Brain tumor detection through image processing

The objective of the project was to detect, outline and compute the area and perimeter of brain tumors in different MRI images.

1. Domain study & Image selection

To better understand how to work with MRI images and the best practices to utilize, a domain study was priorly conducted. The main sources of the search were scientific papers on the topic, slides on neuroradiology, and advice from a medical student.

The study made it possible to understand that MRI images can be very different from each other depending on the type of MRI such as T1, T2, FLAIR, or many others. Therefore it was clear that in order to be able to work on different images with the same software, they needed to be selected from a dataset containing MRI images acquired with the same technique.

5 images containing tumors of different shapes, sizes, positions and colors were selected along with 2 images without tumors.

2. Approach & Methodology

Different approaches were tested before the one considered the best solution was chosen. In particular, the following were tried out:

- Pre-processing and Otsu’s algorithm
- Pre-processing and Canny’s edge detector

but in both cases, the results were good only for some of the images in the selected set. As for edge detection, brain images contain too many edges to get good results without specific tuning of the parameters. Therefore edge detection was considered not worth the effort. Given the obtained results, it was clear that simple pre-processing operations such as masking and a few morphology operations were not enough.

It was pretty clear that more accurate pre-processing was required. Thus trying to improve the intensity contrast and regions' homogeneity seemed a good solution. This led to the first enhancement of the image through the addition of the image to its blurred version. Another problem was the contrast of borders.

The solution was very similar to the previous one but in this case, the morphological gradient was added to the original image. To preserve borders, a median filter was preferred for denoising the image before this second enhancement.

After these refinements, first percentile thresholding was carried out followed by the first round of morphology operations: opening, closing, erosion and dilation. The masking followed right after to be able to work more precisely on the image with the second round of morphology operations (erosion and opening).

After several tests of this entire process, the results were not bad but surely not good enough. This led to further refinements:

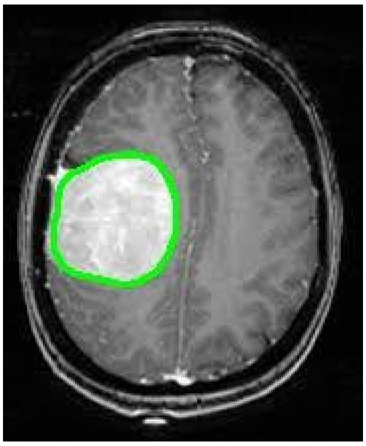
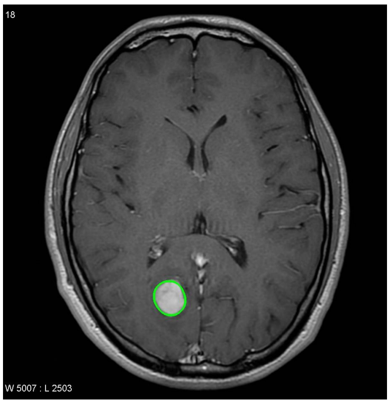
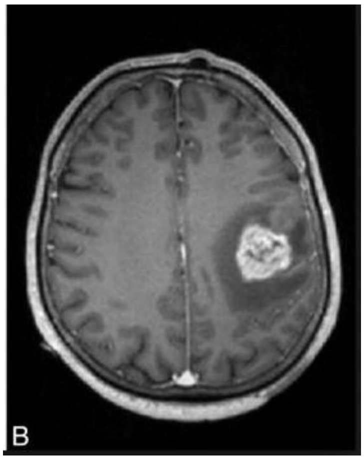
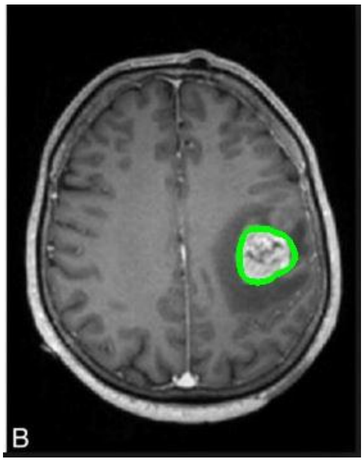
- improved intensity contrast using the same technique utilized in the first enhancement.
- relative scaling of the structured elements used in morphology operations

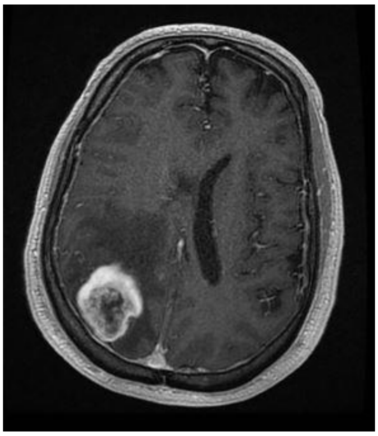
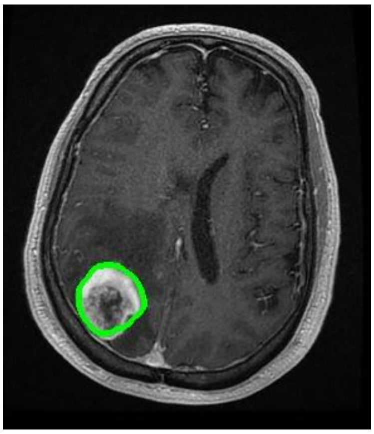
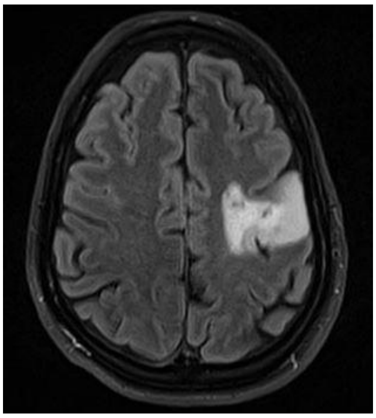
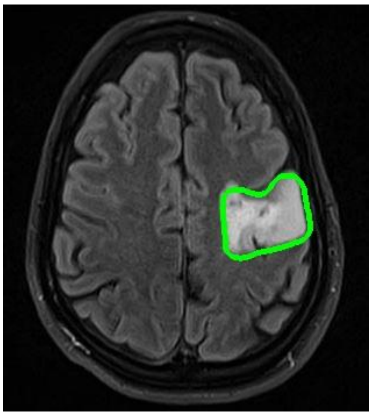
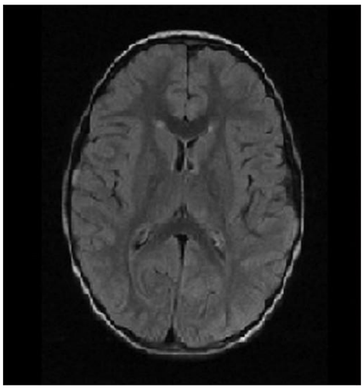
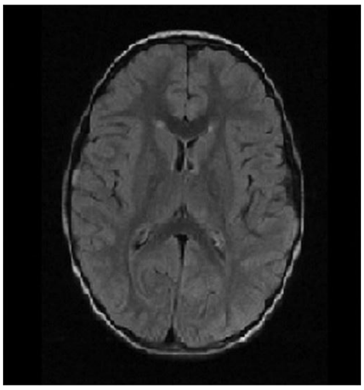
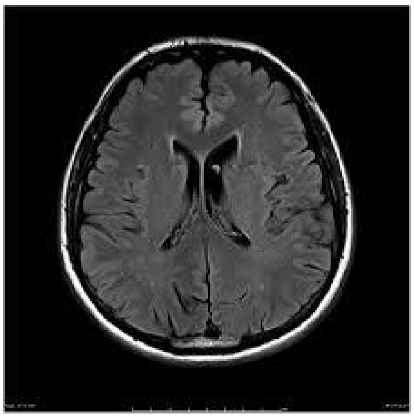
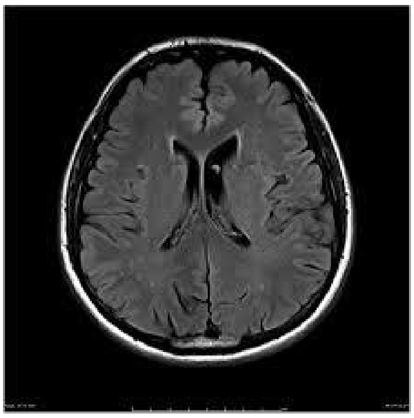
the latter was done using the image's height as a scaling factor.

The last operations were second thresholding and the last closing needed by some of the selected images. As for contouring, the "drawContours" function implemented in OpenCV had some issues dealing with the contour found at the outer borders of the entire image (that is the result of morphology and masking operations performed on the image). To this extent, an if structure has been utilized.

3. Results

The results on the selected set of images are really satisfactory as shown in the following table:

Original	Final	Perimeter	Area
		3216 px	215 px
		4709 px	257 px
		1418 px	143 px

		2114 px	174 px
		3934 px	260 px
		No tumor detected	No tumor detected
		No tumor detected	No tumor detected