Segmentation of Magnetic Resonance Brain Images Using Edge and Region Cooperation Characterization of Stroke Lesions

Yazid Cherfa,(1) Assia Cherfa,(1) Yacine Kabir,(1) Sammyh Kassous,(1)
Assia Jaillard,(4) Michel Dojat, (3) and Catherine Garbay(2)
(1) Laboratoire LARIM, Dpt d'électronique, Université de Blida, Algérie
(2) Laboratoire CLIPS, Université Joseph Fourier, France
(3) Unité mixte INSERM/UJF 594, CHU, France
(4) CHU Michalon de Grenoble, Département Neurologie, France

Abstract: *This paper describes an MR brain image segmentation system based on an edge and region cooperation. After an appropriate preprocessing using an improvement of image quality and brain insulation, we apply the cooperative segmentation to the preprocessed image. This segmentation is evaluated thereafter on reference image. The procedure is applied to several MR images from different subjects having undergone a cerebral vascular attack (stroke), this in order to extract the lesion and characterise them. Furthermore a comparison of our results with these obtained from manual measurements carried out by neurologists is presented.*

Keywords: *Magnetic resonance image, anisotropic filtering, brain segmentation, stroke, characterisation.*

Received May 8, 2006; accepted September 14, 2006

1. Introduction

The brain MRI is an image processing technique that can be used to study the evolution of brain pathologies such as the Alzheimer disease or the cerebral vascular accidents (Stroke). The detection and the characterisation of cerebral structures or cerebral lesions (ischemic lesions for example) in time are indeed important diagnosis elements to monitor. The most important step of the whole procedure is the segmentation phase. Image segmentation is still an unsolved problem [2, 4, and 5], its application to the brain MRI remains a subject of intensive research work [3, 9, 10, 11, and 15]. The brain complexity together with images artefacts and the fact that there exist different images to use the segmentation results contribute to make this procedure even more difficult. Our work is a minor contribution to this very wide field of research.

In evaluating therapies for ischemic stroke patients, many physicians are interested in finding consistent, reliable estimates of lesion volume from MR images [14]. The traditional way for assessing stroke patients is based on a manual segmentation as shown in Figure 1, it consists of a manual tracing of the stroke regions on all contiguous slices in which the lesion was judged to be present.

Practically, the tracing is performed by a Human operator (expert) by pointing and clicking using a mouse-controlled cursor. A simple program connects consecutive points with lines. The lesion region is defined by a closed contour, and the program labels every voxel of the enclosed volume and computes the elementary surface. The volume size is estimated by adding all elementary surfaces of all slices.

This manual segmentation is accurate but is both time consuming and subject to manual variation. Another disadvantage of this intervention is their reliance upon subjective judgments, which raises the possibility that different observers will reach different conclusions about the presence or absence of affected tissue, or even that the same observer will reach different conclusions on different occasions [7].

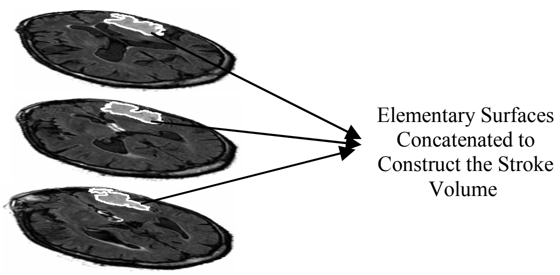


Figure 1. Manual segmentation slice by slice to construct the stroke volume.

In order to resolve the problems listed above, we propose a semi automatic method which consists in segmenting the stroke lesions, after that has been localised by a physician, and to compute some particular geometric features such as the volume, the centre of gravity, the shape, etc. We are interested in preprocessing and segmenting the MR image. Usually, MR Images are corrupted with different kinds of artefacts: the noise, the bias that results from the field inhomogeneities, the inaccuracies due to the patient eventual movements and the partial volume effect [16]. The main parts of our design can be summarised by the bloc diagram represented in Figure 2. The purpose of the first operation is to improve the image quality using a suitable preprocessing before the segmentation step. This is followed by a skull stripping (brain insulation) in order to avoid segmentation errors.

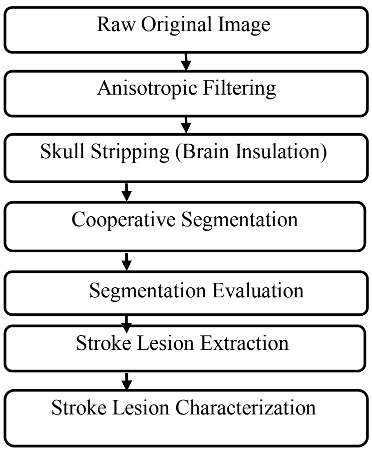


Figure 2. Bloc diagram of the system.

The most important part of the system is the segmentation; it's based on the duality between edge detection and region extraction, it uses a combination of these two tasks. Our 2D segmentation method is evaluated by a comparison to a reference image. It is then applied to stroke images. The advantages of this approach are discussed; this is based on a comparison with the results obtained manually by neurologists.

2. Preprocessing

Preprocessing in image analysis is compulsory, particularly the filtering and the contrast stretching. The segmentation results are closely related to this first step. Indeed, these some operations will allow us to obtain the best possible images that are a very good representation of the actual images, with a high degree of accuracy and reliability.

2.1. Anisotropic Filtering

MR images are strongly corrupted by noise generated by the acquisition system. In order to improve the image quality, we use the technique of anisotropic filtering which allows us to apply a simultaneous filtering and contrast stretching. This kind of filtering belongs to the larger family of Edge Preserving Smoothing Filtering (EPSF) [8, 12]. These filters preserve the edges of the objects while filtering the homogeneous zones. This filtering is based on the anisotropic equation of diffusion (1):

$$\frac{\partial I}{\partial t} = div\left[c(f,t).\nabla I\right] \tag{1}$$

where c (f , t) depends generally on the derivative modulus of f, it reaches a maximum when the derivative is equal to zero and it decreases when the gradient increases. We generally choose equations (2) or (3) according to the expected result, this could be an edge detection or a region extraction.

$$c(f,t) = \exp\left(-\frac{|\nabla f|^2}{k^2}\right) \tag{2}$$

$$c(f,t) = \left[1 + \left[\frac{|\nabla f|}{k}\right]^{1+\alpha}\right]^{-1} \tag{3}$$

where k is the diffusion coefficient; it is proportional to a gradient and characterises the amplitude of the gradients that control a strong diffusion:

- If $\nabla f \approx$ k, the diffusion is strong.
- If $\nabla f <<$ k, the diffusion is very weak because the region is regarded as already smooth.
- If $\nabla f >> k$, the diffusion is not carried out because it considered that there is already an edge which has to be preserved by the diffusion.

This iterative filtering operation delivers a simplified image at each iteration; it therefore belongs to the range of multi scale filters.

In order to apply this filter, we must choose an appropriate k and the total number of iterations that have to be executed. This number has been fixed to 3 iterations as proposed in [8]. The k coefficient influences strongly the smoothing result of a region. In fact, the filter does the smoothing when the region is corrupted and the gradient is close to k. We have fixed k to 14, as this leads to edge preservation and smoothing of homogeneous regions. Also, it should be mentioned that the contrast stretching is fulfilled; this results from the anisotropic diffusion principle.

2.2. Skull Stripping (Brain Insulation)

The goal of this phase is to extract the brain from the acquired image; this will allow us to simplify the segmentation and the characterisation of the stroke [12]. The problems in this operation are the existence of noise on the image and the non-uniformity of the grey levels of the image background. Several methods based on the use of deformable models and mathematical morphology has been proposed. Our original method can be divided in six steps:

2.2.1. Binarisation

Fixing an adequate value of a threshold *S*, the background noise contained in the original image is decreased as shown in Figure 3-b. This is achieved using the following test:

$$I_B(x,y)=\begin{cases}0 & If\ I_{orig}(x,y)<S\\ 255 & If\ I_{orig}(x,y)>S\end{cases} \quad (4)$$

2.2.2. Filtering

The resulting image is filtering using a mean filter; this will decrease the noise present on the input image. This is illustrated in Figure 3-c.

2.2.3. Dilation

This operation consists of eliminating all remaining black spots on the white surface of the image. These spots are covered by the dilation of the white parts. This process is carried out by moving a square $(N\times N)$ mask on our image and applying the logical OR operator on each of the (N^2-1) neighbouring pixels (Figure 3-d).

$$I_D(x,y)=\begin{cases}I_f(x,y) & \text{If the OR operation gives 1}\\ 0 & \text{Otherwise}\end{cases} \quad (5)$$

2.2.4. Erosion

On the other side, the process of erosion consists on applying the logical *AND* operator on the (N^2-1) neighbouring pixels. After this operation, all white spots of the image disappear.

$$I_E(x,y)=\begin{cases}I_D(x,y) & \text{If the AND operation gives 1}\\ 0 & \text{Otherwise}\end{cases} \quad (6)$$

2.2.5. Filling the Holes

The remaining holes in the image are filled using the following procedures:

- *Labelling:* it consists to assign the same label to the black marked pixels that belong to the same connected component.
- *Centre of gravity computation of each component of the labelled image.*
- *Filling the holes:* This step is carried out by checking, for each connected "child" component, whether its centre of gravity belongs to another connected "parent" component whose number of pixels is higher than that of the "child". If this is the case, the grey level of the "child" will be replaced by that of the "parent" (Figure 3-f).

2.2.6. Image Masking

The binary image or the obtained mask is combined with the original image using a logical operator. To extract the cortex, we apply the *OR* operator as shown in Figure 3-h, otherwise we use the *AND* operator to extract the brain as shown in Figure 3-g.

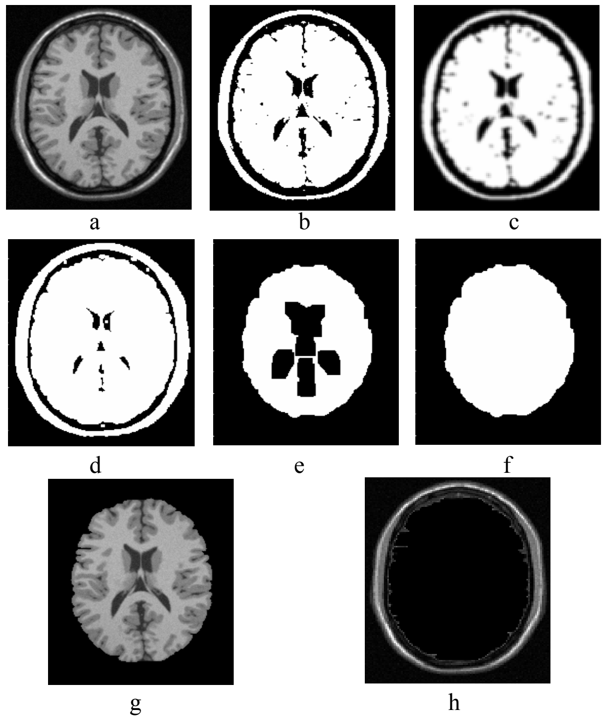


Figure 3. Brain extraction steps.

3. Cooperative Segmentation

This cooperation is based on the edge-region duality, and summarised by the bloc diagram as shown in Figure 4.

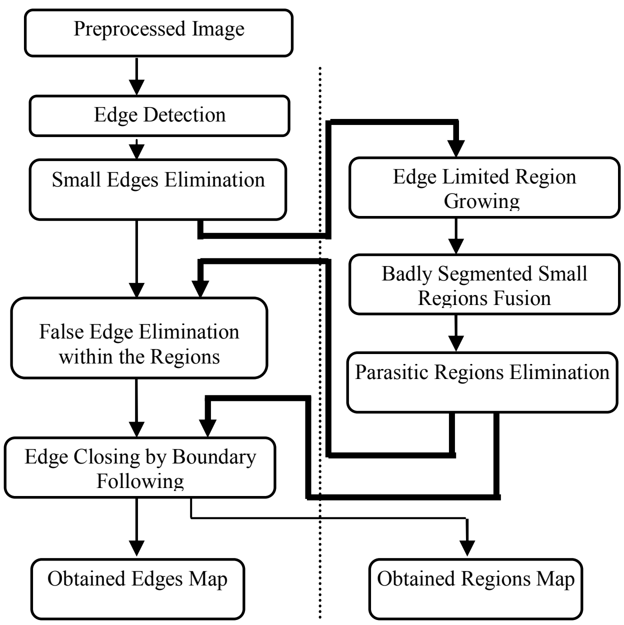


Figure 4. Cooperation block diagram.

3.1. Edge Detection

This is carried out using the Deriche operator [1, 6]. In addition to its robustness, the latter has the advantage of giving the possibility to change the parameters according to our needs. This operation uses an optimal infinite impulse response filter as expressed by the following equation:

$$X \in [-\infty, +\infty]: f(x) = -c \times e^{-\alpha \times |x|} \times \sin w \times x) \quad (7)$$

This method can be divided into the following steps:

- This filter is applied along the x and y directions.
- Derivatives computation with respect to x and y.
- Norm image gradient computation.
- Local maximum extraction.
- Thresholding by hysteresis.
- Edge image creation.

3.2. Small Edges Elimination

In this step, we use a thresholding to eliminate the false edges, due to the eventual presence of disturbed or textured regions. These edges are rather shorts and without semantic interpretation. The used threshold depends on a priori information about the image to be analysed.

3.3. Region Growing

The isotropic growth used [3, 9] is conditioned by the edges, it must also obey to a double criterion; the growing procedure is stopped if:

- The homogeneity criterion is not fulfilled;
- The analysed pixel belongs to an edge chain.

The homogeneity criterion used is the grey level difference. The following consists in placing the seeds at the places within the zones of interest. The isotropic growth is carried out by sequentially testing the seed neighbouring pixels without giving privilege to any direction.

3.4. Badly Segmented Small Regions Fusion

Unwanted small regions are generated because of the edge constraint and the segmentation parameters choices. To correct this problem, these will be merged with the parent region. This method is based on a triple test: on their size, on the grey level comparison with that of the parent region, and on the fact that they coincide with edge pixels. These small regions must be merged with adjacent region having the closest grey level as shown in Figure 5.

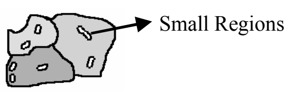


Figure 5. Example of region fusion.

3.5. Removing the Parasitic Regions

After the growing operation, we sometimes have the apparition of small parasitic areas between two adjacent regions. Again, in this case, we proceed as above, i. e. these areas are merged with the closest regions that have the nearest level of grey.

3.6. False Edge Elimination

In addition to the above operation, we must take into account the existence of eventual false edges within homogeneous regions. If this is the case, they must be removed.

3.7. Edge Closing

Segmentation produces some edges that are rarely closed. In order to complete the closing of all the edges, we use the data from the region map that will give us the possibility to follow the closest boundary in terms of the Euclidian distance as shown in Figure 6.

Figure 6. Example of edge closing.

The overall result of segmentation is therefore the availability of two compatible maps, edge and region maps.

4. Segmentation Evaluation

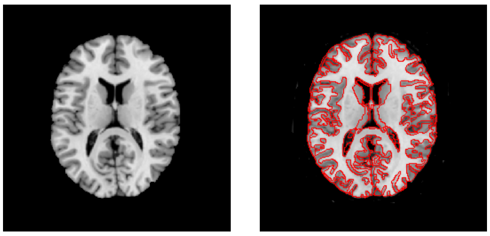
To validate the results obtained by our method, an evaluation of the segmentation will be carried out. Several methods have been proposed in the literature [16]. We have chosen the Pratt method; it's used to assess performance of edge segmentation techniques. This approach is based on the use of a reference image as a ground truth. This allows us to quantify the performance of our segmentation compared with that obtained from a manual segmentation.

Let us consider an edge map A and a reference map I, we define the Pratt index by the following expression:

$$F(I, A) = \frac{1}{\max(I_A, I_i)} \times \sum_{i=1}^{I_A} \frac{1}{1 + \alpha d^2(i)} \quad (8)$$

where *d(i)* is the distance between the edge pixel *i* of map A and the closest edge pixel of the reference map I, I_A and the I_i are the number of the edge pixels of the A and I maps respectively.α is a sealing coefficient used to have $0 \le F \le 1$

A good segmentation is obtained (comparable to that of the reference image) if F is close to 1. The ground truth image used in our application is an MR image manually segmented by a medical expert as shown in Figure 7.

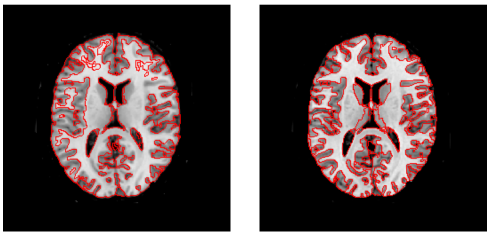


(a) (b)

Figure 7. Original image and reference segmented image.

4.1. The Anisotropic Filtering Effect

The following experiment will show the influence of the anisotropic filtering on the segmentation quality. We use the cooperative segmentation with the same parameters applied on both the preprocessed image and the unprocessed image as shown in Figure 8.Then we use the Pratt index F to evaluate the effect of anisotropic filtering as shown in Table 2.



(a) (b)

Figure 8. (a) The processed segmented image, (b) Anisotropic filtering segmented image.

Table 1. Pratt Index for various segmentations

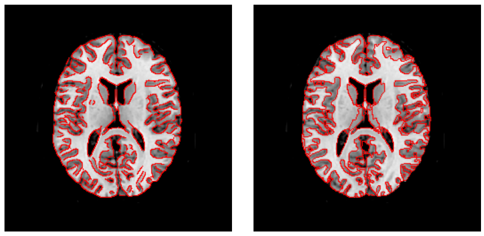
Segmentation	F Index
Unprocessed Segmentation	66,75%
Anisotropic Filtered Segmentation	71,13%

From Table 1, we can clearly see that using a suitable preprocessing improves the segmentation quality.

4.2. The Cooperation Effect

In this experiment, we will show the effect of cooperation on the segmentation results. We apply the Deriche operator and our cooperative approach to the same reference image using the same preprocessing as shown in Figure 9 and Table 2.

The cooperation effect gives also an improvement in the segmentation results. Using the Deriche edge extraction as followed by an application of the cooperative approach improves the segmentation quality.



(a) (b)

Figure 9. (a) Deriche segmented preprocessed image, (b) Our approach segmented preprocessed image.

Table 2. Cooperative effect

Segmentation	F Index
Deriche Operator	64,27%
Our Cooperative Approach	71,13%

5. Applications: Extraction and Characterisation of Stroke Lesions in MR Brain Images

Our system will be used to characterise the stroke region in the brain of an affected patient. Because the procedure of this characterisation is not automated, the user must choose the region to be segmented by manually choosing the growing seeds positions on the stroke lesion. This procedure allows to extract the lesion and to characterise it by some geometrical measurements. We have used three acquisition sequences: Diffusion images, Flair images and T2-Weighted images as shown in Figure 10. a, b, and c. The MR Images are acquired in 3D and are converted in 2D slices (18 to 20 in our case). For each MR image sequence, we used one slice in order to study the evolution of two geometrical characteristics: surface and distance between centres of gravity of the brain and the lesion.

5.1. Preprocessing

In the first step, we apply the anisotropic filtering followed by an extraction of the brain from all images as shown in Figure 10, d, e, and f.

5.2. Segmentation and Characterization

The cooperative segmentation described previously will be applied to extract the stroke lesion which will be characterised using the calculation of it surface, its centre of gravity and that of the brain.

5.2.1. Surface Calculation

This calculation is carried out by counting the number of pixels of the extracted stroke image.

5.2.2. Centre of Gravity Calculation

The centre of gravity coordinates are calculated in the following way:

$$X = \frac{\sum_i m_i x_i}{\sum_i m_i} \quad , \quad Y = \frac{\sum_i m_i y_i}{\sum_i m_i} \tag{9}$$

where xi and yi are the coordinates of the region perimeter points and mi their grey level.

The coordinates of the two centres of gravity (brain and lesion) allow us to calculate the distance between them and informs us about the stroke position. These measurements will be compared with those obtained from medical experts.

5.3. Stroke Medical Expertise

In order to validate this semi-automatic characterisation, a medical expertise is essential. To achieve this, we have developed software that will allow the physicians to delimit the lesion edges on MR brain images. The obtained region is characterised by a similar routine to that of the semi-automatic method. This is illustrated by Figure (10. j, k, l).

5.4. Results and Discussion

In tables 3 and 4, we have gathered all the obtained results. Analysing the above results, the following observations can be made:

- The cooperative segmentation allows an efficient stroke lesion extraction.
- A comparison of the surface of the stroke using both methods shows that the results are very close (2 - 4% error).
- The two methods give very similar values of the stroke centre of gravity.
- The cooperative segmentation simplifies the extraction and the characterisation of the stroke from MR Images. This can be viewed as a minor contribution for stroke diagnosis.
- In addition to its simplicity, the overall procedure is computed in less than 5 seconds.

Table 3. Comparison between stroke surfaces extracted by our method and a medical expertise.

Method	Surface Coop	Surface Exp	Error
Diffusion	2589	2482	4,1%
Flair	2529	2590	2,4%
T2	2655	2595	2,3%

Table 4. Comparison between the co-ordinates of stroke gravity centres extracted by the two methods

Method	Co-ordinates (x, y) of GC segmented stroke	Co-ordinates (x, y) of GC expertised stroke
Diffusion	(173,100)	(172,99)
Flair	(171,97)	(170,96)
T2	(173,101)	(172,100)

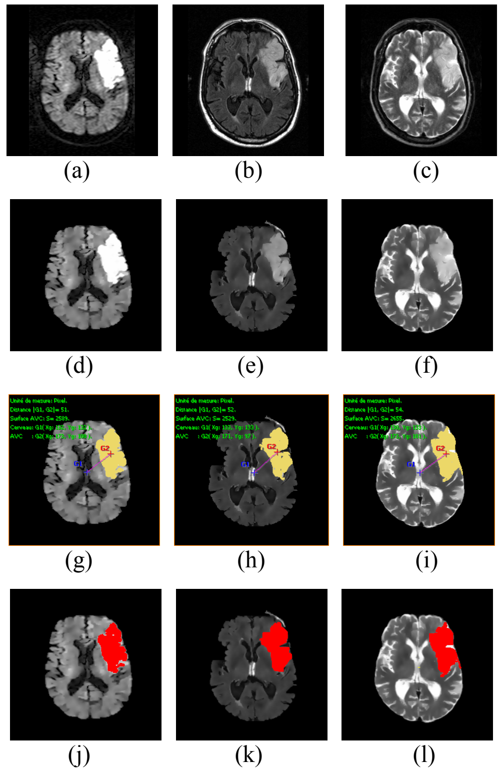


Figure 10. Multi-sequence MR Images (a) Diffusion; (b) Flair; (c) T2-weighted; (d) Preprocessed images; (e), (f), (g) Segmented and characterized images by our method; (h), (i), (j) Manually expertised and characterized images, (k), (l).

5. Conclusion

We have introduced a simplified method that can be used to improve the different steps results applied to medical images.

Our method uses adequate pre-processing followed by an edge-region cooperative segmentation technique to extract stroke lesions. The segmentation allows the characterisation of stroke affected regions; this will give the possibility to study the time evolution of some particular attributes From a medical point of view, this tool improves the harnessing of the information contained in medical images by a better characterisation of the affected regions and cerebral plasticity. It can help and assist physicians in the diagnosis of stroke lesions. This provides information that is clinically relevant to the prognosis of the disease. This system is being applied to study the time evolution of the lesion for 50 stroke patients.

From a methodological point of view, this work is part of a more complete project that aims at an automatization of the cooperative segmentation.

7. Acknowledgments

This work was supported by a special cooperation programs CMEP 03MDU588 between the Saad Dahlab University of Blida (Algeria) and the Joseph Fourier University of Grenoble (France). Many thanks to a neurology department of Grenoble hospital that provides us with the stroke MR Images. The present paper was translated with the help of Dr B.Kazed.

References

[1] Canny J. F., "Finding Edges and Lines in Images, ". *MIT Artificial Intel. Lab*, Cambridge, MA, REP. AI-TR-720, 1983.

[2] Cherfa Y. and Kabir Y., "X-Rays Image Segmentation, "*IEEE-EURASIP Workshop on linear Signal and Image Processing*," 20-23 June 1999, Antalya, Turkey.

[3] Cherfa Y., Jaillard A., Cherfa A., Kabir Y., Kassous S., Gaceb D., Garbay C., and Dojat M., "Segmentation coopérative d'images RMN cérébrales ," *in Proceedings of JETIM'2004*, pp. 35-41, Blida, Algérie, 2004.

[4] Cocquerez J. P. and Philipp S., *Analyse d'images: Filtrage et Segmentation*, Edition Masson, 1995.

[5] Darbane S., Drai R., Cherfa Y., and Kabir Y. "Detection of Welding Defects in X-Ray Images by Image Segmentation," *Annales de Chimie - Science des Matériaux*, vol. 22, no.143, 1997.

[6] Deriche R., "Using Canny's Criteria to Derive a Recursive Implemented Optimal Edge Detector," *International journal of computer vision*, vol. 1, no. 10, pp. 167-187, 1987.

[7] Fiez J., Damasio H., and Grabowski. G. "Lesion Segmentation and Manual Warping to a Reference Brain: Intra- and Interobserver Reliability," *Human Brain Mapping*, vol. 9, no. 4, pp. 192-211, 2000.

[8] Gerig G., Kübler O., Kikinis R., and Jolesz F. A. "Nonlinear Anisotropic Filtering of MRI Data," *IEEE Transactions on Medical Imaging*, vol. 11, no. 2, pp. 221-232, 1992.

[9] Hojjatoleslami S. A. and Kruggel F., "Segmentation of Large Lesions," IEEE Transactions on Medical Imaging, vol. 20 no. 7, pp. 666-669, 2001.

[10] Martel A. L., Allder S. J., Delay G. S., Morgan P. S., and Moody A. R. , "Measurement of Infarct Volume in Stroke Patients Using Adaptive Segmentation of Diffusion Weighted Mrimages", *MICCAI'99 of Computer Science*, vol. 1679, pp. 22-31, Springer, 1999.

[11] Pham D. L., Xu C., and Price J. L., "A Survey of Current Methods in Medical Segmentation", *Technical Report JHU/ECE 99-01*, University of Baltimore, USA, 1999.

[12] Schiess M., "Segmentation d'image anatomique du cerveau chez l'adulte", *Thèse de l'école d'ingénieurs de Genève*, December, 2003.

[13] Shattuck D. W., Sandor-Leahy S. R., Schaper K. A., Rottenberg D. A., and Leahy R., "Magnetic Resonance Image Tissus Classification Using a Partial Volume Model", *NeuroImage*, vol. 5, no.13, pp. 856-876,, 2001.

[14] Stein B., Lisin D., Horowitz J., Riseman E., and Whitten G., "Statistical and Deformable Model Approaches to the Segmentation of MR Imagery and Volume Estimation of Stroke Lesions*," in Proceedings of MICAI*, vol. 4, pp. 14-17, 2001.

[15] Yu S., Pham D., Shen D., and Gerskovits E., "Automatic Segmentation of White Matter Lesions in T1-Weighted Brain MR Images", *in Proceedings of IEEE Int. Symposium on biomedical Imaging*, pp. 253-256, Washington, July 2002.

[16] Zhang Y.J, "A Survey on Evaluation Methods for Image Segmentation", *Pattern Recognition*, vol. 29, no. 8, pp. 1335- 1346, 1996.

Yazid Cherfa received his PHD degree from the National Polytechnic Institute of Grenoble, France. Currently, he is a lecturer at the University of Blida. He is also actively involved in the medical imaging research laboratory. He has been working on the image processing area for 15 years. He is a major member at the special cooperation program CMEP 03MDU588 between University Saad Dahlab of Blida and University Joseph Fourier of Grenoble. In 2005, he set up the medical imaging research laboratory at the University of Blida, where the work is emphasised on the ultrasonic, MRI, microscopic and radiological Images. His area of interests includes image analysis and particularly the segmentation part and all the mathematical tools applied to this area.

Assia Cherfa received the State Engineering Degree from National Polytechnic Institute of Algiers in 1981, and the PhD degree from the National Polytechnic Institute of Grenoble, France 1985. Since 1985, she is a lecturer in the electronic department of Blida, University in Algeria. She is a major member at the special cooperation program CMEP 03MDU588 between University Saad Dahlab of Blida and University Joseph Fourier of Grenoble. She is also actively involved in the medical imaging research laboratory at the University of Blida. Her area of interests includes image analysis and all the mathematical tools applied to this area.

Yacine Kabir received the State Engineering Degree and the Msc degree in electronic engineering from the University Of Blida, Algeria, in 1995 and 1999, respectively. He is working towards his Phd degree jointly at the University of Science and

Technology of Algeria (USTHB) and CLIPS-IMAG CNRS laboratory in France. From 1996 to 2002, he worked as a research officer in the welding and testing research centre (CSC), Algeria. Currently, he is a lecturer in the electronic and computer science departments of Blida University in Algeria. He is also actively involved in the medical imaging research laboratory. His Area of interests includes image processing, pattern recognition, distributed artificial intelligence, parallel computing algorithms and the application of digital image analysis in the field of medical imaging.

Sammyh Kassous received the technical baccalaureate in 1995. His studies focus in electronics at university and AHLAB of lind. The State Engineering in electronics in 2002 option controls. Enquiring student (Master) in medical imagery since 2003 in LARIM Laboratory Research in Medical imagery.

Assia Jaillard received her diploma in medicine in 1991 from the Grenoble University and her "DEA" in neuropsychology in 1993. Currently, she is preparing a thesis in neurosciences. She is neurologist practitioner in a stroke unit university hospital Grenoble in Departments of neurology and member of INSERM U438. Her area of interests includes the neurosciences, the functional imagery and the field of accurate ischemic stroke, where she has many publications in international revues.

Michel Dojat received his engineer diploma in physics from the Institut National des Sciences Appliquées, Lyon, France in 1982, his PhD degree in computer science in 1994 from University of Compiègne, Compiègne, France and 'Habilitation à Diriger des Recherches' in 1999 from University J. Fourier, Grenoble, France. Currently, he is working as research engineer in an industrial research center, Télémécanique, Nanterre, France, on the modelisation and design of sensors for the supervision of industrial processes. Since 1988, he joined INSERM (Institut National de la Santé et de la Recherche Médicale) as research engineer. During the period 1988-1998, he worked on the construction of AI-oriented systems for the supervision of artificially ventilated patients. Presently, he is involved in human brain studies based on functional neuroimaging. His area of interests includes Artificial Intelligence in medicine, physiological signal and medical image analysis, and cognitive science.

Catherine Garbay received her PhD in Computer Science from Institut National Polytechnique de Grenoble in 1979, and the degree of Docteur es Sciences from Université Joseph Fourier (Grenoble) in 1986. Currently, She is employed by the CNRS as Research Director. After several years of research in the field of biomedical informatics, within the TIMC (Techniques de l'Imagerie, de la Modélisation et de la Cognition) laboratory, she has moved and is now director of the CLIPS (Communication Langagière et Interaction Personne Système) laboratory in Grenoble. She has been involved in several european research projects in the framework of the CEE DGXIII AIM (Advanced Informatics in Medicine) and Telematics programmes and has been involved several times in the refeering process of these programmes. Since 2003, she has been acting as expert for the CEE IST-FET-Open call and the Cogntive System call of the 6^{th} Framework programme. She is a member of several editorial boards and scientific committees at the national and international level. Her area of interests includes in the design of computer system able to develop complex interaction schemes with their physical and human environment.