, the accuracy of the CNN model has raised from 60% to 99.89% over 15 iterations or epochs whereas the loss percentage has decreased from 65% to almost 0% percent in the same amount of iterations or epochs.
6. Conclusion and Future Work
This paper consists of the details about the model which was used for the classification of brain tumors using data pertaining to its symptoms and also by using the MRI images of the brain from the normal persons and the persons who had a brain tumor. From the above graphs, it is proven that the accuracy of the model has reached good level, if it is deployed in the real-time scenario then it will help many people in diagnosing the brain tumor without wasting the money on checkup. If the brain tumor is confirmed by both the models, then the person can reach the nearest hospital to get the treatment. It can be the best way of practice for people to save money. As we know that the data plays a crucial role in every deep learning model, if the data is more specific and accurate about the symptoms of the brain tumor then that can help in reaching greater accuracy with better results in real-time applications.

In the future, as the research in the usage of computer vision in the medical field will achieve greater heights, the advancements in the medical field may also increase desperately which may help the
individual to get the treatment by the AI system without human intervention. In the same way, any kind of tumor or any disease can be predicted and cured in a better way with very little cost and with less risk in early stages.

7. References

[1]. Mircea Gurbin, Mihaela Lascu, Dan Lascu, “Tumor Detection and Classification of MRI Brain Image using Different Wavelet Transforms and Support Vector Machines”, 2019 42nd International Conference on Telecommunications and Signal Processing (TSP), Budapest, Hungary, 2019, pp. 505-508.

[2]. M. Rezaei, H. Yang, C. Meinel, “Instance Tumor Segmentation using Multitask Convolutional Neural Network”, 2018 International Joint Conference on Neural Networks (IJCNN), Rio de Janeiro, 2018, pp. 1-8.

[3]. Harshini Badisa, Madhavi Polireddy, Aslam Mohammed, “CNN Based Brain Tumor Detection”, International Journal of Engineering and Advanced Technology (IJEAT), Volume-8 Issue-4, April 2019, pp. 1731 – 1734.

[4]. MB Bramarambika, Seshashayee, “Brain Tumor Detection and Identification Using Histogram Method”, International Journal of Innovative Technology and Exploring Engineering (IJITEE), Volume-8 Issue-10, August 2019, pp. 3517 – 3521.

[5]. Tonmoy Hossain, Fairuz Shadmani Shishir, Mohsena Ashraf, MD Abdullah Al Nasim, Faisal Muhammad Shah, “Brain Tumor Detection Using Convolutional Neural Network”, 1st International Conference on Advances in Science, Engineering and Robotics Technology 2019 (ICASERT 2019), Dhaka, Bangladesh, 2019, pp. 1-6.

[6]. N. Varuna Shree, T.N.R. Kumar, “Identification and classification of brain tumor MRI images with feature extraction using DWT and probabilistic neural network”, Brain Inf. 5, pp. 23–30 (2018), https://doi.org/10.1007/s40708-017-0075-5

[7]. M Malathi, P Sinthia, “Brain Tumour Segmentation Using Convolutional Neural Network with Tensor Flow”, Asian Pacific journal of cancer prevention, APJCP (2019), DOI: 10.31557/APJCP.2019.20.7.2095

[8]. J. Seetha, S. Selvakumar Raja, “Brain Tumor Classification Using Convolutional Neural Networks”, Biomedical & Pharmacology Journal, September 2018, Vol. 11(3), p. 1457-1461.

[9]. M. Usman Akram, Anam Usma, “Computer Aided System for Brain Tumor Detection and Segmentation”, International Conference on Computer Networks and Information Technology, Abbottabad, 2011, pp. 299-302.

[10]. Varun Totakura, Mohana Krishna Janmanchi, Durganath Rajesh, M.I. Thariq Hussan, “Prediction of Animal Vocal Emotions Using Convolutional Neural Network”, International Journal of Scientific & Technology Research, 2020, Volume 9, Issue 2, pp. 6007-6011.

[11]. P. Nirupama, E. Madhusudhana Reddy, "Development of Novel Classifying System to Identify the Right Sense of Image Sharing in Social Networks Using Deep Convolution Neural Network", Indian Journal of Public Health Research & Development, July 2019, Vol.10, No. 7, PP:1244-1247, DOI Number: 10.5958/0976-5506.2019.01757.1

[12]. E. Madhusudhana Reddy, Naidu Srinivas Kiran Babu, “SYSTEM AND METHOD FOR MONITORING AND IMPROVING STRUCTURE OF CALCANEAL SHIFT IMPACTED FOOT”, Indian Patent, Application No.201941009083 A, March, 22, 2019.