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Principal Techniques in Medical Image Analysis Process

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Abstract—Computers have a great effort in medical imaging and medical analysis applications. Proper algorithms and methods in each level of analysis are significant in order to produce the reliable and accurate result. Image enhancement, feature extraction, segmentation and classification are the principal steps in the most of medical image analysis applications. In this paper we discuss and introduce some recent methods and algorithms of each step. However, finding the best method is highly considerable in human health applications.

Index Terms—Medical imaging, enhancement, feature extraction, segmentation, classification.

1 Introduction

MEDICAL imaging is the technique of producing images of human body or any part of organs for using in clinical or medical science purposes such as: diagnosis, treatment or surgery. Computational techniques and computer science filed which are relevant in healthcare called as computational health informatics. Computer scientists are attempting to develop the algorithms and systems in service of medical specialists to improve the quality of human health.

Bioinformatics techniques such as image and signal processing are an important part of many areas of biology, which allows to extract the useful results from large amounts of raw data. Analyzing medical data may involve algorithms in artificial intelligence, soft computing, data mining, image processing, and simulation. The algorithms in turn depend on theoretical foundations such as discrete mathematics, control theory, system theory, information theory, and statistics [1], [2], [3]. Biomedical imaging performs imaging science to the demonstration of and interaction with multi-modality biomedical images with a view to using them productively to examine and diagnose disease in human patients [7].

2 Medical Image Analysis

Medical imaging comprises an important source of anatomical information and is vital for the diagnosis and treatment of disease and other health care investigations. However, it is difficult to effectively processed and utilized these enormous amounts of high-resolution complex medical data with traditional visualization techniques. Although it is difficult and ineffective work for specialists to only inspect visually the collected data from medical images.

Creating suitable and accurate algorithms to analyze the images by using information of raw medical images has become more challenging problem which obliged the medical image analysis community to work with great effort on problems.

Most common technologies to produce these medical images can be mention such as: Radiography (x-ray), Magnetic resonance imaging (MRI), Fiduciary Markers, Nuclear medicine, Photo acoustic imaging, Breast Thermography, Tomography, Ultrasound, Echocardiography.

Among the primary tasks of medical image analysis are image Enhancement, feature extraction, segmentation, and classification. Medical images, for example, are analyzed to ascertain the detailed shape and organization of anatomic structures, in an effort to enable a surgeon to preoperatively plan an optimal approach to some target structure. Medical images can also be analyzed for examining relationships between structural abnormalities and deformations and certain functional abnormalities and diseases. The reader is referred to [4] for a recent overview of the medical image analysis field. See also, for example, [5], [6] for general overview articles related to medical image computing.

Common applications of medical imaging are such as: computer-aided diagnosis in mammography, tumor imaging and treatment, angiography, dentistry, dental diagnosis and treatment, bone strength and osteoporosis, and tortuosity. Fig. (1) shows some examples of medical images uses in analysis applications.

In this paper, the concepts of medical imaging, applications and principal phases of medical image analysis will be investigated and discussed. The most common methods in each stage are demonstrated with related examples.

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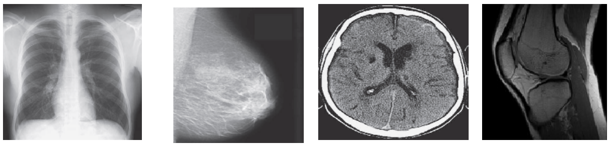


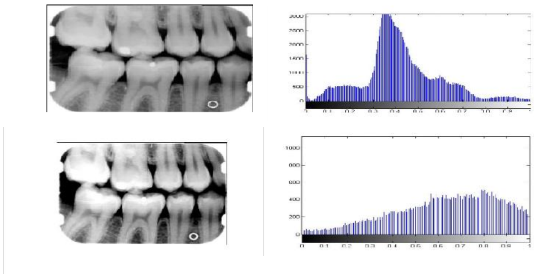
(a) (b) (c) (d)
Fig. 1. a) Chest radiography. b) Breast mammography, c) brain CT scan, d) knee MRI.

3 Enhancement

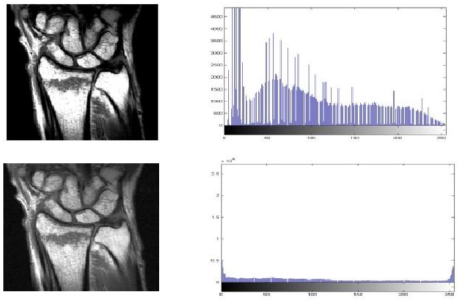
Enhancement of medical images is the process of producing an improved quality image out of a degraded quality input images. Quality of an image is important in order of its suitability for analysis and processing phases. Good quality medical images are those that would make result in accurate analysis when used with proper techniques. Most process and analysis techniques such as segmentation and feature extraction methodsare required high definition of object characteristics and boundaries. The image size depends on the film type and the digitization resolution. Image resolution is characterized by the sampling rate (number of captured pixels per unit length) and the number of bits used in encoding the pixel colors (number of possible quantization levels).
There are two broad categories in image enhancement techniques:

1. Spatial domain methods, which operate directly on pixels.
2. Frequency domain methods, which operate on the Fourier transform of an image.

Almost all medical image analysis applications suffer from low quality of images which affect the result of analysis. There are lots of techniques for image enhancement such as: Histogram Equalization, Negative Image Enhancement, Contrast Stretching, Adaptive Weighted Mean Filter (AWMF), and Edge Adaptive Hybrid Filter (EAHF) and etc. for more detail on techniques, reader referred to [8]. Fig. (2) shows the enhancement of dental x-ray image and knee MRI image with related histograms before and after process.



a)

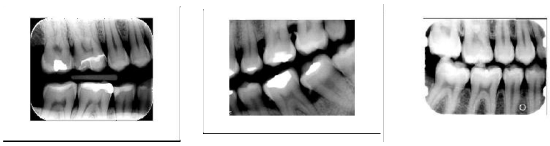


b)
Fig. 2 (a, b). Enhancement of dental x-ray image and wrist MRI image by adjustment of image intensity values and increase the contrast.

4 Feature Extraction

Analysis on medical images is required to extract the information and characteristics of each image which different characteristics are chosen to describe different properties and condition of the images.

This features can consists in five groups, features based on the image characteristics like pixel intensity, maximum pixel intensity, etc. Statistic features as the entropy, mean, variance and more. Region based features such as the Hu moments, the Zernike moments, area, perimeter, etc. Features based on the region segmented boundary, like chain code, Fourier descriptors, signature, angular function, among others. And finally features based on the image texture, like the energy, third moment, etc. There are several features that can be extracted from the image properties. Table (1) demonstrates textural features extracted from different dental x-ray images.



1 2 3

Table 1. Some extracted features from different dental x-ray images

features extracted from dental x-ray images					
Image No	Contrast	Correlation	Entropy	Homoge-neity	Energy
1	0.4648	0.9665	1.7196	0.9512	0.2193
2	0.3160	0.9391	1.6385	0.9650	0.2258
3	0.4513	0.9302	1.5987	0.9637	0.2590

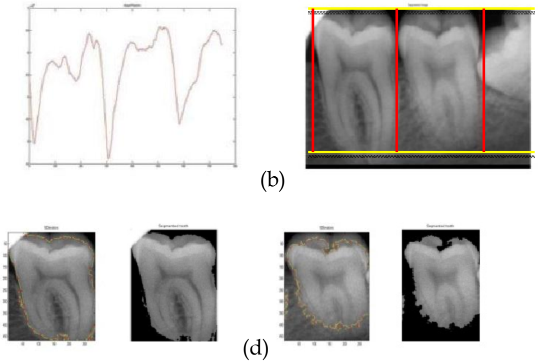
5 SEGMENTATION

Segmentation is the One of essential steps in medical image analysis applications. In medical Image viewpoint, segmentation is to identify and classify each region of body or object in image such as hard tissues or soft tissues. Each extracted region from the image illustrates the Region of Interest (ROI) that includes important data which will be used for later steps in any applications. Usually the location of object calculated by intensity measure, edge detection or a target recognition algorithms. However there are difficulties for these techniques which may suffer from different types of noise due low resolution or poor lighting, which results in un-successful segmentation.

Segmentation process in most of the segmentation techniques is done either by applying a model and trying to adjust its parameters to fit the processed objects or regions or extracting features of regions, which can identify different objects and regions. Although the model based approaches are more complicated but they are more successful and reliable.

Segmentation of such a medical images has more difficulty in process due to a vast variety in topologies, the intricacy of medical structures and poor image qualities caused by some conditions such as noise, low contrast, similarity of body tissues, some sort of artifacts and limitation of scanning methods, which results in un-successful segmentation [9].

Segmentation methods can be divided in three main groups [9], A) pixel based like (thresholding, clustering), B) edge-based like (level set, active contour, edge detection) and C) region based like (region growing, graph cut). Fig.(3) and (4) shows segmentation process on dental x-ray image and also segmentation of brain MRI image.



(a) (b) (c) (d)

Fig..3.(a) vertical integral projection for dental x-ray. (b) straight lines to separate each tooth. (c),(d) segmented tooth based on level set method.

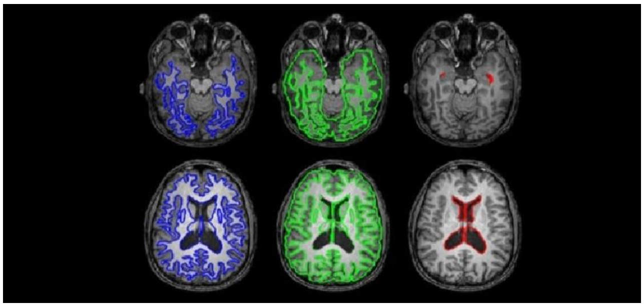


Fig. 4.segmentation of brain MRI image to indicate the matters using snake method [12].

6 CLASSIFICATION

Classification is common human activity. It concerns constructing a decision procedure based on a sequence of cases. The procedure can be applied on a new case to assign a class label from a set of pre-defined classes. Classification is one of the major applications of machine learning, whereby classifiers are constructed based on knowledge observed from examples.

Classification in most cases is the final stage in image analysis process and its in volvees the sorting of objects in an image into different classes. Automatically classification is essential to computer-aided diagnosis systems in medical imaging and many other applications, such as robotic vision and individual recognition. Often the information available to make a decision is imprecise and frequently the decision procedures are statistical in nature. In such cases statistical approaches are used and the diagnostic accuracy of classification can be measured by receiver-operating characteristic (ROC) curves. However, if the fundamental information is provided by the object structure then structural or syntactic methods are more appropriate.

Extracted features in feature extraction stagewill reduce by measuring specific properties or features of the labeled objects. Evaluation of these features performs by applying a classifier on features values to make a decision and assigning the class for each object. In addition classification cab sort the objects into one of several related classes or groups, e.g. is this lesion benign or malignant?

Classification techniques can be divided into two broad areas: statistical or structural (or syntactic) techniques, with a third area that borrows from both, sometimes called cognitive methods, which include neural networks and genetic algorithms. The first area deals with objects or patterns that have an underlying and quantifiable statistical basis for their generation and are described by quantitative features such as length, area and texture. The second area deals with objects best described by qualitative features describing structural or syntactic relationships inherent in the object. Statistical classification methods are more popular than structural methods [10].

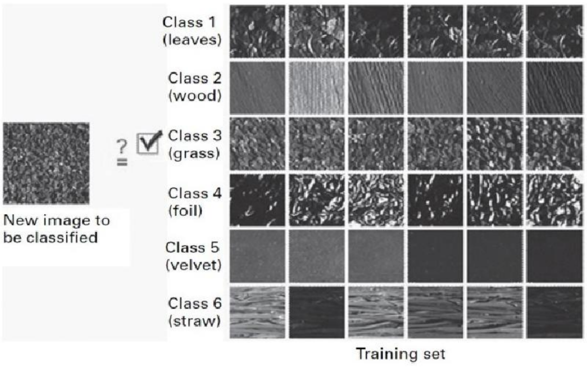


Fig. 5. The image at left has to be classified into one of the classes defined by the training set images. A good classifier will assign it to class 3.from [10].

A classifier is a function or method for conducting classification. It assigns one given example to one of pre-defines classes. There is large number of methods for constricting classifiers [11]. In any effort at designing a classifier it is essential to have a training set of images. Either the classes to which the images belong are known (supervised learning) or they are unknown (unsupervised learning), in which case the most appropriate classes must be found.Fig. (5) demonstrates the sample process of classification.

However the performance of classifiers is usually task specific. There is no single dominant method for all classification tasks. The different types of classifiers can be used as classification function such neural network, k-nearest neighbor, SVM.

7 Conclusion

Medical imaging is an important source of anatomical and functional information which allows experts to diagnosis and treatment of disease.

However, huge amounts of high-resolution three-dimensional spatial and temporal data cannot be effectively processed and utilized with traditional visualization techniques. Among the primary tasks of medical image analysis are image Enhancement, feature extraction, segmentation, and classification. In this paper we discussed about the concept of principal steps in medical image analysis and introduced the some recent methods in each level of process. It is difficult and even impossible to decide the one best method in each process since the images and techniques are totally different. Nevertheless, it is important to find the accurate approaches to obtain the accurate and reliable result in medical image analysis applications.

References

[1] Waterman, Michael S. (1995). Introduction to Computational Biology: Sequences, Maps and Genomes. CRC Press. ISBN 0-412-99391-0.

[2] Mount, David W. (May 2002). Bioinformatics: Sequence and Genome Analysis. Spring Harbor Press. ISBN 0-879-69608-7.

[3] Claverie, J.M.; Notredame, C. (2003). Bioinformatics for Dummies. Wiley. ISBN 0-7645-1696-5.

[4] J. Duncan, N. Ayache. "Medical Image Analysis: Progress Over Two Decades and the Challenges Ahead". IEEE Transactions on Pattern Analysis and Machine Intelligence. Vol. 22(1), 85 -106, 2000.

[5] N. Ayache. "Medical computer vision, virtual reality and robotics". Image and Vision Computing. Vol. 13(4), pp. 295- 313, May 1995.

[6] T. Pun, G. Gerig, O. Ratib. "Image analysis and computer vision in medicine". Computerized Medical Imaging and Graphics. Special Issue: Multimedia Techniques in the Medical Environment, Vol. 18,(2), pp. 85-96, 1994.

[7] GhassanHamarneh, "Towards Intelligent Deformable Models for Medical Image Analysis", PhD thesis, Chalmers University of Technology, Göteborg, Sweden 2001.

[8] Seema Rajput, S.R.Suralkar, "Comparative Study of Image Enhancement Techniques", International Journal of Computer Science and Mobile Computing, IJCSMC, Vol. 2, pg.11 – 21, 2013.

[9] Rad AE, Mohd Rahim M, Rehman A, Altameem A, Saba T. "Evaluation of Current Dental Radiographs Segmentation Approaches in Computer-aided Applications". IETE Tech Rev; 30, 210-22, 2013

[10] GEOFF DOUGHERTY, "Digital Image Processing for Medical Applications", Cambridge University Press, UK, 2009.

[11] T. Lim and Y. Shih. A comparison of prediction accuracy, complexity and training time of thirth-three old and new classification algorithms. Machine Learning, 40(3):203-228, September 2000.

[12] From website available in http://westliberty.edu/college-of-sciences/2013/02/19/mri-of-the-human-brain/

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