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An Early Stage of Brain Tumor Detection and Growth Calculation Using Eight Axis Division Technique

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Abstract

Brain tumor is instinctively serious and life-threatening because of the invasive and the infiltrative character in the limited space of the intracranial cavity. Its intimidation level depends on the consolidation of factors like the type of the tumor, its location, its size and the state of development. Because the brain is well sheltered by the skull, the early detection of a brain tumor occurs only when diagnostic tools are directed at the intracranial cavity. Usually detection occurs in advanced stages when the presence of the tumor has caused unexplained symptoms. Brain tumor can be easier to treat if it is diagnosed at the early stage. Considering the detection process, huge amount of effort has gone into developing ways to detect early signs of the disease. Further studies over the growth and accompanying attributes such as intensity, texture, shape have considerable influences over the health of the patient. This paper introduces novel method for the growth calculation and to detect the tumors at an early stage using 8 axis division techniques (8-ADT). From the first stage itself the tumor values are registered. Corresponding points of later stages of the same patient would render the change in every aspect of the tumor under study. The proposed methodology is proven to be much efficient than other existing methodologies. This research involved a number of test cases, for classification to find the tumor levels. The decision of the system mentions the rate of growth and change in aspects straight enough with great accuracy and interpretability.

Keywords: MRI, Classification, Fixed points, Referential Growth Points, Axis division technique.

I. INTRODUCTION

A brain tumor is a mass of abnormal cells that is growing in or around the brain. It develops when abnormal cells multiply for unknown reasons. Benign and malignant are terms used to describe brain tumors. Benign brain tumors are usually slow growing and have distinct borders and a normal appearance under a microscope. Malignant tumors are considered brain cancer. They tend to invade healthy areas of the brain and may grow rapidly. A benign tumor may be considered malignant if it is located in a critical area of the brain or its size is life-threatening. The cells of the tumor develop in uncontrolled manner under the skull or spinal cranial. Magnetic Resonance Imaging (MRI) provides the fundamental analysis of the brain tumors to the pathologists and the patients. Yet as already mentioned, this analysis could be reported in the advanced stages of tumor development. Precise degree of consequence could only be achieved by open surgery, which is mostly not prompted [1] [2]. Early detection of brain tumor is necessary for the easier recovery of a human being from the disease. Various brain tumor detection methods are introduced by various technicians who led to the effortless detection of the tumor. Earlier detection and characterization aid the pathologists to plan on apt diagnosis strategy to prevent further adverse effects on the patients. But the developed grading systems would be able to detect the growth of tumors only on the advanced stages [3]. Increase in the level of tumor can occur in various ways. Each rise in the level should be identified and compared from the previous form. Tumor measurement is mandatory as fluctuations in the growth of tumor are highly concerned. A feature point is a point of human interest in an image, a place where something happens. It could be an intersection between two lines, or it could be a corner, or it could be just a dot surrounded by space [4]. Such points serve to help define the relationship between different strokes. Two strokes could fully cross each other, come together in a "Y" or a "T" intersection, form a corner, or avoid each other altogether. People tend to be sensitive to these relationships; the fact that the lines in a "Z" connect in a certain way is more important than the individual lengths of those lines. These relationships are what should be used for character identification, and the feature points can be exploited for the task.

II. LITERATURE REVIEW

Pathologists review the tumor cells with distinctive steps to categorize the degree of concentration of tissue damage. The behavior and distribution of tumor tissue are observed based on the histological attributes, yet being unable to estimate the accurate metrics.[1] Complex attributes are considerably numerous to diffuse the accuracy within ranges resulting in unpredictable treatment decisions. The recent methodologies include computer systems to process the input set of images (MRI), compare the differences or growth between them and finally output a particular decision. Many researchers have tried to adapt the WHO grading recommendations to simplify and enhance the rate of accuracy. [2][3][4]. this section discusses the previous methodologies of computer aided decision making systems in tumor grading. [5][6].

EI Papageevgious et.al (applied soft computing 2008) used a fuzzy cognitive map technique to obtain the images, study and propose a decision on treating the malignant and benign grades of tumor [6]. The authors discussed the theory with the expertise of clinical assessments of pathologists. They derived nine stages of results for the comparison of test images. Comprised of a map, with the matches of most feasible connection, the research provided results with an accuracy rate of 90.26% and 93.22% in malignant and benign tumor respectively .

Dvorak.P, Kropatsch.W, Bartusek.K. et al proposed the method of Automatic Detection of Brain Tumors in MR Images. This paper deals with automatic brain tumor detection in magnetic resonance images. Magnetic resonance (MR) is a dynamic and flexible technology that allows one to tailor the imaging study to the anatomic part of interest and to the disease process being studied. With its dependence on the more biologically variable parameters of proton density, longitudinal relaxation time (T1), and transverse relaxation time (T2), variable image contrast can be achieved by using different pulse sequences and by changing the imaging parameters. The goal was to determine whether the MR image of a brain contains a tumor. The proposed method worked with T2-weighted magnetic resonance images, where the head is vertically aligned [18]. To create a T2-weighted image, different amounts of magnetization were allowed to decay before measuring the MR signal by changing the echo time (TE). The detection was based on checking the left-right symmetry of the brain, which is the assumption for healthy brain. The algorithm was tested by fivefold cross-validation technique on 72 images of brain containing tumors and 131 images of healthy brain. This method produced exemplary results the proposed method reaches the true positive rate of 91.16% and the true negative rate of 94.68%.

Young-Joong Kim, and Myo-Taeg Lim et al proposed the Tumor size measurement and feature point extraction using an endoscope. Tumor "size" is used internationally as a surrogate marker for overall survival when following current response assessment protocol. With little evidence of a relationship between tumor "size" and survival in intrinsic brain tumors, this study was undertaken to investigate the predictive value and to compare the different measures of tumor size used in these current response assessment protocols. Development of the medical instrument using the vision information was brisk. Especially, extracting the 3-dimension information from 2-dimension image is the one of the major research topics. This paper proposed the method to measure tumor size by the 3-dimension information extraction, the triangulation using the extracted 3-dimension information and the camera geometry [11]. To extract the 3-dimension information, the Hough circle transform and triangulation are used. The Hough circle transform is used to extract a feature point from tumor models for the 3-dimension information recovery. The Hough transform can be used to determine the parameters of a circle when a number of points that fall on the perimeter are known. An extracted feature point is used for recovering the depth information from the 2-dimension tumor stereo images. A tumor size measurement is done by triangulation using the depth information and camera internal parameters. MATLAB is used for simulation.

III. PROPOSED WORK

The proposed system has mainly four modules: pre-processing, segmentation algorithm, morphological operation and parameter analysis.

A. Data Set

Real Time MRI images are collected from Metro Scans & Laboratory, a unit of Trivancore Healthcare Pvt Ltd, Trivandrum, India .Experiments are conducted on MR images collected from 32 different patients with gliomas. Each patient has 3 sequences of MR images T1, T2 and FLAIR. Each volume contains 24 slices in axial plain with 5 mm slice thickness. MR imaging was performed on 3.0T Siemens devices. The imaging conditions of different protocols are; T1 weighted, T2 weighted, and Flair weighted. Each set of features are individually normalized to the range of 0 to 255.

B. Preprocessing

The MRI comprises of an image of brain surrounded by black matter, which is obvious waste of time and energy to introduce into the analysis processes. Similarly, the image of the brain beside the affected area need not be analyzed. The infected area alone can be differentiated by means of perimeter and area constraints of image processing techniques.

In Preprocessing of the proposed system the following steps namely Gray scale conversion, Noise removal, sharpening and inversion are involved. In computing, a gray scale digital image is an image in which the value of each pixel is a single sample, it carries only intensity information. The gray scale conversion of MRI image is given by [17].

gray(i,j)={0.29*rgb(:,:,1)+0.59*rgb(:,:,2)+0.11*rgb(:,:,3)} (1)

Generally we are using median filter to suppress the noise. The procedures are (i) arranging matrix pixel value in the form of ascending order (ii) find the median value of that matrix (iii) replace that value into that noisy pixel location.

Noisy pixel matrix,

$$X = \begin{Bmatrix} 15 & 25 & 75 \\ 125 & 0 & 85 \\ 100 & 29 & 45 \end{Bmatrix}$$

The above matrix in one dimensional format is written as,

X = [15 125 100 25 0 29 75 85 45]

The one dimensional format is written in the ascending form as,

Modified X = [0 15 25 29 45 75 85 100 125]

The median value is obtained as,

Median value is = 45

De noised pixel matrix is,

$$MX = \begin{Bmatrix} 15 & 25 & 75 \\ 125 & 45 & 85 \\ 100 & 29 & 45 \end{Bmatrix}$$

Above we had mentioned the detailed flow of median filter, with some example matrix input.

Figure 1.a shows the original image of the given input MRI Image. The gray scale conversion result of the input image is shown in figure 1.b. Figure 1.c shows the result of noise removal. Sharpening is one of the most impressive transformations one can apply to an image since it seems to bring out image detail that was not there before. What it actually does, however, is to emphasize edges in the image and make them easier for the eye to pick out while the visual effect is to make the image seem sharper, and no new details are actually created.These techniques make edges appear more defined by darkening the darker pixels and brightening the brighter pixels. This creates a crisp edge between light and dark portions of the image, giving it more contrast. Figure 1.d shows the result of sharpen. An image in which up and down, as well as left and right, are interchanged; that is, an image that results from rotating the object 180° about a line from the object to the observer. Such images are formed by astronomical telescopes. This image is also known as reversed image. The output of inverted image is shown in the figure 1.e.

The process of eliminating the black matter and unaffected space of the brain from the tumor regions is called background subtraction. By this, the resultant set of images to be subjected for analysis into the automated system would be regions of tumor. Separation of such images would render to save execution time to finalize the decision. The output image could be obtained as the foreground or background alone. A parameter is the comparative element to be altered with the pixel of input images and altered with the intensity parameter on proving the condition to be true or false.

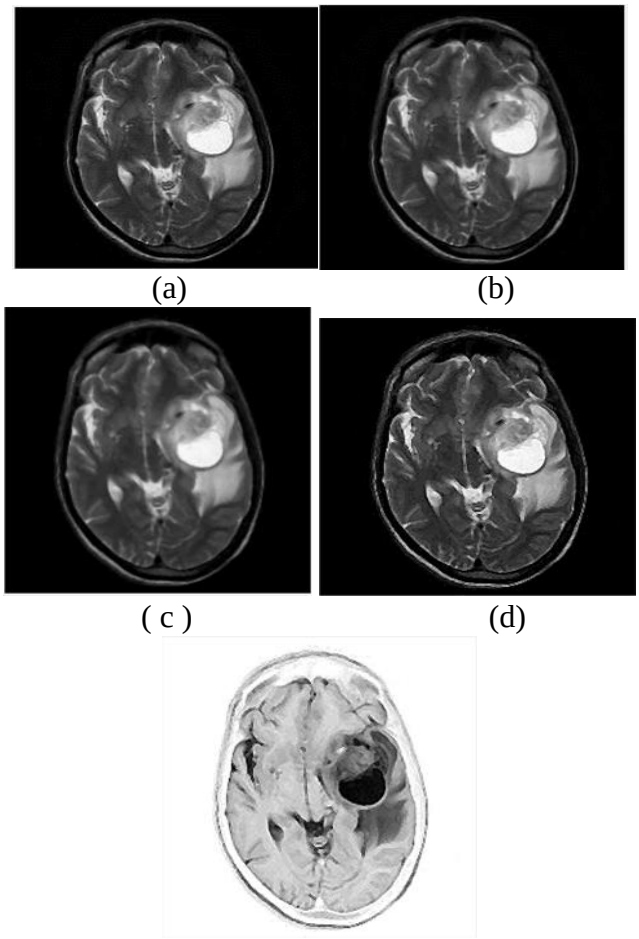


Fig 1 Results of preprocessing: a) Original Image b) gray scale conversion c) noise removal d) sharpen e) inversion

C. Brain Tumor Detection

The proposed method uses Threshold segmentation, erosion, dilation, cropping and enlarge operations to detect the brain tumor. An efficient image segmentation technique can distinguish the tissues such as edema and tumor also from the normal tissues such as White Matter (WM), Grey Matter (GM), and Cerebrospinal Fluid (CSF).

Thresholding is simpler and most commonly used technique in image segmentation and equation is given by [18]. It can be expressed as

$$g(x,y) = \begin{cases} 1 & \text{if pix} > th \\ 0 & \text{if pix} < t\square \end{cases} \qquad (2)$$

This technique can be used to detect the contour of the tumor in brain. When we have a bimodal histogram, we can establish a threshold value (th), and every pixel up that value is the object and every pixel behind that value is the background. The threshold segmentation output is shown in the figure 2.a.

Image Processing is a technique by which we can process any image to extract the real information i.e. useful information from the image. Sometimes we require some specific part of the image to process and for it we have to select that portion only. This technique of selecting useful portion is called cropping. Rectangular Crop is easier to crop image in rectangular form because we have to just select two coordinates on the image and using MATLAB we decide other two coordinates and the image is cropped in rectangular format.

The erosion of a binary image *f* by a structuring element *s* (denoted f ⊖s) produces a new binary image g = f ⊖s with ones in all locations (x, y) of a structuring element's origin at which that structuring element s fits the input image f, i.e. g(x, y) = 1 is s fits f and 0 otherwise, repeating for all pixel coordinates (x, y). Erosion with square structuring elements shrinks an image by stripping away a layer of pixels from both the inner and outer boundaries of regions. The holes and gaps between different regions become larger, and small details are eliminated. Larger structuring elements have a more pronounced effect, the result of erosion with a large structuring element being similar to the result obtained by iterated erosion using a smaller structuring element of the same shape. If s_1 and s_2 are a pair of structuring elements identical in shape, with s_2 twice the size of s_1, then

$$f\theta_{s2} \approx (f\ \theta_{s1})\ \theta_{s1} \qquad (3)$$

Erosion removes small-scale details from a binary image but simultaneously reduces the size of regions of interest, too. By subtracting the eroded image from the original image, boundaries of each region can be found using equation (4).

$$b = f - (f\ \theta_s) \qquad (4)$$

Where *f* is an image of the regions, *s* is a structuring element, and *b* is an image of the region boundaries. The dilation of an image *f* by a structuring element *s* (denoted *f* ⊕*s*) produces a new binary image *g* = *f* ⊕*s* with ones in all locations (*x*, *y*) of a structuring element's origin at which that structuring element *s* hits the input image *f*, i.e. *g*(*x*, *y*) = 1 if *s* hits *f* and 0 otherwise, repeating for all pixel coordinates (*x*, *y*). Dilation has the opposite effect to erosion -- it adds a layer of pixels to both the inner and outer boundaries of regions. The holes enclosed by a single region and gaps between different regions become smaller, and small intrusions into boundaries of a region are filled in. The output result of erosion and dilation are shown in figure 2.b and figure 2.c. figure 2.d and figure 2.e shows result of cropping and enlarging techniques. At first, using grid with biggest meshes, we calculate the grid-grads gg_E of each pixel of *E*(*x*, *y*) using equation (5) and we took equation (5), (6), (7), (8) from the ref paper of [7].

$$gg_E(x,y) = \sum_{(i,j)\in g(x,y)} (d_i + d_j) \qquad (5)$$

Then, we calculate the contrast Contra of every two bilateral symmetry points with equation (6), in which (*x*, *y*) and (*x*', *y*') are two bilateral symmetry points.

$$\begin{cases} Contra(x,y) = \dfrac{gg_E(x',y') - gg_E(x,y)}{R} \\ Contra(x',y') = \dfrac{(gg_E(x,y) - gg_E(x',y'))}{R} \end{cases} \qquad (6)$$

$$R = gg_E(x,y) + gg_E(x',y') \qquad (7)$$

For those pixels, whose Contra is below the threshold δ, we use the grid with smaller meshes to recalculate from equation (5) to equation (7) until the size of meshes is the smallest.

After the iterations have been finished, we calculate the
E(*x*, *y*) again using equation (8).

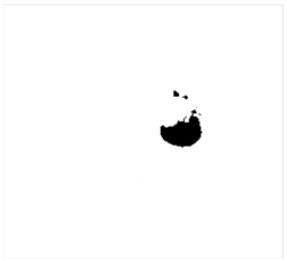
$$E^{(n)}(x,y) = contra(x,y) * E^{(n-1)}(x,y) \qquad (8)$$

where *n* is the reiteration time.

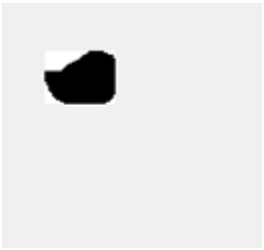
Then, all the edges within the regions having symmetry characteristic will be weakened. In other words, the more symmetrical the two regions are, the more the edges are weakened. At the same time, the edges which are not symmetrical are enhanced. In the end, according to the enhancing effect, the unsymmetrical regions can be detected, which is caused by brain tumor.

In figure [2], we applied threshold based image segmentation technique and morphological operations, to segment the tumor properly for analysis.

(a) (b)



(c)



(d)

(e)

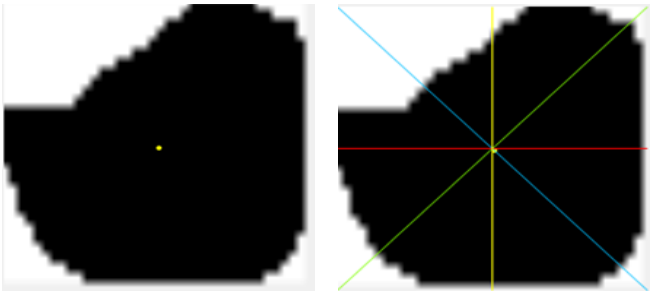
Fig 2 Results of tumor detection module : a) Threshold Segmentation b)erosion c) dilation d) cropping e) enlarge

D. Eight Axis Division Technique -Growth Calculation

The proposed methodology involves the segmentation of the image into four quadrants. Each quadrant is marked by the axes of regular procedure. With the image of tumor mapped into the quadrants, at different stages, the proposed strategy clearly describes the growth of tumor cells with respect to repeated division and time. This proposed method introduces a technique of analyzing the tumors based on the growth and shape metrics. The detected tumor would possibly be mapped to a comparative graph to predict the maximum accuracy. A tumor during the first report of the patient is registered as an input into the system. Subsequent reports are compared under the same name of the patient and stored for future comparisons.

The standard point marks the origin of the tumor, from which the tumor tends to be divisible and expand its size and shape in following weeks without treatments. Being a computer assisted system the standard point could always be allocated. It is clear that the referential Growth Points refers to the increment of tumor cells in certain periods. The standard point is a permanent metric from which the altered regions are compared with. The further week's reports will also be preprocessed and the additional growth could be estimated numerically. The rate of growth can be evaluated which in turn assist a pathologist to recommend medications with

predefined procedures by well qualified medical professionals. An additional advantage of our proposed method is shape should be mentioned in numerical attributes, due to this our system is more accurate with better efficiency. The standard point and 8 axis division output results are shown in the figure 3a and figure 3b.



(a) (b)

Fig 3 Results of ADT a) fixing the standard point b) 8 axis division for referential growth points

IV. EXPERIMENTAL RESULTS

Initially we have taken 4 slices from single patient as input images. Then apply preprocessing and tumor detection techniques, and calculate the growth based on tumor rate of the images, also calculate width and height of tumor. For that the same patient old and new tumor images are taken and analyzed by using standard point and referential growth points. The Standard point will not be altered for any condition, but the referential growth points will be updated based on the tumor growth. The referential growth points represent the treatment condition for the patient. Figure 4 represents the comparison of tumor images for the same patient.

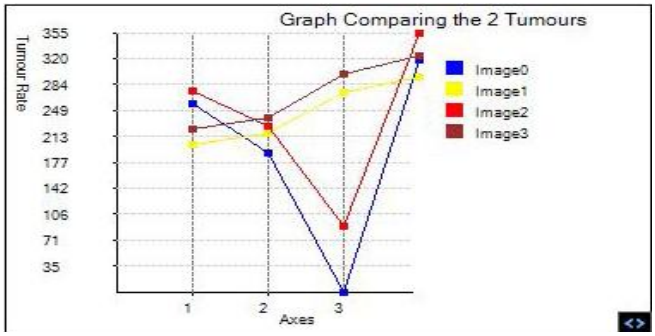


Fig 4 Comparison of input MRI images based on the tumor rate

To predict shape of the affected area we have to calculate the height and width of the growing point's position from the standard point. The height and width of the image are shown in Figure 5. The label values of the input images are calculated first.

Growing point's values and label values are used to calculate the height and width of the tumor area.

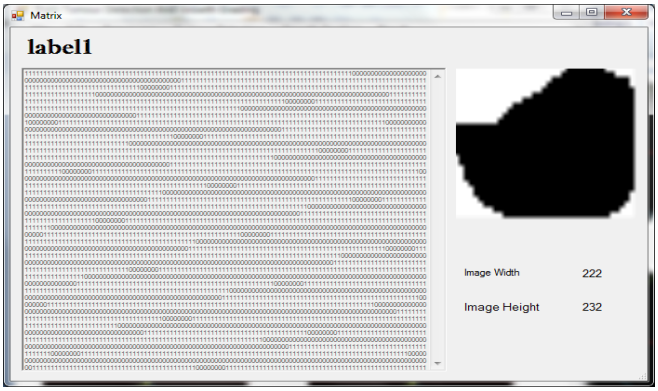


Fig 5 Result of image height, width and label values

The input image for the module would be a cropped image of the tumor with distinct edges. Since Tumor cannot be an even structure, and the measurements of growth cannot be mentioned accurately, we propose a standard methodology of segmenting the tumor with eight axes. From the center point, the growth could be calculated in eight directions. The direction names are wa, wb, xa, xb, ya, yb, za, zb. All 8 axis direction tumor rate values are shown in figure 6. The decision of the system mentions the rate of growth and change in aspects straight enough with great accuracy and interpretability, also we analysis the processing time and accuracy of various methods, like accuracy of SOM Kmeans is 94.2, SOM Fuzzy is 95.3, HSOM Kmeans is 96.5, HSOM Fuzzy is 95.3 and our proposed method is 97.1. The comparison details are shown in the figure 7 and figure 8.

Fig 6 Result of tumor growth for all axis

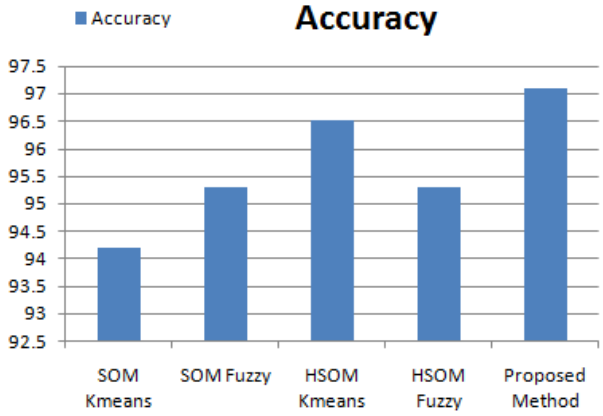


Fig 7. Execution time of various methods

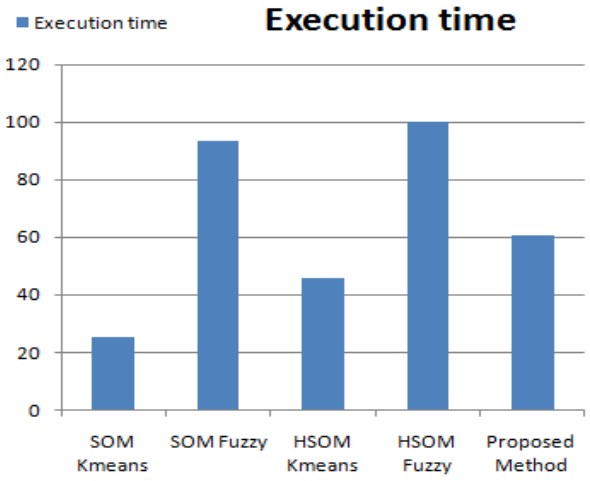


Fig 8. Execution time of various methods

The Accuracy of our proposed methodology is high also it's prove much efficient than other existing methodologies like kmeans and fuzzy based segmentation techniques [5]. The research involved a number of test cases, for classification to find the tumor levels like primary and secondary.

V. CONCLUSION

In our paper we introduce novel method for the growth calculation and to detect of Brain tumor at an early stage using 8 axis division technique (8-ADT). In Preprocessing of the system we followed few steps namely Gray scale conversion, Noise removal, sharpening and inversion are involved. By getting the tumor label levels we can calculate the width and height of the tumor. For that the same patient old and new tumor images are taken and analyzed by using standard point and referential growth points. From the first stage itself the tumor values are registered. Corresponding points of later stages of the same patient would render the change in

every aspect of the tumor under study. The proposed methodology is proven to be much efficient than other existing methodologies. We compared our result with various techniques, like accuracy of SOM Kmeans is 94.2, SOM Fuzzy is 95.3, HSOM Kmeans is 96.5, HSOM Fuzzy is 95.3 and our proposed method is 97.1. While compare to existing methods we are getting better efficiency. This research involved a number of test cases, for classification to find the tumor levels.

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