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A COMPREHENSIVE REVIEW TOWARDS SEGMENTATION AND DETECTION OF CANCER CELL AND TUMOR FOR DYNAMIC 3D RECONSTRUCTION

ZAINAL RASYID MAHAYUDDIN
A F M SAIFUDDIN SAIF

ABSTRACT

Automated cancer cell and tumor segmentation and detection for 3D modeling are still an unsolved research problem in computer vision, image processing and pattern recognition research domains. Human body is complex three-dimensional structure where numerous types of cancer and tumor may exist regardless of shape or position. A three-dimensional (3D) reconstruction of cancer cell and tumor from body parts does not lead to loss of information like 2D shape visualization. Various research methodologies for segmentation and detection for 3D reconstruction of cancer cell and tumor were performed by previous research. However, the pursuit for better methodology for segmentation and detection for 3D reconstruction of cancer cell and tumor are still unsolved research problem due to lack of efficient feature extraction for details surface information, misclassification during training phases and low tissue contrast which causes low detection and precision rate with high computational complexity during detection and segmentation. This research addresses comprehensive and critical review of various segmentation and detection research methodologies for cancer affected cell and tumor in human body in the basis of three-dimensional reconstruction from MRI or CT images. At first, core research background is illustrated highlighting various aspects addressed by this research. After that, various previous methods with advantages and disadvantages followed by various phases used as frameworks exist in the previous research demonstrated by this research. Then, extensive experimental evaluations done by previous research are demonstrated by this research with various performance metrics. At last, this research summarized overall observation on previous research categorized into two aspects, i.e. observation on common research methodologies and recommended area for further research. Overall reviews proposed in this paper have been extensively studied in various research papers which can significantly contribute to computer vision research and can be potential for future development and direction for future research.

Keywords: 3D Reconstruction; Segmentation; Detection; Deep Neural Network.

INTRODUCTION

Cancer is one of the deadliest diseases out of the numerous diseases of human beings which have become one of the most occurring diseases in the last few decades. Cancer is a dense and abnormal cells proliferation in the body tissue. Cancer cells do not have the longer respond to some or many of the signals that mainly control cellular growth and death. Previous research occurred in various aspects for detection, segmentation and 3D reconstruction of cancer cells. However, these research lack in various aspects, i.e. absence of detailed surface information, misclassification, huge training phases. This research presents comprehensive reviews for detection, segmentation and three-dimensional reconstruction of cancer cell image exists in previous researches.

Abnormal growth of tumors turns into cancer. To remove tumor based on operation, position and shape of the tumor and cancer cells are important issue to know for successful operation. In addition, position and shape of the tumor and cancer cells helps to know the stage of cancer. Magnetic resonance imaging (MRI) is well known procedure that excellently shows the internal soft tissue organs of brain. However, MRI slice shows two dimensional form of the particular position in brain along to axis (Bashir et al. 2015). Viewing two dimensional image may loss information which can be reason for unsuccessful operation. Besides, two dimensional views do not represent the complexity of the brain which initiates the need of three dimensional reconstructions of tumor and cancer cells to observe the actual size and shape of the brain as well as the cancer cells. Before 3D reconstruction of cancer cell, there needs a perfect detection and segmentation of cancer cell and cancer classification. Segmentation is a process of dividing an image into useful components that can be further utilized for various purposes. In addition, segmentation is achieved on the basis of similar attributes. Accurate segmentation of brain tumors from MRI images is a challenging task. Implication of various learning perspectives, i.e. supervised and unsupervised learning, neural network (Damodharan and Raghavan 2015; Mahayuddin and Saif 2018), Genetic Algorithm (Singh et al. 2016; Mahayuddin and Saif 2019), deep neural network (Rathi and Palani 2015; Mahayuddin and Saif 2019), k-means clustering (Farzana and Sathik 2017; Mahayuddin et al. 2015), Multiple kernel based probabilistic clustering approach (Rathi and Palani 2015), Volumetric exclamation (Roy et al. 2015), feature extractions (Damodharan and Raghavan 2015; Saif and Mahayuddin 2018) for cancer cell and tumor segmentation and detection from MRI or CT slice images is a significant research problem in the area of medical image processing, computer vision research domains. This research demonstrated comprehensive and critical review from the previous research for detection, segmentation and 3D reconstructions of cancer cell and tumor.

Rest of this paper is demonstrated as follows: section 2 illustrates core research background of this research, section 3 depicts comprehensive review on existing methods with advantages and disadvantages, section 4 presents critical review based on various frameworks used in the previous research, section 5 demonstrates extensive experimental results and analysis used in the previous research, section 6 illustrates observation and proposed recommendation for further investigation and finally, section 5 illustrates concluding remarks of this research.

CORE RESEARCH BACKGROUND

Previously, various research methodologies exist for segmentation, detection and 3D visualization of tumors which acted as motivation towards formulating core research concerns addressed by this research. Various research aspects, i.e. Gaussian filtering and edge enhancement based segmentation (Bashir et al. 2015; Saif et al. 2014), volumetric 3D rendering and marching cube for 3D modeling (Arakeri et al. 2013), multiple kernels based probabilistic clustering for segmentation and neural network for classification (Rathi and Palani 2015; Havaei et al. 2017) were used for segmentation, detection and 3D visualization of tumors. However, most of these previous approaches exist with various advantages and disadvantages which were addressed by this research for further investigation.

Bashir et al. (2015) used Otsus thresholding followed by binarization and some other morphological operations such as dilation and erosion (Bashir et al. 2015). As preprocessing phases, their research used high pass Gaussian filtering and edge enhancement where segmented tumor was reconstructed using slicer as 3D visualization perspectives. Although, segmentation accuracy by their research addressed high accuracy, validation of the 3D visualization was not presented evidently. Regarding the usage of Gaussian filtering, Arakeri et al. (2013) also used Gaussian low pass filter using K-Mean clustering and adaptive thresholding for segmentation and classification purpose. For 3D reconstruction perspectives, Arakeri and Reddy (2013) used volumetric 3D rendering and marching cube where their research generated 3D model with high accuracy and precision. However, their research did not provide adequate details in terms with features properties about the generated 3D model. In this context, Rathi and Palani (2015) proposed multiple kernels based probabilistic clustering for segmentation of tumor extracting shape, texture and intensity features. In addition, their research used neural network for classification which performed well comparing with region growing and modified region growing segmentation approach. However, specificity was high in their research which indicates that false negative rate was lower than other research methodologies. Havaei et al. (2017) segmented tumor with deep neural network approach where proposed networks are tailored to glioblastomas from MRI images. Segmented tumors could appear anywhere in the brain regardless of shape, size and contrast which motivated their exploration that exploits a flexible, high capacity DNN while being extremely efficient. Havaei et al. (2017) also proposed novel approach based on convolutional neural network (CNN) architecture to exploit both local features as well as more global contextual features simultaneously. Difference from most traditional uses of CNNs, their networks uses a final layer that is a convolutional implementation of a fully connected layer which allows a 40-fold speed up where two phase training procedures where used to tackle difficulties related to the imbalance of tumor labels. However, as research by Havaei et al. (2017) used deep neural network approach, learning strategy towards network design perspectives might not help to improve overall computation cost (Saif et al. 2013). Singh et al. (2016) applied Intra-Genetic algorithm which was composed into four phases, i.e. Intra – Member building, Intra – Fitness evaluation, Intra – Crossover and Intra – Mutation. However, as their research involved in evolution process in the basis of genetic algorithm, i.e. crossover and mutation, computation time is the prime concern which should be further investigated by Singh et al. (2016). A power law transformation with accuracy estimation, Al-hadidi (2016) used gamma transformation for image segmentation where tumor region is turned into complete white region and the rest is black. After that, all image slides are stacked connecting white tumor regions using linear interpolation. The main shortcomings of their research are the inability to reconstruct the tumor efficient enough if the tissue contrast is relatively poor. Overall strategy towards critical and comprehensive review and analysis performed by this research based on previous research is mentioned in Figure 1.

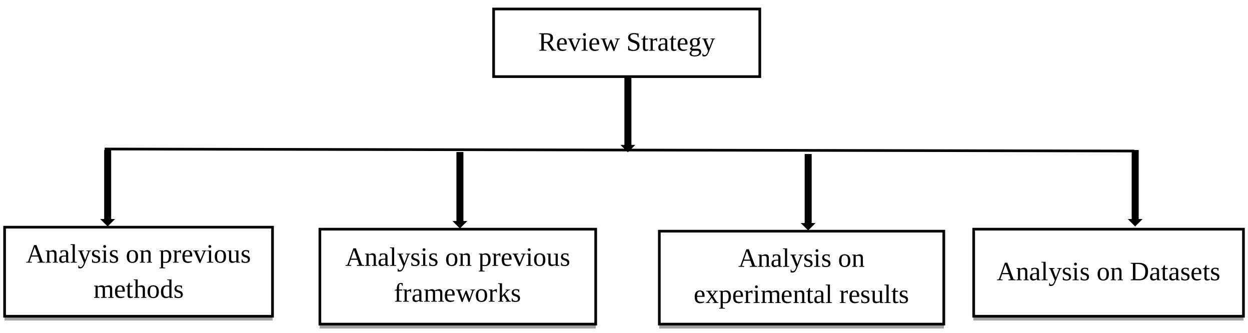

FIGURE 1. Framework for critical and comprehensive review on previous research

REVIEW BASED ON METHODS

Previously various methods were used based on mainly three perspectives, i.e. segmentation, detection and 3D reconstruction. To properly diagnose and treat cancer, various tumor characteristics such as specific type, dimensions, location, cancer stage, appearance, growth rate, etc are important issues. In this context, segmentation, detection and 3D reconstruction can play crucial role for medical images analysis for diagnosis, surgical planning and biological research (Bharathi and Manimegalai, 2015). In this context, various previous research methods exist, i.e. region property based segmentation (Damodharan and Raghavan 2015; Saif et al. 2013), neural network based learning approach (Damodharan and Raghavan 2015; Saif et al. 2014), multiple kernel based probabilistic clustering approach (Rathi and Palani 2015), random forest classifier (Usman and Rajpoot 2017), geometric moments with discrete cosine transforms and wavelets with k-NN and SVM classifier (Alarabeyyat and Alhanahnah 2016), Jacobian matrix and Levenberg-Marquardt algorithm (Muniganti and Gope 2016), Delaunay triangulation and patches (Bharathi and Manimegalai 2015), k-means clustering (Farzana and Sathik 2017; Saif et al. 2015), volumetric exclamation (Roy et al. 2015), modified Mumford – Shah cartoon model (Müller et al. 2016), modified multiple fuzzy c-means clustering (Arakeri et al. 2013; Saif et al. 2013; Saif et al. 2013) shown in Figure 2 and illustrated in Table 1 with advantages and disadvantages. Damodharan and Raghavan (2015) proposed orthogonal polynomial transformation and region property-based segmentation for detection and neural network for classification of tumor. Their proposed segmentation involves classification of tumor from images obtained using modalities such as CT, X-ray, MRI, Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT) or ultrasound. For preprocessing, they used thresholding binarization and region based binary mask extraction (Damodharan and Raghavan 2015). Grey matter, white matter and cerebro-spinal fluids are segmented by their proposed methodology from MRI images. Although, performance of the overall proposed methodology was good, performance based on computation was not justified by Damodharan and Raghavan (2015) due to huge amount of complex calculations was used during segmentation and custom feature extraction method. In this context, Rathi and Palani (2015) proposed multiple kernel based probabilistic clustering approach for segmentation with deep learning approach and they received higher accuracy and sensitivity compared to region growing with neural network. They extracted features based on shape, texture and intensity with linear discriminant analysis. However, their proposed segmentation method had lower specificity than other segmentation methods with which their proposed methodology was compared for validation.

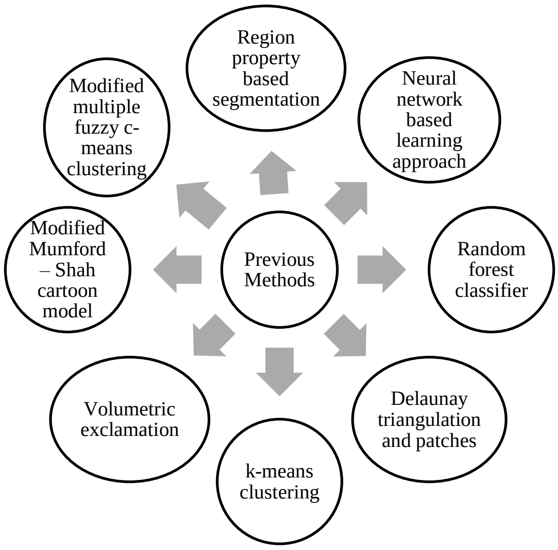

FIGURE 2. Previous methods in existing research

Usman and Rajpoot (2017) classified tumor from multi-modality MRI using wavelets to extract features and random forest classifier. They classified tumors into several categories with higher accuracy. However, during training phase their research misclassified data due to error. Alarabeyyat and Alhanahnah (2016) used geometric moments with discrete cosine transforms and wavelets with k-NN and SVM classifier to detect tumor. However, learning perspectives needs to address more robustly for efficient validation for their research. In this context, Muniganti and Gope (2016) computed Jacobian matrix and Levenberg-Marquardt algorithm to measure scattered electric field and multilevel voxel discretization to identify and separate fine regions and detect cancer. However, computational complexity and computability for the overall research methodology addressed by this research is the main concern.

Zahira and Sathik (2016) proposed effective analysis of MRI images where they used region growing approach for segmentation. Their research used hybrid of Gray-Level Co-Occurrence Matrix. Although, classification and segmentation approach proposed by their research received high accuracy, their overall methodology was multithreaded and consumed more time than other research methodologies. In this context, Bharathi and Manimegalai (2015) proposed 3D digital reconstruction of brain tumor from MRI images using Delaunay triangulation and patches. To reconstruct shape of the tumor, overall brain image was used in this research where volume of the tumor was not estimated. Farzana and Sathik (2017) used k-means clustering for segmentation and marching cube for 3D reconstructions over Brain MRI where they generated 3D model of brain with high accuracy and precision. However, their research used volumetric rendering, detailed surface information was absent during features phase. Roy et al. (2015) proposed useful approach towards 3D representation of brain abnormality from 2D MRI with volumetric exclamation. Their research determined volume of the tumor with minimal error comparing manually estimated volume and system estimated volume. However, if the tissue contrast becomes relatively poor, their proposed methodology provided poor reconstruction performance. Müller et al. (2016) proposed modified Mumford – Shah cartoon model on filtered MRI where he applied Otsu threshold in the post processing phase. Although computational cost is low for modified Mumford – Shah cartoon model by Müller et al. (2016), in the case of low grade glioma precision rate was low. Arakeri et al. (2013) proposed modified multiple fuzzy c-means clustering on MRI with tumor in lieu with mesh simplification algorithm for 3D reconstruction with volume estimation from slice thickness, inter slice gap and area of tumor in each slide. Their proposed methodology generated excellent mesh which results into quite precise and clear 3D tumor image. However, their proposed overall method required high computation time comparing with other research methodology for segmentation or 3D reconstruction strategy.

TABLE 1. Review based on methods used in core researches

Previous Research	Method name	Advantages	Disadvantages
Farzana and Sathik (2017)	k-means clustering	Generated 3d model of brain with high accuracy and precision.	Due to volumetric rendering, detailed surface information was absent.
Usman and Rajpoot (2017)	Random forest classifier	Classified tumors from multi-modality MRI into 3 categories with higher accuracy.	Misclassified data during training phases causes high error rate.
Damodharan and Raghavan (2015)	Region property based segmentation	Segmented gray matter, white matter, Cerebro-spinal fluids, and tumor separately from MRI images.	Although overall performance based was good, performance based on computation is expected to be complex due to huge amount of complex calculations

			during segmentation and their custom feature extraction methodology.
Zahira and Sathik (2016)	Region property based segmentation, neural fuzzy logic.	Received high classification and segmentation.	Overall methodology for 3d reconstruction was multithreaded causes consumption of high computation time.
Rathi and Palani (2015)	Multiple kernel based probabilistic clustering approach	Multiple kernel based probabilistic clustering achieved higher accuracy and sensitivity compared to region growing with neural network and modified region growing with neural network.	Received lower specificity than traditional segmentation methods.
Roy et al. (2015)	Volumetric exclamation	Estimated volume of the tumor with minimal error.	Could not reconstruct the tumor efficiently if the tissue contrast is relatively poor.
Müller et al. (2016)	Modified Mumford – Shah cartoon model	Extremely fast approach for tumor detection compared to other methods having near DICE scores	Precision is quite low for low grade glioma's tumor
Arakeri et al. (2013)	Modified multiple fuzzy c-means clustering	Generates excellent mesh caused clear tumor 3d image.	Required huge computation phases.

REVIEW BASED ON FRAMEWORKS

Various frameworks were proposed for detection, segmentation and three-dimensional reconstruction of cancer cell image in previous researches. Bashir et al. (2015) proposed slice selection mechanism which was composed into two parts, i.e. Segmentation and 3D reconstruction (Bashir et al. 2015). They improved quality of the image by color scale conversion using contrast enhancement and emphasizing edges in lieu with morphological operation. Although, they applied various morphological operations, multiple suspicious regions still existed due to artifact affects, heavy tissue area, and tumor region where research by Hussain et al. (2015) aimed to extract brain tumor regions only. For 3D reconstruction, Hussain et al. (2015) used cubic interpolation technique to identify the curve around the segmented tumor area in the MRI images known as main slice. Yang et al. (2015) used Fuzzy c-means to model tumor and 3D breast model by detecting contours of tumor. Additionally they used Multi-Spectral Gradient Vector Flow Snake (MGVFS) method, Constraints Energy Minimization (CEM) and Gradient Vector Flow Snake (GVFS) (Yang et al. 2015). However, their research used several gradient measurements, rotation of gradient measurements along x and y axes might cause huge calculation overheads for feature extraction. Yong et al. (2015) proposed volume reconstruction and volume rendering based 3D reconstruction of tumor using data interpretation where volume rendering techniques basically renders every voxel in the volume raster directly. In this context, Naveenkumar and Sanjay (2014) also used volume calculation in lieu with morphological processing for 2D to 3D reconstructions of tumor. However, volume rendering methodology does not provide efficient performance in case of poor contrast. In this context, Muller et al. (2016) proposed fast Mumford-Shah algorithm which was used for automatic brain tumor segmentation in lieu with confidence refinement of the segmented region and segmentation of the tumor fine structure. However, as segmentation approach alone cannot extract complete shape of the tumor, proposed research by Muller et al. (2016) demands for hybrid methodology to be integrated with segmentation of tumor.

Various learning based methodologies were proposed previously for segmentation, detection and reconstruction of cancer cell. In this context, Singh et al. (2016) proposed two-fold genetic evolution of neural network ensembles where an innovative approach for the creation of NNE was used for classification of cancer tumors. Two variants of Genetic Algorithm i.e. The Intra-Genetic Algorithm and the Inter Genetic Algorithm were proposed by Singh et al. (2016) which were consist of some small modules such as intra-member building, intra-fitness evaluation, intra-crossover operator. Due to evolving cross over methodologies, their research depends efficient selection of features which might require robust validation. For multi-modality image, Zahira and M. Sathik (2016) extracted wavelet-based texture features to predict tumor labels and exploring supervised classifiers for brain tumor classification where they used region growing approach for segmentation. In this context, Rathi and Palani (2015) proposed deep learning classifier approach for brain tumor detection from MRI images. For segmentation, their research used probabilistic clustering and fuzzy c-means clustering methods in lieu with extraction of three types of features i.e. shape based features, texture based features and intensity based features. However, as Rathi and Palani (2015) and Zahira and M. Sathik (2016) included region growing approach for segmentation, overall methodology depends on specific region classifying tumor which was not realistic. In addition, Muniganti and Gope (2016) used k-nearest neighbor for tumor detection where cropping processing Multilevel Inverse EM Solver for 3D Image Reconstruction towards Radio Frequency was also proposed. However, due to usage of excessive phases in their overall methodology, their proposed research required high computation time.

REVIEW BASED ON EXPERIMENTAL RESULTS

Previous research validated various research methodologies based on various performance metrics, i.e. accuracy rate, false alarm rate and computation time for detection and segmentation for 3D reconstruction of cancer cells or tumors shown in Figure 3. Farzana and Sathik (2017) used two types of detection techniques, i.e. adaptive threshold and k means clustering with two types of reconstructions techniques such as volume 3D rendering and marching cubes for each combination. Out of all combinations, detection using k means clustering and marching cubes reconstruction technique has the highest accuracy rate of 97.6204% with least false alarming rate of 5.1786%. The method with the least accuracy rate of 76.179% is adaptive threshold with marching cube that also happens to have the highest false alarming rate of 35.3471%. In this context, Antony et al. (2017) and Havaei et al. (2017) also used k means clustering approach to segment tumors (Rathi and Palani 2015; Havaei et al. 2017). Antony et al. (2017) received accuracy rate of 99.90% where they used X-ray images as data (Rathi and Palani 2015). Although previous research by Farzana and Sathik (2017), Antony et al. (2017) and Havaei et al. (2017) received promising accuracy rate, however these research did not provide detailed surface information during segmentation.

Damodharan and Raghavan (2015) received classification results of 83% by applying region property based segmentation with neural network for classification. High false positive rate of 25%, made the research achievement by Damodharan and Raghavan (2015) weak. Rathi and Palani (2015) also used neural network for classification where they received accuracy rate of 75%. However, due to complicated adjustment of hidden neurons research by Rathi and Palani (2015) needs further investigation. In this context, Zahira and Sathik (2016) used region growing and fuzzy logic for segmentation where they received detection rate of 89.6%. Similarly, Yong et al. (2015) used modified multi fuzzy C means algorithm with histogram analysis where their proposed methodology received low error rate of 1.8% for automated segmented tumor. Muniganti and Gope (2016) used modified Mumford-Shah algorithm for segmentation where during experimentation they processed high glioma and low glioma for active tumor regions which the accuracy rate of 83.15%. In this context, Al-hadidi et al. (2016) segmented tumor with the accuracy rate of 98.39% and Roy and Bandyopadhyay (2017) segmented tumor with the accuracy rate of 93% (Alarabeyyat and Alhanahnah 2016; Roy and Bandyopadhyay 2012). In this context, Yang et al. (2015) proposed segmentation with 3D reconstruction approach where volume error metric was used for experimentation with 3.4% error rate with the respect to the actual tumor volume (Yang et al. 2015). In addition, Chen (2012) used volume estimation using symmetric series of CT scans are used for 3D reconstruction where skin-sparing volume was about 91.64%. However, due to usage of volumetric rendering, detailed surface information extraction can be addressed for further experimentation in these researches. Muller et al. (2016) used two types of samples for experimentation, i.e. high grade and low grade. For high grade samples they achieved accuracy rate of 95.3% and for low grade data they received accuracy rate of 81.9% (Müller et al. 2016) shown in Figure 3.

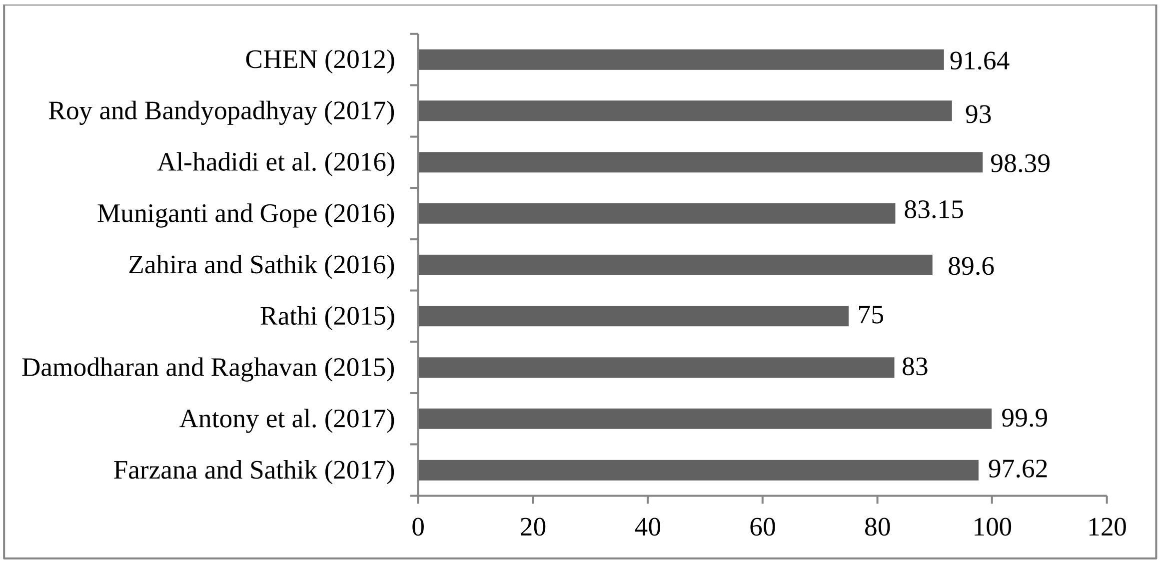

FIGURE 3. Accuracy exists in previous research.

OBSERVATION AND DISCUSSION

For safe surgery and proper treatment, tumor must be detected as trustworthy rate which initiates the demand for robust investigation on segmentation and detection for 3D reconstructions of tumor. In this context, even though various previous researches were proposed in the context of segmentation and detection for 3D reconstruction, critical and comprehensive observation is illustrated by this research towards limitation and future improvement. Proposed research categorized observation in the existing researches as two subcategories, i.e. observation towards existing common research methodologies based on previous most of the researches and proposed recommendation by this research for further investigation based on existing research. Subsequent section describes these two categories.

OBSERVATION ON PREVIOUS RESEARCH TOWARDS COMMON RESEARCH METHODOLOGIES

Overall framework from all the previous research methodologies demonstrated in various sections, i.e. core research background, review based on methods, review based on frameworks and review based on experimental results, mainly consists of some steps, i.e. preprocessing, segmentation of suspicious area, extraction of tumor area, slice matching and selection, 3D modeling and volume estimation shown in Figure 4.

1. Preprocessing: Pre-processing aims to improve the quality of the image which was achieved by noise removal, color scale conversion, contrast enhancement, and emphasizing edges.
2. Segmentation: Segmentation was achieved in two basic steps: first thresholding is applied on the enhanced image and then morphological operations are carried out.
3. Suspicious region of interest segmentation and feature extraction: After segmentation and morphological operations, image may still consist of multiple suspicious regions due to artifact affects, heavy tissue area, and tumor region. The purpose of this step is to extract brain tumor regions only.
4. Matching and selection of slice: As an MRI brain scan of a single patient consists of many slices and its reconstruction takes plenty of computational time and increases algorithm complexity. To overcome this problem, further investigation is needed towards proposed various methodologies, i.e. Rapid Mode Image Matching (RMIM) technique was applied for the selection of slices.
5. 3D modeling and volume estimation: For 3D reconstruction, efficient technique previously proposed to identify initially the curve around the segmented tumor area from MRI images known as main slice, i.e. cubic interpolation technique. However, to achieve this aim exiting research methods required complex computations although the accuracy was high. Besides, 3D reconstructions of the tumors have ambiguous texture and make it hard to understand the model of the tumor. However, there is no apparent reconstruction method that allows a clear understanding of the tumor position, depth and/or volume with respect to the brains position or volume.

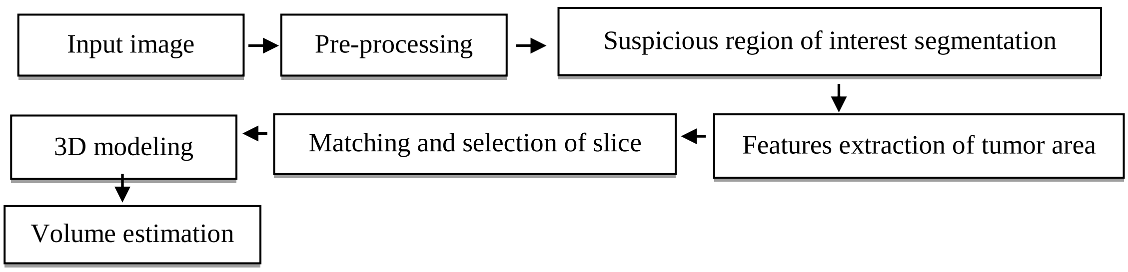

FIGURE 4. Overall framework from previous research methodologies

PROPOSED RECOMMENDATION FOR FURTHER RESEARCH BASED ON EXISTING RESEARCH

This research found seven core phases for detection, segmentation and 3D reconstructions of tumors, i.e. input image, preprocessing, suspicious region of interest segmentation, features extraction of tumor area, selection of slice, 3D modeling and volume estimation. In the preprocessing part, this research recommends to use adaptive histogram equalization for effecting denoising effect in the input frames. An efficient segmentation methodology is needed where variations of deep neural networks like Convolutional Neural Networks (CNN) should be investigated further for the intention to receive efficient classification results based on supervised and unsupervised learning perspectives. In this context, segmentation can be performed on both the brain contour and the tumor area simultaneously. Later, reconstruction of the brain contour and tumor in single space can be potential experimentation for increasing accuracy. In this context, reconstruction of all the segmented parts and creation as clear a picture of the brain to provide a total insight of all the elements of the brain and how are they situated with the tumor is expected to influence significantly for 3D modeling of brain. Additionally, controlled animation method should be investigated to view the brain 3D model with details parts in a slicing view where the animation will control the slices in lieu with creating an illustration that would let the observer to view the parts of brain from top to bottom or vice versa, as in multi modal MRI images. Finally, a depth and volume estimation should be developed to efficiently visualize 3D reconstructed image.

CONCLUSION

Cancer and tumor cell image segmentation and detection for 3D visualization are indispensable processes in visualizing abnormalities in human body. Segmentation, detection and 3D reconstruction of cancer cell and tumor using proper methodologies is a significant research area nowadays. However, segmentation and detection of cancer cell for 3D reconstruction is very helpful to find out the perfect shape and position of cancer and tumor cells which is a challenge too. Various methods and frameworks were used for detection, segmentation and 3D reconstruction, but there are some limitations such as higher computation time and lower accuracy rate. Tumor images were reconstructed in three-dimensional shape but the visualization is not efficient or perfect enough and volume or depth could not be estimated efficiently. Previous researchers confess that their research methodologies cannot reconstruct the tumor well if the tissue contrast is relatively poor. Various limitation, i.e. inability to segment multiple suspicious regions due to artifact affects, complex computations although the accuracy was satisfactory in some cases, ambiguous texture which makes it hard to understand the model of the tumor, lack of efficient methodology to track tumor position, depth and/or volume with respect to the brains position or volume, lack of proper methods for reconstruction of the brain contour and tumor in single space, lack of efficient method for controlled animation to view the brain 3D model with details parts in a slicing view in lieu with creating an illustration that would let the observer to view the parts of brain from top to bottom or vice versa will encourage the researchers to extend their further investigation towards detection and segmentation for 3D reconstruction of cancer cells or tumors. Judging from the previous research in computer vision field, it is certain that further investigation towards various research aspects with advantages and disadvantages presented in this research will significantly contribute for clear illustration of the tumor and cancer cell for three-dimensional visualization which is expected to be helpful to reconstruct the tumor with the body part in the same space that would enable a better understanding and insight of the tumor position and volume and help strategizing surgery.

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REFERENCES

Alarabeyyat, A. & Alhanahnah, M. 2016. Breast cancer detection using k-nearest neighbor machine learning algorithm. *2016 9th International Conference on Developments in eSystems Engineering (DeSE),* pp.. 35-39. https://doi.org/10.1109/DeSE.2016.8

Antony, A., Brigit, A., Fathima, K., Raju, D. & Binish, M. 2017. Brain Tumor Detection and Classification in MRI Images. *International Journal of Innovative Research in Science, Engineering and Technology* 6(5):84-89.

Arakeri, M. P., Reddy, G. R. M. & Mohana, R. 2013. An effective and efficient approach to 3D reconstruction and quantification of brain tumor on magnetic resonance images. *International Journal of Signal Processing, Image Processing and Pattern Recognition* 6(3): 111-128.

Bashir, H., Hussain, F. & Yousaf, M. H. 2015. Smart Algorithm for 3D Reconstruction and Segmentation of Brain Tumor from MRIs using Slice Selection Mechanism. *SmartCR* 5(3): 187-200.

Bharathi, A. S. & Manimegalai, D. 2015. 3D digital reconstruction of brain tumor from MRI scans using Delaunay triangulation and patches. *ARPN J. Eng. Appl. Sci* 10:9227-9232.

Chen, Y.-T. 2012. Brain tumor detection using three-dimensional Bayesian level set method with volume rendering. *2012 International Conference on Wavelet Analysis and Pattern Recognition*. pp. 158-163. https://doi.org/10.1109/icwapr.2012.6294771

Damodharan, S. & Raghavan, D. 2015. Combining Tissue Segmentation and Neural Network for Brain Tumor Detection. *International Arab Journal of Information Technology (IAJIT)* 12(1):42-52.

Farzana, A. & Sathik, M. M. 2017. Analysis of 2D to 3D reconstruction techniques over brain MRI. *International Journal of Innovative Research in Computer and Communication Engineering* 5(5): 9370-9376.

Havaei, M., Davy, A., Warde-Farley, D., Biard, A., Courville, A., Bengio, Y., Pal, C., Jodoin, P.-M. & Larochelle, H. 2017. Brain tumor segmentation with deep neural networks. *Medical image analysis* 35:18-31. https://doi.org/10.1007/978-3-319-75238-9_30

Mahayuddin, Z. R. & Saif, A. S. 2018. Fast and Effective Motion Model for Moving Object Detection Using Aerial Images. *International Journal of Computer Vision and Signal Processing* 1(1): 1-11.

Mahayuddin, Z. R. & Saif, A. S. 2019. A COMPARATIVE STUDY OF THREE CORNER FEATURE BASED MOVING OBJECT DETECTION USING AERIAL IMAGES. *Malaysian Journal of Computer Science* (Special Issue 2019), pp 25-33. https://doi.org/10.22452/mjcs.sp2019no3.2

Mahayuddin, Z. R. & Saif, A. S. 2019. A Comprehensive Review Towards Appropriate Feature Selection for Moving Object Detection Using Aerial Images. *International Visual Informatics Conference.* pp. 227-236. https://doi.org/10.1007/978-3-030-34032-2_21

Mahayuddin, Z. R., Saif, A. S. & Prabuwono, A. S. 2015. Efficiency measurement of various denoise techniques for moving object detection using aerial images. *2015 International Conference on Electrical and Informatics (ICEEI).* pp. 161-165.https://doi.org/10.1109/iceei.2015.7352488

Müller, S., Weickert, J. & Graf, N. 2016. Automatic brain tumor segmentation with a fast Mumford-Shah algorithm. Conference: SPIE Medical Imaging. Retrieve from https://doi.org/10.1117/12.2214552

Muniganti, H. & Gope, D. 2016. MIEMS: Multilevel inverse EM solver for 3D image reconstruction towards radio-frequency based breast cancer detection. *2016 IEEE International Symposium on Antennas and Propagation (APSURSI).* pp. 1483-1484. https://doi.org/10.1109/aps.2016.7696448

Naveenkumar, R. & Sanjay, S. 2014. Morphological Image Processing Approach for 2D to 3D Reconstruction of MRI Brain Tumor from MRI Images. *Proceedings of 3rd IRF International Conference, 10th May-2014, Goa, India.* pp. 18-21.

Rathi, V. G. P. & Palani, S. 2015. Brain tumor detection and classification using deep learning classifier on MRI images. *Research Journal of Applied Sciences, Engineering and Technology* 10(2): 177-187.

Roy, S. & Bandyopadhyay, S. K. 2012. Detection and Quantification of Brain Tumor from MRI of Brain and it's Symmetric Analysis. *International Journal of Information and Communication Technology Research* 2(6): 477-483

Roy, S., Sadhu, S. & Bandyopadhyay, S. K. 2015. A useful approach towards 3D representation of brain abnormality from its 2D MRI slides with a volumetric exclamation. *Proceedings of the 2015 Third International Conference on Computer, Communication, Control and Information Technology (C3IT).* pp 1-6.. https://doi.org/10.1109/c3it.2015.7060227

Saif, A. & Mahayuddin, Z. R. 2018. Moving Object Segmentation Using Various Features from Aerial Images: A Review. *Advanced Science Letters* 24 (2): 961-965.

Saif, A., Prabuwono, A. S. & Mahayuddin, Z. R. 2014. Moving object detection using dynamic motion modelling from UAV aerial images. *The Scientific World Journal* 2014:1-12. https://doi.org/10.1155/2014/890619

Saif, A. S., Prabuwono, A. S. & Mahayuddin, Z. R. 2013. Adaptive motion pattern analysis for machine vision based moving detection from UAV aerial images. *International Visual Informatics Conference*. pp. 104-114. https://doi.org/10.1007/978-3-319-02958-0_10.

Saif, A. S., Prabuwono, A. S. & Mahayuddin, Z. R. 2013. Real time vision based object detection from UAV aerial images: a conceptual framework. *FIRA RoboWorld Congress*, FIRA 2013: Intelligent Robotics Systems: Inspiring the NEXT. pp. 265-274. https://doi.org/10.1007/978-3-642-40409-2_23

Saif, A. S., Prabuwono, A. S. & Mahayuddin, Z. R. 2014. Motion analysis for moving object detection from UAV aerial images: A review. *2014 International Conference on Informatics, Electronics & Vision (ICIEV)*. pp. 1-6. https://doi.org/10.1109/iciev.2014.6850753

Saif, A. S., Prabuwono, A. S. & Mahayuddin, Z. R. 2015. Moment feature based fast feature extraction algorithm for moving object detection using aerial images. *PloS one* 10(6): e0126212. https://doi.org/10.1371/journal.pone.0126212

Saif, A. S., Prabuwono, A. S., Mahayuddin, Z. R. & Himawan, H. T. 2013. A review of machine vision based on moving objects: object detection from UAV aerial images. *International Journal of Advancements in Computing Technology* 5(15): 57-72.

Saif, A. S., Prabuwono, A. S., Mahayuddin, Z. R. & Mantoro, T. 2013. Vision-based human face recognition using extended principal component analysis. *International Journal of Mobile Computing and Multimedia Communications (IJMCMC)* 5(4): 82-94. https://doi.org/10.4018/ijmcmc.2013100105

Singh, I., Sanwal, K. & Praveen, S. 2016. Breast cancer detection using two-fold genetic evolution of neural network ensembles. *2016 International Conference on Data Science and Engineering (ICDSE).* pp. 1-6. https://doi.org/10.1109/icdse.2016.7823969

Usman, K. & Rajpoot, K. 2017. Brain tumor classification from multi-modality MRI using wavelets and machine learning. *Pattern Analysis and Applications* 20(3): 871-881. https://doi.org/10.1007/s10044-017-0597-8

Yang, S.-C., Yu, C.-Y., Lin, C.-J., Lin, H.-Y. & Lin, C.-Y. 2015. Reconstruction of three-dimensional breast-tumor model using multispectral gradient vector flow snake method. *Journal of applied research and technology* 13(2): 279-290. https://doi.org/10.1016/j.jart.2015.06.014

Yong, H. W., Bade, A. & Muniandy, R. K. 2015. 3D reconstruction of breast cancer from mammograms using volume rendering techniques. *Jurnal Teknologi* 75(2): 57–62. https://doi.org/10.11113/jt.v75.4978

Zahira, M. F. & Sathik, M. M. 2016. An Effective Analysis Of Mri Brain Images And 3d Reconstruction. *International Journal of Advanced Research in Biology, Ecology, Science and Technology (IJARBEST)* 2(2):1-13.

Zainal Rasyid Mahayuddin
Faculty of Information Science and Technology
University Kebangsaan Malaysia
Selangor, Malaysia
zainalr@ukm.edu.my

A F M Saifuddin Saif
Faculty of Science and Technology
American International University - Bangladesh
Dhaka, Bangladesh
saif@aiub.edu