Segmentation of a Cerebral Tumor from an MRI Volume

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Abstract—Since it is a non-invasive method, MRI is one of the most efficient medical imaging technique in the visualization of the brain. As one of the main steps of MRI images analysis, segmentation is fundamental in several activity such as the visualization of cerebral anatomy, surgical planning and highlighting of pathological areas. In this document, after a brief introduction and review of the technique of segmentation of tissues and lesions over MRI images, we provide a description of the analysis process of an MRI brain image comprehensive of the chosen workflow and of the drawn conclusions.

Index Terms—MRI, Segmentation, Brain, Cerebral tumor, Medical imaging

I. Introduction

The role of image segmentation is crucial in medical images analysis. This practice is fundamental in several fields such as tissue classification, tumor individuation, volume evaluation, surgical planning and blood cells delineation. More specifically, in the case of brain tumor, methodical and reproducible quantification and morphology of the lesions are essential for clinical studies and for the enhancement of care techniques. The development of computational techniques is crucial for specialists to better understand and manage the huge amount of data contained in medical images. Brain tumor segmentation consists of separating the tumor tissues from normal brain tissues. this could be a though task because of MRI images, despite describing the brain structure accurately, could present poor spatial resolution, low contrast, ill-defined boundaries, inhomogeneity, noise and other acquisitions artifacts. Beyond that, because of the heterogeneous appearance of tumor themselves makes it difficult to devise effective segmentation rules. Nevertheless the continuous advancement in instrumentation and computer technology are leading to notable successes in this field.

II. Materials

A. Image

We were provided with a Matlab file in which it was present the data corresponding to an MRI Volume. There are 3 variables inside: the dimension of the pixels, the dimension of the volume and the volume itself.

B. Instruments

In order to analyze the data, we decided to use Matlab as main instrument and the Image Processing Toolbox, also using the VolumeViewerApp. In particular the principal functions used were *getpts()*, *imfill()*, and *bwselect()*.

III. Methods

A. Preliminary analysis

In order to carry out a more in-depth and correct analysis, we used the Volume Viewer app in the Image Processing toolbox, to view the total volume of the MRI.

B. Code Description

The code presented together with this report is divided into two main parts:

- Sagittal slices analysis;
- Axial slices analysis;

They are really similar but of course one gives the possibility to analyze the sagittal slices, one-by-one, and the other the axial ones. The code tries to create a general workflow for performing the segmentation of a **ROI** (region of interest) inside an MRI volume. The code is structured in such a way as to give the user the possibility to accurately analyze the input volume. In particular, through the use of different GUIs, the user can make different choices in order to act on the data in the way it seems most appropriate,following the steps of an automated program.

C. Noise and Edge detection

At the beginning, a prompt appears, asking the user to choose between three different scenarios. If the salt and pepper
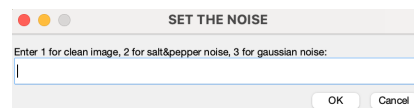

Fig. 1. First Prompt.

or the gaussian noise are chosen, then the parameters for each noise are asked of to the user : the density for the salt and pepper; and the mean and the variance for the gaussian. After that, the selected noise is applied to all the slices (or not, in case of the choice of clean image); then the program shows in a big picture, Figure 2, all the sagittal or axial slices, already converted in binary images containing only the contour of the original ones. The edge detection is made along three different
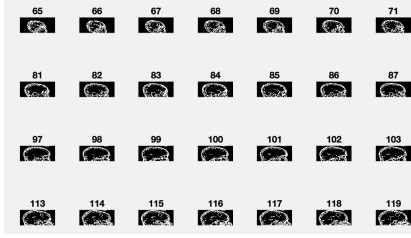
Fig. 2. Some slices seen at the beginning

direction: horizontal (0°), vertical (90°) and diagonal (45°), using *Prewitt's* kernels. Two different noise filters are applied for the two different type of noise: a median filter for the salt and pepper ([6,6]) and an averaging filter for the gaussian (*fspecial('average',3)*).

D. Restriction of the dataset

To facilitate the calculations, the user is asked to enter the number of the first slice containing the lesion, the number of the last slice and that of a *"main"* that may represent the region of the lesion with the largest area. In our analysis, we selected from the 109th to 142nd for the sagittal, with the 135th as the *"main"* and from the 66th to 86th with 76th as *"main",* for the axial.
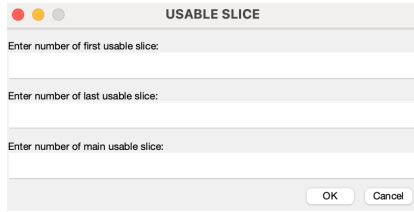

Fig. 3. GUI for insertion of first, last and main slice

E. Cropping the slices

At this point the main slice will appear and the user must indicate on it the left, lower, right and upper mid points of the rectangle with which the image will be cropped (following exactly this order).
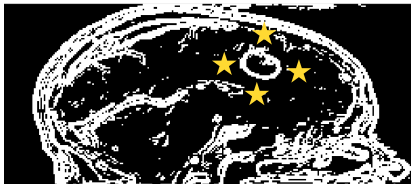

Fig. 4. Showing an optimal selection of the points to crop the image

F. Isolate the lesion

Now all the previously selected slices will appear in sequence, already binarized with highlighted edges accompanied by the original images. Therefore, the user can first select the pixels to be made black in order to isolate the lesion, as

shown in Figure 5, and then indicate a central point so that the program can fill the region (adjacent pixels) in white and isolate it from the background.
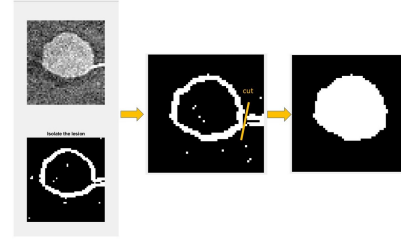

Fig. 5. Showing a successful isolation

G. Corrector Tool

Once the operation of isolation of all the slices has been carried out, there is the possibility for the user to correct certain slices that he believes contain obvious errors (for example, isolated black pixels may still be present inside the lesion). All the slices are shown in a cumulative single figure and the ones chosen will be zoomed in a bigger picture to make corrections. The slice already corrected will appear in the cumulative figure with an hashtag # after the slice number. It is essential that at the end of this operation (carried out by writing '0' in the appropriate prompt) all the pixels that *"belong"* to the lesion are white, because only they will enter the area calculation.
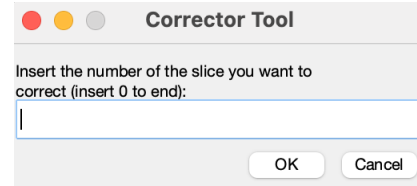

Fig. 6. GUI for insertion of the number of slices entering the corrector tool

H. Area and Volume calculation

At the end of the program all the white pixels of each image are considered, added together and multiplied by the surface of each pixel (0.9375 * 1.400, as indicated in the MRI). To calculate the volume, all the surfaces just calculated are added and multiplied by the thickness of one pixel (0.9375). We show the results obtained in Table I and II.

IV. CONCLUSIONS AND RESULTS

The values of the different areas referring to the different cases (clean image and noise) do not differ much more than expected. The reason why is because we performed filtering, as explained in III-C, before contouring the image. Therefore, our pipeline works pretty well with the majority of the slices, except for those which don't present a *"closed"* contour, however it's possible to correct them through the corrector tool.

TABLE I
AREAS OF THE SAGITTAL SLICES FOR THE THREE SCENARIO EXPRESSED IN MM^2

Slice	Clean Image	Salt and Pepper	Gaussian
109	119	89	119
110	213	205	208
111	297	269	301
112	373	334	376
113	466	441	207
114	551	521	206
115	631	625	644
116	727	688	728
117	780	761	790
118	840	812	846
119	890	861	906
120	934	902	944
121	963	916	970
122	978	950	1017
123	1010	962	1047
124	1024	979	1072
125	1022	983	1114
126	1013	972	1028
127	1026	992	1089
128	1038	1035	1092
129	966	948	1077
130	893	881	1088
131	912	894	1071
132	923	874	942
133	771	748	802
134	633	594	626
135	496	441	482
136	373	352	380
137	271	268	263
138	154	135	164
139	141	111	141
140	127	91	132
141	108	80	102
142	77	48	75

TABLE II
AREAS OF THE AXIAL SLICES FOR THE THREE SCENARIO EXPRESSED IN MM^2

Slice	Clean Image	Salt and Pepper	Gaussian
66	287	260	335
67	383	335	469
68	514	487	538
69	595	577	614
70	675	678	683
71	722	735	766
72	755	796	796
73	799	819	833
74	815	848	853
75	841	868	872
76	860	897	903
77	865	862	915
78	832	839	913
79	810	814	842
80	794	736	758
81	743	687	723
82	612	616	690
83	579	570	605
84	512	543	584
85	429	459	546
86	367	372	440