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A Survey On Recent Techniques In Medical Image Processing

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Abstract- Medical image processing requires high accuracy and real-time response. Several image processing techniques are available in the literature for processing medical images. Medical image processing is a complex task and involves a number of phases. In each phase, several solutions are provided to improve the performance or response time. This paper provides a survey of various image processing techniques adopted at each phase and provides a comparative study.

Keywords: Real-time response, complex task.

I. INTRODUCTION

Image processing is the process of manipulating the image to achieve a standard realistic quality. Image Processing are becoming popular due to easy availability of powerful computers, large size memory devices, graphics software's etc. The main purpose of image processing is to observe the objects that are not visible, to distinguish and to create a better image. The image processing can be performed to any images in two ways: one is analog and another one is digital form. Analog image processing can be done using any electrical means by modifying/altering the image. Digital image processing refers to processing of images by using digital computers etc. Digital image processing is more advantageous than Analog since it is versatile in nature. While doing digital image processing, it requires various stages to process the image. Image Processing is used in various applications such as Remote Sensing, Medical Imaging, Non-destructive Evaluation, Forensic Studies, Textiles, Material Science, Military, Film industry, Document processing, Graphic arts and Printing Industry. Various techniques have been developed in Image Processing during the last four to five decades.

Medical image processing plays a vital role in the application of medical treatment and diagnosis of disease. It allows the doctor to see the interior portion of the body and to diagnose it easily. Medical image processing gives the best advantage to analyses the disease of the patients. Many of the image processing techniques has been developed based on the medical images like Magnetic Resonance Imaging (MRI), X-ray, Computed Tomography, Endoscopy image, Ultrasound and etc. The medical image processing consists of following phases:

A) Image Acquisition: Image acquisition is the process of retrieving the image from any physical device such as hardware based like camera, software, etc.

B) Pre-processing: The aim of pre-processing is an enhancement of the image data that suppresses unwanted distortions or enhances the image features. It removes the noise like salt and pepper, Gaussian noise and speckle noise present in the image.

C) Feature Extraction: The main objective of feature extractions is to represent the raw image by reducing it into smaller size based on its feature.

D) Segmentation:The goal of segmentation is to simplify and/or change the representation of an image into another form that is easier to analyze.

E) Classification:Image classification can be done efficiently with the help of machine learning which is used to diagnose the medical images.

This paper provides the comparative study of techniques available in the medical imaging field. Section II provides the detailed study of survey made with the techniques. Section III gives the overall conclusion of this paper.

II. IMAGE PROCESSING STAGES

The stages of digital image processing discussed in this paper are:

1. ***Image Acquisition***

Image acquisition is the process of retrieving the image from any physical device such as hardware based like camera, software, etc. Once the image is acquired, further image processing techniques are performed many different vision tasks required today. If the acquired image is not of high resolution, then the processing cannot be done satisfactorily. Some of the image acquisition devices and softwares are:

- Camera
- Image acquisition hardware: monochrome devices, color devices, multichannel devices, digital devices.
- NI-IMAQ Driver Software: robust API for image acquisition

Table 1: Image acquisition parameters using cameras

Characteristics	Analog Cameras	Link Cameras	Digital Cameras	IEEE 1394
Functionality	Simple and easy	Advanced	Advanced	Simple
Data Rate	Slow	Fast	Fast	Slow
Resolution	Low	High	High	Medium
Depth of image pixel	8-bit to 10-bit	Up to 16-bit	Up to 16-bit	8-bit

Table 1 gives the parameters of camera related to image acquisition phase.

2. ***Image Pre-processing***

Pre-processing is a process to suppressunwanted distortions or enhance the image features.The various image preprocessing techniques are discussed below:

- Noise removal:eliminates the unwanted noise from the image.
- Mathematical operation: to enhance precise features of images.
- Manual correction: fine tune an image but editing it.
- Image resampling: regulate the digital values to place in the new pixel locations of the modified output image.
- Grayscale contrast enhancement: Improve the visualization by enhancing the dataset.

Table 2 gives a performance comparison technique in each of the sub-phase of pre-processing. The noise removal approaches in image pre-processing is used to remove the unwanted disturbance in the image. Some of the noise are Gaussian noise, salt and pepper noise, poison noise, impulsive noise, etc. These noises are removed using various filtering methods to enhance the image feature. The Mathematical operation is used to perform the basic operations like arithmetic operations and morphological operations. Image resampling is one of the preprocessing techniques used to increase or reduce the number of pixels of the dataset. Image resampling is the process of transforming a sampled image from one coordinate system to another.

3. ***Image Segmentation***

Image segmentation is the process of partitioning a digital image into multiple segments. Image segmentation phase is used to identify the region of focus where further processing done. This requires techniques to mark boundaries even if they are not uniform. There are several image segmentationalgorithms available. They are categorized based on the generations. The various image segmentation techniques are discussed below:

- Threshold based [7,16]
- Region based [7,16]
- Edge based [7,16]
- Clustering [7,16]
- Deformable models [7,18]
- Atlas guided [7]
- Artificial Neural Network (Supervised approach) [7,19]
- Artificial Neural Network (unsupervised approach) [7]
- Genetic algorithm [7,20]

Table 3 gives a performance comparison technique of various segmentation algorithms.

4. ***Feature Extraction***

The process of obtaining the set of features by transforming the input image is called as feature extraction. An individual feature consists of information about color, shape, texture, edge etc. The main objective of feature extraction is to represent the raw image by reducing it into smaller size based on its feature. A set of features are extracted in order to allow the classifier to identify whether it is supervised or unsupervised. The feature that is extracted allows the classifier to assign the unknown object to appropriate class to get high classification rate. Some of the feature extraction methods are spatial, color, shape, texture, transform and edge and boundary.

Table 2: Image pre-processing techniques

Preprocessing techniques	Noise removal approaches	Advantages	Disadvantages
Noise removal techniques	Gabor Filter [1]	• Used for edge detection • Identical to human vision system	• Problem with boundary condition. • Time domain is inverse to frequency domain description of a signal.
	Adaptive Median Filter [1, 2]	• Reduces impulsive noise. • used to cancel unknown interference	It does not perform well when impulse noise is greater than 0.2.
	Mean Filter (or)Average filter [1]	• Improves the image quality • Easy to use.	• Lead to blurring of an image. • Impulse noise is not completely removed.
	Image Normalization[1]	• achieve consistency for a set of data • Prevent printing problems.	Time consuming process.
	Histogram Equalization [1]	• Simple and enhance contrasts of an image. • Provides better intensities.	This method fails when the gray values are far apart.
	Weighted Median Filter [3]	• reducing noise without blurring edges of the image	Rounding corners and mapping texture region to a uniform shade is the most important deficiency.
	Weiner Filter [4]	• Capable to handle both degradation function and noise. • Restoration of blurred and noise image.	Used for gray scale image only.
Mathematical operation	Arithmetic operation	Simple and fast	Operations between two images are only useful if the images can be ranged closely enough.
	Morphological Operations	Reduce the size of ROI	Morphological operators rely on the concept of infimum and supremum.
Image Resampling	Nearest Neighbor[5]	suitable for re-projecting a raster object without a change in cell size	Sometimes it produces incorrect values
	Bilinear[5]	minimizes aliasing but introduces significant blurring	It is suitable for smaller size only.
	Bicubic (cubic convolution)[6]	reduces both aliasing and blurring	It is not suitable for continuous value image.
	Bicubic Sharper and Bicubic Smoother [6]	It performs both upsampling and downsampling.	The result can be viewed after overlapping it.
	Lanczos 4 x 4 [6]	Performs downsampling efficiently.	Upsampling is not applicable.

The spatial feature extraction is done by gray level, amplitude and spatial distribution of an object in the acquired image. Histogram feature belongs to spatial feature extraction which shows the distribution of pixels based on the gray scale values. Histogram feature includes mean, median, energy, variance etc. The color [21] feature extraction is characterized from the histogram of the image since color is the main attribute that is emitted or transmitted or reflected from the light. The histogram of two different images may be of same color which is a disadvantage. Some of the color feature extraction methods are color histogram (global and local),geometric moments, color moments, color correlogram and color coherence vector.

Table 3: Image Segmentation Techniques

Approaches	Algorithm	Advantage	Disadvantage
Threshold Based Approach [7,16]	Global Thresholding [8]	Uses only single threshold value.	This iterative process stops if the difference between the new threshold and the previous one is marginally small.
	Adaptive Thresholding [8]	The threshold value at each pixel location depends on the neighboring pixel intensities	It provides incomplete solution in some case.
Region Based Approach [7,16]	Region Growing [9,16]	It determines the region directly based on its properties.	Noise sensitive.
	Region Split and Merge [9,16]	It will merge the object until there is no further merging can be done.	Merging operation is little complex.
	Statistical Region Merging [10]	It is simple and fast segmentation algorithm	Provides over-merging
Edge Based Detection Methods [7,16]	Watershed algorithm [11]	It provides continuous boundaries.	It leads to over-segmentation
Clustering Approach [7,16]	K-means clustering [11]	It does not require the calculation values of distance but minimizes the total distance value.	The cluster values must be assigned initially to perform the operation.
	Fuzzy C-Means clustering [11,23]	more robust to Gaussian noise	It cannot differentiate the two clusters with different distributions of feature vectors
	Spectral Clustering [12]	It can be solved efficiently by standard linear algebra methods	It fail to correctly cluster multi-scale data
	Superpixel segmentation [13]	The size of super-pixels is to be regularized	Small super-pixels are discouraged because they contribute a higher cost of the stitching energy.
	Supervoxel segmentation [14]	Super-voxels have more precisions.	Supervoxel labels cannot cross over object boundaries that are not actually touching in 3D space
Deformable Models Approach [7,18]	Active Contour Model [15]	Robust to noise.	Manual interaction is required.
	Active Contour Model without Edges [15]	It detects smooth and discontinuous edges.	Parameter choosing is difficult.
Atlas Guided Approach [7]		It performs both segmentation and classification in single step.	It is difficult to perform segmentation for complex structure.
Artificial Neural Network (ANN)(Supervised Approach) [7,19]		Solve complex problems within real time.	Time consuming, costly and prone to human error.
Artificial Neural Network (ANN)(Un- Supervised Approach) [7]		It does not require human annotation, it is fully automated.	time consuming
Genetic Algorithm Based Methods [7,20]		crackcomposite optimization problems	GA may meet extremely slowly or it may miscarry, due to merging to an intolerable local optimum.

The shape [21] feature extraction represents the physical structure of an object. Shape feature is used to find the shape of an object, to identify which object it is and to calculate the size of an object. The shape of an object is determined by its color, material, and content of its boundary in the image which includes the spatial properties. Texture [21] feature extraction is done by surface characteristics and appearance of the object obtained by size, shape etc. It plays a vital role in medical imaging. Texture is a repeated pattern of evidence or procedure of the organization with regular intervals. Various other texture based feature extraction

techniques are based on structure, statistical, model and transformation.

The structural based represents the texture by means of well-defined primitives and spatial properties of those primitives. This texture gives good symbolic description of the image. This method will not be appropriate for naturally formed texture. The statistical based techniques characterize the texture based on the non-deterministic properties of a gray scale image. It can be classified into first order (one pixel), second order (two pixel) and higher order (more than two pixels) statistics. The model based approach is based on the fractal model and markov model. Transform methods, such as Fourier, Gabor and wavelet transforms represent an image in space whose co-ordinate system has an interpretation that is closely related to the characteristics of a texture.

5. *Image Classification*

Image classification can be done efficiently with the help of machine learning which is used to diagnose the medical images. Image classification can be classified into three categories:

- Supervised learning: suitable for test images which share a common relationship with training images.
- Unsupervised learning: suitable when the relationship between training and test images is unknown and unpredictable.

Some of the supervised learning's are Naïve Bayes, Decision tree, K Nearest Neighbor (KNN) and Multi-Layer Perceptron Neural Networks (MLP NN).Clustering algorithm is a representative method of the unsupervised learning. Some of the unsupervised learning are K-means, Fuzzy c-means, Optimized c-means and Spectral clustering.

Table 4: Image classification Techniques

Classification Techniques	Advantages	Disadvantage
rtificial Neural twork [22]	fficiently handles put data along with ise.	me consuming
ecision tree 2]	mple and easy	mplex lculation
pport Vector achine [22]	eduction in mputational mplexity	fficult to derstand
zzy Measure 3]	fficient handles the put data.	tput will not good.

Table 4 gives the comparison of various image classification techniques used in the medical imaging.

III. CONCLUSION

In this paper, a survey of various techniques for medical image processing is analyzed. This paper provides a comparison study of pros and cons of each techniques and its suitability for an application is given.

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