Systems & Biomedical Engineering
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Brain Tumor Detection using Deep Learning

Dr. Samah El-Tantawy

Abstract

During the last decade, Computer vision and machine learning have altered the world in every way possible. Deep Learning is a subfield of machine learning that has shown impressive results in a variety of fields, particularly in the biomedical industry, because of its ability to handle large amounts of data. Deep learning methods such as the convolutional neural network (CNN) model (developed from scratch) are tested and used in the research to identification and prognosis tumor regions in scanned brain images. From the first stage which serves as the input, through the last stage which is image detection, the backpropagation of the model will use PDE to calculate the gradient of the loss function with respect to parameters as it is a technique for swiftly calculating derivatives.

Introduction

Machine learning and computer vision revolutions have paved the way for ground-breaking inventions and algorithm development. It has demonstrated outstanding performance and has applications in a variety of fields, including self-driving automobiles, health, education, and the Internet of Things.

Machine learning and artificial intelligence applications in biomedical have recently captured the attention of researchers, particularly in the field of anomaly detection.

Because of its rising prevalence and deaths rate in people of all ages, brain tumors are regarded one of the world's deadliest diseases. According to the American Cancer Society's recent publication "Cancer Statistics 2020," around 24000 persons would be infected with brain tumors in 2020, with an anticipated 19000 deaths. Approximately 120 various types of tumors have been discovered to date, and they all present in varied shapes and sizes, making diagnosis more challenging due to the brain's intricate anatomy. Early detection of brain tumor helps the radiologists for effective prognosis and increase the chance of long-term survival.

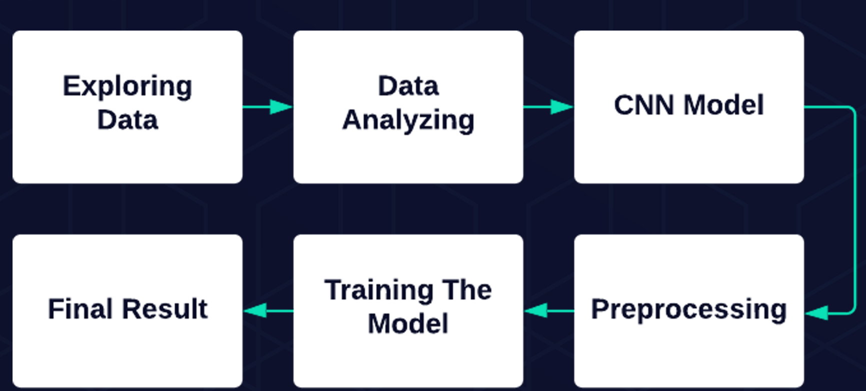
For many years, several medical imaging techniques have been used to detect brain disorders but recently studies have started to focus on various machine learning and Deep Learning techniques.

Material & Methods

Materials:

- Google Colaboratory.
- Brain Tumor Detection 2020 kaggle dataset.

Methods:



- Exploring data

The dataset used is Brain Tumor Detection 2020 kaggle dataset. It consists of 3065 MRI images separated to two classes (Tumor - Non-Tumor) with the same number of images.

- Data analyzing

1- Image histogram: graphical representation of tonal distribution of an image represents the number of pixels in each tonal value by plotting it.
2- Equalization histogram: equalization implies mapping one distribution to another so the Intensity value are spread over the whole range.

- Preprocessing

Resizing input shape to be (64,64,3), (64,64) make sure all inputs are in the same size.

- CNN Model

Model consists of:
- Three Conv2D Layers that creates a convolution kernel that is convolved with the layer input to produce a tensor of outputs.
- Flatten layer that flattens the multi-dimensional input tensors into a single dimension, so the input layer can be modeled and the neural network model can be build.
- Dense Neural Network
- Activation functions (ReLU & Sigmoid)
- Dropout that helps prevent overfitting

- Training the model

- Compile parameters:
- Loss function (Binary Crossentropy): is the function we use for backpropagation.
- Optimizer (Adam): is a function or an algorithm that modifies the attributes of the neural network, such as weights and learning rat.
- Metrics (Accuracy, AUC metric): Metric functions are similar to loss functions, except that the results from evaluating a metric are not used when training the model.

Test & Results

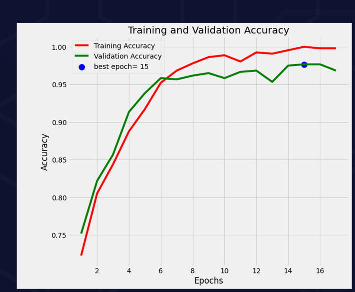
Through training the model, we should compile the parameters like Loss (Cross-entropy loss is used for binary classification), Optimizer (helps in reducing the overall loss and improve the accuracy) and Metrics (the results from evaluating a metric are not used when training the model).

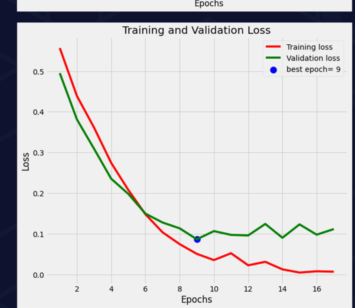
Then we Fit parameters as x_train, y_train, Batch size (Number of training examples), Epochs (how many times you go through your training set), Validation data (used to update the model) and Shuffle.

- Results

our model had been trained 17 epochs to determine accuracy and validation accuracy and give the following results:

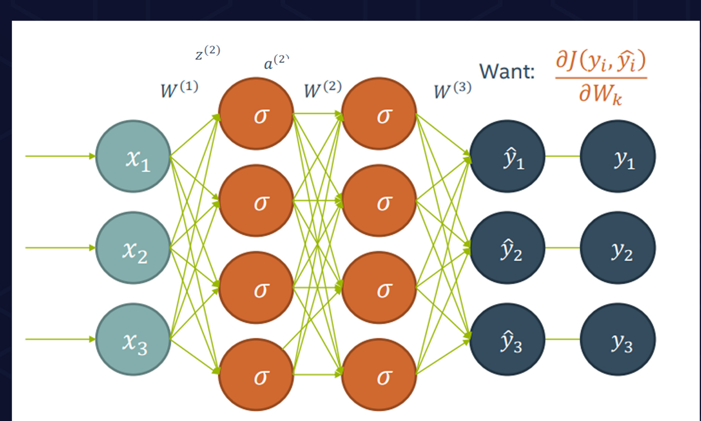
Accuracy: 99.8%
Validation accuracy: 97%






```
Epoch 16/17
150/150 [==============================] - 4s 30ms/step - loss: 0.0084 - accuracy: 0.9979 - val_loss: 0.0984 - val_accuracy: 0.9767
Epoch 17/17
150/150 [==============================] - 4s 25ms/step - loss: 0.0074 - accuracy: 0.9979 - val_loss: 0.1121 - val_accuracy: 0.9683
```

Analysis



In this point, it's the way to implement the model of deep learning, which need some steps to work properly, one of these steps is Forward Propagation (Calculating the intermediate variable and output of neural network from the input values), in this step we assume that a^{(1)}=x which is the input layer of the neural network, so the intermediate variable can be calculated as

$$z^{(2)} = W^{(1)}x + b$$

Where $W^{(1)}$ is the weighted parameters of the hidden layer, and b is the bias of this layer, so after calculating the output of a hidden layer, activation function is used to make it the input of the next layer, as needed, ReLU and Sigmoid function well be used in this neural network, the sigmoid is like:

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

And with this, the output can be in a shape of 1 or 0 and has tumor or not, after calculating the output, the weighted parameters need to be updated to give results close to the data set, so PDE is used here

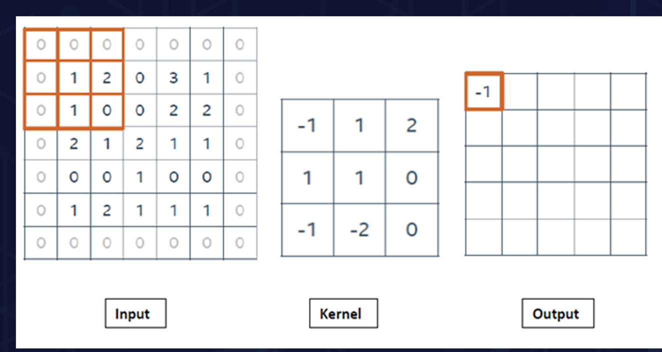
$$\frac{\partial J}{\partial W_{(1)}} = \frac{\partial J\, \partial z_{(2)}}{\partial z_{(2)} \partial W_{(1)}} + \frac{\partial J\, \partial s}{\partial s\, \partial W_{(1)}} = \frac{\partial J}{\partial z_{(2)}}\, a_{(1)+} \lambda W_{(1)}$$

$$W^{(1)} : W^{(1)} - \alpha \frac{\partial J}{\partial W_{(1)}}$$

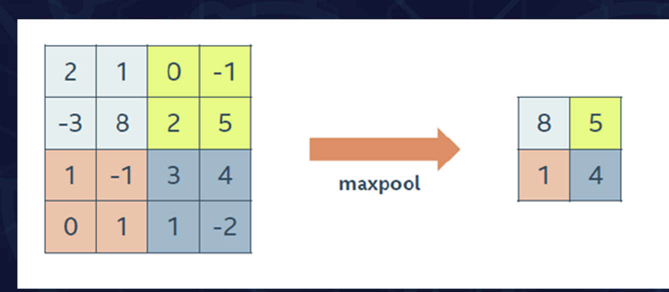
Where α is the learning rate, after that a big problem appears which is the input is a picture with huge amount of pixel, so the neural network can't handle all these pixels or it will be huge with millions of neurons, to avoid this from happening CNN (Convolutional neural network) is used, CNN is based on filters or kernels that slide along input features and provide feature maps and these maps can be calculated by:

$$\sum_{p=1}^{p} = W_{(p)} \times (pixel)_p$$

Using this method directly, there will be an "edge effect" so Padding technique adds extra zero pixels around the frame so the original pixels will be at center



and Last thing used in this neural network is Pooling, its an operation used to map a patch of pixels to a single value, and at this NN max pooling method is used.



Conculsion

It can be concluded that there is a strong need of fully automatic unified framework that can efficiently detect and classify the brain tumor into multiple classes with less complexity, Using CNN most commonly applied to analyze visual imagery then pooling which reducing the image size by mapping a patch of pixels to a single value and finally the Forward and Backward Propagation as it is clear that Deep Learning algorithms have great power and ability.

Recommendation

In the future, the project subjective will be satisfied with itself without any external factors to work. The project will have an additional file to do all pre-processing steps of any external image. The model will be uploaded to google cloud to integrate with a mobile app or website that will offer usability to all the users. The project is based on brain tumor detection with CNN, so google cloud platform AI solutions can be used to improve our model. We can use a deploy model solution to deploy our model. Also, the google cloud solution - text to speech - can be used to offer customer service to our users.

Citiaion

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