Medical Image Segmentation Assessment

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Abstract

Image segmentation is a very censorious task in image analysis and image processing. And image segmentation is the most important process for providing depiction, fantasy, and characterization of different zones in any medical image. So, it is important to find the different methods and techniques for segmenting the medical images that may provide the best result. In this paper, we would see the crucial place of segmentation in medical images for best decision making. As there are different techniques for segmentation, Clustering-based segmentation, Threshold-based segmentation, Kernel based segmentation, Edge based segmentation, Mathematical segmentation, and CNN which play an important role in segmenting medical images. Otsu thresholding method is implemented for diabetic retina eye with 96% accuracy. We would see a proper difference between the techniques used by different researchers.

Keywords: Medical Images, CNN, U-Net, Thresholding, Clustering.

I. INTRODUCTION

Medical images are very important for the treatment and diagnosis of patients in any hospital or health care department. Medical images are the visual interpretation of the radiologists[1]. Digital image processing is a very productive image technique when it is combined with artificial intelligence, machine learning, pattern recognition, fuzzy logic, and also with deep learning.

As, the number of patients with various serious diseases like cancer, lung cancer, brain tumor, retinal issues, and many more diseases is expanding day by day, so huge number of deaths, cause of these diseases are predictable every year. Cancer starts in the human body parts when there are out of control of growing cells. And the out-of-control growth of abnormal cells is the reason for the beginning cancer cell. It is very complicated for machines to solve the problems which have the requirement of hearing and insight in any application. As machines have into senses of hearing and sighting like humans. But it has become easy for machines due to new emerging technologies such as artificial intelligence, machine learning, and deep learning [1]. Artificial neural networks are the largest jump in machine learning and deep learning. In the current era, deep learning has been a marketable emerging technique in biomedical image classification and many more fields. Deep learning technology has given many algorithms for solving various provocations and hurdles in region of natural language processing, image processing, and signal processing. Convolutional Neural Networks (CNNs) are vastly used in classification, segmentation, and pattern recognition jobs in computational pathology and these are the main components of machine learning devices for decision making. The pathologists perform a laborious and exclusive task with the help of CNN and it is the advantage of CNN [2]. Currently, deep convolutional neural networks have achieved success in the field of medical image segmentation. And the encoder-decoder has given different approaches for getting the sharp object boundaries from the low-level information. For better segmentation, 3D icons have given development over the 2D image parts as these are liable to traverse the provisional information of various slices. Through interslice provisional information, we can improve the quality of medical image segmentation. Ronneberger gave the concept of U-like architecture also known as U-Net was given for segmentation results and that has a path for an encoder to capture high-level semantics from the image and decoder has skipped relation with encoder.

In this paper, literature review is described in section I, followed by methodology in section III and result analysis is described in section IV. The conclusion of the paper is talked over the section.

II. LITERATURE REVIEW

Some significant computational research papers based on medical image segmentation are reviewed here. The research papers are related to image segmentation of retina images. These papers proposed different techniques for retina image segmentation which are covered here. All types of medical images use different methods for segmentation such as Clustering-based segmentation[4], Threshold based segmentation[3], Machine Learning Approach[5,6], Convolutional Neural Network(CNN)[2], Kernel-Based Segmentation[9,10], Mathematical Morphology[12,13], Adaptive Thresholding[14] and Edge Based Segmentation[15]. Every methods have its own efficiency and accuracy.

III. METHODLOGY

The methodologies used for the medical image segmentation are:

A. PREPROCESSING

Image preprocessing is used to process the mathematical computations in the medical image at the basic level. Some image preprocessing techniques are such as resizing the image, sharpening the image, linearizing the image, isolating the colors, enhancing the image, and many others [2]. Preprocessing increases the image parameters, used by the next processing and it also develops the quality of the image. And the resulted image of this step is given to the segmentation. This technique develops the information of the input image and increases the features of the retina image. It also reduces the noise and strips the skulls.

B. SEGMENTATION TECHNIQUES

Segmentation is the process of segmenting an image into different segments for finding the problematic area. The image segmentation has an important role in the medical imaging process where semiautomatic and automatic phenomenon for pulling out the images Region of Interest (ROI). It is widely used in medical applications such as mass detection, tumor segment, and border detection for segmenting patient's tissues from retina. There are various image segmentation methods:

Threshold Based Segmentation

Thresholding is a moderate approach for medical image segmentation but a good approach for segmenting the image which has a dark background with a light object. Thresholding has a step of transforming the medical image into a binary image, for it selects the threshold value for dividing the pixels into various zones of an image, and the light object is separated from the dark background. The pixels are taken if the threshold value is smaller or equals to the value of its x, y coordinate (intensity). This technique is based on the pixel range found from the input image. The pixel range is related to the intensities of pixels which is used to distinguish the pixels of a normal zone or abnormal zone of a medical image. Thresholding has two defined methods, the first one is local and global thresholding, and the second one is intensity value. The histogram is used local thresholding for recognizing the pixel intensity with each level of intensity[3]. And in global thresholding, the pixels are gathered on the basis of threshold values and the threshold value has been chosen prior. If the threshold value is constant then it is called Global thresholding otherwise it is known as local Thresholding.

Clustering-based segmentation

It is the process of grouping pixels having the same properties, this provides the foreground and background pixels partly. Clustering is the method used for identifying the pixels in different regions, signals, and artifacts. The clustering-based segmentation collects the pixels having alike properties and segments the medical image on the basis of pixel features[4]. Different clusters are created without the help of training medical images and clusters are formed on the basis of the same intensity of the pixel. The training and segments of the retina images are brought into two different monotonies as the training process is brought according to the obtainable dataset. The first step is to create the clusters of images and the second step is to get the evaluation of specific organs' properties.

Fuzzy C- Means clustering

There are two different approaches for clustering as fuzzy C-means clustering and also K-mean Clustering. In fuzzy C- means clustering, numerous classes are created based on pixel values[4]. According to typical Fuzzy C -Means, c clusters are made through splitting the medical image. The function is used for creating the cluster.

K-mean Clustering

In the k-means approach k classes are collected by splitting the image. A process is used here for creating a class, is to calculate the mean intensity value for each separate class. And according to this method, segmentation is based on the classification of every pixel by the closest centroid value[4]. But it can give incorrect results, so the accuracy of the process is reduced. Because of this reason, it is taken as an inappropriate classification.

Machine Learning approach

Fu, Huazhu[5] proposed Convolutional Neural Networks (CNNs) for creating a probability map in vessel segmentation of retina. This probability map is used for differentiating the background information and vessels from the bad quality contrast zone of the retina. The pixels of the medical image are combined on the basis of a probability map and the interaction among the pixels by using conditional random fields (CRFs). And finally, the segmented blood vessel image is obtained.

Rani [6] proposed an algorithm for retinal images by using classification and filtering processes. The algorithm used the filter process for the segmentation of vessels and the refinement in contrast to the medical image. A classification approach through the means of machine learning approach was proposed for the systematic distinction among various blood vessels and in on-vessels.

Convolutional Neural Network(CNN)

Convolutional Neural Network is a machine learning approach for classification. CNN plays an important role in image identification and classification[1]. The CNN does not collect the input in the form of a vector because it learns the features as it considers an image in the form of input. CNN has different layers and steps for preprocessing the data. It helps in providing the accuracy of the method as preprocessed data can be used to predict that a person is suffering from disease or not[2].

UNET Architecture

This architecture is a deep learning model that is used for segmenting medical images. The whole architecture of UNET has two parts. The first part is the encoder which is used for minimizing the context of medical images. This encoder is the union of two distinct layers: The convolutional layer and the Pooling layer[2]. The second part is a decoder which is used to enlarging the path in a symmetric way and it also provides the utilization of some certain positions. This architecture does not use a dense layer, it uses only a convolutional layer. In the convolutional layer, the first step is for converting an image of 3D volume and should be contained into pertinent size. And it uses k filter having a size of the channel, the output image should be the size of the channel. The pooling layer has the purpose of reducing the spatial size of the convolved feature of medical images.

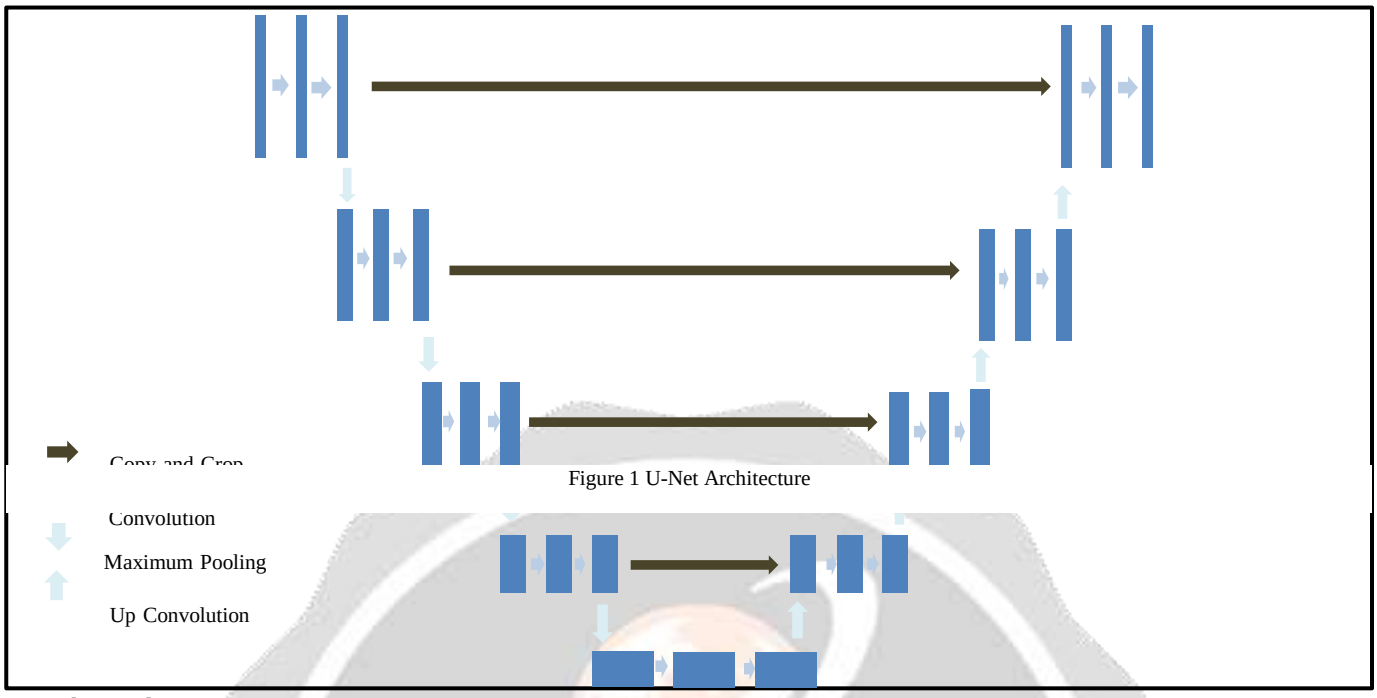

Figure 1 U-Net Architecture

Kernel-Based Segmentation

An ingenious edge detection algorithm was proposed by Naz et al.[9] for right retinal layer segmentation. In this, the structure tensor algorithm was added with the kernel-based segmentation technique for getting better segmentation. Abbasi-Sureshjani et al.[10] proposed a method which was authenticated on non-real images and retina images. This method was related to the multi-direction score which is energized through contextual associations and the visual cortex also increased with an affinity matrix. A method was proposed by Cha et al.[11] in which clustering and a cerebral tracing kernel were developed on Gaussian Mixture Model. With the use of GMM, the sides of the image are removed from the clustered images. So, an assortment of blood vessels of a particular pixel is allowed by the clustering. So this method has been used for medical image segmentation in different areas as Vessel segmentation of a retinal image etc.

Mathematical Morphology

This technique was mainly used for blood vessel segmentation in the retina. At first, for recognizing the vessels mathematical morphology was used. The vessels were developed by morphology steps such as supreme of opening, toggle mapping, and morphology reconstruction. The filtering technique were used in the Fourier domain for recreating the got output. Morphology technique can successfully identify the finer details in blood vessels.

Another approach, in which preprocessing used green channels and for enhancing the vessels, the bottom and top hat conversion are performed on retina images. Kohonen Clustering Network is used to distinguish vessels and non-vessels from the input retina image. Aswini S et al. [12] proposed an approach for extracting the vessels from the retina image. In this, the Morphological process and top-hat transform techniques are used for the smoothing method and enhancing the blood vessels in the medical images. Rodrigues et al. [13], used morphological techniques and a combination of topological for the extraction of vessels. By extracting the bogus objects, smoothening the vessel borders of the image, a segmented image is found and then two resultant images are intersected.

Figure 2 Healthy Retina Image(HRI)[24]

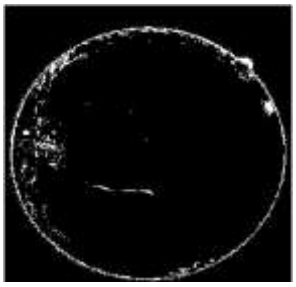

Figure 3 Otsu thresholding of HRI

Adaptive Thresholding

There should be a system that can classify and segment any type of medical image and also can remove the noise. Dash et al. [14] proposed an amalgamation of CLAHE and Principal Component Analysis is used for developing the contrast of an image. And also provided the thresholding method for removing the vessels from the image. Otsu thresholding method is used for removing the blood vessels from the retina image. The cleaning step removes the undesired frills from the resultant image. But previously, four steps were covered for the segmentation in adaptive thresholding are matched filtering, thresholding based on local entropy, length filtering, and vascular detection. The matched filtering develops the contrast of a medical image. A tree structure is formed using thresholding based on local entropy. The third step length filtering extracts the misclassified pixels.

Figure 4 Diabetic Retina[25]

Figure 5 Otsu Thresholding Value(0.4)

Figure 6 Otsu Thresholding Value(0.5)

Figure 7 Otsu Thresholding Value(0.6)

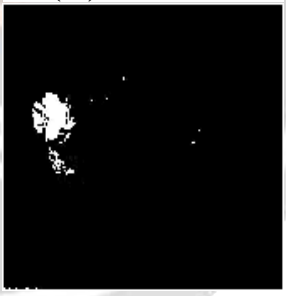

Figure 8 Otsu Thresholding Value(0.7)

Figure 9 Otsu Thresholding Value(0.8)

Edge Based Segmentation

A segmentation method was proposed previously with edge detection and line operator. This method was used for blood vessel segmentation from retina. It also used for developing the contrast of the green channel. The proposed method used a Canny edge detector that was constituted for uniform blood vessel growth, for generating the edge map. Sivakmasundar et al[15] gave a method for finding the edges for recognizing DR through CBIR. For segmentation, Canny edge detection and Kirsch template are used. The best features are identified of the image from the quantifiable frameworks. At last, the Kirsch template edge detection algorithm got success in finding the edges from the medical image. Akshay S and P Apoora [16] proposed a methodology in which they used Watershed lines for finding the organ. The density, intensity, and position divergence are extracted from the medical image. According to the features given by the SVM classifier, all normal and abnormal segments are separated.

Otsu Thresholding for Retina images

This image thresholding method is related to adaptive thresholding. The Otsu algorithm is used with bimodal histogram. It attempts to minimize within the class variance and maximizes between the class variance at the similar time. The total variance is the sum of within and between class variance[8].

Table 1:Implementation value Table

S.No.	Method	Threshold Value	Accuracy
1	Otsu Thresholding	0.4	70%
2	Otsu Thresholding	0.5	76.87%
3	Otsu Thresholding	0.6	82%%
4	Otsu Thresholding	0.7	94%
5	Otsu Thresholding	0.8	96%

IV. RESULT ANALYSIS

We have implemented the Otsu thresholding on diabetic retina and healthy retina. The segmented images help to identify the patient is suffering from disease or not. The result analysis is discussed in two parts pros, cons and comparison of segmentation techniques:

A. Pros and Cons

All advantages and disadvantages of all segmentation methods are here:

Table 1:Pros and Cons

Methods	**Pros**	**Cons**
K-means clustering	When a small k value is taken then it performs fast.	When the number of pixels is constant then it's difficult to get the k value.
Fuzzy C means	The result of fuzzy C means is better.	It's difficult to find the Fuzzy mean function.
Threshold-based	There is no requirement for prior information of input.	It's difficult for broad and flat images.
Mathematical Morphology	It uses different classifiers for better segmentation.	The computation takes time in it.
Kernel-based segmentation	Kernel based method is used along Structure tensor algorithm.	Computation takes time.
CNN	It does not collect the data, it learns the features.	It is time-consuming without pre-trained data
Edge Based	It performs well with the Canny edge detector.	It gives image-based continuous or discontinuous areas.

B. Comparison

There is a comparison of different medical image segmentation methods. It describes, how distinct researchers used the same method but gave different accuracy and classifiers. Also, the description of different segmentation methods with different accuracy, classifier, and application area is given:

Table 2: Comparison

Segmentation method	**Application area**	**Dataset**	**Accuracy**	**Authors**
CNN	Glaucoma	DRIVE	96%	A. Oliveira[2]
Otsu thresholding	Retina disease	Diabetic images	93%	Dash et al[7]
Otsu thresholding	Retina disease	Diabetic eye	95%	Mapayi[8]
Thresholding	Glaucoma	Diabetic images	95%	Sarker et al [18]
CNN	Retina disease	DRIVE and STARE	94.8%	T. A. Soomro et al[21]
Mathematical Morphology	Eye diseases	HRF consisting 45 images	95.3%	Viraktamath,S.V.,et al. [22]
Kernel-Based Method	Eye diseases	Retinal images	94.3%	Selvathi, D., and P. Lalitha Vaishnavi [23]

V. CONCLUSION

In this paper, we see different methods for medical image segmentation. All methods are playing their important role in retina image segmentation but these also can be used for different medical areas such as Lung Cancer Detection, Brain Tumor detection, Glaucoma, and in many other fields. These researches show various classifiers which classify the medical image. We have covered differences among segmentation methods on the basis of dataset, application area, and accuracy. Otsu thresholding provides proper segmentation of retina images with good accuracy. In future, we can use Otsu thresholding for other medical image segmentation of different diseases.

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