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Can we rely on AI or Deep Learning to read or detect brain tumors using MRI scan and images?

Rayna Jindal[1]

[1]California High School

ABSTRACT

The brain is one of the complex and most significant organs in the human body. It controls every process that regulates our body and affects how we think, feel, act and is indispensable to living a happy and balanced life. Due to the current lifestyle, depression, stress, and anxiety have risen to an extreme, especially during COVID. Researchers have found that people with mental disorders are more prone to brain tumors and develop cancers early than people without mental illness. Therefore, it is worthwhile to invest time and research to improve our ability to diagnose brain tumors in early stage. This research aims to use the Deep Learning model to detect brain tumors. The dataset used for this research project is the Brain MRI segmentation dataset (LGG lower-grade gliomas) taken from The Cancer Imaging Archive (TCIA). This dataset is open source and available on Kaggle. Using the Keras library, I used the Convolutional Neural Network (CNN) for tumor detection to get concrete results. I got approximately a 90% accuracy which shows us it is very promising that Deep Learning can help with brain tumor predictions, thereby making the diagnosis easy, correct, and prompt, which allows early diagnosis and reduces the mortality rate.

Introduction

A brain tumor is an unwanted growth of abnormal cells inside the brain. Some brain tumors are noncancerous (benign), while others are cancerous (malignant). The investigators found that rates of noncancerous tumors are slowly increasing. Brain tumors can grow in your brain (primary brain tumors), or cancer can begin in other parts of your body and then spread to your brain as secondary (metastatic) brain tumors. This global pandemic due to COVID-19 has raised depression, stress, and anxiety to an extreme. 32.8% of adults had elevated depressive symptoms in 2021, compared to 27.8% in the early 2020 and 8.5% before the pandemic in the U.S. Stress, depression have signals that cause a cell to develop into a tumor or cancer. Some of the prevalent brain tumor symptoms are:

- new or increasingly intense headaches
- blurred vision
- loss of balance
- confusion
- seizures
- hearing problems

But sometimes, there are no symptoms. Early diagnosis of brain tumors is vital in cancer diagnosis, treatment planning, and evaluation of treatment outcomes. Currently, brain tumor detection still relies on a histopathological diagnosis. The final diagnosis usually depends on clinical examination and interpretation of imaging modalities such as magnetic resonance imaging (MRI) followed by pathological studies. "Magnetic Resonance Imaging (MRI) is a non-invasive imaging technology that produces three-dimensional detailed anatomical images based on sophisticated technology. That excites and detects the change in the rotational axis of protons found in the water that makes up living tissues" (National Institute of Biomedical Imaging and Bioengineering). MRI creates a strong magnetic field that forces protons in the body to align with it using powerful magnets. When a radiofrequency current is passed through the patient body, the protons are triggered and spin out of balance, straining against the magnetic field's pull. Once the radiofrequency field is turned off, the MRI sensors can detect the energy created as the protons realign with the magnetic field. The amount of energy is released, and the time for the protons to realign with the magnetic field varies. These variations are dependent on the chemical makeup of the molecule inside your brain and the environment. Medical images are currently analyzed manually by radiologists. Physicians can distinguish between different types of tissues based on their magnetic characteristics. But the most significant disadvantages of this diagnostic method are that they are time-consuming, and accuracy depends on human experience, and they are prone to errors. It takes years and substantial financial costs to train a radiologist, and incorrect diagnosis can be harmful to the patient.

Consequently, the Machine Learning (ML) model technique can be used to diagnose a brain tumor from MRI scans and images, thereby making the diagnosis easy, correct, and prompt, which helps early diagnosis and reduce the mortality rate. Machine learning is the field of computer science that uses data to create computational models to analyze, make predictions, or as a tool to help decision making. Machine learning algorithms have the scope to be used in all fields of medicine, from drug discovery to clinical decision-making, significantly altering the way medicine is practiced today. This research aims to build an efficient machine learning model using CNN (Convolution Neural Network) to identify a tumor based on the MRI scan images within the acceptable accuracy for medical-grade application.

Material and_Methods

Dataset Description

The dataset used for this research project is the Brain MRI segmentation dataset (LGG lower-grade gliomas) taken from The Cancer Imaging Archive (TCIA). This dataset is open source and available on Kaggle. We will use this data to create a model which tries to predict if a patient has a brain tumor or not.

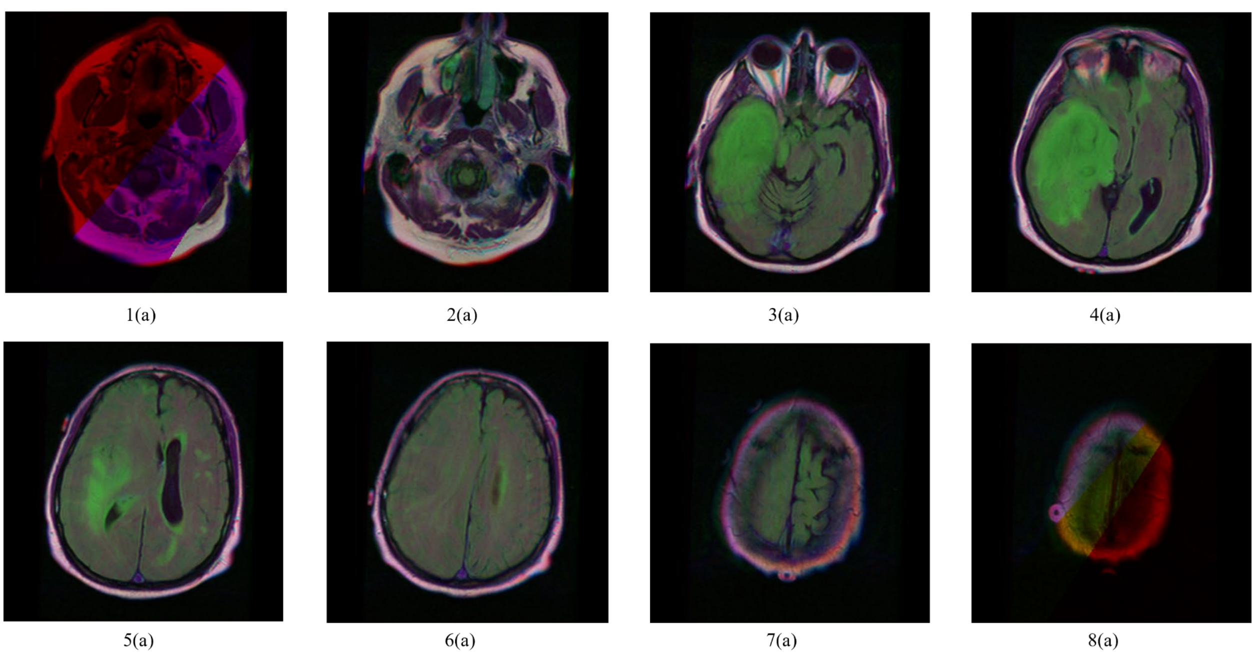

Fig 1. Sample Images from the dataset with and without tumor

Procedure

First, let's go back to our question, "Can we rely on AI or Deep Learning to read and detect brain tumors using MRI scans and images?" I am sharing two sample MRI images, one with a tumor and one without a tumor.

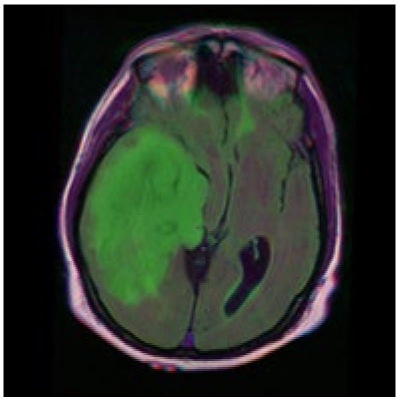

Fig 2: Image with Tumor

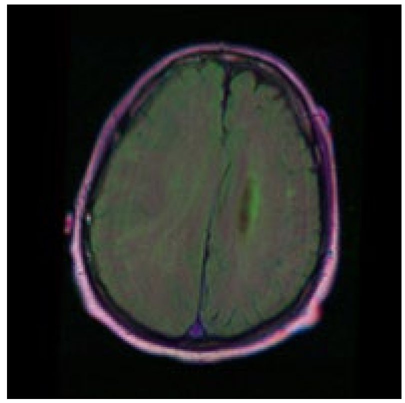

Fig 3: Image without Tumor

You can see that there is a clear distinction between the two images. Now can we use AI or Deep Learning to classify the images as a tumor or not? The answer is Yes. Thanks to technology nowadays using intelligent data retrieval and classification techniques, it is possible to explore diseases and even predict abnormal health problems. Currently, CNNs are the most reliable machine learning algorithms in medical image analysis as CNN preserves spatial relationships when filtering input images. The spatial relationship is a property of data that defines how the data points in a data unit are related to each other. Hence, if you modify them independently, it will corrupt the whole data unit. Therefore, spatial relationships are crucial in radiology, such as how the standard tissue interfaces with cancerous tissue or how the edge of a bone joins with muscle. There are many frameworks in python to apply CNN. But we will be using the Keras library with TensorFlow backend to train this model.

Step 1: Data Visualization

As mentioned earlier, We are using a Brain MRI segmentation dataset from Kaggle. This dataset consists of 110 individuals' data. There are 3929 images in the dataset, out of which approx. 1373 have tumors (yes), and 2556 are negative (no).

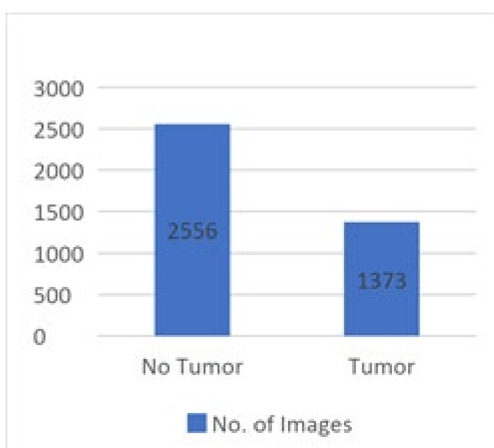

Fig 4: Bar graph of the number of negative and positive tumors in the dataset.

ML models are like a human brain. We train our brains to do the stuff the same way in ML; we train our models using algorithms. Therefore, our next step is to prepare the neural network with a set of images (yes or no) labels to understand the difference between the two classes. Once our model is trained, we will input the unlabeled image, and our trained model will be able to classify the image. But before that, let's spend some time understanding our data. We have 1373 images with tumor (yes) and 2556 with no tumor (no). Using these images, we are training our model with more "no" options than "yes." This discrepancy is called **Data imbalance** in ML.

Step 2: Data Augmentation

This technique is used to solve the data imbalance problem. It is a common problem in the medical field where we will get fewer unhealthy patients than healthy patients. To overcome this issue, we will take a particular MRI image. We will perform **image enhancements** by rotating, mirroring, and flipping the MRI scans to get more shots. In the end, we will try to get an approximately equal number for both "yes" and "no" images.

Step 3: Splitting the Data

Split the dataset into two sets:

- Training Set – Used by CNN model to get trained
- Validation Set – Used to test the accuracy of our trained CNN model

Step 4: Building the CNN Model

I will design the neural network using *the Keras* library with various convolutional and pooling layers. CNN takes an input image of raw pixels and transforms it using Convolutional Layers, Rectified Linear Unit (RELU) Layers, and Pooling Layers to the final Fully Connected layer to assign class scores or probabilities. Based on that, it classifies the input into a class with the highest probability.

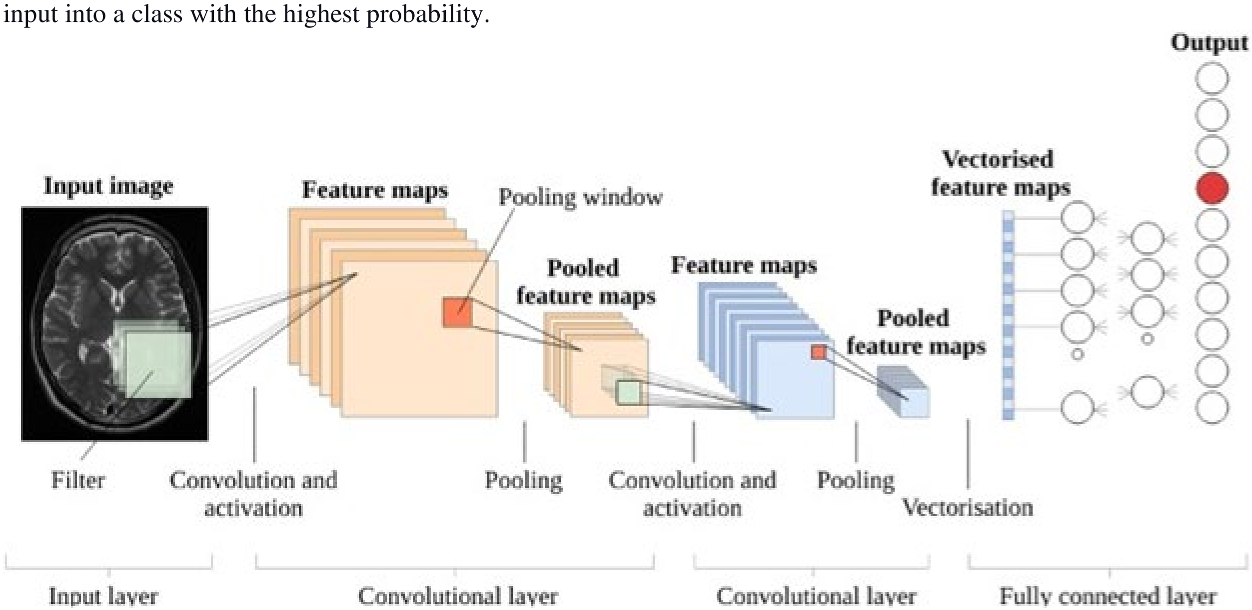

Fig 5: CNN model

Step 5: Hypothesis

If we have good data and a good understanding of Machine Learning algorithms, then I believe we can certainly alter the way medicine is practiced today. Machine Learning model technique can be used to diagnose a brain tumor from MRI scans and images, thereby making the diagnosis easy, correct, and prompt, which helps early diagnosis and reduce the mortality rate.

Step 6: Training the CNN model

We are planning to train the model for around 50-100 “epochs”. Epochs are defined as the number of passes of the entire training dataset the machine learning algorithm has completed. This technique helps to train the model better for more accuracy.

Step 7: Analysis of the CNN model

After the training step, we will finally plot the “accuracy” and “loss” for all the 50-100 iterations (epochs) to calculate the accuracy of our CNN model.

Risk Associated with ML Models

The major problem with Machine Learning is the lack of good data. While enhancing algorithms often consumes most of the time of developers in AI, good quality data is essential for the algorithms to function as intended. Machine Learning requires a considerable amount of data to perform better than other techniques; otherwise, your analysis can be highly error prone. You may hear that "Garbage in Garbage out" correctly fits when it comes to machine learning. Data may be limited to one region, race, country, population, etc. Therefore, you face a situation where you find an imbalance in data that leads to poor accuracy of models. Secondly, a machine learning problem can implement various algorithms to find a solution. It is a manual and tedious task to run models with different algorithms and identify the most accurate results.

Conclusion

The goal of this research was to predict if the person has a brain tumor or not using Deep Learning. In this research, to get concrete results, I used the Convolutional Neural Network for detecting tumors. From the below graph, the CNN has the appx (90%) accuracy. This dataset gives promising results and confidence that machine learning can help reduce the mortality rate by diagnosing brain tumors early and accurately. We can further extend this research by adding other features like country, city, family history of illness. We can use the same machine learning models to analyze physical health problems like heart disease, depression, diabetes, history of trauma, etc. It will result in geographical data on top of demographic data and can apply for geospatial analysis.

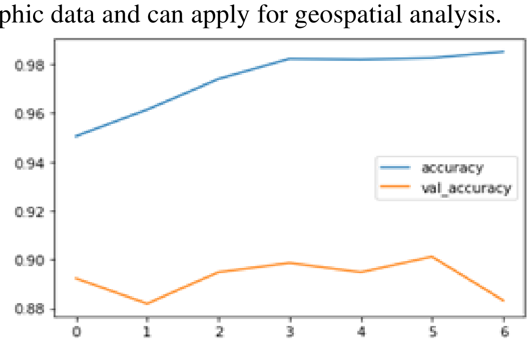

Fig 6: Accuracy plot

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