FAST AND AUTOMATIC TUMORAL AREA LOCALISATION USING SYMMETRY

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ABSTRACT

Our research deals with a fully automatic and fast localization of possible tumoral areas on computed tomography scanner (CT Scan) images. The aim of this method is not to segment tumors but only to highlight the areas where tumor has the greater probability to be located. To achieve this task, we use the bilateral symmetry of the human body and the asymmetry introduced by the presence of tumors. Our work was initially dedicated to the head and neck area but it should work well for any other body part and even better for more symmetric areas like the brain.

1. INTRODUCTION

When we look to an image, we first get a global view, than we "instinctively" focus very fast on some "interest regions" in order to get more information about them. We can say that our vision system has a bi-scale architecture: first a larger scale to have a global view where details are not so important and than, a finer scale to focus on details and to analyze an "interesting region". This is due to the fact that our environment is full of images and even a super-computer as our brain cannot directly analyze every detail of the huge amount of information surrounding us at each moment. In order to manage this complex vision situation, the brain use some characteristics to first provide a quick selection of potential interesting areas to reduce the amount of data to compute. Symmetry is one of the most important of these characteristics.

The idea of the method described in this paper came after an observation of the specialists modus operandi for tumor detection on CT Scan images. In their case, even more than in the every day life, they use this bi-scale approach because of the huge amount of data which is stored into a CT Scan image. Their tumor detection is based on several characteristics, but any lack of bilateral symmetry is for them a serious alert. The human body is quite symmetric and if asymmetry appears on some slices, there are very high chances to have a tumor which is located in this area. Actually, tumors are tissues which grow anarchically and do not care about symmetry.

That is only after remarking an asymmetric area that their attention grows and they look more carefully to the gray levels and to the structure regularity of the region of interest to precisely locate the tumor.

In this paper, after a short description of the previous work on symmetry, we will first show how we can compute the global symmetry on axial slices of CT Scan images. Then we will add some spatial information and we will show some of the preliminary results we already obtained. Finally we will conclude with promising perspectives for our approach.

2. PREVIOUS WORK

Symmetry is known as an important mechanism to identify the structure of objects and it was used in many domains. Most of the approaches use an a priori knowledge on the image and the kind of symmetry we are looking for (rotational or bilateral). One of the first studies was made by Atallah [1] and it needed objects to be presented as points, lines or circles. Some morphological methods as thinning or "grass fire" were tested but only on binary images. Xia [2] provided a survey which also showed the sensitivity of these methods. Reisfeld [3] provided a first symmetry detection which does not need object recognition or segmentation. Kovesi [4] managed to compute symmetry without any a priori on the image by using the local phase. An algebraic approach is presented by Keller [5] which is based on the Fourrier transform.

In the medical imaging field symmetry was mainly applied to the brain were statistical measures and symmetry axis computation methods were proposed by Tuzikov [6]. A tumor detection method using histograms was also proposed by Wang [7].

3. MATERIALS

For testing our approach we used CT Scan images because this modality is the most used in radiotherapy planning for two main reasons. The first reason is that scanner images

contain anatomical information which offer the possibility to plan the direction and the entry points of the radiotherapy rays which have to target the tumor and to avoid some risk organs. The second reason is that CT Scan images are obtained using rays, which is the same physical principle as radiotherapy. This is very important because the radiotherapy rays intensity can be computed from the scanner image intensities.

For the preliminary tests we present in this article we used images from three patients with very different tumors: these images contains sometimes infected ganglions, tumors close to the tongue in the higher part of the neck or closed to the larynx in the lower part of the neck.

4. GLOBAL SYMMETRY MEASURE

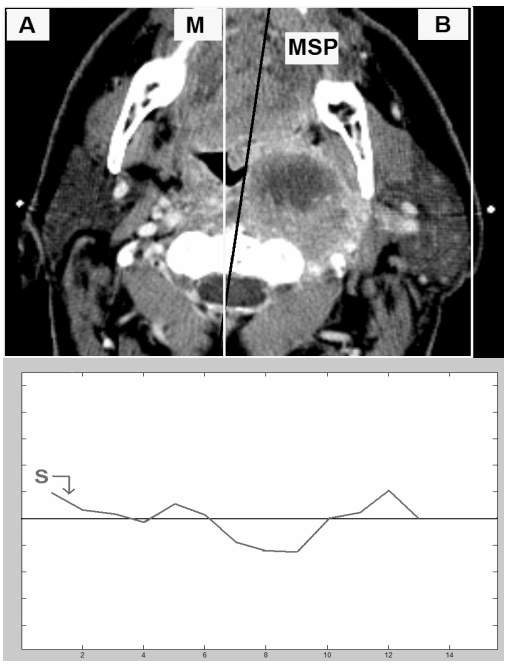
First of all, according to our bi-scale approach, the symmetry is a fast large scale characteristic. Large scale means that details are not interesting and we look to the image as if we were far from it. This means that a low definition image is enough.

Scanner images contain information on 12 bytes, so 4096 gray levels. This range is reduced by the medical doctors to a window of 8 bytes centered on the tissues were tumors are possibly localized which are mainly the muscles.

For our algorithm we used just 12 gray level images. We made tests with other numbers of gray levels and if we keep a high resolution as 256 gray level, we found much noise in symmetry computation and results are less interesting. Moreover it is more difficult to choose the remaining asymmetric gray classes. These tests showed that low resolution is not only used for computation reasons but it is very important for the final results. We see here again that symmetry is a large scale characteristic.

We will use here an a priori on the type of symmetry we are looking for: the human body has a bilateral symmetry on its vertical axis according to the Mid Sagittal Plane (MSP). This MSP is a very important parameter: this is the symmetry plane (*Image 1*). We first tried to co-register the image with its left to right flipped image. But this method is slow and results are sometimes surprising. So we decided to concentrate our study on the airways: tumors are often located in this area because smoke and alcohol which are the main head and neck tumor factors have a direct contact with the airways.

As it was difficult to find a good MSP, we decided to use a vertical axis called “M” on Image 1 and located in the middle of the throat which should be on the MSP. The symmetry is simply computed by subtracting the histograms of the windows “A” and “B” centered on the “M” axis (*Image 1*). We obtain the result called “S” on *Figure 1*. The result is normalized for each bean in order to avoid false alarms with classes having many pixels.



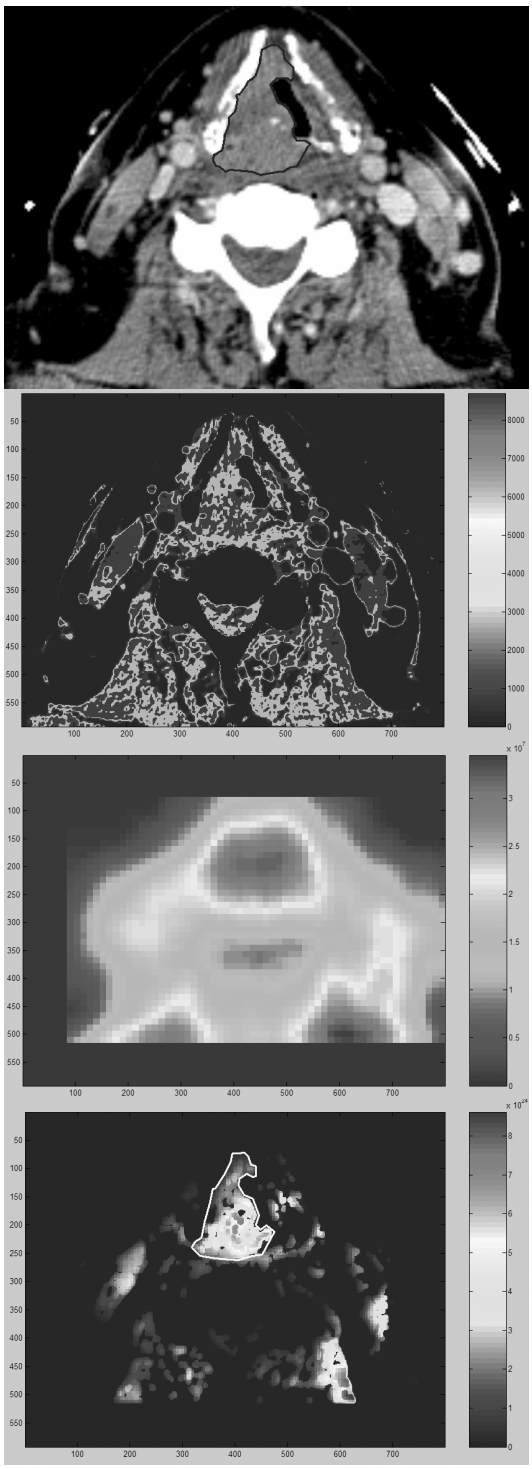
Top -Image 1: Symmetry Axis
Bottom -Figure 1:Assymetry classes

When the “S” curve is close to the horizontal axis, the gray levels are quite symmetric: there are as many pixels of this gray level on both parts of the symmetry axis. When the curve “S” is far from the horizontal axis we have asymmetric gray levels.

We also can see if the asymmetry is due to pixels on the right or left side and to locate the side where the tumor is. We assume that the tumor is located on the side of the most important asymmetric classes which was verified on all our images.

When we reconstruct an image from the “S” curve we get the *Image 3*. On *Image 2*, we can see the initial CT Scan and the specialist segmentation. The *Image 3* is obtained by assigning to the 4 more asymmetric classes the values they have on the “S” curve. In all cases the two classes with the highest asymmetry are enough to describe a coarse tumor location, but we consider 4 classes to avoid to loose any useful information about the tumor as our first image database is not yet representative. We do not use more classes because they just introduce useless noise.
We only made 2D tests until now but at this stage we should have enough information to detect if tumors are suspected in a slice or not. We just have to compute the asymmetry classes on all the slices and compare there values. If asymmetry dramatically grows on a compact set of slices, tumors are probably located within these slices.

This global symmetry measure was implemented in Matlab and it only uses a simple thresholding to locate the airways, a bounding box of the airways to get the “M” axis and a 12 bins histogram subtraction.



From top to bottom:
Image 2: Original image and specialist's segmentation
Image 3: Asymmetry classes on the image
Image 4 : Spatial information
Image 5: Final result and specialist segmentation

The hole process needs a mean of 1.5 seconds under Matlab. Even for modern scanners with a 1 mm resolution on the Z axis and their almost 260 slices should take only 6.5 minutes in Matlab. This relative time should dramatically decrease after a C implementation.

5. SPATIAL INFORMATION

Until this point we just made a global asymmetry study. As you can see on *Image 3* even if we visualize better the gray levels composing the tumor, there is still a lot of noise (as muscles have often gray levels closed to tumors). We rapidly get some spatial information by computing for each asymmetric class the sum on a large window (160 pixels size). This is equivalent to a median filtering.

The spatial map is computed in *Image 4*. The resolution is very low because of the large window size used for the filtering but we get images where the approximate tumor locations is quite clear. This images are quite similar to those of functional images as PET images (Positron-Electron Tomography).

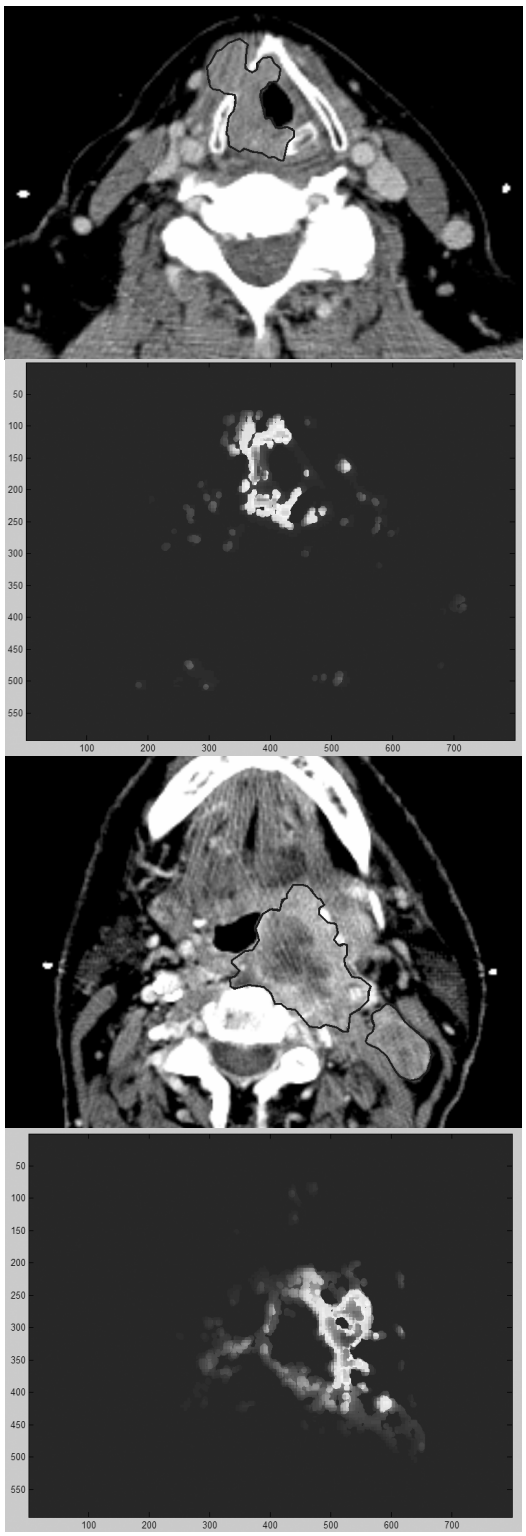
By multiplying *Images 3 and 4*, we can mix the information from the global asymmetric classes with the spatial information. We do not obtain a good spatial definition which is not our purpose but we eliminate much of the noise. After an image opening and a median filtering we get the final *Image 5* where the tumor is well highlighted. The two last steps use textural information.

These spatial computations should be applied only on the sets of slices eventually containing tumors and detected by the global symmetry to avoid useless computation. In Matlab the spatial information add a mean of 20 seconds. Usually there are not more than 30 slices were the tumor is located in, so the hole time to have a 3D approximation of the tumor should be about 10 minutes. In this case too, the C implementation should highly decrease the computation time.

6. RESULTS

We can see some results from the *Images 6 and 8* where you can see the specialist segmentation. Even if this method aims only to visualize the suspect gray levels, very difficult tumors are well detected and almost segmented (*Images 7, 9*)! We made some preliminary tests on several patients with tumors located closed to the throat and larynx, and each time we had a positive asymmetry response in the majority of the slices containing the tumor. As we use the image intensity information, some tumor parts as the necrosis or sometimes some peripheral tissues considered as tumoral but having different gray levels are not detected for instance.

No parameter is needed except the filtering window size which can be fixed once. All the process is fully automatic and fast.



From top to bottom:
Image 6: Original image and specialist's segmentation
Image 7: Final result
Image 8 : Original image and specialist's segmentation
Image 9: Final result

7. PERSPECTIVES

The purpose of this research is to obtain a system which will be able to rapidly detect the potential tumoral area and show a coarse location of the tumor in this volume. This visualization should be a considerable help for the medical doctors who will only have to validate or not these first results. They will be able to spend more time with the patients then with their computer screen.
Another major effect is that as tumors are quite well located, other finer scale segmentation methods can be used to refine these results. Seeds or other initial model parameters could be automatically initialized from the first large scale analysis and reproduce the entire bi-scale human vision model.

8. CONCLUSION

This work is still at its beginning but the first results are already encouraging. First of all more tests are needed and the 3D generalization should be done rapidly. This generalization could bring some more information by comparing the asymmetric classes in neighbor slices. Finally the algorithm will be implemented in C to make it faster. We will also try this method on other body parts as the brain where it should work too. And last but not least we will try to incorporate finer scale methods to accurately and (semi)automatically segment the tumors.

9. REFERENCES

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