Chapter 30
Fuzzy-Based Medical Image Processing

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ABSTRACT

Medical Image Processing (MIP) is a set of tools applied over medical images, which consists of several components such as image acquisition, enhancement, segmentation, restoration, etc. The most important component of MIP is medical image segmentation used in Computer-Aided Diagnosis (CAD) systems used for detection of abnormalities in medical images. This chapter presents an overview and the importance of soft computing techniques in solving the problems of medical imaging. The authors highlight the significance of fuzzy-based clustering and similar methods for MIP and its applications. Fuzzy C-Means Clustering Method (FCM) is found the most suitable method among existing clustering methods for medical images. FCM addresses the problem of over-segmentation and helps in improvement of diagnosis accuracy. Application of optimization tool causes the reduction of execution time. A comparison of fuzzy-based methods over conventional methods suggests that neuro-fuzzy system as hybrid approach is an efficient method for medical image analysis.

INTRODUCTION

A digital image is a digital representation of a real world objects whose elements are called as pixels (picture elements). The pixels of images carry particular gray scale or intensity values and follow coordinate system and therefore any pixel is represented as a function of coordinate values along with its intensity value. The digital images may be of two types namely still and moving images. Image processing is a collection of tools such as image acquisition, image enhancement, image restoration etc. Image enhancement is used to reduce the amount of noise present in digital images. Image segmentation deals with portioning the image into certain number of sub-images or regions. Medical image processing is a digital image processing applied over medical images. Raw data or images are subjected to preprocessing and image enhancement methods so as to make them suitable for further application. The images may be acquired through several sources such as cameras/sensors, probes and communication channels. There are other several applications of

DOI: 10.4018/978-1-4666-8789-9.ch030

image processing such as remote sensing, satellite imaging, underwater imaging, diagnostic radiology, military and document processing. Medical image processing mainly deals with capturing, analysis and interpretation of medical images such as X-rays, mammogram, MRI (magnetic resonance imaging) images, CT (computed tomography) scan images etc. These images are produced by using different types of medical imaging techniques (Sinha et al., 2006; Sinha et al., 2014)

Now, computer-aided diagnosis (CAD) based systems are used all modern hospitals to diagnose various types of disease or abnormalities present in medical images. However, validation of results is all time challenging task since there is no general theory in image processing. The statistical parameters used in CAD, the algorithms used in interpretation and measurement of various nodules or tumor size; do not have any robust approach. The accuracy of systems is greatly improved by using soft computing techniques such as neural network, fuzzy logic and genetic algorithms. The present work is an attempt to suggest recommendations for using fuzzy logic in medical image processing to improve the accuracy of CAD based diagnosis systems. Fuzzy image processing can help in overcoming imperfections in digital imaging modalities and processing algorithms. Fuzzy based medical image processing (FIP) is the collection of all methodologies in digital image processing, with which the images, image features and their segments are represented and processed as fuzzy sets. The present work aims at achieving following learning objectives:

- To present an overview of CAD based systems in medical image processing (MIP);
- To highlight the challenges in existing systems;
- To suggest fuzzy based approaches in CAD and medical image processing;
- To emphasize practical aspects of fuzzy based methods; and
- To recommend neuro-fuzzy systems as effective soft computing techniques in medical image processing and analysis.

BACKGROUND OF MEDICAL IMAGE PROCESSING

An overview of medical image processing including various imaging modalities, medical image processing using various techniques are discussed here. Medical imaging is the visualization process of the human body or some parts of the body for clinical purposes and diagnosis. This helps in producing various types of medical images which are subjected to medical image processing. The processing is applied over medical images and some useful information from the images are extracted and based on this information an analysis is made that subsequently helps in diagnosis of the images to predict about the diseases. Medical image processing gives an understanding and knowledge to research scholars, students, scientist, physicians and others to reveal, diagnose or examine diseases and to study normal anatomy and physiology. Due to increased size of databases of patient information, health care sectors require proper and systematic databases and retrieval of information; which can be easily addressed with the help of suitable medical image processing techniques. MRI images, CT scan images and ultrasound images are the examples of the medical imaging modalities (Sinha et al., 2014).

Medical image processing is applied over various types of medical images which are produced by different medical imaging techniques. The techniques are used to produce X-ray images, radiographic images, MRI images etc. Medical images are then subjected to image pre-processing, enhancement, restoration, segmentation, post-processing, registration, 2D/3D visualization etc. Image segmentation is major component of CAD and medical image analysis, which has following challenges: