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A Review of Digital Image Processing in Biomedical Application

Vipra Bohara, Honey Agarwal, Lokesh Sharma, Devendra Sharma, Deepak Shankhala, Rakesh Kardam

***Abstract*— Biomedical Medical imaging is the process of experienced dramatic expansion and then producing visible images of inner structures of the body for scientific and medicinal study and treatment as well as a visible view of the function of interior tissues. This medical imaging plays a necessary role on a daily basis. it is absolutely mandatory when tracking the progress of an ongoing illness. MRI's and CT scans allow the doctor to monitor the effectiveness of treatment and adjust protocols as necessary. This Biomedical Medical imaging has been an interdisciplinary research field attracting expertise from applied mathematics, computer sciences, engineering, statistics, physics, biology and medicine**.

Whereas in medical reports the detailed information generated by medical imaging provides patients with better, more comprehensive care. This chapter summarizes fundamental steps in digital image processing as well utilization and benefit of digital image processing techniques in bio-medical field.

***Index Terms*— Digital Image Processing, Acquisition, Segmentation, Enhancement**

I. Introduction

With the growth of computer and image technology medical imaging has greatly influenced medical field. Modern science also has been doing wonders in the surgical field. But, the proper and correct diagnosis of diseases is the primary necessity before the treatment. The more sophisticate the bio-instruments are, better diagnosis will be possible. The medical image plays an important role in clinical diagnosis and therapy of doctor and teaching and researching etc. Medical imaging is often thought of as a way to represent anatomical structures of the body with the help of X-ray computed tomography and magnetic resonance imaging. But often it is more useful for physiologic function rather than anatomy. The medical imaging processing refers to handling images by using the computer. These images are constantly gets dirtied by noise during picture acquisition and transmission, resulting in low quality images.

Vipra Bohara, ECE Department, JECRC, Jaipur,).
Honey Agarwal, ECE Department, JECRC, Jaipur,
Lokesh Sharma, ECE Department, JECRC, Jaipur,).
Devendra Sharma, ECE Department, JECRC, Jaipur,).
Deepak Shankhala ECE Department, JECRC, Jaipur,
Rakesh Kardam, ECE Department, JECRC, Jaipur,

As the quality of medical imaging affects diagnosis the medical image processing has become a hotspot and the clinical applications wanting to store and retrieve images for future purpose needs some convenient process to store those images in details. Noise is the unwanted signal which corrupts the important and desirable information[1]. The noises can be categorized into different types based on their nature and origin. e.g. Gaussian, the impulsive and speckle noise etc.

Accompanied by a rush of new development of high technology and use of various imaging modalities, more challenges arise; for example, how to process and analyze a significant volume of images so that high quality information can be produced for disease diagnoses and treatment. The removal of noise is very necessary for proper analysis and diagnosis. Filtering noise helps to recreate a high-quality image in digital image processing for further image processing such as segmentation of images, identification, recognition and monitoring, etc
here are various approaches to denoise medical images based on transform approach, machine learning, filtering method and statistical method. This processing includes many types of techniques and operations such as image gaining, storage, presentation, and communication [2].

These techniques or approaches is subject to noise type exist in the image. To evaluate the denoising performance, parameters like SNR, PSNR etc

II. Classification of Image Processing methods

The image is a function that signifies a measure of characteristics such as illumination or color a viewed sight. The digital images have several benefits such as faster and cheap processing cost, easy storing and communication, immediate quality assessment, multiple copying with reserving the quality, fast and cheap reproduction, and adaptable manipulation. The disadvantages of digital images are exploitation copyright, inability to resize with preserving the quality, the need of large-capacity memory, and the need of faster processor for manipulation.

The two types of methods used for Image Processing are Analog and Digital Image Processing. Analog or visual techniques of image processing can be used for the hard copies like printouts and photographs. Image analysts use various fundamentals of interpretation while using these visual techniques [3]. The image processing is not just confined to area that has to be studied but on knowledge of analyst. Association is another important tool in image processing through visual techniques.

So analysts apply a combination of personal knowledge and collateral data to image processing. Digital Processing techniques help in manipulation of the digital images by using computers. As raw data from imaging sensors from satellite platform contains deficiencies. To get over such flaws and to get originality of information, it has to undergo various phases of processing. The three general phases that all types of data have to undergo while using digital technique are Preprocessing, enhancement and display, information extraction.

Digital images have two main types of images. Raster image is described as a four-sided arrangement of frequently sampled values known as pixels. The digital images are usually inaccessible images and involve multifaceted color difference. The digital images have fixed resolution due to their pixels size. The digital images lose their quality in the resizing process due to some missing data. The digital images are used mainly in photography images because of their good color shades [4].
The image-gaining instrument controls the resolution. The digital images include many formats such as BMP (Windows bitmap), TIFF (Tag Interleave Format), PCX (Paintbrush), PNG (Portable Network Graphics), etc.A vector is described as a wrinkled and a bent object that is defined precisely by the computer. The vector has many qualities such as line width, dimension, and hue. The vectors are easily scalable images and can be reproduced in different magnitudes without change in its quality. The vectors are suitable for design, line painting, and diagrams.

III. HUMAN VISUAL SYSTEM

The human visual system is one of the most complex schemes that ever existed. This system allows living beings to organize and understand the many complex elements in their external environment. The visual system comprises of the eye that transmutes light into neural signals and the related parts of the brain that process those signals and excerpt essential data. The human eye is bilateral cylinder structures that are located anteriorly in the skull. The eyes are 2.5 cm in both crosswise and lengthwise diameters. In the middle of the eyeball, there is a blackened structure called the pupil. This system permits the light to cross the eye. This system narrows when exposed to a heavier light source.

This reduces the light to the retina and enhances the visual process. There are many muscles surrounding the eye and that control the widening of the pupil. The eye always has some supporting structures called the sclera. The lens is a ligamentous part located behind the cornea. The shape of the lens changes continuously due to muscle contraction (Figure 1) shows the cross-sectional view of the eyeball. The light concentrates into the middle part of the eye and focuses from the cornea and lens on retinae. The fovea emphases the image into the retina [5]. Finally, the brain forms the details and colors using its perception through multiple processes.

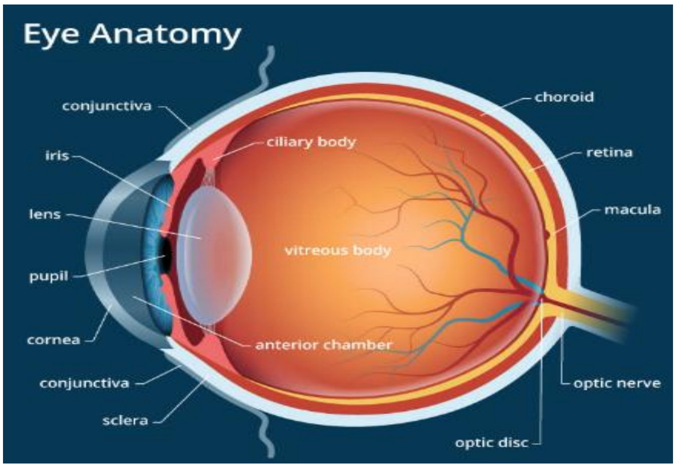

Figure:1 Eye Anatomy

In addition, data imbalance and multi-source data will also have impact on the effectiveness of the segmentation. Because the principle of deep neural network design is to train and adjust the parameters to make the network and the data set itself produce a better fitting effect. Therefore, the network parameters and the data set itself have a strong coupling. When pursuing a high recognition rate of a single data set, it often brings the negative effect of overfitting. Therefore, the accuracy of a model that achieves good results on a certain dataset tends to drop a lot when applied to other data. When dealing with such problems, one method is to use multi-source data to perform secondary training on the model, which can ensure the fitting performance between different data sets to improve the generalization of the model. However, it requires expanding the parameter space and the complexity of the model to fit more data distribution. In addition, this method lacks sufficient adaptability. When a new data set is added again, the model may need to be redesigned and trained.

IV. APPLICATIONS OF DIGITAL IMAGE PROCESSING

It is used to analyze, diagnose, recognize and treat the illness or disease

- Radiography:
- Electrocardiography (ECG)
- Ultrasound
- Magnetic resonance Imaging (MRI)
- Positron Emission Tomography (PET)
- X-ray imaging systems
- Endoscopy
- Stereo Endoscope
- Computer Tomography

V. FUNDAMENTAL STEPS IN DIGITAL IMAGE PROCESSING

As mention above in digital image processing technique Fundamental steps are Preprocessing, enhancement, information extraction and display sown in below figure 2.

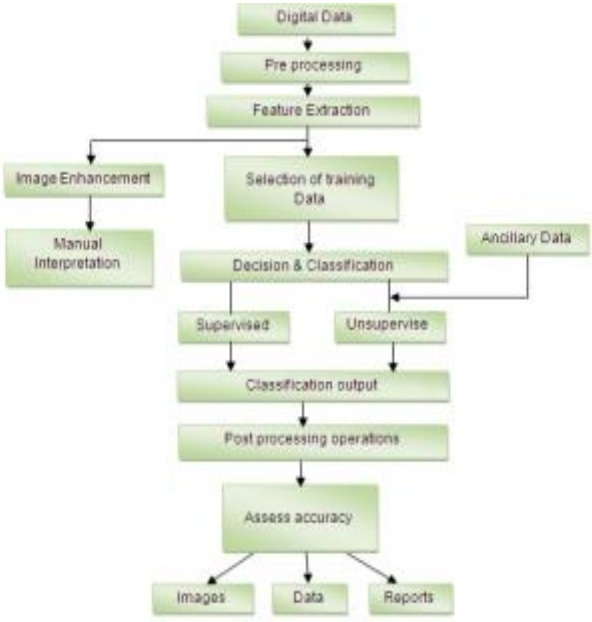

Figure:2 Fundamental Steps

- **Image acquisition:** To acquire a digital image, It is a basic step which involves capturing images through sensors and various image modalities and is represented by a matrix.

- **Image Enhancement:** It is a fundamental supporting aid for reviewing atomic region in MRI and Ultrasound in medical field by decreasing noise and used to enhance visual representation of an image. Image enhancement is a technique used to improve the image quality and perceptibility by using computer-aided software. This technique includes both objec-tive and subjective enhancements. This technique includes points and local operations. The local operations depend on the district input pixel values. Image enhancement has two types: spatial and transform domain techniques. The spatial techniques work directly on the pixel level, while the transform technique works on Fourier and later on the spatial technique.

- **Edge detection:** It is an essential pre-preparing system in medical image segmentation used of recognition of organs of the human body, for example, lungs and ribs. Edge detection is a segmentation technique that uses border recognition of strictly linked objects or regions as shown in figure 3. This technique identifies the discontinuity of the objects [6].

  This technique is used mainly in image study and to recognize the parts of image where a huge variation in intensity arises. Some types of edge detection:

  a) Roberts kernel
  b) Prewitt kernel
  c) Sobel kernel

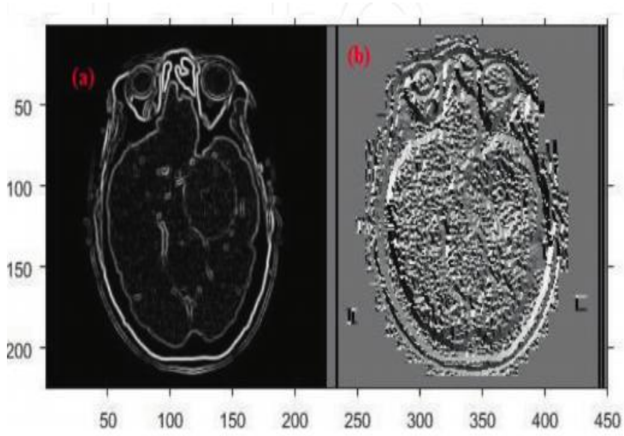

Figure:3 Edge detection technique, (a) gradient magnitude, and (b) gradient direction

- **Image segmentation:** Segmentation is the process of partitioning an image into different segments. In medical imaging, these segments often correspond to different tissue classes, organs, pathologies, or other biologically relevant structures. Medical image segmentation is made difficult by low contrast, noise, and other imaging ambiguities. Although there are many computer vision techniques for image segmentation, some have been adapted specifically for medical image computing [7]. The implementation relies on the expertise that clinicians can provide. Image segmentation is a technique of segregating the image into many parts.

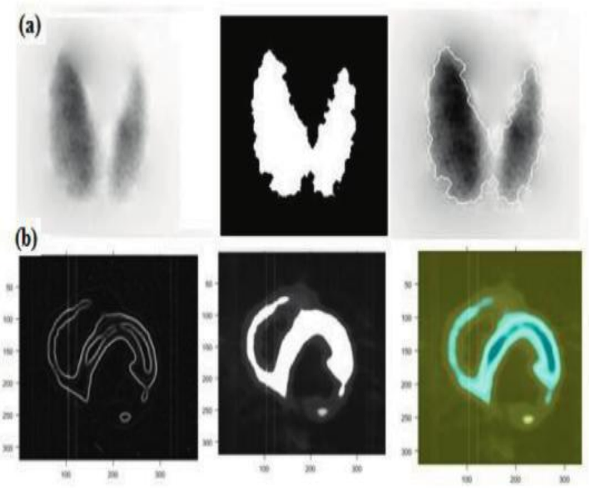

Figure:4 Segmentation process of (a) thyroid gland and heart [3]

The basic aim of this segregation is to make the images easy to analyze and interpret with preserving the quality. This technique is also used to trace the objects borders within the images.
This technique labels the pixels according to their intensity and characteristics. Those parts represent the entire original image and acquire its char acteristics such as intensity and similarity. The image segmentation technique is used to create 3D contour of the body for clinical purposes [8].

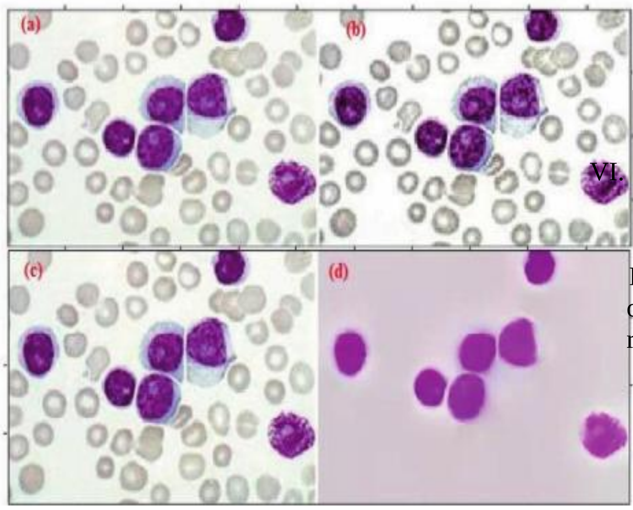

Figure:5 Edge-aware local contrast manipulation of leukemia cell images (a) and (c) original image, (b) Edge threshold, and (d) Reduced contrast

Segmentation is used in machine perception, malignant disease analysis, tissue volumes, anatomical and functional analyses, 3D-rendered technique, virtual reality visualization and anomaly analysis, and object definition and detection Image segmentation is divided into kinds:

a) Local segmentation
b) Global segmentation

The local segmentation works particularly in one subdivision of the image. This technique has a fewer number of pixels compared to the global type. The global segmentation works in the whole image as one unit. This technique has more pixels to manipulate [9-10].

- **Image preprocessing:** To improve the image in ways that increases the chances for success of the other processes.

- **Manipulation of color within an image:** It can change and correct the color of medical images essentially under the indoor natural light condition.

- **Image representation:** To convert the input data to a form suitable for computer processing.

- **Image description:** to extract features that result in some quantitative information of interest or features that are basic for differentiating one class of objects from another.

- **Image recognition:** to assign a label to an object based on the information provided by its descriptors. It is utilized for reclamation of restorative images like X-ray pictures, ultra sound images, CT filter images.

- **Image interpretation and Smoothing:** to assign meaning to an ensemble of recognized objects. It is used to suppressing the noise of medical images.

VI. DIGITAL IMAGE PROCESSING ADVANTAGES IN MEDICAL APPLICATIONS

Digital data is non changeable and always retains its originality; irrespective of how many times the data is reproduced.

- Digital processing is a powerful tool to the doctors that moderate the search for representative images.

- Once the image is acquired then immediately it displays.

- Physicians can easily interpret the enhanced/ intensified images.

- It quantifying the changes over time. Quick comparisons of images can be done.

VII. BIOMEDICAL APPLICATION

Doctors in the medical field require a high level of spatial and spectral images and soft tissues offer soft tissue information . The defecient of soft tissue information with defecient boundary information. Complementary evidence Deep learning has been widely used in medical image processing, and has great achievement in medical image segmentation, multi-dimensional reconstruction and other fields. The MRI, CT, and ultrasound images collected by research institutions provide data for researchers and make great progress in the interdisciplinary of artificial intelligence and medical diagnosis [11].

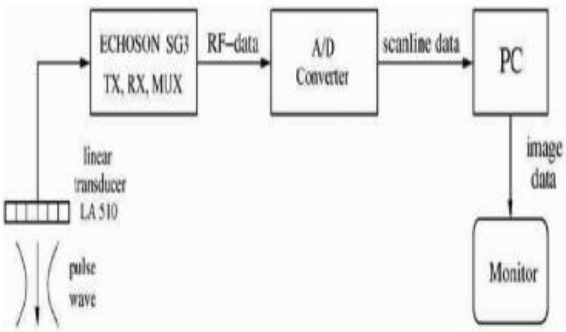

Figure:6 Ultrasound imaging diagram

However, the medical image data set has many limitations. One issue is the lack of training samples. The end-to-end deep learning model is large in scale and deep, and requires a large number of training samples to complete the fitting effect. But unlike natural image acquisition in natural scenes, it is difficult to acquire medical images. For reasons of expensive equipment and patient privacy protection, medical image datasets are small and rarely shared publicly. The particularity of the disease itself also hinders researchers from obtaining samples [12].

Only a few hundred images can be found for some rare diseases. The small sample issue makes it difficult for the network to achieve the ideal fitting effect.

The commonly used term "biomedical image processing" means the provision of digital image processing for biomedical sciences. In general, digital image processing covers four major areas:

- Image formation includes all the steps from capturing the image to forming a digital image matrix.
- Image visualization refers to all types of manipulation of this matrix, resulting in an optimized output of the image.
- Image analysis includes all the steps of processing, which are used for quantitative measurements as well as abstract interpretations of biomedical images. These steps require a priori knowledge on the nature and content of the images, which must be integrated into the algorithms on a high level of abstraction. Thus, the process of image analysis is very specific, and developed algorithms can be transferred rarely directly into other application domains.
- Image management sums up all techniques that provide the efficient storage, communication, transmission, archiving, and access (retrieval) of image data.

Thus, the methods of telemedicine are also a part of the image management. In contrast to image analysis, which is often also referred to as high-level image processing, low level processing denotes manual or automatic techniques, which can be realized without a priori knowledge on the specific content of images. This type of algorithms has similar effects regardless of the content of the images. For example, histogram stretching of a radiograph improves the contrast as it does on any holiday photograph. Therefore, low-level processing methods are usually available with programs for image enhancement [12].

VIII. Conclusion

In this paper, we sketched some of the fundamental concepts of medical image processing. The analog image processing methods which require single modality are now being replaced by techniques which involve date acquired from multiple modalities as in digital image processing. The computational approaches is to integrate the imaging data with non-imaging data. To face this challenge the image processing methods like enhancement, segmentation, restoration morphological systems are integrated with expert systems like neural network and fuzzy logic. The interoperability of necessary integration of algorithms and support to standard techniques should pave way for physicians for future diagnosis.

References

[1] Tim McInerney and Demetri., "Terzopoulos Deformable models in medical image analysis: a survey", Medical Image Analysis (1996) volume 1, number 2, pp 91–108. Thomas M. Deserno , Biomedical Image Processing, Biological and Medical Physics", Springer-Verlag Berlin Heidelberg 2011.
[2] Thomas M. Deserno , Biomedical Image Processing, Biological and Medical Physics", Springer-Verlag Berlin Heidelberg 2011.
[3] Abdallah Y. An accurate liver segmentation method using parallel computing algorithm. Journal of Biomedical Engineering and Medical Imaging. 2015;3(2):15-23.
[4] Anwar Abdalbari, et.al., "Endoscopy-MR Image Fusion for Image Guided Procedures" International Journal of Biomedical Imaging, Hindawi Publishing Corporation, 2013.
[5] Tianyang Zhang, Huazhu Fu, Yitian Zhao, Jun Cheng, Mengjie Guo, Zaiwang Gu, Bing Yang, Yuting Xiao, Shenghua Gao, and Jiang Liu. Skrgan: Sketching-rendering unconditional generative adversarial networks for medical image synthesis. In International Conference on Medical Image Computing and Computer-Assisted Intervention, pages 777– 785. Springer, 2019.
[6] L. Alvarez, P. L. Lions, and J. M. Morel, Image selective smoothing and edge detection by nonlinear diffusion, SIAM J. Numer. Anal. 29 (1992), 845–866.
[7] Axioms and fundamental equations of image processing, Arch. Rat. Mech. Anal. 123 (1993), no. 3, 199–257.
[8] 4. S. Pereira, A. Pinto, V. Alves and C. A. Silva, "Brain Tumor Segmentation Using Convolutional Neural Networks in MRI Images," in IEEE Transactions on Medical Imaging, vol. 35, no. 5, pp. 1240-1251, May 2016
[9] Yong Xi et.al., "Dual-modality brain PET-CT image segmentation based on adaptive use of functional and anatomical information" Computerized Medical Imaging and Graphics(2011).
[10] Abdallah Y, Mohamed S. Automatic recognition of leukemia cells using texture analysis algorithm. International Journal of Advanced Research (IJAR). 2016;4(1):1242-1248
[11] Heran Yang, Jian Sun, Aaron Carass, Can Zhao, Junghoon Lee, Zongben Xu, and Jerry Prince. Unpaired brain mr-to-ct synthesis using a structure-constrained cyclegan. In Deep Learning in Medical Image Analysis and Multimodal Learning for Clinical Decision Support, pages 174–182. Springer, 2018.
[12] Tianyang Zhang, Jun Cheng, Huazhu Fu, Zaiwang Gu, Yuting Xiao, Kang Zhou, Shenghua Gao, Rui Zheng, and Jiang Liu. Noise adaptation generative adversarial network for medical image analysis. IEEE transactions on medical imaging.