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Brain Tumor Detection Using Convolutional Neural Network

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Abstract : **Brain Tumor segmentation is one of the most crucial and arduous tasks in the terrain of medical image processing as a human-assisted manual classification can result in inaccurate prediction and diagnosis. Moreover, it is an aggravating task when there is a large amount of data present to be assisted. Brain tumors have high diversity in appearance and there is a similarity between tumor and normal tissues and thus the extraction of tumor regions from images becomes unyielding. In this paper, we proposed a method to extract brain tumor from 2D Magnetic Resonance brain Images (MRI) by convolutional neural network. The experimental study was carried on a real-time dataset with diverse tumor sizes, locations, shapes, and different image intensities. We applied Convolutional Neural Network (CNN), CNN gained an accuracy of 95.45%, which is very compelling.**

IndexTerms **- Image processing, brain tumor, convolutional neural network**

I. Introduction

The brain is one of the Organs most important organs in the human body and it is responsible for Our ability to Think, Voluntary Movement, Language, Judgment, and Perception. Responsible for the functions of Movement, Balance, and Posture. Without it, we would act like a 'walking puppets'.

The word cerebellum comes from the Latin for "small brain". A brain tumor is characterized by the growth of a tumor in the brain, distinguishing it as benign (non-cancerous) or malignant (cancerous). A brain tumor is a collection, or mass, of abnormal cells in your brain. Your skull, which encloses your brain, is very rigid. Any growth inside such a restricted space can cause problems. Brain tumors can be cancerous (malignant) or noncancerous (benign). When benign or malignant tumors grow, they can cause the pressure inside your skull to increase. This can cause brain damage, and it can be life-threatening. Brain tumors are categorized as primary or secondary. A primary brain tumor originates in your brain. Many primary brain tumors are benign. A secondary brain tumor, also known as a metastatic brain tumor, occurs when cancer cells spread to your brain from another organ, such as your lung or breast. A brain tumour is a mass or growth of abnormal cells in your brain. Many different types of brain tumours exist. Some

Brain tumours are noncancerous (benign), and some brain tumours are cancerous (malignant). Brain tumours can begin in your brain (primary brain tumours), or cancer can begin in other parts of your body and spread to your brain as secondary (metastatic) brain tumours. How quickly a brain tumour grows can vary greatly. The growth rate as well as the location of a brain tumour determines how it will affect the function of your nervous system. Brain tumour treatment options depend on the type of brain tumour you have, as well as its size and location.

1. Symptoms

The signs and symptoms of a brain tumour vary greatly and depend on the brain tumour’s size, location and rate of growth. General signs and symptoms caused by brain tumours may include:

- New onset or change in pattern of headaches
- Headaches that gradually become more frequent and more severe
- Unexplained nausea or vomiting
- Vision problems, such as blurred vision, double vision or loss of peripheral vision
- Gradual loss of sensation or movement in an arm or a leg
- Difficulty with balance
- Speech difficulties
- Feeling very tired
- Confusion in everyday matters
- Difficulty making decisions

- Inability to follow simple commands
- Personality or behaviour changes
- Seizures, especially in someone who doesn't have a history of seizures
- Hearing problems

2. CAUSES

Brain tumours that begin in the brain Acoustic neuroma acoustic neuroma (Schwannoma) Open pop-up dialog box Child with a medulloblastoma brain tumour Medulloblastoma Open pop-up dialog box Primary brain tumours originate in the brain itself or in tissues close to it, such as in the brain-covering membranes (meninges), cranial nerves, pituitary gland or pineal gland. Primary brain tumours begin when normal cells develop changes (mutations) in their DNA. A cell's DNA contains the instructions that tell a cell what to do. The mutations tell the cells to grow and divide rapidly and to continue living when healthy cells would die. The result is a mass of abnormal cells, which forms a tumour.

In adults, primary brain tumours are much less common than are secondary brain tumours, in which cancer begins elsewhere and spreads to the brain. Many different types of primary brain tumours exist. Each gets its name from the type of cells involved. Examples include:

- Gliomas. These tumours begin in the brain or spinal cord and include astrocytomas, ependymomas, glioblastomas and oligodendroglias.
- Meningiomas. A meningioma is a tumour that arises from the membranes that surround your brain and spinal cord (meninges). Most meningiomas are noncancerous.
- Acoustic neuromas (schwannomas). These are benign tumours that develop on the nerves that control balance and hearing leading from your inner ear to your brain.
- Pituitary adenomas. These are tumours that develop in the pituitary gland at the base of the brain. These tumours can affect the pituitary hormones with effects throughout the body.
- Medulloblastomas. These cancerous brain tumors are most common in children, though they can occur at any age. A medulloblastoma starts in the lower back part of the brain and tends to spread through the spinal fluid.
- Germ cell tumours. Germ cell tumours may develop during childhood where the testicles or ovaries will form. But sometimes germ cell tumours affect other parts of the body, such as the brain.
- Craniopharyngiomas. These rare tumours start near the brain's pituitary gland, which secretes hormones that control many body functions. As the craniopharyngioma slowly grows, it can affect the pituitary gland and other structures near the brain.

Cancer that begins elsewhere and spreads to the brain Secondary (metastatic) brain tumours are tumours that result from cancer that starts elsewhere in your body and then spreads (metastasizes) to your brain. Secondary brain tumours most often occur in people who have a history of cancer. Rarely, a metastatic brain tumour may be the first sign of cancer that began elsewhere in your body. In adults, secondary brain tumours are far more common than are primary brain tumours. Any cancer can spread to the brain, but common types include:

- Breast cancer
- Colon cancer
- Kidney cancer
- Lung cancer
- Melanoma
- Risk factors

In most people with primary brain tumours, the cause of the tumour isn't clear. But doctors have identified some factors that may increase your risk of a brain tumour. Risk factors include: Exposure to radiation. People who have been exposed to a type of radiation called ionizing radiation have an increased risk of brain tumour. Examples of ionizing radiation include radiation therapy used to treat cancer and radiation exposure caused by atomic bombs.

Family history of brain tumours. A small portion of brain tumours occurs in people with a family history of brain tumours or a family history of genetic syndromes that increase the risk of brain tumours. A brain tumor occurs when abnormal cells from within the brain. There are two main types of tumors: malignant tumors and benign (non-cancerous) tumors.

These can be further classified as primary tumors, which start within the brain, and secondary tumors, which most commonly have spread from tumors located outside the brain, known as brain metastasis tumors. All types of brain tumors may produce symptoms that vary depending on the size of the tumor and the part of the brain that is involved. Where symptoms exist, they may include headaches, seizures, problems with vision, vomiting and mental changes. Other symptoms may include difficulty walking, speaking, with sensations, or unconsciousness. The cause of most brain tumors is unknown.

Uncommon risk factors include exposure to vinyl chloride, Epstein–Barr virus, ionizing radiation, and inherited syndromes such as neurofibromatosis, tuberous sclerosis, and von Hippel-Lindau Disease. Studies on mobile phone exposure have not shown a clear risk. The most common types of primary tumors in adults are meningioma’s (usually benign) and astrocytoma’s such as glioblastomas. In children, the most common type is a malignant medulloblastoma. Diagnosis is usually by medical examination along with computed tomography (CT) or magnetic resonance imaging (MRI). The result is then often confirmed by a biopsy.

Based on the findings, the tumors are divided into different grades of severity. Treatment may include some combination of surgery, radiation therapy and chemotherapy. Since the brain is the body's only non-fungible organ, surgery carries a risk of the tumor returning. If seizures occur, anticonvulsant medication may be needed. Dexamethasone and furosemide are medications that may be used to decrease swelling around the tumor. Some tumors grow gradually, requiring only monitoring and possibly needing no further intervention. Treatments that use a person's immune system are being studied. Outcomes for malignant tumors vary considerably depending on the type of tumor and how far it has spread at diagnosis.

Although benign tumors only grow in one area, they may still be life-threatening depending on their size and location. Malignant glioblastomas usually have very poor outcomes; while benign meningioma's usually have good outcomes. The average five-year survival rate for all (malignant) brain cancers in the United States is 33%.Secondary, or metastatic, brain tumors are about four times as common as primary brain tumors, with about half of metastases coming from lung cancer. Primary brain tumors occur in around 250,000 people a year globally, and make up less than 2% of cancers. In children younger than 15, brain tumors are second only to acute lymphoblastic leukemia as the most common form of cancer. In NSW Australia in 2005, the average lifetime economic cost of a case of brain cancer was AU$1.9 million, the greatest of any type of cancer.

II. WHAT IS A BRAIN TUMOR?

First, it's helpful to understand the main functions of your brain. Your brain and spine make up the central nervous system — the body's command center. It sends out and receives a constant stream of messages through other branches of the nervous system to regulate your breathing, heart rate, and other vital functions; to enable you to see, hear, feel, walk, and talk; to make it possible for you to acquire, organize, and remember new knowledge; to feel anger and fear and love, and to dream and imagine.

The brain has three main parts:

The cerebrum is the largest part of the brain. It controls thinking, learning, problem-solving, emotions, speech and voluntary movement. The cerebellum controls movement, balance and posture. The brain stem connects the brain to the spinal cord. It controls breathing, heart rate, nerves and muscles, and enables you to see, hear, walk, talk and eat. A brain tumor occurs when abnormal cells begin to grow in your brain. There are two main types of brain tumors: malignant (cancer) and benign (not cancer).

What's the difference between malignant and benign brain tumors? A malignant brain tumor contains cancer cells, grows rapidly, invades healthy brain tissue nearby, and may be life-threatening. There are two main types of malignant brain tumors: primary and secondary

Primary tumors begin in the brain. A secondary brain tumor, also called a metastatic tumor, begins in another part of the body (for example, the breast or lung) and spreads to the brain. Primary and metastatic brain tumors are usually treated differently. Many malignant tumors can be treated successfully, and improvements in therapy are enabling patients to live longer while preserving their quality of life.

A benign brain tumor does not contain cancer cells, rarely invades nearby tissue or spreads to other parts of the body, and usually does not grow back after it is removed. However, even a benign brain tumor can press on sensitive areas of the brain and cause life-threatening health problems. Some benign tumors can become malignant in time.

III. PROPOSED METHED

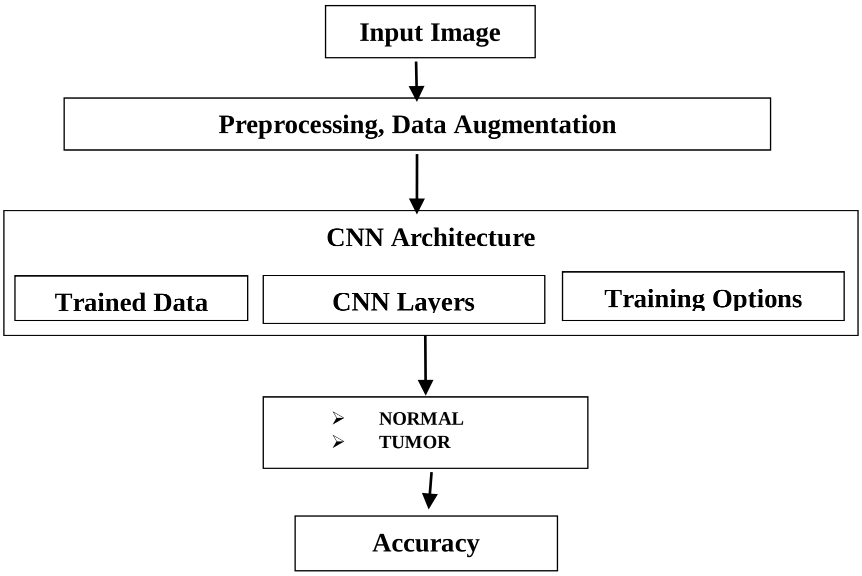

Fig1: Block diagram for proposed method

1. CNN

A convolutional neural network (CNN or convent) is a subset of machine learning. It is one of the various types of artificial neural networks which are used for different applications and data types. A CNN is a kind of network architecture for deep learning algorithms and is specifically used for image recognition and tasks that involve the processing of pixel data. There are other types of neural networks in deep learning, but for identifying and recognizing objects, CNNs are the network architecture of choice. This makes them highly suitable for computer vision (CV) tasks and for applications where object recognition is vital, such as self-driving cars and facial recognition. CNNs are used for image classification and recognition because of its high accuracy. The CNN follows a hierarchical model which works on building a network, like a funnel, and finally gives out a fully- connected layer where all the neurons are connected to each other and the output is processed.

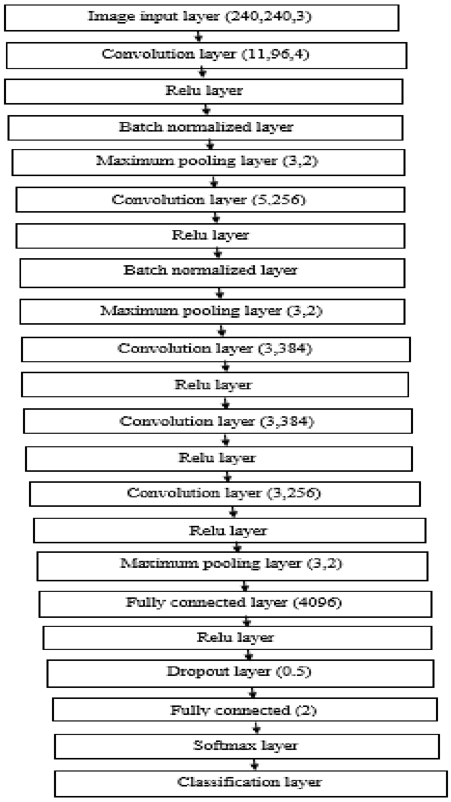

Fig2: layer architecture of proposed method

2. DEEP LEARNING

Deep learning (also known as deep structured learning) is part of a broader family of machine learning methods based on artificial neural networks with representation learning. Learning can be supervised, semi-supervised or unsupervised. Deep-learning architectures such as deep neural networks, deep belief networks, deep reinforcement learning, recurrent neural networks and convolutional neural networks have been applied to fields including computer vision, speech recognition, natural language processing, machine translation, bioinformatics, drug design, medical image analysis, climate science, material inspection and board game programs, where they have produced results comparable to and in some cases surpassing human expert performance.

3. CONVOLUTION 2D-LAYER

The convolutional 2D layer is by far the most essential element of a CNN and it is where the majority of the computation actually occurs. It requires data input, a kernel filter, as well as a feature map, among many other things. A feature detector, often referred as a kernel or a filter, analyzes the picture's receptive fields for something like the existence of the feature. Convolution is indeed the label for this technique. The feature detector is indeed a two-dimensional (2-D) weighed array that signifies a portion of the picture. The kernel size, that can vary enormously, is typically a 3x3 matrix, which determines the dimensions of the receptive field too though. After trying to apply the filter to a section of the image, the dot product of the input image and the filter is calculated. The dot product would then be written to the output vector.

By altering the filter by something like a stride, the kernel would then be wiped throughout the entire image, and the process repeats until the kernel has drifted throughout the image plane. A region of interest, activation function map, or convolved feature is the end product of a series of dot products from source and the filters. Parameter sharing ensures that the feature detector's weights remain constant as it traverses across the picture. Back propagation and stochastic gradient are used to change some characteristics during training, such as weighting factor.

However, three hyper parameters that determine the higher size must always be presented yet when the neural network can indeed be trained.

Here are few examples:

1. The intensity of the result is associated with the quantity of filters employed. For instance, three distinct maps would come from three various filters, yielding a depth of 3.

2. The kernel's stride is perhaps the number of pixels it traverses with in input matrix. Despite the reality that two or more stride values are uncommon, a longer stride means less output.
3. Whenever the filters don't accommodate the image as input, zero-padding is regularly utilized. All elements are set to zero outside of the input matrix, resulting in a greater or equal result.

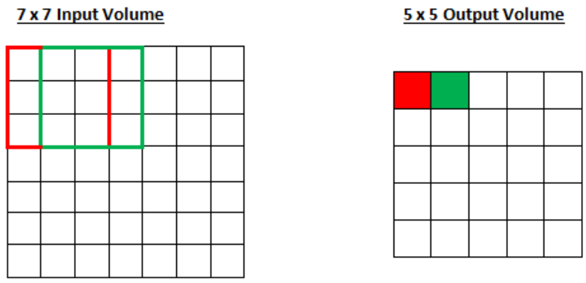

Fig3: Stride

4. RECTIFIED LINEAR UNIT LAYER (ReLU)

To train deep neural networks employing stochastic gradient with back propagation of defects, an activation function which resembles and functions just like a linear function is however truly a nonlinear function is essential. In order to prevent overloading, the goal needs to be more responsive to the activated aggregate input. A rectified linear activation unit (or ReLU for short) has been used to construct this activation function. Neural networks having hidden convolution layers that use the rectifier function are commonly known to as rectified networks.

Both the rectification layer and the non-linearity function will be combined in the Rectified Linear Unit Layer. These combinations will operate in between convolutional neural network layers as a rectified linear unit layer. In a nutshell, the ReLU layer is a rectified linear unit

$$Y_i^{(l)} = \max\left(0, Y_i^{(l-1)}\right) \qquad \dots (1)$$

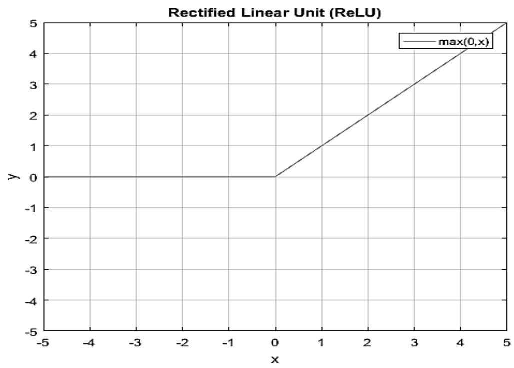

Fig4: ReLU curve

5. BATCH NORMALIZATION LAYER

A batch normalization layer normalizes a mini-batch of data across all observations for each channel independently. To speed up training of the convolutional neural network and reduce the sensitivity to network initialization, use batch normalization layers between convolutional layers and nonlinearities, such as ReLU layers.

6. MAXIMUM POOLING LAYER

Down-sampling, also referred as max pooling, is a form of dimensionality reduction which limits the number of input elements to the bare minimum. The pooling technique, like the convolutional 2d layer, runs a filter throughout the entire input image, but this filter has no weights. Rather, the kernel uses a summation function to populate the result array with the values of the receptive field. Since feature detection is much more crucial to the accurate location of such feature, particularly in picture identification projects, the pooling layer's main purpose should be to provide feature lessening. Max pooling produces greater results as compared to average pooling. As a result, we will conduct our investigation using the maximum pooling layer.

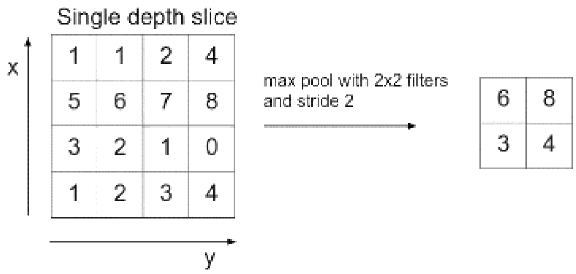

Fig5: Maximum Pooling

7. FC Layer

The full-connected layer gets its name from the fact that it is completely connected. In partly linked layers, as previously mentioned, the pixel values of such test pictures are not specifically correlated to the output hidden layers. Every output node creates a connection to such a node as in preceding layer mostly in fully-connected structure. Utilizing the information and filters gathered by the earlier layers, the present layer performs the multi class classification tasks. Although convolution layers categories inputs using ReLU activation functions, FC layers utilize a softmax activation function that serve a probability in between 0 and 1.

Stochastic gradient descent is used to train the network. The cross-entropy that penalises at each place is defined as:

$$En = \sum_{x \epsilon \Omega} \omega\,(x) \log\,(p_{l(x)}(x)) \quad \dots (2)$$

The separation border is calculated using morphological processes. The weight map is then calculated as follows:

$$\omega(i) = \omega_c(i) + \omega_0 \ \exp\left(\frac{-((d_1(i) + d_2(i))^2}{2\sigma^2}\right) \dots (3)$$

The weight map is $\omega_c(i)$ and the distance to the border/boundary is d 1 and d 2.

Convolutional Neural Networks come under the subdomain of Machine Learning which is Deep Learning. Algorithms under Deep Learning process information the same way the human brain does, but obviously on a very small scale, since our brain is too complex (our brain has around 86 billion neurons)

8. SOFTMAX-LAYER

A multidimensional generalization of the logistic function is the softmax functionality. It really is generally implemented as the final activation functionality of a network in multiple regression analysis to standardize the network's result to a probability distribution function over possible output class. The soft-max function normalizes the vector x of J real numbers into a probability distribution with J probabilities proportional to input number exponentials. In this example, some vector components may be below zero or greater than one, and that they might not stack up to the value one; nonetheless, but upon performing softmax, every other component will be in the range (0,1), and also the components will total to 1, letting them to also be interpreted as chances. Furthermore, the higher the input component, the higher the probability.

I. OUTPUT LAYERS

Softmax and Classification Layers

1. A softmax layer applies a softmax function to the input. Create a softmax layer using softmaxLayer.
2. A classification layer computes the cross-entropy loss for classification and weighted classification tasks with mutually exclusive classes. Create a classification layer using classification Layer

IV. RESULTS AND DISCUSSION

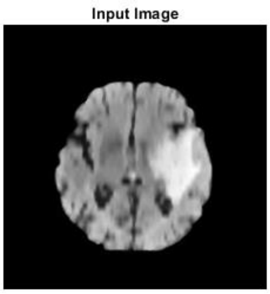

Fig1: Input Image

The model is evaluated by applying the test image dataset. The confusion matrix for the predicted output is given as in the following Figure 2. The output of making predictions for the testing and validation given below

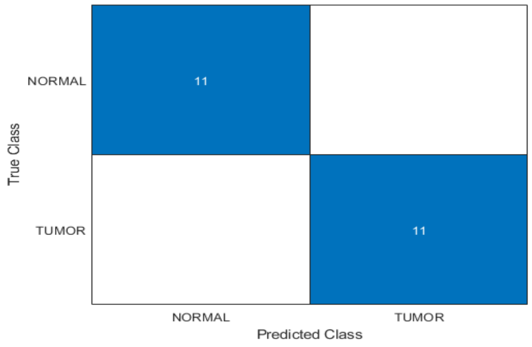

Fig 2: Confusion Matrix

In the table above, we have the comparison of the predicted value by the model with the real value of an observation. As the names suggest:

True Positives (TP) are observations whose actual value is positive and the predicted value is positive, i.e., the model got it right. In this work 11 images were evaluated.

True Negatives (TN) are observations whose actual value is negative and the predicted value is negative, that is, the model got it right. In this work 11 images were evaluated.

False Positives (FP) are cases in which the correct result is negative, however, the result obtained is positive, that is, the model was wrong. In this work 0 images were evaluated.

False Negatives (FN) are cases in which the correct result is positive but the result obtained is negative, that is, the model was wrong. In this work 0 images were evaluated

Table 1: Classification Output and Accuracy

Command Window

Initializing input data normalization.

Epoch	Iteration	Time Elapsed (hh:mm:ss)	Mini-batch Accuracy	Validation Accuracy	Mini-batch Loss	Validation Loss	Base Learning Rate
1	1	00:00:08	40.91%	50.00%	1.4480	1.6094	0.0010
45	45	00:01:49	100.00%	100.00%	1.6418e-06	3.0548e-06	0.0010

Output of CNN Classifier is: TUMOR

Accuracy of CNN Classifier is: 95.454545

Fig 3: Training the dataset

Table2: Comparison Table

S.N0	Existing Method	Proposed Method
Image1	50	95.45
Image2	50	95.45
Image3	50	95.45
Image4	50	95.45
Image5	50	95.45

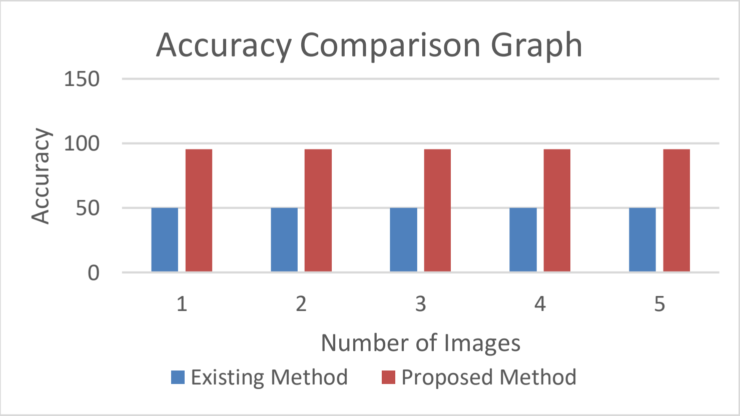

Fig6: Comparison Graph

IV. ACKNOWLEDGMENT

The main goal of this research work is to design efficient automatic brain tumor classification with high accuracy, performance and low complexity. In the conventional brain tumor classification is performed texture and shape feature extraction and SVM and Mobile Net V2 based classification are carried out. The complexity is low. But the computation time is high meanwhile accuracy is low. Further to improve the accuracy and to reduce the computation time, a convolution neural network based classification is introduced in the proposed scheme. Also the classification results are given as tumor or normal brain images. CNN is one of the deep learning methods, which contains sequence of feed forward layers.

REFERENCES

[1] Raheleh Hashemzehi Seyyed Javad Seyyed Mahdavi Maryam Kheirabadi Seyed Reza Kamel 2020 Detection of brain tumors from MRI images base on deep learning using hybrid model CNN and NADE Biocybernetics and Biomedical Engineering of the Polish Academy of Sciences Elsevier B.V. on behalf of Nalecz Institute of Online Publication.
[2] Javeria Amin Muhammad Sharif Mudassar Raza Mussarat Yasmin 2018 Detection of Brain Tumor based on Features Fusion and Machine Learning Journal of Ambient Intelligence and Humanized Computing Online Publication.
[3] Rajeshwar Nalbalwar Umakant Majhi Raj Patil Prof.Sudhanshu Gonge 2014 Detection of Brain Tumor by using ANN International Journal of Research in Advent Technology 2.
[4] Fatih Özyurt Eser Sert Engin Avci Esin Dogantekin 2019 Brain tumor detection based on Convolutional Neural Network with neutrosophic expert maximum fuzzy sure entropy Elsevier Ltd 147.
[5] S. Murugavalli, V. Rajamani, "A high speed parallel fuzzy c-mean algorithm for brain tumour segmentation"," BIME Journal", Vol. no: 06, Issue (1), Dec., 2006
[6] Sandler, Mark et al. "MobileNetV2: Inverted Residuals and Linear Bottlenecks." 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition (2018): 4510-4520.