Image Processing using Deep Learning and Brain Tumor Detection

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***Abstract*—Medical image processing,medical imaging, web mining , image mining etc. are some of the most important applications of image processing. Medical study with the help of Content Based Medical Image Retrieval(CBMIR) systems where the query image is compared with images in the database to find similar image. Deep learning is a part of machine learning algorithms which are inspired from human brains and can be used in the field of image segmentation. This article provides an overview of the potential applications of deep learning in the realm of medicine.**

***Index Terms*—image processing, machine learning, deep learning , activation function, convolutional neural network**

I. INTRODUCTION

A part of machine learning is called deep learning. It makes the machine "learn" from a large amount of data and take decisions to replicate the functioning of brain. Optimized accuracy of the model can be achieved by adding multiple layers to the neural network. Technologies which require automation and undertaking analytical and physical tasks require the help of deep learning. Thus, Deep learning can particularly be used in the area of analyzing medical images to improve the accuracy and delay. Image enhancement and image analyzing are two major objectives of image processing. Image enhancement involves adjusting images in such a way that the images become better and give accurate results while analysis. There are various techniques to enhance images which include filtering,noise removal, linear contrast adjustment, histogram equalization etc. Implementation of these techniques result in a better understanding of the images. Analyzing medical images is becoming of greater importance day by day as the number of medical emergencies are increasing and the study of images is must for understanding the diseases better. Many medical image segmentation techniques such as edge based segmentation, region based segmentation, model based segmentation, atlas based segmentation are used to achieve our goal of analyzing medical images accurately[1].

II. LITERATURE SURVEY

Rao et al.[1] mentioned a summary of the numerous applications of deep learning that can be used in mining of image and medical imaging. This paper contains the model training process followed in convolutional neural network The benefit of deep learning algorithms is particularly relevant to the processing of medical images, therefore a number of potential applications for deep learning algorithms are emphasized.

Razzak et al.[2] analyzed the most recent deep learning architecture and how it was optimized for segmenting and categorizing medical images along with the issues with open research and the difficulties with deep learning-based methods for medical imaging.

Xj A et al.[3] discussed one of the advance methods of image processing using DL called pruning where unnecessary or unwanted information in form of convolution cores is discarded thus reducing redundant computations.

Gampala et al.[4] mentioned about the mobile photography can't be so picture perfect and the image captured can be blurry having low resolution. Sharp information is lost due to the movement blur, resulting in poor picture quality. Thus, he discussed how blurry image can be made image next to real ones using various advance deep learning algorithms namely particle swarm optimization.

Venkata Sai et al.[5] with the objective of extracting in-depth information from images along with searching of query by user taking image as input presented the paper. He used google's reverse image search algorithm for retrieval of content from that image. The major application of this model include detecting person's identity just by face and also generating high precise caption from image.

III. MACHINE LEARNING

In order for computers to determine how jobs can be completed without particular programming, machine learning techniques are required. Computers must learn from the knowledge in order to carry out such functions. Algorithms can be built such that when a required computer task is completed, the system is instructed to take particular actions to address the issue.In actual use, it benefits the computer to build its own algorithm rather than explain any necessary steps. In the field of machine learning, tasks for which an algorithm is not totally suitable are explained to computers.

IV. Deep Learning

A part of machine learning is called deep learning. Deep learning is a type of machine learning that teaches computers to learn by imitating human behavior. It allows the machine to work like human brain and react to inputs given. Deep learning is rapidly becoming popular nowadays because the growth in data. This is the general principle behind neural networks that we need to have huge volume of data. Python and open source ecosystems and the advancements in hardware have made implementing deep learning algorithms easier.

A. *Artificial Neural Networks*

A massively parallel distributed processor made up of simple processing units called a neural network has a natural tendency to store and make use of experimental knowledge. A neuron collects information in the form of input and creates a linear function by multiplying the inputs with their corresponding weights.

$$y = \sum_{i=0}^{n} w^i x^i + b \tag{1}$$

Equation 1: Linear Function

Equation 1 shows the linear function used in ANN. This linear function is then used as an input in the activation function to give the final output. The motivation behind neural networks comes from the way human brain works. The weights of the inputs are constantly changed through back propagation until we get into a situation where we make minimum mistakes or error. Figure 1 shows the structure of artificial neuron.

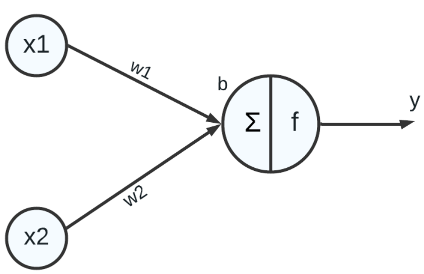


Figure 1: Artificial Neural Network

It is possible to add one(shallow neural network) or more than one(deep neural networks) layers in between the output and input layers. These added layers are called hidden layers and the neural network now becomes multi layer neural network. In multi-layered neural networks, the weights are updated through the back propagation algorithm.

Benefits of ANN

- Non linearity is distributed throughout.
- Input-output mapping is done by adjusting the free parameters of inputs until we get the desired output and thus the model is well trained because of the learning ability of the model.
- Evidential response - It can give a confidence level about its output.
- Fault tolerance -Under challenging operating conditions, performance declines gracefully.

B. *Convolutional Neural Network(CNN)*

CNN is a deep learning system that can take in an input image, rank the significance of different objects within the image, and distinguish between them. A hierarchical network is presented. To obtain a result, each level only multiplies the original image by two and adds the residuals. A sub-field of CNN called deep learning methodology is more adaptive for evaluating visual pictures. CNN are a part of machine learning algorithms that deal with representation of knowledge. When separating the images into layers as opposed to using the traditional analysis method, the deep learning algorithms aid in the greater understanding of the features because each layer is examined and can be more precisely evaluated.[1]

How CNN works on Images?

Template Matching is the process of moving the template across the entire image and comparing it to the image's covered window is a procedure known as "template matching." Window will be compared to every pixel value over the image, so rather than being static it's moving across the entire grid of the image and once the window finds a particular pattern it will generate a probability distribution denoting that this image belongs to this person. Figure 3 shows the actucal process as explained. This is the key concept for detection of images using CNN algorithm. Multiple layers of CNN are possible, and each layer trains the network to recognize the various aspects of an input image. Input, output, and hidden layers are all features of CNNs that help in the processing and classification of images. Convolutional layers, ReLU, pooling, and fully connected layers are among the hidden layers, and they all have a significant impact.

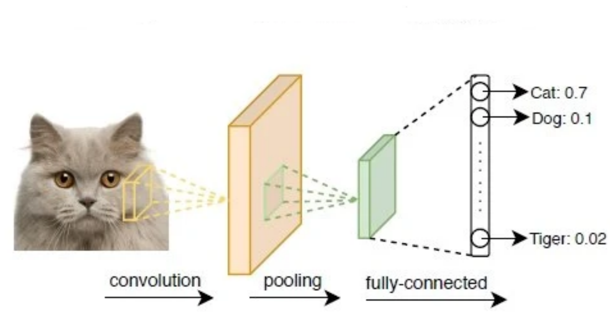


Figure 2: CNN[6]

CNN Architecture

1) Convolution Filters

Convolution filter is taken as 3x3 or 5x5 filter. Each filter is responsible for taking out every element of the respective character in the image. Filters extract each individual map by moving over the function's input grid horizontally and vertically, one pixel at a time. **Fig 3** depicts how filters are created and treated as hidden layers in CNN.[1] As zooming more and more into the image at every filters, image gets smaller and will get minute details from that image. This is how exactly convolutional filters work by eliminating the unnecessary filters or characters and focus on those which are really important. The amount of features that the CNN does eliminate rises along with the number of filters being applied.

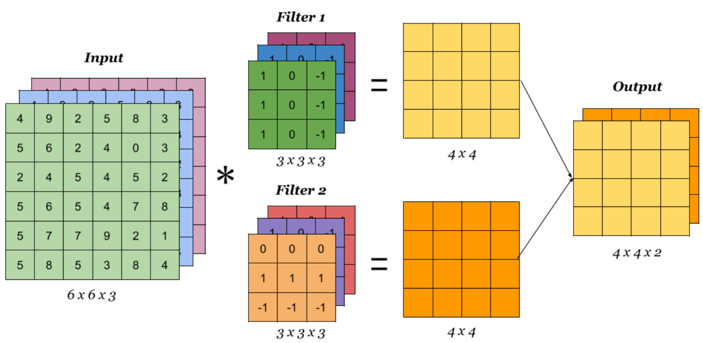
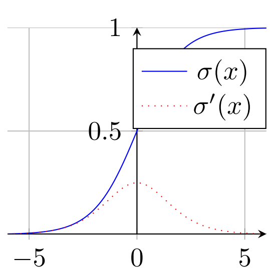


Figure 3: Convolutional Filters in CNN[6]

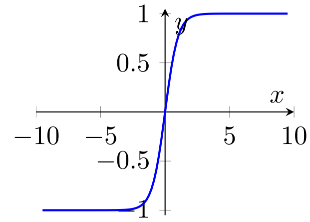
2) Activation Function

The activation function refers to the non-linear change we do on the input signal. This altered output is given to the next layer of neurons as input. Since these are nonlinear activation functions, we must make sure that our network is linear.A stage feature that produces zero or one output can be used as our enabling function. Neurons are destroyed if their output reaches a particular point, and we already had one. Commonly used activation functions along with equations and graphs are mentioned below:

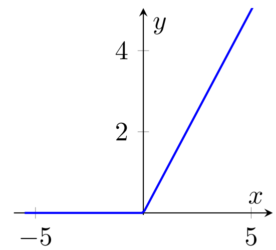
1) Sigmoid Function [eq 2]
2) Tanh Function [eq 3]
3) ReLU [eq 4]
4) Leaky ReLU [eq 5]



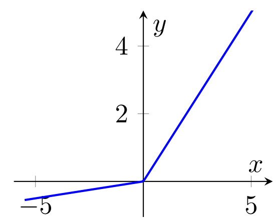
$$\sigma(x) = \frac{1}{1+e^{-x}} \tag{2}$$



$$tanh(x) = \frac{e^x - e^{-x}}{e^x + e^{-x}} = \frac{1-e^{-2x}}{1+e^{-2x}} \tag{3}$$



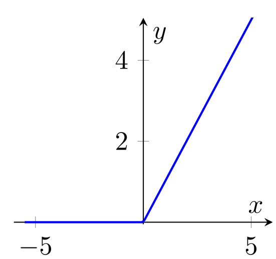
$$f(x) = max(0, x) \tag{4}$$



$$f(x) = \{ \begin{array}{rcl} 0.01x & \text{for} & x < 0 \\ x & \text{for} & x \geq 0 \end{array} \tag{5}$$

3) ReLU

One of the most well-known Activation functions is the ReLU. For each value of x that is less than zero, the ReLU outputs a zero. The function returns x, then zero for every x number that is larger than or equal. In order to implement non-linearity inside the pattern, the network applies a transformation of ReLU to the converted element following each CNN convolution step.[7] Below mentioned graph and function of ReLU *equation 6*.



$$f(x) = max(0, x); \tag{6}$$

4) Pooling Layers

After ReLU , the next stage, pooling, allows the CNN to retain the most important feature data while reducing the sample feature and number of feature map dimensions. This technique reduces size of feature map. The amount of network processing and the number of parameters that need to be learned are thereby reduced. The feature map created by the feature pooling layer of a convolution layer summarises the features that are present in a certain area. Max pooling operates in the same manner as convolution filter. The method iterates through the feature map, selecting tiles of a specific size, and outputs the highest value from each extracted tile to a new function map while discarding out all other presumptions. The usual filter's maximum pooling size is 2x2 pixels.Figure 4 shows max pooling. The term "stride" in pixels refers to the separation between each extracted tile. In contrast to convolution filters, the step in max pooling specifies the locations from which each tile is drawn. Convolution filters slide over the feature map pixel by pixel. [8] A phase 2 of 2x2 is specified in such a way that the tiles which do not overlap are taken out by max pooling.

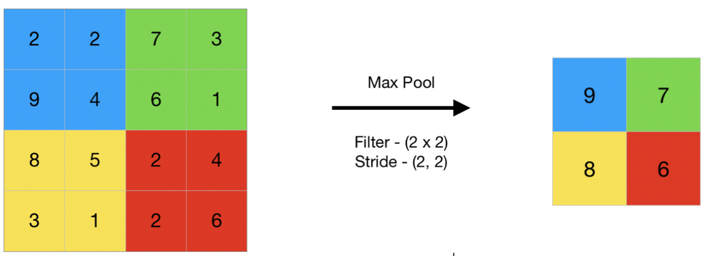


Figure 4: Max Pooling[6]

5) *Fully Connected Layers*

A CNN has one or more fully connected layers at its end. When each node in layer one is connected to each node in layer two cap, four layers are entirely connected. They must perform categorization based on the data that the convolutions gather.Neurons are typically fully linked from beginning to end. The activation function softmax in the final, every rating label that the model tries to predict is given a probability value between 0 and 1 by the fully-connected layer. CNN is actually made up of hidden layers and fully-connected layer(s).

V. Image Processing using Deep Learning

The contemporary technique of transformation of an image into digital data in order to gather some important information from the data is known as Image Processing Image coding, categorization, compression, enhancement, and feature extraction are a few of the activities that make up image processing. Processing should be assisted by a variety of technologies to increase the quality of image and it's resolution to make sure that it is clear enough and can successfully identify information. Pattern recognition, machine vision, multimedia technology are just a few examples of fields where image processing technology is widely employed as a result of the advancement of artificial intelligence technology. Deep learning is extensively employed in the field of images, including medical diagnosis testing and motion detection, and the most common use is face recognition. This is as a result of DL algorithms being used in numerous areas of life. Soon, all phases of image recognition and processing will use deep learning. Since existing image recognition algorithms' drawbacks and subjectivity prevent many research from meeting application requirements. Image Segmentation is a big issue when it comes to the traditional approach of image processing. And majority of the time it fails to extract the vital information from the image and even can't avoid the unimportant data. The same thing when done with Deep Learning has proven to be more optimised and can do processing of big data and solve the problem efficiently.

The following three steps are essentially involved in picture processing:

1) Using image capture software to import the image.
2) Examining and adjusting the picture
3) Report or updated picture being created as a result of the image analysis.

A. *Phases of Image Processing:*

- Image Acquisition - The first step in processing images is acquisition.It is pre-treating phase of image processing.The image is obtained from a hardware based source.
- Image Enhancement - Optimizing image is the method of focusing on intriguing features.This can be done by changing image Contrast, highlights, Vibrance etc.
- Image Restoration - Image appearance is enhanced by the method of restoration of image. Mathematical tools and probability models are used to carry out the task.
- Colour Image Processing - Numerous digital colour modelling approaches are used while processing coloured images.Because digital images are so widely used online, this stage is now more important than ever.
- Wavelets and Multi-resolution Processing - Images of various resolutions are represented by wavelets. Pyramidal presentation and data compression is done by dividing images into wavelets/small sections.
- Compression - Reduction of storage space and transmission space needed for an image is reduced using compression technique. Generally used when images are to be uploaded online.
- Morphological Processing - Morphological processing is method to change shape of images using many post processing practices.
- Segmentation - One of the most challenging aspects of processing images is segmenting them. Images are broken down to small elements and items.
- Recognition - Recognition based on a description of the object allows for the assignment of a label. [2]

B. *Application of Image processing*

Image Processing is being used at many different domains and has a vast application all around.

- Image Resolution rectification and Sharpening is one of the basic uses of IP technique where all detection of edges, high resolution dynamic range edits can be done.

- Filters and Presets of photo editing application and social media.
- Machine Vision is also another big application of image processing. Identification of obstacles and objects is done from the environment. Autopilot vehicles and drones use this type of image processing.
- Image processing is also used for pattern and face recognition. This uses many AI ML libraries for analysis of the digital data from image.
- Medical Technology is one of the big domain where image processing is used. Tasks like XRay, CT and PET scanning, UV and cancer cell processing of images. This has helped vastly in diagnosis.

Some other applications of image processing in various domains are listed in Table 1

Domain	Application
Physics,Chemistry	Spectrum analysis, Pressure analysis Gene Character Analysis
Agriculture	Yield Estimation, Natural Disaster Detection
Ocean	Fish Exploration,Wave Observation Pollution Detection
Communication	Multimedia Communication LCD characterisitcs analysis
Trasnportation	Tunnel Motoring Railway Line Selection
Industry	Crystal oscillator component defect detection
Military	Military reconnaissance, Missile Guidance Special Forces Training

Table 1 : Application of Image Processing

VI. Deep Learning in Medical Imaging

Preliminary study is frequently required for image diagnosis activities in order to identify anomalies, quantify measures, and monitor changes over time. ML based image analysis tools and algorithms are major facilitators to enhance the accuracy of interpretation and diagnosis of images. Table 2 shows some of the results in diagnosing various diseases using deep learning. One widely used method that offers cutting-edge accuracy is deep learning. It unlocked previously closed doors in the field of medical image analysis. A wide range of difficulties are addressed by deep learning applications in the healthcare sector, from monitoring illnesses to identifying cancer. Today, doctors have access to a vast quantity of data thanks to a variety of sources, including genetic sequencing, pathological imaging, and radio-logical imaging.

Disease	Affects	DL Algorithm	Accuracy Tests
Diabetic Retinography	Eye Blindness	DCNN on retina images	∼80% accuracy 96% sensitivity 97% specificity
Histological and microscopical elements detection	Used for Malaria, TB and hookworm.	CNN models and SVM for cellular testing and categorizing.	100% Malaria 98% TB 98% Hookworm
Alzheimers	Neurological Disorder	CNN for MRI,endoscopy PET. DBN for fundus and microscopic.	95-97% on different datasets
Cardiac Imaging	Cardiac Disorders	CNN for Calcium score qualifying and CT	∼99% accurate
Gastrointestinal Disease	Gastric and digestion problems	DCNN on reports of endoscopy, colonoscopy and MRI	90-92% accuracy

Table 2: Results and analysis of various diseases diagnosed using Deep Learning

A. Tumor Detection

Abnormal enlargement of cells in any part of the body and making mass out of it is termed as Tumor/Neoplasm. Tumor is basically classified into two types Benign which are non cancerous and they do not spread to other organs. The other one is Malignant which is cancerous where the cells have uncontrollable growth and spread within other parts of the body as well. [9]

Deep Learning techniques have made it pretty easy and accurate to detect Tumor on basis of features extracted from multiple lateral , oblique and mammographic views.CNN is employed first for feature extraction from the images and based on that SVM model classifies it into Benign or Malignant. Several tests have been done for Tumor Detection using Deep Learning and the results are as follows in Table 3:

Tester	Sample Size	Accuracy
Arevalo	736	82.6%
Huynh	2393	88%
Antropova	4096 Ext. 551 MRI	84%
Shin	2282	94% Acc
Test 5	607	86%

Table 3: Results and analysis of Tumor Detection using Deep Learning

VII. Development of Image Processing Based on Deep Learning Algorithm

Some issues that traditional image processing techniques have are image segmentation and frequently fail to acknowledge or can only partially remove the image's hidden meaning when extracting its features. This issue can be effectively solved by large data processing techniques for image optimization based on deep learning models.

A. Pruning Strategy

The majority of neighbourhood neural network-based image pre-processing methods have trouble correctly classifying the image's characteristics. This is mostly caused by the networks' inter-connectivity patterns' redundancy. These networks' greater link density also suggests more network complexity. We provide a fuzzy set-theoretic pruning approach to improve the neighbourhood neural network architectures' interconnection pattern. The algorithm's main goal is the careful selection of the network topology's participating neurons. The segmentation and extraction of synthetic and real-world photos serve as a demonstration of the pruning algorithm's effectiveness. The algorithm's use in the binary, multilevel, and colour domains is evidence of its universality.[3]

B. Particle Swarm Optimization

A fundamental technology for processing complicated images is segmentation of images, which is a key stage in image processing. With notable and effective outcomes, this technique is frequently used in compression, fusion, calibration, enabling segmentation,pattern recognition and image processing technology, and synthesis. The most crucial characteristic of PSO is its ability to deliver better results with parameter fine adjustment. PSO can address the issue of blurring of image and clear restoration brought on by motion and defocus the blur part during the acquisition of the image, as well as the issue of image degradation and an improvement in the realism of the image, this is the advantage of PSO over traditional image processing techniques.[4]

C. Image Matching

For many computer vision applications, like object tracking, picture retrieval, etc., image feature matching is an integral task. No matter how the image changes due to geometric alteration (such as rotation and translation), illumination, etc., the images may still be matched. Deep learning has an edge in feature extraction of images as a result of its successful application in image processing. Three categories of image matching algorithms exist: relational, feature, and grayscale. The idea of feature extraction serves as the foundation for feature matching. In order to accomplish the task of image matching and bring the matching to the best possible resolution, on the basis of preventing outside intervention sources, it collects the image's attributes through preliminary processing and uses the PSO for matching precisely, identify changes in shapes, grayscale, along with occlusions. Since it forms the foundation of many applications requiring multi-view geometry, feature-based image matching has been a research focus both computer vision and photogrammetry for decades.

VIII. RESULTS

In our model, we have used a dataset consisting of 1966 MRI images of human brain. Out of these, 1085 have brain tumor(class: yes, Fig. 8) while 881 are healthy(class: no, Fig. 7). From this data, 80% data has been used for training the model, 10% for validation and 10% for testing. We have implemented a sequential deep learning model with 4 convolution layers, 3 pooling layers, 2 dense layers and 2 dropout layers. The final activation function used is sigmoid so the output ranges between 0 and 1, if the output is below 0.5, it indicates that the image belongs to class 'no' and if the output is more than 0.5, it belongs to class 'yes'. The accuracy of our model ranges between 72 - 82%.

Figure 5. shows the variation in accuracy after each epoch. The epoch at which the accuracy is the highest is saved and used. Here, the highest accuracy achieved is 80.07%. The test accuracy achieved is 78.78%. Accuracy is calculated by dividing the total number of correct predictions by the total number of predictions made by the model.

Figure 6. shows the variation of loss at each epoch. Loss indicates how much the predicted values are differing from the actual values.

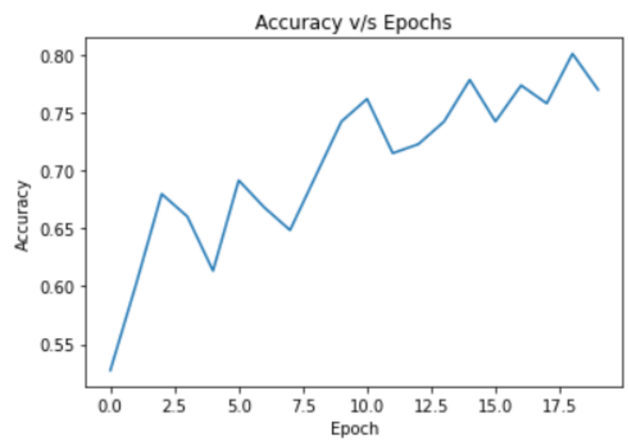


Figure 5: Accuracy at each epoch

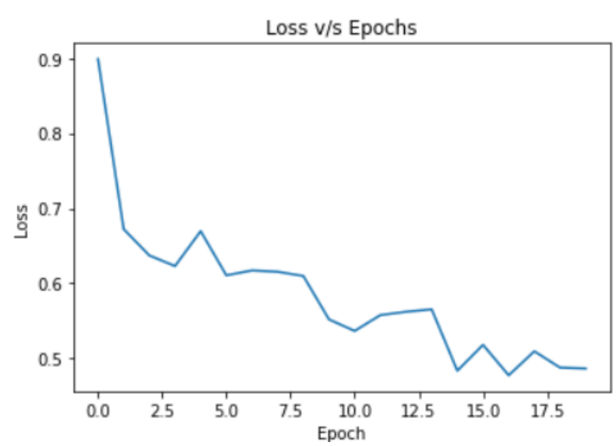


Figure 6: Loss at each epoch

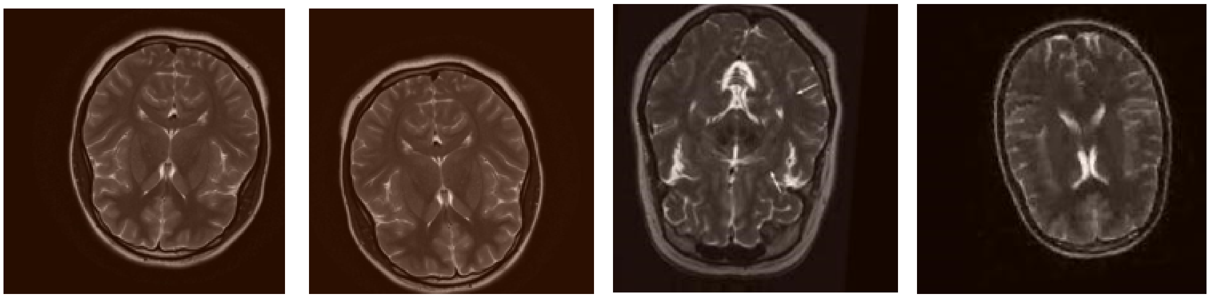


Figure 7: MRI images of healthy brain

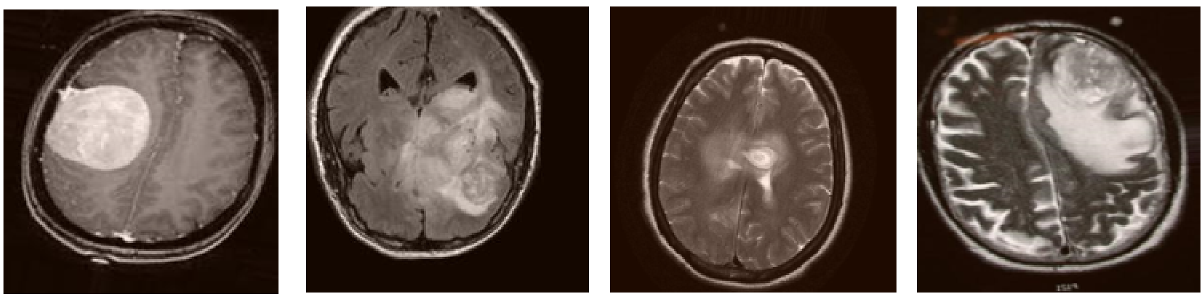


Figure 8: MRI images of diseased brains

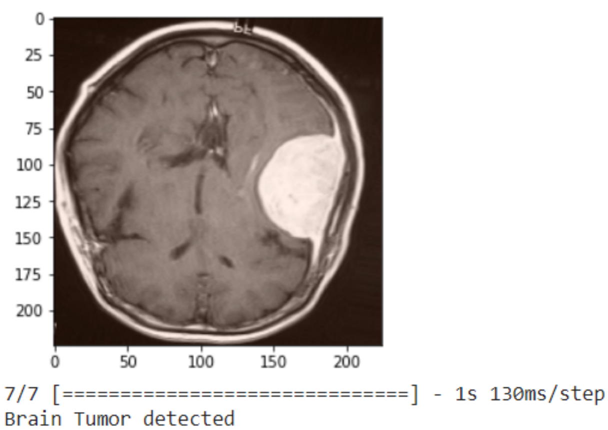


Figure 9: Image of diseased brain as input

In Figure 9., input of an image with brain tumor is given and our model correctly predicts the tumor.

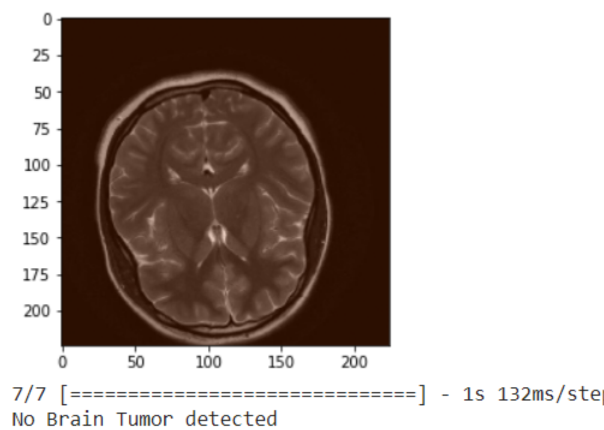


Figure 10: Image of healthy brain as input

In Figure 10., an image of a healthy brain is given and our model is able to classify it correctly.

No. of Epochs	20
Batch Size	32
Steps per epochs	8
Learning Rate	0.001

Table 4:Parameters used in model

Algorithm	Accuracy
Neural Network	66.6%
C4.5	59.2%
Naive Bayes	59.2%
KNN	62.9%

Table 5: Accuracy comparison with different classification models. [10]

The accuracy of our model with CNN is 78.78%.

CONCLUSION

Deep learning can very accurately classify images and help in image processing. With multiple deep learning layers, classification of images becomes better and more accurate. We have implemented CNN model to detect brain tumor. Image processing is done with the help of deep learning techniques in medical sector. Our CNN model can prove to be very effective as it is quite accurate due to the various steps taken by us during data pre-processing and to remove over-fitting. Our model can be effectively used to classify images of human brain as healthy or diseased and thus, patients can be treated at the earliest. **

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