IJCSE International Journal of Computer Sciences and Engineering Open Access
Review Paper Vol.-7, Issue-12, Dec 2019 E-ISSN: 2347-2693

A Review of Current Methods in Medical Image Segmentation

Shaik Salma Begum[1*], D. Rajya Lakshmi[2]

[1]Dept. of CSE, JNTUK, Kakinada, AP, India
[2]JNTUK, Narasaraopet, AP, India

**Corresponding Author: shaiksalma.gec@gmail.com*

DOI: https://doi.org/10.26438/ijcse/v7i12.6773 | Available online at: www.ijcseonline.org

Accepted: 10/Dec/2019, Published: 31/Dec/2019

Abstract: The goal of segmentation is to alter amendment the illustration of a image into one thing that's additional meaningful and easier to research. During this segmentation methodology, the particular portion of a image is highlighted keep with the matter printed. During this paper, we've got an inclination to examine the performance of various algorithms for various footage. Medical image method wishes continuous enhancements in terms of techniques and applications to help improve quality of services in health care business. Here during this paper totally different approaches of medical image segmentation are classified at the side of their sub fields and sub strategies. Recent techniques planned in every class also will be mentioned followed by a comparison of those strategies.

Keywords: Medical image segmentation, Thresholding, Region growing, Classifiers, Clustering, Compression

I. INTRODUCTION

Segmentation is a process in which an image is divided into several sub regions based on a specific feature in order to pick up a region of interest [1]. Segmentation process has enormous applications in the medical field [2]. In the field of research and development much work has been done to overcome the problems faced by the segmentation process and yet there is a need of more effective and efficient work. Popular techniques of image segmentation which are still being used by the researchers are Edge Detection, Threshold, Histogram, Region based methods, and Watershed transformation. Since images are divided into two types on the basis of their color, i.e. gray scale and color images. Therefore image segmentation for color images are totally different from gray scale images, e.g., content based image retrieval. Also which algorithm is robust and works well is depends on the type of image. The property of a pixel in an image and information of pixels near to that pixel are two basic parameters for any image segmentation algorithm. It can also be representing as similarity of pixels in any region and discontinuity of edges in image. Edge based segmentation is used to divide image on their basis of their edges. Region based methods used the threshold in order to separate the background from an image, whereas neural network based techniques used the learning algorithm to train the image segmentation process. The result taken from image segmentation process is the main parameter for further image processing research; this result will also determine the quality of further image processing process. Image segmentation algorithm play an important role in medical applications, i.e., diagnosis of diseases related to brain, heart, knee, spine, pelvis, prostate and blood vessel and pathology localization. Therefore, Image segmentation is still a very hot area of research for image processing field. It is still a challenging task for researchers and developers to develop a universal technique for image segmentation. Image segmentation is also used to differentiate different objects in the image, since our image is divided into foreground and background, whereas foreground of image is related to the region of interest, and background is the rest of the image. Hence, image segmentation will separate these two parts from one another. The basic medical image processing system is presented in figure1.

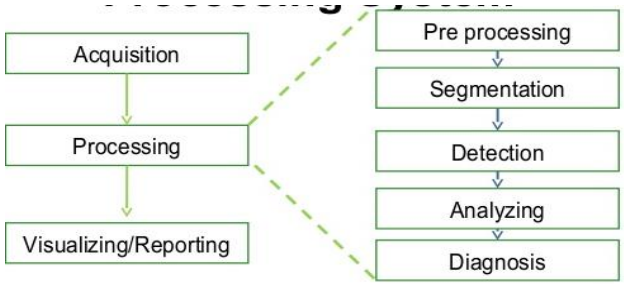

Figure 1: Basic medical image processing system

The purpose of segmentation is to enhance method of visual image to handle the detection process additional effectively and with efficiency. The analysis of functions of anatomy issues is administrated through the segmentation process [3]. It covers all the factors that influence the analysis of a sickness. Through the method of segmentation one will analyze, diagnose, quantify, monitor and set up the

navigation of a sickness. The process of segmentation is administrated on the premise of 2 central principles. These principles as shown in Figure two area unit classified on the premise of options that contain texture, intensity, sharpness of edges and every one the numerous options during this context [4]. Segmentation of medical image faces several issues thanks to that the standard of segmentation method gets affected [5]. The matter of uncertainty arises once there's noise within the image that makes the classification of image difficult[6]. The rationale is that intensity values of pixels area unit amended thanks to noise within the image. This alteration within the intensity values of pixels disturbs uniformity within the intensity vary of image [7]. Noise are often within the image thanks to motion within the image, blurring impact and lack of numerous options etc. the matter of partial volume averaging causes the problem of inconsistency within the intensity values of image pixels. Thus so as to handle this uncertainty within the diagnosis systems image segmentation is taking part in an important role [8].

1.1 Modalities of Medical Image Segmentation

Segmentation method has several applications within the medical field. There area unit completely different medical modalities that area unit handled through the segmentation method [9]. Here during this section, we'll have a fast summary of medical modalities. These modalities area unit mentioned within the prospect of reconstruction in [10] whereas careful analysis of those modalities is bestowed in [11]. equally improvement of those modalities is mentioned in [12].

1.1.1. **MRI** If we tend to analyze the applications of segmentation within the medical field we will say that the majority work is dispensed on the imaging brain pictures. magnitude is that these pictures contain high signal to noise ratio which needs improvement and segmentation of image to search out out the region of interest. Another issue concerning these pictures is that they contain a spread of resolution attributable to that segmenting the image with needed level of distinction could be a nice downside. The most applications is that this regard ar extracting volume of brain, segmenting totally different problems in matter of gray, white neural structure liquid and to stipulate precise brain formations [13].

1.1.2. CT Segmentation method has several applications within the analysis of computed axial tomography pictures. The most use of segmentation method during this regard is within the analysis of bones, pectoral scans, and segmentation of heart, stomach, brain and liver pictures and demarcation of abdominal arterial blood vessel aneurysms [14]. The distinction and backbone of those pictures isn't nearly as good as MRI pictures. form of ways is applicable within the segmentation method of CT pictures.

1.1.3. Ultrasound Ultrasound pictures are sometimes with high rate of imperfectness that makes it tough to section out the region of interest accurately. This reason caused several strategies irrelevant for the segmentation of ultrasound pictures. Not with standing this issue some work still has been wiped out this regard. In most of the cases manual segmentation is completed however these pictures are used for the estimation of motion concerned alongside distinctive pathology by suggests that of textural classifiers [15].

1.1.4. Multimodal In this case completely different modalities are used at the same time to find a tangle. The data provided by completely different modalities is used to phase out a selected region of interest. The matter with this modality is that it's not perpetually potential to collect multimodal knowledge. Another issue during this regard is that they principally need alignment method [16].

1.1.5. Digital Mammography Detection of various tumors is largely distributed within the segmentation of digital diagnostic procedure. commonest ways used for the diagnostic procedure segmentation ar variations within the method of thresholding.

II. LITERATURE REVIEW

Looking back at the history of methods and techniques proposed in the context of medical image segmentation, we can say that there is a great improvement in this regard. Here in this section we will analyze different methods that have been developed and utilized in the process of medical image segmentation. Recent work will also be taken into consideration.

2.1. Thresholding

Thresholding is one among the only and quickest segmentation ways supported the belief that pictures are formed from regions with totally different gray levels. The bar chart of pictures has totally different peaks and valleys which can divide pictures into different elements. Threshold could be a price during a bar chart that divides intensities into two halves: the primary half is that the “foreground” that has pixels with intensities bigger than or adequate to the brink and the second part is that the “background” during which pixels have intensities but the brink .An inappropriate threshold price results in poor segmentation results. To divide quite one object with different gray levels, quite one threshold is employed, is thought as multi thresholding. Thresholding segmentation typically doesn't take into account the spatial info of pictures that results in sensitivity to noise and intensity in homogeneities. These issues could occur in magnetic resonance imaging pictures that basically destroy the bar chart and build partitioning a lot of complex. Global thresholding works on the thought that a picture features a bimodal bar chart and also the object is separated from the background employing a threshold price. within the

following, adaptive thresholding that uses a neighbourhood threshold price that uses AN automatic threshold price are delineated [17].

Local Thresholding:

Global thresholding doesn't give satisfactory results for a few style of pictures like pictures that don't have a relentless background and have diversity across the item. For medical pictures, thresholding provides an honest end in one region however fails in alternative elements of pictures. So as to seek out totally different threshold values for various elements of pictures, the native thresholding technique divides pictures into sub images so calculates the threshold price for every half. The results of thresholding for every a part of a picture square measure then integrated. During this technique, a picture is split into vertical and horizontal lines, whereas every half includes a locality of each the background and therefore the object. Finally, associate interpolation is required to supply acceptable results. Totally different applied math strategies square measure accustomed choose the edge price for every sub image, as an example, mean, variance, mean and variance along, and mean of most and minimum. Native thresholding desires longer to phase a picture compared to world thresholding. This technique is additional helpful within the case of pictures with variable backgrounds.

2.2. Region Growing

Region Divide the entire image into sub regions or clusters, e.g. all the pixels with same grey level in one region. Region growing could be a technique for extracting a locality of the image that's connected based on some predefined criteria. This criteria may be supported intensity info and/or edges within the image. In its simplest type, region growing needs a seed purpose that is manually chosen by Associate in nursing operator, and extracts all pixels connected to the initial seed with identical intensity price. Like thresholding, region growing isn't typically used alone however at intervals a group of image processing operations, notably for the delineation of little, easy structures such as tumors and lesions. Its primary disadvantage is that it needs manual interaction to get the seed purpose. Thus, for every region that must be extracted, a seed should be planted. Split and merge algorithms are associated with region growing however do not need a seed purpose. Region growing may also be sensitive to noise, causing extracted regions to possess holes or maybe become disconnected. Conversely, partial volume effects will cause separate regions to become connected. to assist alleviate these problems, a homotopic region growing algorithmic program has been planned that preserves the topology between Associate in Nursing initial region Associate in nursing an extracted region . Fuzzy analogies to region growing have additionally been developed [18].A region growing method applied on knee is illustrated in the figure 2.

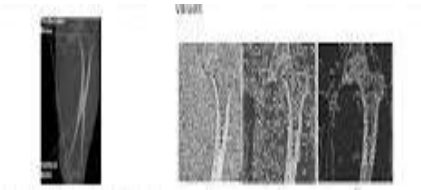

Figure2 : Region growing method on knee

2.3. Classifiers

Classifier ways ar employed in image process, they request to partition a feature house derived from the image exploitation knowledge with acknowledged labels. A feature house is that the vary house of any operate of the image, with the foremost common feature house being the image intensities themselves. Classifiers ar called supervised ways since they need coaching knowledge that ar manually metameric and so used as references for mechanically segmenting new knowledge [19]. Classifiers ways are more divided into numerous techniques which might be seen below.

2.3.1. Nearest Neighbour

It is a non-parametric technique. the strategy works by coaching all information for the classification purpose. the most disadvantage of technique is that it involves high machine convolution within the method of classification. The error rate which will occur in an exceedingly method is doubly during this case as compared to the byes technique [20]

2.3.2. KN-Nearest Neighbor

It is a non-parametric technique. the tactic works by putting k totally different points within the feature house characterised by clustered objects. These points primarily represent the centroids of initial teams. once putting the points every object is appointed to the cluster that has the contiguous center of mass. once assignment the teams the position of every k purpose is altered once more. This step is perennial till the movement of centroids becomes static. This repetition can formulate a metric to be calculated by separating the objects into numerous clusters. The most advantage of the tactic is that it needs no coaching summit of assurance in results. On the opposite hand low accuracy in classification and high needed storage could be a main disadvantage of the tactic[21].

2.3.4. Parzen Window

Parzen windows classifier may be a methodology for non-parametric density assessment that is employed in support of classification method. By means that of a given kernel operate, the tactic estimates an explicit coaching set allocation through a linear mix of kernels supported the experimental spots. The likelihood distribution operate during this case is approximated through the weighted common of various Gaussians. The performance and quality of the technique is comparable to KNN methodology [22].

2.3.5. Artificial Neural Networks

Artificial neural networks (ANNs) are massively parallel networks of process components or nodes that simulate biological learning. Every node in associate ANN is capable of playacting elementary computations. Learning is achieved through the variation of weights assigned to the connections between nodes. attributable to the numerous interconnections utilized in a neural network, abstraction data will simply be incorporated into its classification procedures. Though ANNs are inherently parallel, their process is typically simulated on a typical serial laptop, so reducing its potential process advantage[23].

2.3.6. Decision Tree Decision

Decision Tree Classifier is a straightforward and ordinarily used methodology of classification. The choice tree classifier structures a succession of assessment queries and provisions during a tree formation. within the call tree, the foundation and internal nodes enclose feature assessment circumstances to detach evidences that comprehend various distinctiveness. the complete terminal node is allotted a category labeled with affirmative or No [24].

2.4. Clustering

If we tend to compare the performance of clusters and classifiers are able to say that each are finishing up identical function with the distinction in their manner of operating. The classifiers build use of coaching information to classify the image and therefore are referred to as supervised strategies. Cluster approach contains unsupervised strategies because it doesn't build use of coaching information. This inability of learning in clump approach is paid by iteratively dividing the image through the segmentation method then illustrating the possessions of each division. In alternative words we will say that clustering techniques instruct themselves by suggests that of existing statistics [43]. Clustering method is principally appropriate for applications wherever the intensities distributions of pixels within the image are work detached. The most application of this technique is determined within the segmentation of MRI. There are two main strategies of clustering approach that are usually used for the segmentation of medical pictures.

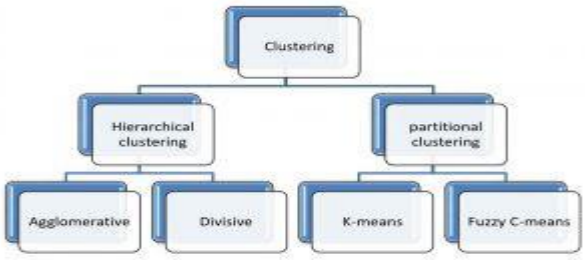

Figure 3: categories of clusters

2.4.1. K-means The clustering process partitions a collection of data into a k number group of data. It classifies a given set of data into k number of disjoint cluster. K-means algorithm consists of two separate phases. In the first phase it calculates the k centroid and in the second phase it takes each point to the cluster which has nearest centroid from the respective data point. There are different methods to define the distance of the nearest centroid and one of the most used methods is Euclidean distance. Splits an image into K groups or clusters by adding points p, to the cluster where the difference between the point and the mean is smallest. The clustering process in this case is carried out by iteratively calculating the mean of intensities values of each separated class or cluster of the image. And the segmentation is carried out by categorizing each pixel with the closest obtained mean of the image [25]. An example of k-means clustering is illustrated in figure 4.

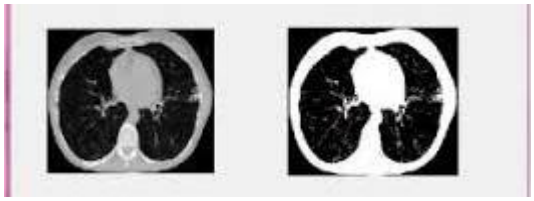

Figure 4: K.means clustering

2.4.2. Fuzzy c-means Fuzzy segmentation strategies area unit of appreciable edges, as a result of they might retain rather more data from the initial image than arduous segmentation strategies. especially, the fuzzy C-means (FCM) rule, assign pixels to fuzzy clusters while not labels. These strategies rule and techniques will improve remote sensing image threshold segmentation with less iterations times and smart stability and hardiness . A fuzzy set could be a set of sophistication time points of membership grades with no sharp boundary. Fuzzy-based segmentation technique is ready to integrate skilled data. This method is a smaller amount computationally high-priced compared to fuzzy c-mean cluster. In contrast to the arduous cluster strategies otherwise referred to as k-means cluster that force pixels to belong completely to 1 category, FCM permits pixels to belong to multiple clusters with variable degrees of membership. owing to the extra flexibility, The Fuzzy C-means cluster rule (FCM) could be a soft segmentation technique that has been used extensively for segmentation of man pictures applications recently. However, its main disadvantages embrace its machine quality and also the undeniable fact that the performance degrades considerably with inflated noise Fuzzy c-means (FCM) could be a technique of cluster that permits one piece of information to belong to two or a lot of clusters. In different word, every purpose features a degree of happiness to clusters, as in mathematical logic, instead of happiness fully to one cluster. Thus, points on the sting of a cluster could also be within the cluster to a lesser degree than points within the center of cluster. Fuzzy c-means has been a really vital tool for image process in cluster objects in a picture. The strategy makes use of applied mathematics bar graph data to attain the task.

Within the 70's, mathematicians introduced the abstraction term into the FCM rule to enhance the accuracy of cluster below noise[26].

2.5. Compression Based Approaches

Digital medical images have potential benefits in terms of durability, portability and versatility. However, problems involving storage space and network bandwidth requirements arise when large volumes of images are to be stored or transmitted, as is the case with medical images. From the diagnostic imaging point of view, the challenge is how to deliver clinically critical information in the shortest time possible. A solution to this problem is through image compression [27].

As medical/biological imaging facilities move towards complete film-less imaging, compression plays a key role. Although lossy compression techniques yield high compression rates, the medical community has been reluctant to adopt these methods, largely for legal reasons, and has instead relied on lossless compression techniques that yield low compression rates. The true goal is to maximise compression while maintaining clinical relevance and balancing legal risk. Keeping this in mind many new methods for Medical Image compression were proposed in the past two years.

2.5.1 A Model Based Approach for Medical image compression A new model-based approach to medical image compression by the use of image registration is proposed. An image that needs to be compressed will first be aligned to an image of its own type prestored in an atlas (such as the head or chest). Once a film is registered, two possibilities exist. The simpler approach is simply to read off the 'relevant' regions and then use lossless compression in relevant regions and lossy compression in the others. The alternative is that the new image can be subtracted from the prestored atlas image generating a residual image. This residual image will be compressed. If the alignment is done well, the residual information is minimised, thus yielding higher compression. The regions will be defined to classify areas of the image into those that are clinically relevant and those that are not clinically relevant. These regions are stored in the atlas and have been predefined by radiologists. Depending on the need the physician may override the default regions and define new relevant regions of his own. Lossless compression will be used in the clinically relevant regions and lossy compression will be used in areas that are not clinically relevant. Lossy compression such as JPEG, utilise a compression amount parameter that defines the amount of compression, and hence degradation, used on the image. Varying these parameter different ratios of compression can be obtained. Simple example is illustrated in the figure 5.

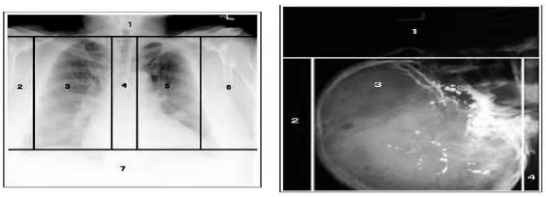

Figure 5: Medical image compression

The first image is that of a partitioned chest X-ray. Regions 3 and 5 are defined to be clinically relevant. Though all other regions are clinically non-relevant region 4 is defined to be more important than the others. Hence region 3 and 5 are compressed losslessly , region 4 is compressed with lossy JPEG quality of 50 whereas all other regions are compressed data quality of only 10. This yields compression ratio as good as 18:1 whereas 9:1 ratio is obtained if the whole image is compressed in a lossless fashion. Similarly region 3 is defined as relevant for the second image which is a partitioned skull image. The compression ratio obtained using the novel method was 3.8:1 compared to only 2.3:1 using traditional lossless compression. This image alignment model is based on a hybrid registration technique that makes use of mutual information maximisation between two images as an initial step, followed by another methodology based on deformable modelling.

2.5.2 Medical Image Compression based on Region of Interest The method proposed is a complete hybrid coder that uses a motion compensated coder in the overall image and an entropy minimizing, lossless coder for coding the error in the ROI (region of interest) region. The first step of an ROI based system is segmentation. Generally the image is segmented through a sequence of 3-D morphological image processing techniques. Next, motion vectors are coded for each block of the image. Finally, the error between the real image and the motion predicted image is coded for ROI blocks. Compression ratios as high as 40:1 can be achieved using this technique. Once the ROI is segmented in each slice, a hybrid compression scheme is used for coding the images. The first slice of the volume is compressed with a lossless coder. Each slice is then coded by motion compensated coding, which also acts as a prediction filter for ROI. Finally, the difference between the real-image ROI block and the predicted-image ROI block is coded by an entropy minimizing lossless coder, e.g. Huffman coder.

III. ANALYSIS AND DISCUSSION

After having an summary of basic approaches within the medical image segmentation method, it are often detected that with advancements within the method of search and development new effective and economical approaches are returning into existence. The strategies classification in keeping with the group is often analyzed to grasp this time. Approaches that exist during this regard are categorised into 3 groups; first, second and third respectively as shown in figure 6.

Figure 6: Different groups of image segmentation algorithms

Development and progress within the field of medical image segmentation are often analyzed by inserting the strategies into completely different teams. This classification can show us the analysis and development administrated during this regard. initial generation cluster contains strategies that need very little previous data for process the image thence involves low level techniques. With the passage of your time and advancement in technology some new and simpler strategies came into existence; second group occupies strategies supported improvement, image and uncertainty models. Third group techniques are extremely keen about previous data of the image and need consultants outlined models and rules for classification of a picture. Discussion may also be created on the comparison of various strategies given in Table 1.

Table1: Comparison of various strategies

S.No	Method	Advantages	Limitations	Applications	Memory usage
1	Thresholding	These methods are simple, easy and very fast to implement.	These methods are responsive to artifacts and piecewise continuity is not assured by them.	They are in the main applicable to structures that have divided intensity allotment.	Fastest
2	Region Growing	These ways assure the piecewise continuity and are less sensitive to noise.	Position of the beginning purpose and blurring affects ar the most limitations of those ways.	Work well for the structures with high distinction boundaries.	Fast
3	Clustering	These ways square measure straightforward to implement and may even be used as place to begin for different approaches.	They need a abstraction constraint to perform well.	Mainly work well for MR pictures; not able to handle CT images.	Medium
4	Classifiers	Most widely used approaches for segmentation method.	They are computationally complicated and slow approaches.	Work well for MR and CT images.	Slow
5	Edge based methods	They are easy to implement and offer effective computational factor.	Not appropriate to figure out all kinds of problems.	Can be applied in all modalities of medical image segmentation.	Fast
6	Compression based methods	They provide an advantage of less storage consumption.	These approaches are relatively slow.	These approaches have main applications for MR and CT images.	Medium

IV. CONCLUSION

This paper provides a short survey of some ways and techniques on the techniques of medical image segmentation. Medical field is comprised of variety of medical modalities and every one amongst them contains variety of diseases and problems below its heading. Therefore this paper is essentially analyzing the techniques projected and enforced in all of those modalities to assist medical field seeable of analyzing or determining a specific drawback. Every methodology has its own execs and cons. The usage of every methodology depends on the sort of application engineered alongside the resources available. Though abundant analysis work has been done in this regard however, we are able to still say that there's large room on the market for additional economical and effective techniques.

REFERENCES

[1] Saleha Masood et al. " A survey on medical image segmentation" Curent Medical Imaging Reviews ISSN: 1875-6603 Benham Science Publishers 2015 pg:3-14
[2] Zuva T, Oludayo OO, Ojo SO, Ngwira SM. Image segmentation, available techniques, developments and open issues. Canadian Journal on Image Processing and Computer Vision 2011; 2(3): 209.
[3] Sharma N, Aggarwal LM. Automated medical image segmentation techniques, Journal of medical physics/Association of Medical Physicists of India 2010..
[4] Costin H. A Fuzzy Rules-Based Segmentation Method for Medical Images Analysis, International Journal of Computers, Communications & Control 2013;8(2).

[5] Shrimali V, Anand R, Kumar V. Current trends in segmentation of medical ultrasound b-mode images: a review. IETE technical review 2009; 26(1).
[6] Birkfellner W. Applied medical image processing: a basic course: Taylor & Francis; 2014.
[7] Al-amri SS, Kalyankar NV, Khamitkar SD. A Comparative Study of Removal Noise from Remote Sensing Image, International Journal of Computer Science Issues (IJCSI) 2010; 7(1)
[8] He BS, Zhu F, Shi YG. Medical Image Segmentation, Advanced Materials Research 2013; 760: 1590-3.
[9] Pham DL, Xu C, Prince JL. Current methods in medical image segmentation 1, Annual review of biomedical engineering 2000; 2(1): 315-37.
[10] Yasmin M, Sharif M, Masood S, Raza M, Mohsin S. Brain image reconstruction: A short survey. World Applied Sciences Journal 2012; 19(1): 52-62.
[11] Yasmin M, Mohsin S, Sharif M, Raza M, Masood S. Brain Image Analysis: A Survey, World Applied Sciences Journal. 2012; 19(10): 1484-94.
[12] Yasmin M, Sharif M, Masood S, Raza M, Mohsin S. Brain image enhancement-A survey. World Applied Sciences Journal, 2012; 17(9): 1192-204.
[13] Masood S, Sharif M, Yasmin M, Raza M, Mohsin S. Brain Image Compression: A Brief Survey, Research Journal of Applied Sciences, 2013.
[14] Xiao-juan C, Dan L, editors. Medical image segmentation based on threshold SVM. Biomedical Engineering and Computer Science (ICBECS), 2010 International Conference on; 2010: IEEE.
[15] Aja-Fernandez S, Vegas-Sanchez-Ferrero G, Fernandez M, editors. Soft thresholding for medical image segmentation, Engineering in Medicine and Biology Society (EMBC), 2010 Annual International Conference of the IEEE; 2010: IEEE
[16] Shahzad A, Sharif M, Raza M, Hussain K. Enhanced watershed image processing segmentation, Journal of Information & Communication Technology. 2008; 2(1): 01-9.
[17] Abubaker A, Qahwaji R, Aqel MJ, Saleh MH, editors. Average Row Thresholding Method for Mammogram Segmentation. Engineering in Medicine and Biology Society, 2005 IEEE-EMBS 2005 27th Annual International Conference of the; 2006: IEEE.
[18] Haider W, Sharif M, Raza M. Achieving accuracy in early stage tumor identification systems based on image segmentation and 3D structure analysis. Computer Engineering and Intelligent Systems 2011; 2(6): 96-102.
[19] Bezdek JC, Hall L, Clarke L. Review of MR image segmentation techniques using pattern recognition, MEDICAL PHYSICSLANCASTER PA- 1993; 20: 1033
[20] Arya S, Mount DM, Netanyahu NS, Silverman R, Wu AY. An optimal algorithm for approximate nearest neighbor searching fixed dimensions. Journal of the ACM (JACM) 1998; 45(6): 891-923.
[21] Liao Y, Vemuri VR. Use of K-nearest neighbor classifier for intrusion detection, Computers & Security 2002; 21(5): 439-48.
[22] Yeung D-Y, Chow C, editors Parzen-window network intrusion detectors, Pattern Recognition, 2002 Proceedings 16th International Conference on; 2002: IEEE.
[23] Song T, Jamshidi MM, Lee RR, Huang M. A modified probabilistic neural network for partial volume segmentation in brain MR image Neural Networks, IEEE Transactions on. 2007; 18(5): 142432.
[24] Safavian SR, Landgrebe D. A survey of decision tree classifier methodology, IEEE transactions on systems, man, and cybernetics 1991; 21(3): 660-74.
[25] Lee TH, Fauzi MFA, Komiya R, editors. Segmentation of CT brain images using K-means and EM clustering. Computer Graphics, Imaging and Visualisation, 2008 CGIV'08 Fifth International Conference on; 2008: IEEE.
[26] Muda TZT, Salam RA, editors Blood cell image segmentation using hybrid k-means and median-cut algorithms, Control System, Computing and Engineering (ICCSCE), 2011 IEEE International Conference on; 2011: IEEE.
[27] Bhattacharyya S, A brief survey of color image preprocessing and segmentation techniques, Journal of Pattern Recognition Research 2011; 1(1): 120-9.

