Brain Tumor Detection

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1 Introduction

Brain tumor detection is very hard in the beginning stage because it cannot find the accurate measurement of tumor. To avoid human based diagnostic error, computer aided diagnosis system is needed. Throughout the few years, different segmentation methods have been used for tumor detection but it is a time consuming process and also gives inaccurate results. Implementation and identification of brain tumor are done by segmentation and detecting the brain image from the MRI scans. In the system, pre-processing of the image is the primary step which removes noises and smooths out the input MRI brain image. And, segmentation is carried out using thresholding technique. Then, the brain tumor region is detected from the segmented image using region properties. The purpose of the system is to assist doctors and radiologists who examine and determine the symptoms of brain tumor in the biomedical field by using image processing techniques. Therefore, once it gets identified brain tumor, it gives to start the proper treatment and it may be curable.

1.1 Problem Statement

The segmentation, detection, and extraction of infected tumor area from magnetic resonance (MR) images are a primary concern but a tedious and time taking task performed by radiologists or clinical experts, and their accuracy depends on their experience only. So, the use of computer aided technology becomes very necessary to overcome these limitations.

1.1.1 Objective

The objective is to detect the presence of tumor in the MRI images of the brain using CNN.

2 Literature Survey

2.1 Research questions

1. Is it possible to determine the severity of a tumor by calculating the percentage area of the tumor in the MRI image ?
2. How can we increase the accuracy of brain tumor detection ?
3. Which classification algorithm is best suited for this purpose and why ?
4. How can we identify part of the brain where a tumor resides ?

3 Proposed Methodology

3.1 Dataset Description

Details	Count
Number of instances	2065
Number of attributes	1

3.2 Attribute Description

There is only one attribute that consists of MRI images of brain with or without tumor

3.3 Image Annotation

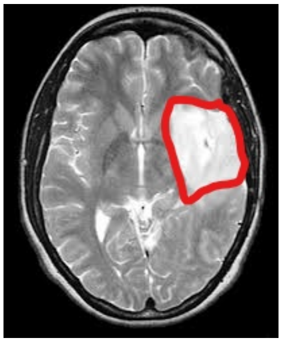
How to identify tumorous area for annotation?

In order to annotate images, we need to identify tumorous area. MRI is very good at finding and pinpointing some cancers. An MRI with contrast dye is the best way to see brain and spinal cord tumors. Using MRI, doctors can sometimes tell if a tumor is or isn't cancer.

MRI can also be used to look for signs that cancer may have metastasized (spread) from where it started to another part of the body.

We have annotated the brain MRI images to highlight the region of the brain where tumor is present.

(a) Figure 1



(b) Figure 2

3.4 Data Augmentation

Since this is a small dataset, There weren't enough examples to train the neural network. Also, data augmentation was useful in tackling the data imbalance issue in the data.

- The most commonly used operations in data augmentation are-

  1)Rotation

  2)Shearing

  3)Zooming

  4)Cropping

  5)Flipping

  6)Changing the brightness level

- Before data augmentation, the dataset consisted of: 155 positive and 98 negative examples, resulting in 253 example images.

- After data augmentation, now the dataset consists of: 1085 positive and 980 examples, resulting in 2065 example images.

- We have performed data augmentation by using the ImageDataGenerator class. It takes in various arguments like – rotation-range, brightness-range, shear-range, zoom-range etc.

3.5 Data Preprocessing

1. **Converting the image to Grayscale:** Converting the image to Grayscale: A grayscale image is simply one inwhich the only colors are shades of gray. The reason for differentiating such images from any other sort of color image is that less information needs to be provided for each pixel. In fact a 'gray' color is one in which the red, green and blue components all have equal intensity in RGB space, and so it is only necessary to specify a single intensity value for each pixel, as opposed to the three intensities needed to specify each pixel in a full color image.

2. **Removing Noise from the Image:** As in any other signal, images also can contain different types of noise, especially because of the source (camera sensor). Image Smoothing techniques help in reducing the noise.We've used the GaussianBlur function for image smoothing. Gaussian filters have the properties of having no overshoot to a step function input while minimizing the rise and fall time. In terms of image processing, any sharp edges in images are smoothed while minimizing too much blurring.

3. **Segment the image using the threshold function:** Thresholding is a segmentation technique, used for separating an object from its background. The process of thresholding involves comparing each pixel value of the image (pixel intensity) to a specified threshold. This divides all the pixels of the input image into 2 groups:

   – Pixels having intensity value lower than threshold

   – Pixels having intensity value greater than threshold.

   These 2 groups are now given different values, depending on various segmentation types.

4. **Outlining the brain:** In order to detect the outlines of the brain, we make a call to cv2.findContours , followed by sorting the contours to find the largest one, which we presume to be the brain itself .Contour is simply a NumPy array of (x, y)-coordinates. Therefore, we can leverage NumPy functions to help us find the extreme coordinates.Using the contour function, we'll find out our leftmost,rightmost,topmost and bottommost pixel and highlight it.This'll help us set the brain boundary.

5. **Crop the image:** Using the boundaries set by outlining the tumor, we now crop the image to contain only the brain, cropping out the unnecessary background image.

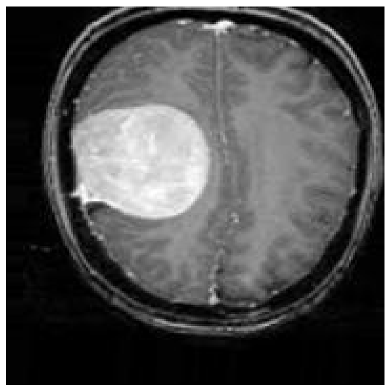


Figure 2: Original Image

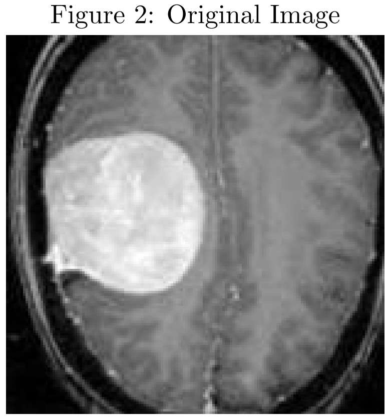


Figure 3: Cropped Image

6. **Resize the image:** We need to resize the image because the images in the dataset come in different sizes (meaning width, height and no of channels). So, we want all of our images to be (240, 240, 3) to feed it as an input to the neural network.

7. **Normalization and shuffling of Data:** We have to normalize the im-

ages because we want pixel values to be scaled to the range 0-1.After that, the data is shuffled, because the data is ordered (meaning the arrays contains the first part belonging to one class and the second part belonging to the other class, and we don't want that).

8. **Plot Sample Images:** 50 sample images are plotted for both the labels 'yes' and 'no' after augmentation and preprocessing.

4 Data Exploration and Segmentation

- **Enhancement of brain image:** The MRI image is enhanced to reduce the noise and to remove unwanted data, this is achieved using an average low-pass filter. This filter is used to smooth as well as enhace the MRI image. Figure 4 shows the effect of applying the average filter to the input MRI human brain image.

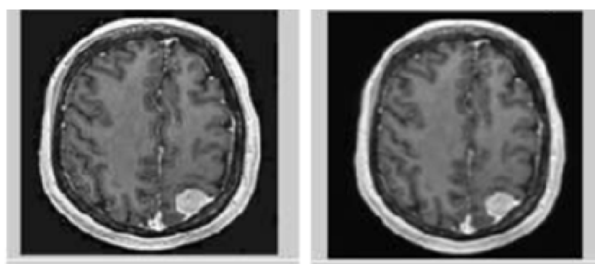


Figure 4

- **Skull stripping in MRI image:** The human brain surrounded by a bone area called the skull that protects the brain from external effects. This phase attempts to isolate the skull area from the background of the human brain image as illustrated in Fig. 5. This technique allows reducing the testing area and the possibility of errors, since, it puts all the background areas aside from the examination. The following steps achieved this process.
  - Take the MRI image of the human brain and then store it in a two dimensions matrix.
  - Start scanning the image from the left-top side to the right-bottom.
  - Detect the threshold value based on selecting the peak threshold value for each side.
  - If the intensity value for the left side is less than the threshold value and then set these values to zero. This step ensures the detection of the left side of the skull was achieved.

– Repeat the above steps to detect the right, top and bottom portions of the MRI skull image.

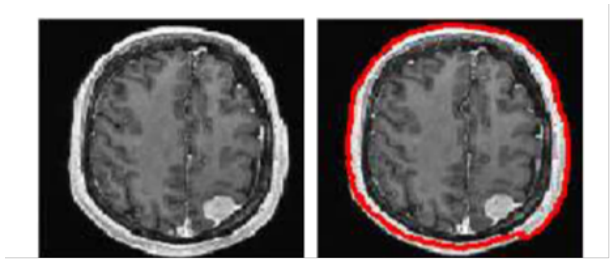


Figure 5

- **Conversion of MRI image to binary:** This phase converts the enhanced MRI image to binary image. This process is applied to the thresholding image. Binarization the threshold image is used to detect the boundary of the patient brain

Figure 6

- **Apply watershedding operation:** Any grayscale image can be viewed as a topographic surface where high intensity denotes peaks and hills while low intensity denotes valleys. You start filling every isolated valleys (local minima) with different colored water (labels). As the water rises, depending on the peaks (gradients) nearby, water from different valleys, obviously with different colors will start to merge. To avoid that, you build barriers in the locations where water merges. You continue the work of filling water and building barriers until all the peaks are under water. Then the barriers you created gives you the segmentation result.

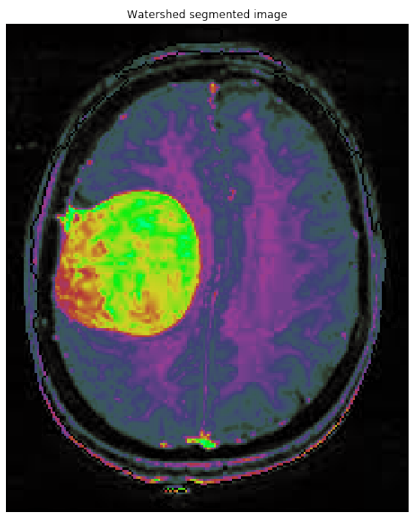


Figure 7

- **Apply morphological operation:** At this phase, the binary image is indexed into regions and each region is compared with the neighborhoods. Structural pixels are called the morphological technique which is used to test a small shape or template. The structuring pixels are placed in all probable locations in the image and then matched to the identical neighborhood of pixels. The process then starts to exam the pixel if it is “fit” with in the neighborhood or else it “hits” or intersects the neighborhood. The regions are labeled by numbers to allow subsequent detection of the one with the greatest intensity where this represents the tumor region.

- **Detection and extraction of tumor region:** The tumor region is detected and extracted in the MRI image based on the determination of the high-intensity region in the image.

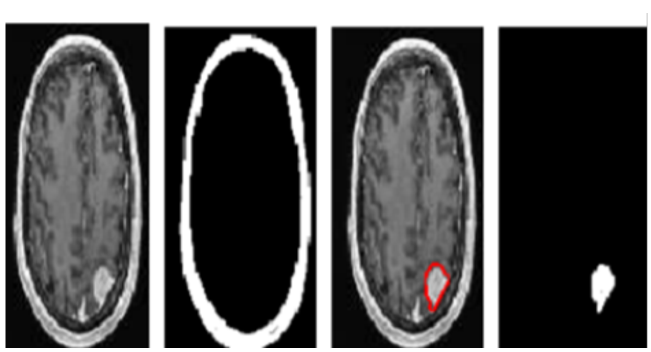


Figure 8

5 Algorithms

5.1 Convolutional Neural Network

5.1.1 Description

Convolutional Neural network is a deep learning technique which is feed forward artificial neural networks that are applied to visual images. These are also called as CONV NETS. These are combined set of layers that can be worked on group functionalities.

Convolutional Neural Networks have a different architecture than regular Neural Networks. Regular Neural Networks transform an input by putting it through a series of hidden layers. Every layer is made up of a set of neurons, where each layer is fully connected to all neurons in the layer before. Finally, there is a last fully-connected layer — the output layer — that represent the predictions.

CNN is composed of two major parts:

- Feature Extraction:

In this part, the network will perform a series of convolutions and pooling operations during which the features are detected. If you had a picture of a zebra, this is the part where the network would recognize its stripes, two ears, and four legs.

- Classification:

Here, the fully connected layers will serve as a classifier on top of these extracted features. They will assign a probability for the object on the image being what the algorithm predicts it is. Convolutional Neural Networks are a bit different.

First of all, the layers are organised in 3 dimensions: width, height and depth. Further, the neurons in one layer do not connect to all the neurons in the next layer but only to a small region of it. Lastly, the final output will be reduced to a single vector of probability scores, organized along the depth dimension. It

has following steps:

- Input image
- Convolutional Neural Network
- Output label (image class)

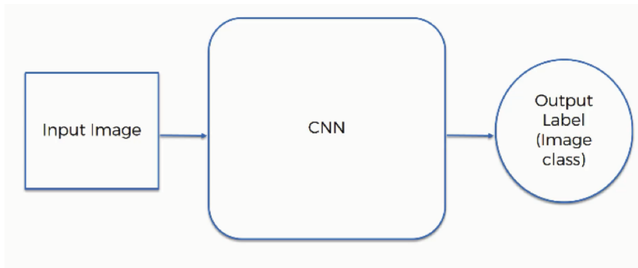


Figure 9

Following is the neural network architecture:

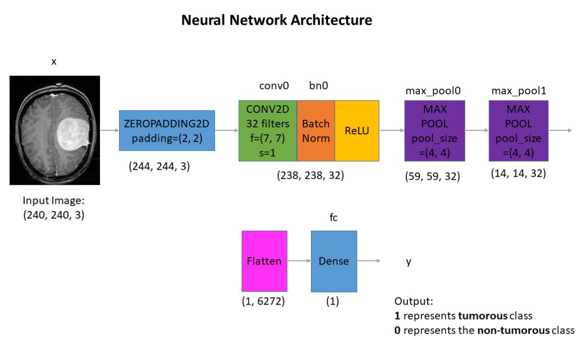


Figure 10