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RESEARCH ARTICLE

BRAIN TUMOR DETECTION AND BRAIN TUMOR AREA CALCULATION WITH MATLAB

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ABSTRACT

Brain tumors that impair the functionality of the person in daily life occur for many different reasons. Treatment of a brain tumor depends on accurately identifying the type, location, size and boundaries of the tumor. Magnetic Resonance Imaging (MRI) technique is used to diagnose the disease. However, this method cannot detect tumors below a certain size due to its nature. The aim of this study is to calculate the area of the tumor region through the successful method after determining which of the Fuzzy C-Means (FCM), Herbaceous Method, Region Growing and Self-Organizing Maps (SOM) methods are more successful in the analysis of MR images. The threshold values of the algorithms used, the number of clusters and the similarity coefficients of jaccard and dice were determined one by one by changing the index codes in the software.The highest similarity index was found in the K-means 10 cluster numbered segmentation in all trials.In general, K-means and Very Grassy Threshold gave very close results. In this context, advanced imaging technique was used by separating the MR image; Tumor spots and brain fluids were detected. Fuzzy C Mean (FCM) was found to be the best method during detection. Brain fluid pushes segmentations used in area calculations to miscalculate. For this reason, while calculating the tumor area, the brain fluids that appear in white spots are completed by point filling. Then, after the tumor zone was identified, the area of this region was used to produce the volume of the region by using Watershed, Graph-Cut and Active Counter segments. It is aimed to determine the number of tumors in which the tumor is in the detection area.

Keywords: *Image processing, Magnetic Resonance Imaging, Glioma, Image Segmentation*.

1. INTRODUCTION

The brain, as one of the vital organs of the body, responsible for the task of managing the body as well as for many processes such as controlling the body's organs, maintaining logic functions, providing learning, memory and emotion in the context of remembering and forgetting. A brain tumor is a mass formed by cells that proliferate and grow uncontrollably in the brain [1]. Brain tumors that impair the functionality of the person in daily life occur for many different reasons.

While methods such as radiotherapy and chemotherapy are used in addition to surgical methods for the treatment of brain tumors, Magnetic Resonance Imaging (MRI) technique is used for the diagnosis of the disease. The most appropriate treatment for brain tumors depends on the physician's precise determination of the tumor type, its location, size, and frame [2]. However, this method cannot detect tumors below a certain size due to its nature. Therefore, there is a need for the use of Computer Aided Diagnostic Systems in the diagnosis of diseases such as tumors.

Computer aided diagnostic systems are actually based on artificial neural networks in the field of artificial intelligence within the principle of machine learning. Artificial neural networks have the ability to make machine decisions on the basis of classification, clustering, pattern recognition, estimation and optimization. YSA learns the problem given from the examples and decides using the information obtained when it encounters the examples that have never been seen before. The most important feature of the YSAs is that it can make inferences for different situations by using the experience gained by learning from information. YSAs consist of two stages: training and testing. In the first step, YSA is trained with training data. The network is then tested using test data to evaluate the performance of the trained YSA. The most important and laborious part of the method is the educational process of the network, which includes the presence of the most suitable values for weights in network architecture, which is a challenging optimization problem. [3,4]

Computer Aided Diagnostic Systems are mainly studied under the headings of image recognition, image segmentation and image analysis. Image is the process of perceiving and describing concretely where and what objects are in the world. This covers the points that we can perceive within the volume in which the image is located [5]. Image recognition is the ability of a computer-integrated device to detect features of objects contained in a digital material, such as an image. Image segmentation is the process of dividing an image into meaningful regions according to a specific application area. These meaningful regions should not overlap with each other and should show continuity within themselves according to a defining feature. These regions that emerge as a result of segmentation are called segments. Therefore, improving segmentation is of great importance for automatic vision [6].

Grayness level, texture feature, color information, striation and continuity can be taken as determining features in image segmentation. If RGB (Red_Green_Blue) color is taken, the process is repeated three times. However, the gray level can provide enough information for an image [7]. The segmentation process is used in every area of the automatic view. Yaman et al., the gray level images of the passengers waiting at the station in the Ankara High Speed Rail System, detected by the cameras used for security purposes in the system, were transferred to the computer environment, and then the objects were separated from the background by image segmentation processes.

The images of the separated objects were clarified by image enhancement methods and the number of passengers in the station was determined from the image histogram [8]. Image analysis, on the other hand, are the methods in which the threshold values of the methods are examined by using the Fuzzy C-Means (FCM), Herbaceous Method, Region Growing and Self-Organizing Maps (SOM) methods. The explanations about these methods are discussed in detail in the next sections of the study. The aim of this study is to calculate the area of the tumor region through the successful method after determining which of the Fuzzy C Means (FCM), Herbaceous Method, Region Growing and Self-Organizing Maps (SOM) methods are more successful in the analysis of MR images.

In the area calculation, it was determined that the area where the tumor and brain fluids appeared as white dots. Brain fluid pushes segmentations used in tumor area calculations to miscalculate. For this reason, while calculating the tumor region, the brain fluids appearing as white dots were completed by point filling. Moreover, after the tumor region was detected, the area of this region was determined spatially using Watershed, Graph-Cut and Active Counter segmentations. It is aimed to determine the stage of the tumor by using the detected area.

2. MATERIALS AND METHODS

In this study, MR images were first collected for examination. Collected MR images were collected on the basis of image quality in T1 and T2 sequences. An image database was created with the collected MR images [9]. In this database, a database was created using 40 MR images of 40 different patients, 20 males and 20 females. MR images can be taken in DICOM format. After the captured format, two-dimensional images were converted into data sets.

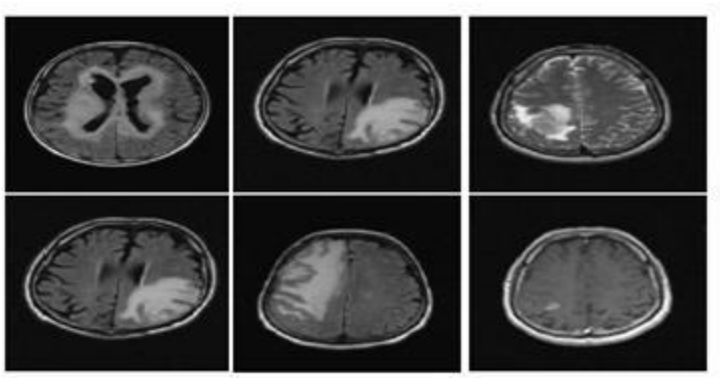

Figure 1. Brain mrı ımages.

Image segmentation methods, one of the image processing methods, should be used in order to detect

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the tumor region in the obtained MR images. Among these methods, Fuzzy C-Means (FCM), Herbaceous Method, Region Growing and Self-Organizing Maps (SOM) were used separately to determine the best image section and the result was compared.

2.1. Fuzzy C-Means (FCM)

The Fuzzy C-Means (FCM) algorithm was introduced by Dunn in 1973 and was developed by Bezdek in 1981 [10]. This method is frequently used in image processing, clustering and segmentation [11]. FCM, a widely used algorithm for image segmentation, uses an objective function based on a weighted similarity criterion between the pixels in the image and each segment center forming the image. It performs segmentation by dividing the resulting image into two or more clusters. The fuzzy c-mean formula is as in Eq. 1.

$$W_m(U,V) = \sum_{k=1}^{n} \sum_{i=1}^{c} (u_{ik})^m \ (d_{ik})^2 \tag{1}$$

Here, the fuzzy membership value of the k.ci pixel in the i.ci clump indicates the distance of the perpendicular k.ci pixel from the i.ci clump center.

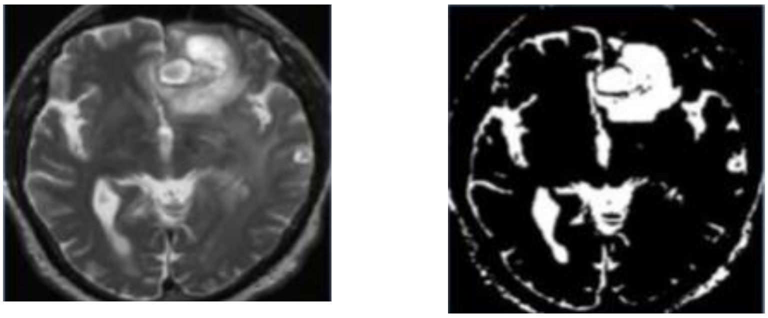

Figure 2. Fuzzy c mean mr ımage segmentation.

2.2. Region Growing

Region Augmentation Method is an approach used in image segmentation in which a corner is included in a region class if no corner is detected as a result of the evaluation of a pixel with neighboring pixels [12]. This process is iteratively executed for each border in the region. The method first starts by selecting a seed pixel point on a specific region of the image. Then, the region is enlarged by testing the similarity of neighboring pixels to the selected seed pixel in terms of color, intensity and brightness. The first pixel/pixel group is determined manually or automatically on the image. By calculating a similarity value between the initial seed pixel and the new/candidate pixel, if the new pixel is smaller than this similarity value, it is included in the region.

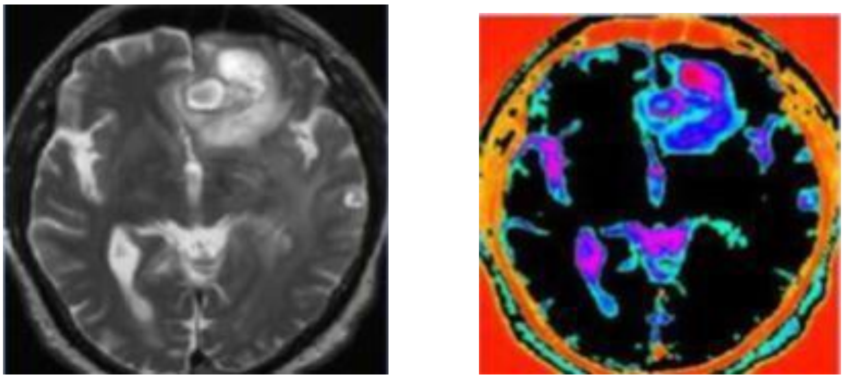

Figure 3. Region magnification mr ımage segmentation.

2.3. Self-Organizing Maps (SOM)

Self-Organizing Maps (SOM) are a special form of artificial neural networks and an unsupervised learning method developed by Kohonen [13]. It is frequently preferred in applications such as image segmentation, classification and clustering [14]. In its basis, there is a process of converting very large inputs to small-sized inputs, and size reduction is applied. This application takes place in 2 stages. In the 1st stage, competitive learning is carried out and the system is self-training. In the second stage, mapping is done to reduce the incoming input and the output is transferred to the system with correct mapping.

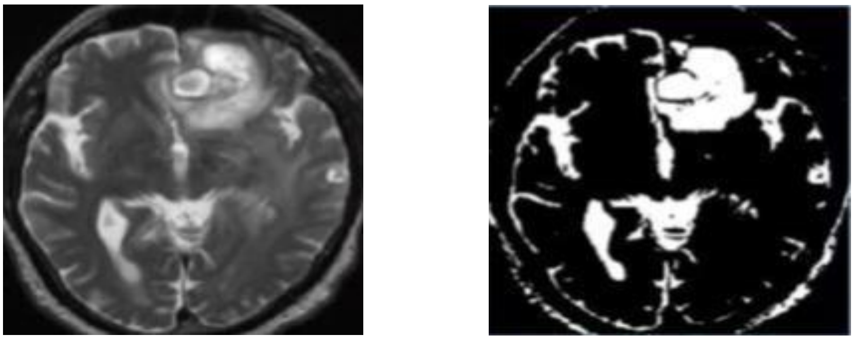

Figure 4. Som mr image segmentation.

2.4. Herbaceous Method

Herbaceous Method is one of the image segmentation methods applied on gray levels. Herbaceous Method is very effective on the images that have a bimodal histogram. However, it is difficult to segment an image that has overlapped regions [15]. In this method, it is assumed that the image consists of two parts. Part 1 contains the background colors of the image, and part 2 contains the foreground colors of the image. Then, the threshold value of the background and foreground colors is

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calculated and their variance value is revealed. The threshold value that ensures the variance value to take the lowest value is selected. According to the selected threshold value, the image is converted to a binary image and image segmentation is completed. In this method, a histogram of colors is used.

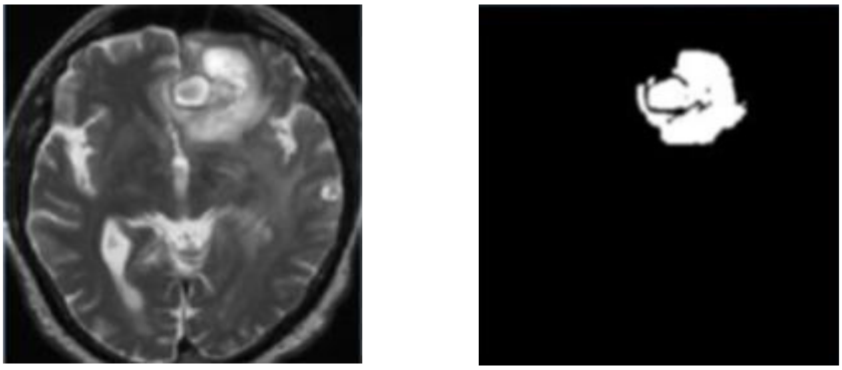

Figure 5. Herbaceous method mr image segmentation.

3. EXPERIMENTAL STUDIES AND EVALUATION

In order to perform thresholding, the image must be read by the algorithm and the histogram must be obtained. With the histogram, the lower and upper borders of the image must be established [16]. The algorithm used generates the threshold values randomly between the determined limits. The threshold values created must be sequential. After the threshold value calculations were made, the fitness values of the functions were determined. The solution archive set is created by combining the applied solution values until the function fitness values are determined. An iterative loop is created to construct the algorithm steps.

In the loop, the algorithm updates the threshold values for an optimum segmentation and executes the algorithm, and a balanced solution set is created. It can choose between expert solutions using algorithms. Four methods used to separate the images obtained from MR images and to find the tumor region were examined, and as a result of the examinations, using the Fuzzy C Mean (FCM) method for the detection of the tumor region was found to be more successful in the detection of the tumor region. Two parts that needed improvement in this study drew attention. First, as a result of the Fuzzy C Mean (FCM) method used, the tumor areas and the parts where the brain fluid remains are shown in white in the final image. The method is unable to separate the brain fluid from the tumor region while separating it. Secondly, tumor stages cannot be determined since the calculation of the size of the tumor area cannot be made with the Fuzzy C Mean (FCM) method. However, if the cross-sectional area of the tumor area could be utilized, the determination of tumor stages would be easier. For this reason, in this study, basically these methods were tried to be developed.

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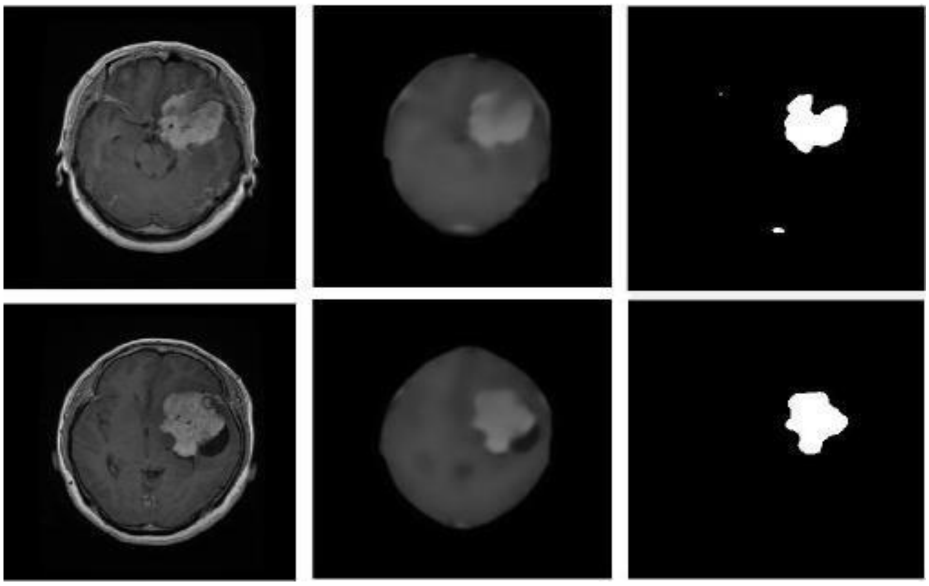

Figure 6. Brain tumor and brain fluid imaging by methods.

Threshold values, cluster numbers and similarity coefficients of jaccard and dice values of Single threshold, Multiple Herbaceous threshold, K-means, Fuzzy C-means segmentations were determined one by one by changing the index codes in the software and these were tabulated. These index values are needed to extract brain fluid from the brain tumor area.

Table 1. Threshold values and similarity indices of the methods.

	Threshold Value	**Jaccard**	**Dice**	
Single Threshold	1 (233)	0.8549	0.9217	
	1 (245)	0.8406	0.9134	
	Number of Thresholds	Number of Clusters	Jaccard	Dice
Very Grassy Threshold	7	8	0.8395	0.9128
	4	5	0.8067	0.8930
	10	11	0.8549	0.9217
	Number of Clusters	Jaccard	Dice	
K-means	6	0.8534	0.9209	
	8	0.8551	0.9219	
	10	0.8580	0.9236	
	Number of Clusters	Jaccard	Dice	

Fuzzy C-means	0.79	0.82	0.79

In all trials, the highest similarity index was found in the K-means ten cluster numbered segmentation. In general, K-means and Very Grassy Threshold gave very close results. As an algorithm, it has a simple algorithm. It separates our tumor image into ten clusters according to their color in my best algorithm. In the prepared algorithm, the tumor image is in cluster no. An algorithm that removes other clusters was designed and only tumor image was obtained.

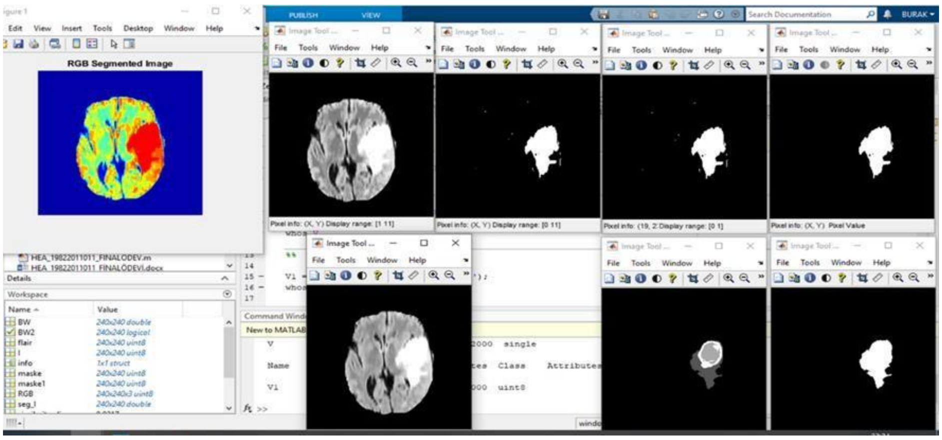

Figure 7. Detection of tumor area in mr images.

Tumor areas with brain fluid are shown in white. The white parts shown as dots in this study show the brain fluid. Finally, a tumor image was obtained by using an algorithm to fill in unwanted small spots.

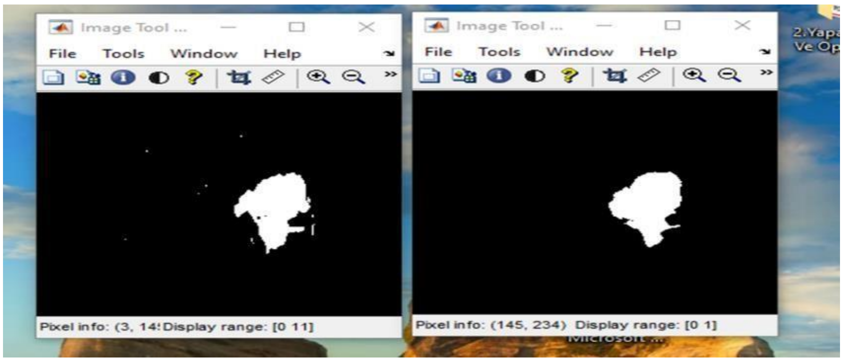

Figure 8. Algorithm for separating brain fluid from the tumor area.

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Table 2. Tumor area calculation algorithms.

	Required Remarks Parameter Values	Jaccard	Dice
watershed	840 from the cluster 579.	0.8339	0.9094
graph-cut	254 from the cluster 238.	0.7834	0.8785
active counter	30 iteration	0.4863	0.6544

The image in the area, centroid and rectangle after the Watershed segmentation is as follows;

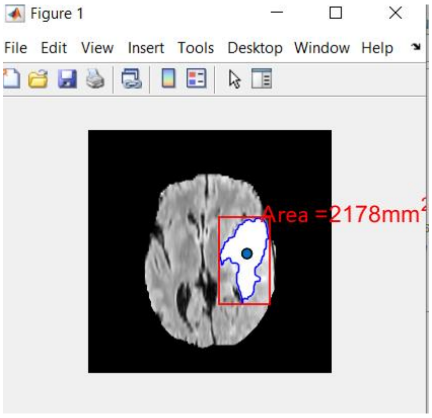

Figure 9. Watershed segmentation area.

The image in the area, centroid and rectangle after Graph-cut segmentation is as follows;

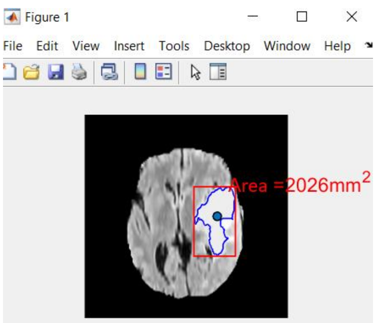

Figure 10. Graph-cut segmentation area.

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Active counter codes are taken from the official site of MATLAB. The mask was adjusted around the tumor area and the number of iterations was found by experimenting.

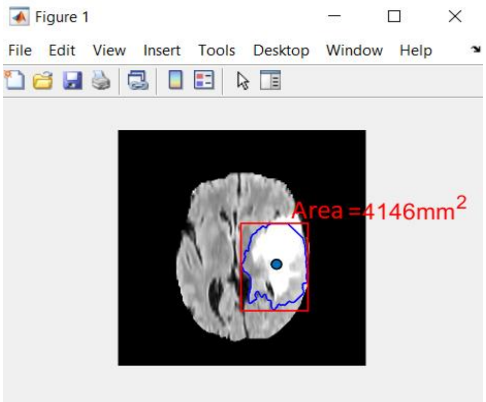

Figure 11. Active counter segmentation area.

Then, the accuracy rate was found with the best tumor image masked with jaccard and dice. After these procedures, the features of the shape of the tumor in which it is best found in the image were taken and the surrounding area was drawn. Then the smallest rectangle that will surround it is drawn and the center point is marked. The area of the tumor image was found to be mm2, and they were all plotted and printed on the first plain tumor image.

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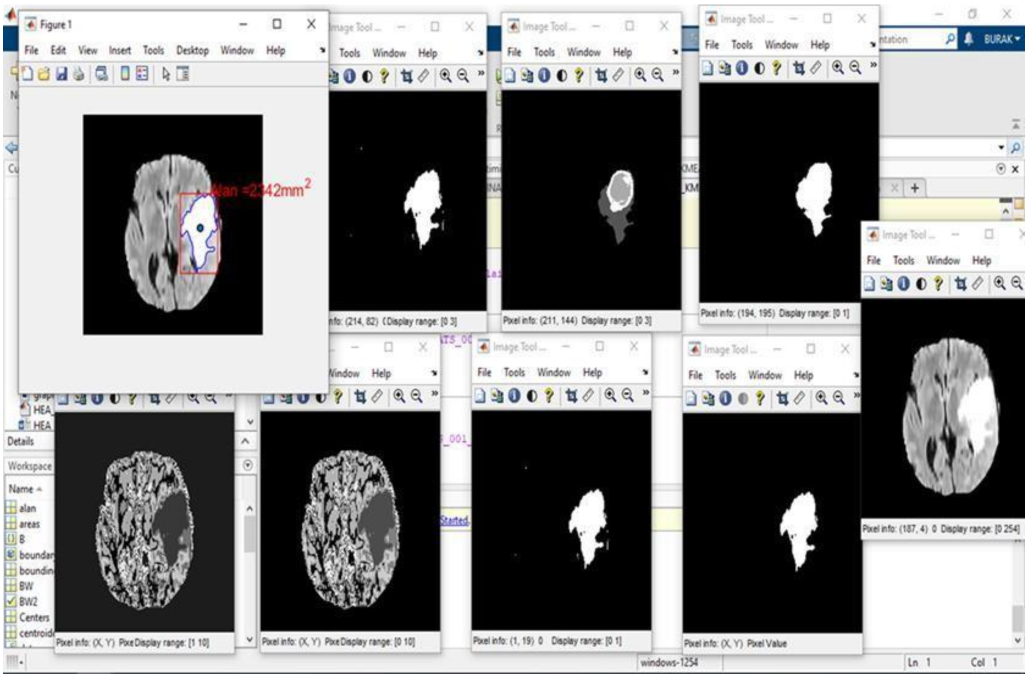

Figure 12. Process steps of brain tumor.

4. CONCLUSION

It has been determined that there are some deficiencies in the Herbaceous Method and FCM methods when their software is examined. One of them is that the brain fluids enter the white color area as in the tumor region, so the algorithm detects the brain fluid as a tumor, this deficiency will cause doctors to be wrong in determining the tumor stage and will cause wrong calculations as it will shift the central point in tumor area calculations. An algorithm that removes other clusters was designed and only tumor image was obtained. Finally, a tumor image was obtained by using an algorithm to fill in unwanted small spots.

The other point that is seen as a deficiency is that the tumor area cannot be calculated after the brain fluid is distinguished. In this regard, three segmentations were used. The accuracy rate was found by finding jaccard and dice values from watershed, graph-cut, and active counter segmentations. After these procedures, the tumor was drawn around by taking the features of the shape that he found best in the image. Then the smallest rectangle that will surround it is drawn and the center point is marked.

The area of the tumor image was found to be mm^2, and they were all plotted and printed on the first plain tumor image. It has been shown that the developed software can be used as a tool for physicians to determine the location of the tumor at the brain tumor point, how much the tumor has spread, how much area it has, and what stage the tumor has reached. As a future development, training time can be shortened by adding new models to feature extraction.

5. DISCUSSION

In this study, in order to detect the brain tumor area on MR images, the Fuzzy C-Means (FCM), Herbaceous Method, Region Growing and Self-Organizing Maps (SOM) methods were used and the threshold values of the methods were examined and the best method that distinguishes the brain tumor from the other parts of the brain. method was tried to be determined. Herbaceous and FCM methods differentiate tumors more successfully than the other two methods (region augmentation and SOM).

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