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Detection and GTV Definition of Brain Tumors in MRI Images Using Image Processing Technique

Abdoelrahman Hassan A. B [1, 2, 3], M. E. M. Gar-elnabi [1, 2]

[1]Sudan University of Science and Technology, College of Medical Radiological Science, Khartoum, Sudan

[2]Radiology department, Elnileen Diagnostic Medical Center, Khartoum, Sudan

[3]Radiology Department, Antalya Medical Center, Khartoum, Sudan

Abstract: ***This was experimental study conducted to detect and determination of the GTV for radiotherapy planning in brain tumor in MRI images using edge detection and image processing techniques. For brain MRI images was done using GE MR Scanner (1.5 tessla) then treated as dicom format preparing for image processing program (IDL), where the region of interest segmentation was studied. The scanned image was saved in a TIFF file format to preserve the quality of the image in order to segment the background from the foreground brain tissue. Brain tissue can be easily detected in MRI image because it has better image contrast and resolution. T_1 weighted images with gadolinium contrast enhancement where used in this study. We use the histogram equalization function for more uniform pixel distribution and differentiation, edge detection and basic morphology tools to detect a tumor margin using laplacian filter, Roberts and sobel function of edge detection and label region segmentation after thresholding process of tumors intensities. The results of this study were that it showed an alternate method for displaying, detection and tumor delineation accurately, where the outline was drown around the irregular tumor margin accurately and the GTV was identified for radiotherapy further planning. Those processing approaches can help in achieving of radiotherapy goals and for better diagnosis also by increase diagnostic information of Brain tumors in MRI.***

Keywords: Gross target volume, Hassan, Brain tumor, radiotherapy, MRI.

1. Introduction

Primary tumours of the central nervous system (CNS) are relatively uncommon, accounting for only 2% of cancer deaths [2]. However, the effect on the individual with a primary CNS tumor is frequently devastating, and brain tumours lead, on average, to a greater loss of life per patient than any other adult tumor. Primary CNS tumours affect patients of all ages, from childhood to old age, with a rising incidence from middle age onwards. In childhood, they are the commonest solid tumours (as opposed to leukaemias). The overall annual incidence is around 7 per 100 000 population, giving approximately 4400 people newly diagnosed with a brain tumour in the UK each year [2]. Many type of tumors arising from the brain tissue, overall, about 80% of CNS tumours are primary and 20% secondary. However, the proportions depend exactly on how the patient population is gathered. In our center, approximately 200 new CNS cases are seen per year, and only 6% are due to metastases. Intrinsic tumours (i.e. those arising within the brain substance) which are Glial tumours, Astrocytoma, Oligodendrogliomas, Oligoastrocytoma, Glioblastoma (GBM), Ependymomas, Medulloblastoma, Germinoma/teratoma and Lymphoma (primary CNS lymphoma – PCNSL). Extrinsic tumours of the brain covering, Meningioma, Other tumours, Pituitary adenoma and Craniopharyngioma, Acoustic (vestibular) schwannoma, Skull base chordoma and chondrosarcoma and Cerebral metastases that come from outside the brain. Glioma 58%, Meningioma 10%, Pituitary and Cranio 9%, Acoustic 5%, Ependymoma 3%, Lymphoma 2%, 'Other' 7%. [2]

According to the WHO 2000 classification the glioma according to pathological examination was categorizes into Grade I (3%), Grade II (15%), Grade III (15%) and Grade IV (67%). Radiotherapy is one of the most affected method that used to eradicate the tumors of brain the fundamental principles of radiotherapy (RT) planning and treatment delivery apply to CNS tumours. These include accurate and reproducible immobilization, high quality imaging to localize the tumour and critical normal structures, 3DCRT or IM planning, and high precision treatment delivery. The optimal position for the patient depends on the location of the tumour, a supine position is more comfortable for the patient. Using couch extensions, such as an 'S' frame or a relocatable stereotactic radiotherapy (SRT) head frame, Most planning is based on CT, because this delivers exact patient geometry and position without distortion, and because CT density is required for accurate dosimetry calculation. Preferably, intravenous contrast should be used because this enhances discrimination of the target. Although this changes the CT numbers slightly, dosimetry is affected by 1% or less. MRI should be considered an essential modality for planning. Typically, MRI does not have to be performed in the treatment position, provided suitable image co-registration software is available. Because its provide better visualization and tumor detection, While MRI is in general the better modality for showing tumour, CT is extremely useful to determine the extent of bone involvement, or the extent of a non-invasive tumour which is limited by bone. Moreover in the next view years the using of MR spectroscopy, PET-MR, PET-CT, will give clear result in tumor planning. The definitions of gross tumour volume (GTV), clinical target volume (CTV) and planning target volume (PTV) as outlined in ICRU 83, this paper will focus on the margin making using

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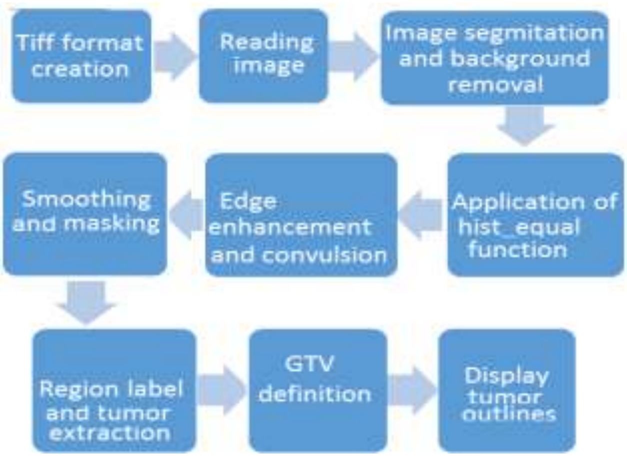
image processing programs using density data for tumor and MRI resolution also.

Many of the data on radiation tolerance in the CNS are based on literature reports which predate the use of modern imaging, especially ***MRI***. Tolerance doses are thus far from absolute. Tolerance of the brain itself (to avoid necrosis) is in the region of ***54–60 Gy*** in approximately **30** fractions, depending on volume treated and dose per fraction. A volume effect also exists for intellectual damage. Using 3D conformal RT, intellectual damage in adults is uncommon with doses up to ***54Gy*** in 30 fractions. The brainstem is said to have a slightly lower tolerance than brain substance, approximately ***54*** Gy in 30 fractions (or ***55 Gy in 33*** fractions). The optic nerves and chiasm are also thought to be more sensitive than brain parenchyma. For benign tumours in this region, a ***dose of 45*** Gy in ***25*** fractions to ***50Gy in 30*** fractions should be safe, with a risk of blindness which is virtually zero. MRI is more sensitive than CT scanning for demonstrating tumour extent. Tumours are non-enhancing with low signal intensity on T1 weighted and high signal on T2. Active tumour lies mainly within areas of T2 hyperintensity but can extend up to 2 cm from it. Since MRI cannot be used for planning treatment alone, CT planning scans using intravenous contrast are taken with 1–3 mm slices from the vault to the base of the skull. Pre-and postoperative MR images are then co-registered with the CT planning scans and the target volumes delineated. [2]

2. Target volume

The gross tumour (GTV) is defined as the visible contrast-enhancing edge of tumour, shown most clearly on MRI, using T_1W with gadolinium contrast. GTV G I-II = mass+ areas of peritumoural oedema, G II–IV= contrast-enhancing edge of the tumour in T_1 weight images, for palliative tumor = visible tumor in CT images. From these points we are focusing in margin detection accurately rather than using of image co-registration algorithm either for fusion or else. [3]

In ***case of treatment*** Conformal RT should be considered as standard. The use of non-coplanar beams, with field-in-field boosts is advantageous for most gliomas. The latter amounts to forward planned IMRT. TLD with lithium fluoride (LiF) is recommended to estimate doses to the eye, and portal imaging confirms patient positioning [2].



3. Finding

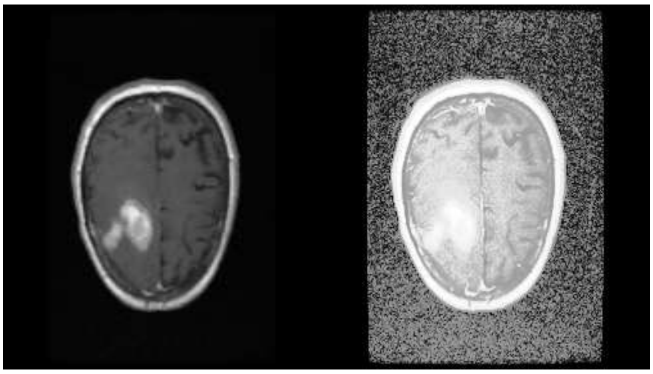


Figure 1: showed the original MRI T1 weight image with gadolinium enhancement (left), increasing the image contrast among the uniform areas using histogram equalization function (right).

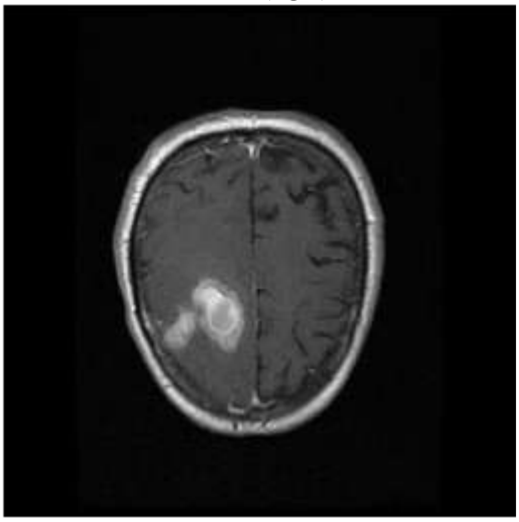


Figure 2: The image with color bar next to it showing the colors gradations

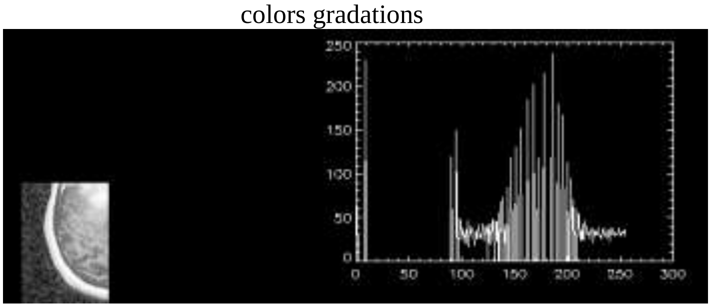


Figure 3: Showed the histogram of equalized certain image region after density distributions among the peaks and valley of normal image histogram.

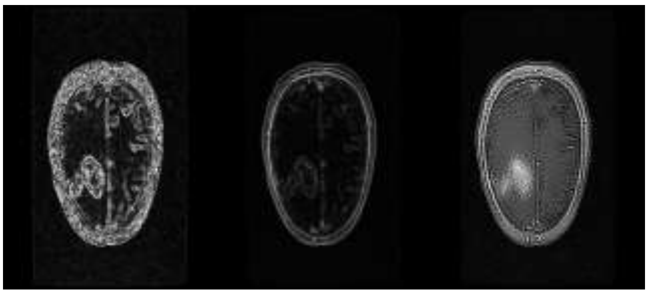


Figure 4: Three different method to enhance the edges of the image, (left) SOBEL method, (middle) Roberts's method and (right) convolving the image using laplacian kernel.

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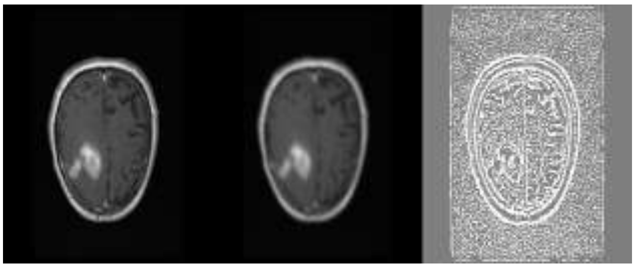

Figure 5: The original image in the left smoothed image in the middle an unsharp masked image on the right.

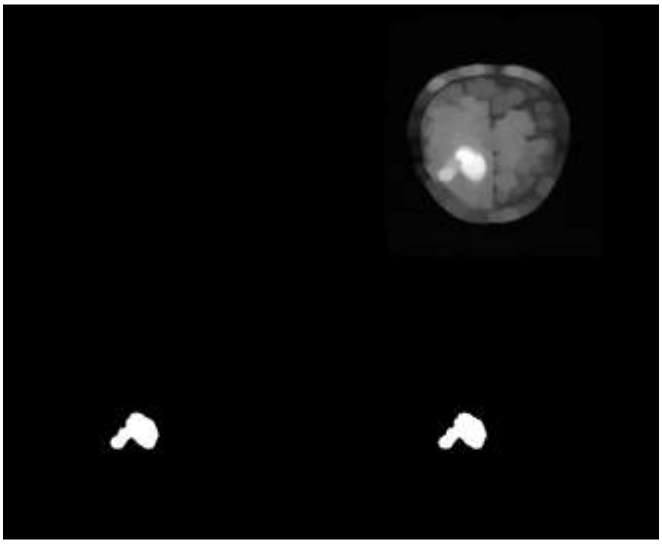

Figure 6: Original Image (upper right) and Application of Opening Operator (lowers L, R). Showed the tumor intensities with its nearby edema

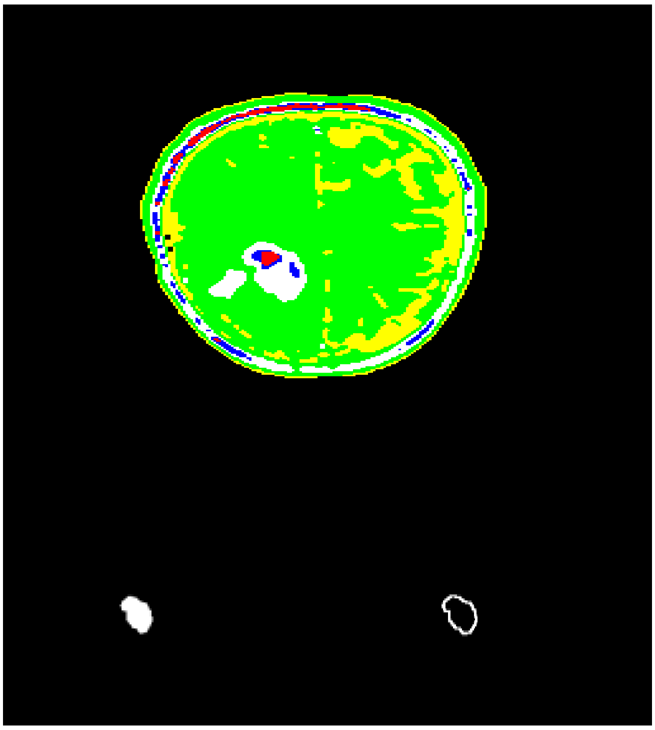

Figure 7: tumor segmintion with its color index in brain image

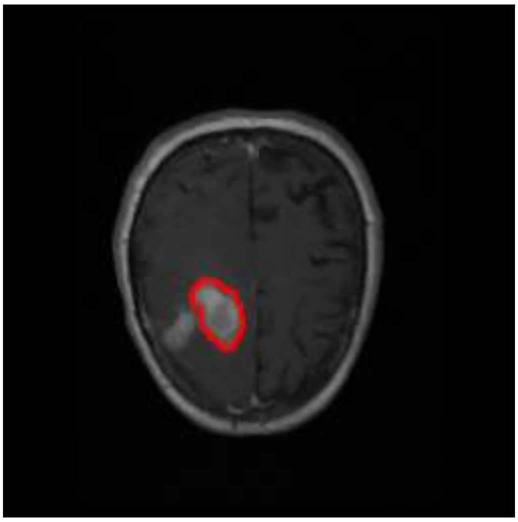

Figure 8: clearly defining tumor margin with its irregularity

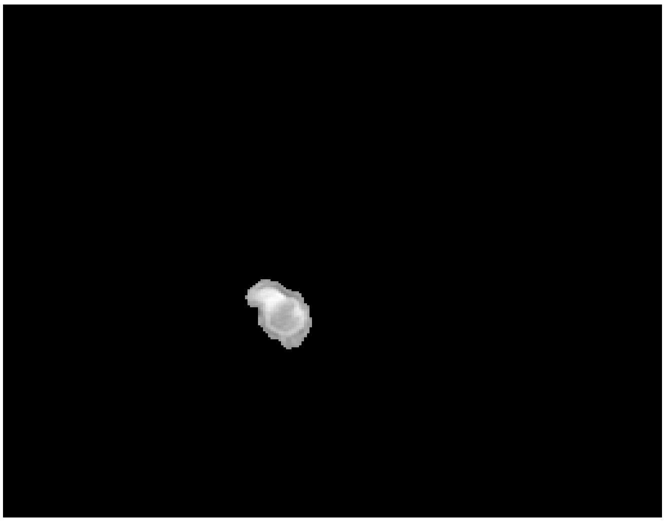

Figure 9: Segmintation of the tumor alone with its pixel intenstities

4. Image Processing

Contrast within an image is based on the brightness or darkness of a pixel in relation to other pixels. Modifying the contrast among neighboring pixels can enhance the ability to extract information from the image.

4.1. Image segmentation

The brain images using magnetic resonance imaging was clearly grown in few last years, that used in detection of brain tumors A T1 weighted images with gadolinium contrast enhancement used to extract mass information and differentiate it from other lesions so the application of image processing techniques is considered significant using image density data for its pixels and matrix. Segmentation is the process of partitioning a digital image into multiple segments .The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze [10].

Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images [10]. More precisely, image segmentation is the process of assigning a

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label to every pixel in an image such that pixels with the same label share certain visual characteristics.

5. Discussion

This research paper introduce a new method in definition of GTV for radiotherapy treatment of brain glioma in magnetic resonance images based on signal intensities of the tumor bulk and its own properties (pixel by pixel distribution and scaling), The image was firstly displayed in byte-scaling rang, the data values above 255 are wrapped around the range of 0 to 255 [1]. This type of display may produce discontinuities in the resulting image. ***Histogram equalization*** we found that the pixel distribution tend to cluster in a narrow range of values so when the pixel is spread-out again in very narrow dynamic range of colors among the peaks and valley (replacing nearly uniform values) of normal image histogram from this step we can apple to enhance the brain image contrast then more visualization available for the tumor and its surroundings, This was showed in figure 1. Figure 2. Showed the image with color bar next to it showing the colors gradations from the darkest 0 value to the brightest one as in color table or index having 255 value every pixel value over these values set to zero or 255 as in gray scale images. An example of image histogram for histogram equalization function are performed and displayed in figure 3 which demonstrate the histogram for ***[0.5, 0.15, 0.95, 0.95]*** pixel location within the image (part of gray, white matter and also edematous part of tumor).

Figure 4: this steps was performed using smoothing function which was often used to reduce noise within an image or to produce a less pixelated image when the random pixels having an extreme values. So firstly we create a noisy images then using the *median* and *smooth* commands to remove noise from the images, median is similar to smooth except it calculate the median value of pixel neighborhood instead of mean value.

Figure 5: Sharpening an image increases the contrast between bright and dark regions to bring out features. the sharpening process is basically the application of a high pass filter to an image but here we used laplacian kernel for edge enhancement using Roberts and sobel function and we convolved the image with laplacian kernel because it work greatly in rounded region:
[1, 1, 1], [1, -7, 1], [1, 1, 1].
Robert's function used for edge detection:

$$G_{jk} = |F_{jk} - F_{j+1,k+1}| + |F_{j,k+1} - F_{j+1,k}|$$

$$\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \text{and} \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

Sobel function:

$$G_{jk} = |G_x| + |G_y|$$

$$G_X = F_{j+1,k+1} + 2F_{j+1,k} + F_{j+1,k-1} - (F_{j-1,k+1} + 2F_{j-1,k} + F_{j-1,k-1})$$

$$G_Y = F_{j-1,k-1} + 2F_{j,k-1} + F_{j+1,k-1} - (F_{j-1,k+1} + 2F_{j,k+1} + F_{j+1,k+1})$$

where (*j*, *k*) are the coordinates of each pixel F_{jk} in the *Image*. This is equivalent to a convolution using the masks

$$\text{X mask} = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad \text{Y mask} = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

• "Enhancing Edges with the Roberts Operator"
• "Enhancing Edges with the Sobel Operator" These two operation resulted in Edges have been highlighted around all elements separated by significant differences in pixel values. And the tumor clearly appear different from the original or nearby tissues preparing for the next function applied in figure (6, 7) so we introduce this by clarifying basic image features. While individual morphological operations perform simple functions, they can be combined to extract specific information from an image. Morphological operations often precede more advanced pattern recognition and image analysis operations such as segmentation. Shape recognition routines commonly include image threshing or stretching to separate foreground and background image features moreover separation of the foreground elements itself that exactly what we did *using label region* function. Using an intensity histogram as a guide for determining **threshold** values is described in the section, which showed that the minimum pixel intensity value of the tumor in range from 90-95. Preparing for the next operation which was the extraction of tumor and its margin using segmentation process. As showed in figure 7, 8, 9.

6. Conclusion

This paper introduce new method in radiotherapy target volume delineation using image processing techniques in order to extract the tumor margin accurately and to deliver the maximum dose to the tumor while minimizing the dose to the normal tissue, this is better can be applied using the advance techniques in radiotherapy planning (2DRT, IMRT and IGRT) and can be written as a basic program for tumor margin segmentation.

References

[1] David W. Fanning, IDL programing techniques, 2nd edition, fanning software consulting 1997.
[2] Symonds et.al 2012, Textbook of Radiotherapy, 7th edition, 2012, Elsevier Ltd. 432, 456.
[3] Jane De et.al, Practical Radiotherapy Planning, 2008, 4rd Edition, Arnod Publisher, Lodon.
[4] Abdallah YMY. Wagiallah EW. 2014. Segmentation of Thyroid Scintography Using Edge Detection and Morphology Filters, International Journal of Science and Research. Volume 3, Issue 11,pp.2768-2771
[5] Adam MJ, Wilbur DS .2005. Radiohalogens for imaging and therapy. Chem Soc Rev 34:153–63.
[6] R.C. Gonzalez, R.E. Woods, Digital Image Processing, Prentice-Hall, Englewood Cliffs, NJ, 2002.

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[7] B. Georgescu, I. Shimshoni, P. Meer, "Mean Shift Based Clustering in High Dimensions: A Texture Classification Example", Intl Conf on Computer Vision, 2003.
[8] Burnet NG, Thomas SJ, Burton KE, Jefferies SJ. Defining the tumour and target volumes for radiotherapy. Cancer Imaging 2004; 4:1–9.
[9] M. Lalitha et.al, A Survey on Image Segmentation through Clustering Algorithm, International Journal of Science and Research (IJSR), Volume 2 Issue 2, February 2013, pp 348-358.

Author Profile

Mr. Abdoelrahman Hassan Ali Bakry (Sudan) received the B.Sc. in radiotherapy technology from College of Medical radiological Science, Sudan University of Science and Technology in 2013, M.Sc. student (2014) in radiotherapy technology (SUST). During 2013 up to date, he is staying in College of Medical radiological Science, Sudan University of Science and Technology, Radiology Department, Antalya Medical Center and Elnileen Diagnostic Medical Center, Also he has been active in Computerized Texture Analysis, Radiotherapy-Oncology, and nuclear Medicine and radiation protection researches. Now he is assistant teacher at college of medical radiologic science, SUST also.

Proff. Mohamed Elfadil Mohamed Gar-elnabi (Sudan Medicine (1987) and M.Sc. in Radiation Therapy) awarded the B.Sc. in Radiotherapy and Nuclear (2000-SUST) and Ph. D. degree in Medical Physics (Natal University-South Africa) in 2007. During 1996-2012 he has been working as lecturer as well as Associate Prof. at SUST department of Radiation therapy. Also he has been active in Computerized Texture Analysis, Radiotherapy-Oncology, Ultrasound and Nuclear Medicine researches.

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