Chapter

Feature Extraction Methods for CT-Scan Images Using Image Processing

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Abstract

Medical image processing covers various types of images such as tomography, mammography, radiography (X-Ray images), cardiogram, CT scan images etc. Once the CT scan image is captured, Doctors diagnose it to detect abnormal or normal condition of the captured of the patient's body. In the computerized image processing diagnosis, CT-scan image goes through sophisticated phases viz., acquisition, image enhancement, extraction of important features, Region of Interest (ROI) identification, result interpretation etc. Out of these phases, a feature extraction phase plays a vital role during automated/computerized image processing to detect ROI from CT-scan image. This phase performs scientific, mathematical and statistical operations/algorithms to identify features/characteristics from the CT-scan image to shrink image portion for diagnosis. In this chapter, I have presented an extensive review on "Feature Extraction" step of digital image processing based on CT-scan image of human being.

Keywords: medical images, CT-scan image, feature extraction, image processing, image diagnoses

1. Introduction

In recent medical revolution, Computer Aided Diseases Diagnoses (CADD) plays an important role. The basic aim of CADD is to detect diseases on the basis of human image as an input at low cost, better accuracy and patient's satisfaction. There are many bio-medical imaging technologies available such as Radiography, computed tomography (CT-Scan), electrocardiography (ECG), Ultrasound, magnetic resonance imaging (MRI), etc. All these medical imaging modalities are best suited depending on the type of diseases to be detected from human body [1, 2].

In the human body, e.g., arm, leg, scalp, etc., each and every bone plays an important role and function. **Figure 1(a)** shows human being's head CT-scan image; and **Figure 1(b)** shows human being's chest CT-scan image.

CADD system can be developed with the use of image processing. **Figure 2** depicts steps of digital image processing [2].

Figure 2 shows basic steps to perform digital image processing. Image acquisition is the process of obtaining a digitized image from a real world source using imaging devices e.g., camera, cell phone, CT-scan, MRI, ultrasound etc. Images which are acquired in the first step may be blurred, out of focus or noisy so, in the

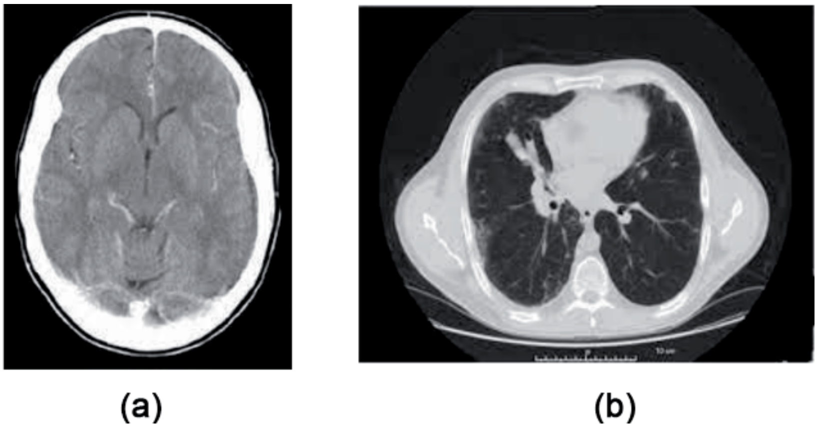

Figure 1.
(a) Head CT-scan image; and (b) chest CT-scan image. Courtesy: https://images.google.com/.

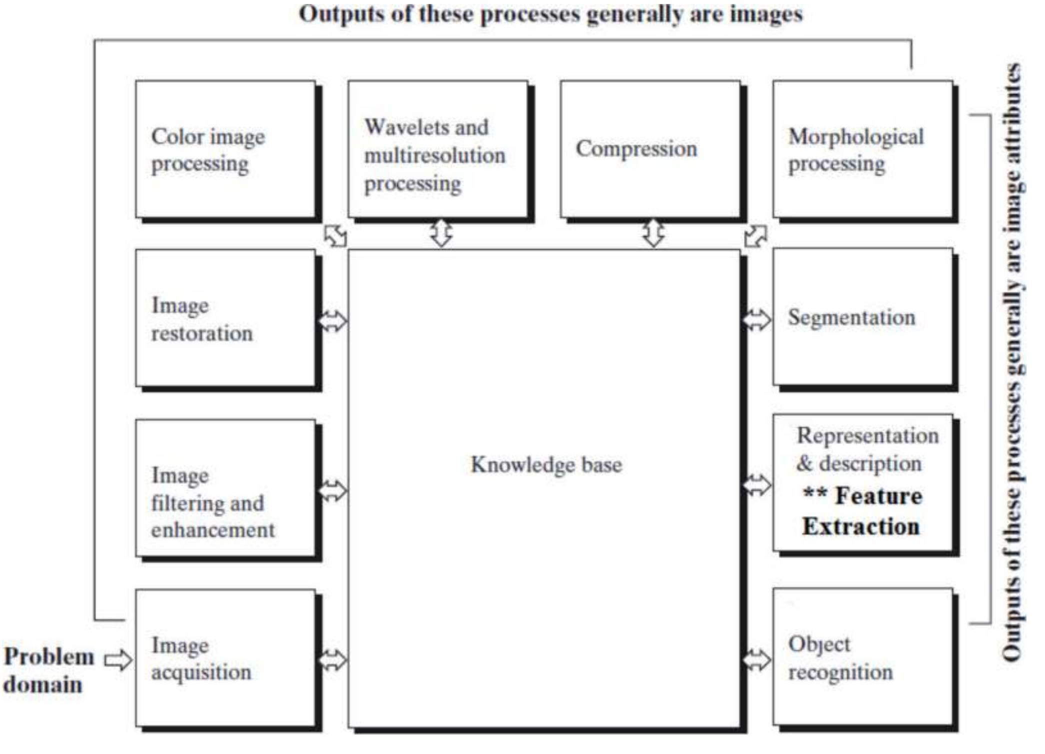

Figure 2.
Basic steps in digital image processing.

next step that is image filtering and enhancement which is used to improve the quality of image. This step includes various filtering and enhancement algorithms.

Image quality can also be improved with the use of Image restoration. The main difference between image enhancement and image restoration is that former is subjective and later is objective. Image restoration methods are based on mathematical/probabilistic models/algorithms of image degradation. While, Image enhancement methods are based on subjective liking of human preference during visualization [3]. The next step is Color Image Processing which deals with feature extraction on the basis of image color. Wavelet is the foundation for image resolution. This step focuses on use of wavelet to perform image resolution analysis. The next step is image compression. This step is used to decrease the size of image so that it can be stored in minimum space or can be transmitted even on low bandwidth channel. Morphological processing step includes tools for extracting image components that are useful in the step that is representation and description of image shape. The next step is image segmentation, it means dividing the image in constituent segments on the basis of boundary, similarity, color, shape etc.

Representation and description always follow the output of a segmentation step. The first option to be taken is whether to portray the data as a border or a complete region. When the focus is on external shape properties such as corners and inflections, boundary representation is appropriate. When the focus is on internal qualities such as texture or skeletal shape, regional representation is acceptable. A strategy for characterizing the data must also be defined in order to highlight features of interest. Description, also known as feature selection, is the process of selecting features that produce quantitative information of interest or are necessary for distinguishing one object class from another [3]. The last step is object recognition which deals with assigning the label to the object/information extracted during feature extraction step. Finally, the result is displayed in the form of data or image.

The aim of this chapter is to present an extensive research review on feature extraction sub-step of image processing cycle applied to human CT-scan images. The chapter is organized as follows: Section 2 gives a brief of different feature extraction techniques; Section 3 discusses work on CT-scan Image feature extraction; finally, the paper is concluded in Section 4.

2. Feature extraction techniques

Data/dimensionality reduction, which is performed by intelligently changing the image from the lowest level of pixel data into higher level representations, is a key component in image analysis. We can extract relevant information from these representations through a process known as feature extraction [4].

The ultimate aim in a large number of image processing applications is to extract important features from image data, from which a description, interpretation, or understanding of the scene can be provided by the machine [5].

As per Nixon and Aguado [6] feature extraction techniques are broadly classified into two categories that is low level feature extraction and high level feature extraction. Low-level features extraction deals with basic features that can be extracted automatically from an image without any shape information such as thresholding and edge detection.

Edge Detection: It highlights image contrast. Edge is generally boundary of the image objects where intensity of the pixel changes abruptly [6].

Thresholding: It chooses pixels within a specified range that have a specific value or arc. If the brightness level (or range) of an object is known, it can be used to locate it within a photograph. This implies that the brightness of the object must also be known [6].

Detecting image curvature (corner extraction): Curvature is normally defined by considering a parametric form of a planar curve. This technique is used to detect corner from the image [6].

Region/patch analysis: Collection of pixel is usually refers to region of the image. This technique is used to detect particular region on the basis of certain algorithm [6].

Hough transform: It defines an efficient implementation of template matching for binary templates. This technique is capable of extracting simple shapes such as lines and quadratic forms as well as arbitrary shapes [6].

Image motion detection: In the case of motion there is more than one image. If we have two images obtained at different times, the simplest way in which we can detect motion is by image differencing [6].

Histogram: The intensity histogram shows how individual brightness levels are occupied in an image; the image contrast is measured by the range of brightness levels [6].

Haar wavelets: Haar wavelets are binary basis functions. There is (theoretically) an infinite range of basis functions. Discrete signals can map better into collections of binary components rather than sinusoidal ones [6].

Texture extraction: Texture is an arrangement of pattern after certain interval in the image. Many techniques are used to extract texture from the image such as Local Binary Pattern (LBP), Fourier Transform, Co-occurrence matrices etc. [6, 7].

The above discussion provides brief overview of different techniques that can be used in digital image processing for the feature extraction from digital image. However, it is not an exhaustive discussion of the feature extraction techniques.

3. CT-scan image feature extraction

A feature extraction is a process through which region of interest (ROI) extracted for analyzing image. It includes modifying the image from the lower level of pixel data into higher level representations. From these higher level representations we can gather useful information; a process called feature extraction [8].

Ma and Wang [9] proposed a novel method to automatically detect the texts embedded in CT-scan Image. Authors have used Histogram of Oriented Gradients (HOG) as a statistical feature descriptor which reflects the distribution of oriented gradients in a selected region. Further, they have adopted AdaBoost classifier to separate the text regions from non-text regions. This method achieved 84% precision rate which is greater than edge base method (45%) and hybrid method (76%).

Shuqi et al. [10] proposed an algorithm to extract local features from mammographic image. In this paper, the SIFT algorithm is combined with the sliding window to extract the ROI region, that is, the breast region, and remove most of the background region. It follows the experimental process as Background de-noising, Using SIFT to extract the key point, Using the SVM and sliding window to detect the ROI position, Extract the features of the ROI region and Design BP neural network. The experimental results show that the accuracy of neural network classifier based on SIFT is 96.57%, which is 3.44% higher than that of traditional SVM classification accuracy.

Poomimadevi and Sulochana [11] presents an automated approach to detect tuberculosis using chest radiographs. The proposed approach basically includes three main steps such as Preprocessing, Registration and watershed segmentation. Lung region is extracted by using registration based segmentation methods. The accuracy of proposed segmentation and global thresholding is 59.8 and 59.4% respectively. While, the accuracy of active contour method is 34.4%. Joykutty et al. [12] also proposed a novel mechanism to detect tuberculosis in chest radiographs. The proposed method includes a three stage process of accurate detection of tuberculosis.

Barabas et al. [13] have developed a software namely Visualizer which allows the viewing of individual CT/MRI image slices, slice reconstruction in various projections, detailed analysis of slices and 3D reconstruction of desired object(s) as well as localization of various anatomical structures for further evaluation of parameters.

Chaudary and Sukhraj et al. [14] have worked on lung cancer detection from CT scan images using image processing steps such as pre-processing, segmentation and feature extraction. In this paper, authors have used MATLAB as image processing tool and concentrated on Area, Perimeter, Roundness and Eccentricity features of image.

Suzuki et al. [15] have used computer aided diagnostic scheme to detect abnormalities from Chest radiograph image of human beings using means of massive training artificial neural network.

Chen and Huang [16] presented an image feature extraction and fusion algorithm based on K-SVD, in order to better fuse CT and MRI images. The sliding window divides images into chunks in this technique. The column vectors are compiled into the dictionary. The K-singular value decomposition (K-SVD) approach is used to learn the redundant dictionary. The image feature fusion is then realized by solving the sparse coefficient matrix for each original picture and then combining sparse coefficient of nonzero members.

Ding et al. [17] have proposed a method based on the exploitation of features closely related to image inherent quality. Specifically, in the novel method, Sobel operator, log Gabor filter and local pattern analysis are employed for complementary representation of image quality. Finally, support vector regression is implemented for the synthesis of the multiple distortion indices and mapping the quantification into an objective quality score.

Litjens et al. [18] presented a survey on deep learning in CT-scan Image analysis. Authors have stated that feature extraction from CT-scan Image can also be done through efficient deep learning algorithm. Kaur and Jindal [19] have worked on OPEN CV Environment to extract features using SURF technique. They have emphasized on the feature extraction phase of content-based image retrieval (CBIR) [20] and concluded that SURF is efficient image processing technique in terms of detect ability, accuracy, rotation and execution time.

According to Hossein and Jacques [21], if prior shape and a straightened boundary image (SBI) based algorithm are applied on CT-scan Image segmentation then, feature extraction will be more easy. Using an adaptive thresholding technique, Oishila et al. [22] provided a tool that first segments the bone region of an input digital CT-scan Image from its surrounding flesh region and then generates the bone contour. It then undertakes unsupervised rectification of bone-contour discontinuities that may have been caused by segmentation mistakes, before detecting the presence of a fracture in the bone.

Seyyed et al. [23] has presented a novel feature which is the combination of shape and texture features. The feature extraction is started by edge and shape information of CT-scan Image then, Gabor filter is used to extract spectral texture features from shape images.

Ratnasari et al. [24] have concentrated on five statistical features like mean, standard deviation, skewness, kurtosis, and entropy to find out the CT-scan Image features for the development of computer applications for identification of lung tuberculosis (TB) disease and concluded that features extraction can be done effectively using combination of thresholding-based ROI template and PCA (Principle Component Analysis) methods.

Kazeminia et al. [25] proposed a novel method to eliminate the non-ROI data from bone CT-scan Images based on the histogram dispersion method. ROI is separated from the background and it is compressed with a lossless compression method. This method contains 3 steps such as Noise Reduction and Smoothing, ROI Boundary Detection and Compression.

Kumar and Bhatia [26] discussed different methods of feature extraction such as Diagonal based feature extraction technique, Fourier descriptor, Principal

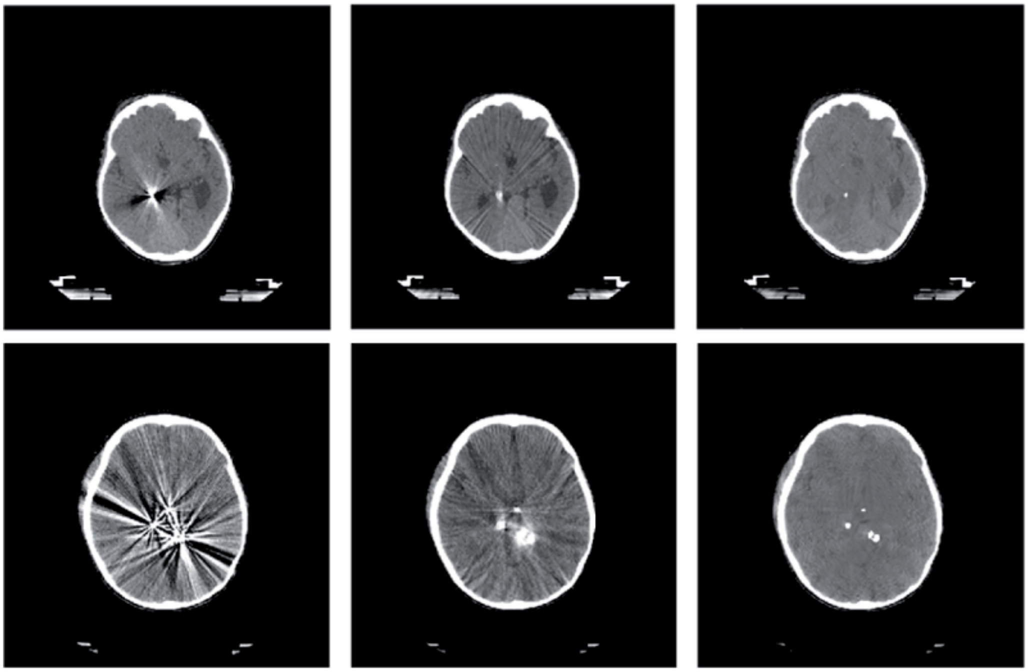

Figure 3.
Brain CT-scan image processing.

component analysis (PCA), Independent Component Analysis (ICA), Gabor filter, Fractal theory technique Shadow Features of character, Chain Code Histogram of Character Contour, Finding Intersection/Junctions, Sector approach for Feature Extraction, Extraction of distance and angle features, Extraction of occupancy and end points features, Transition feature and Zernike Moments.

As per Dubey et al. [27] edge detection techniques are also used for feature extraction. These techniques can be pewitt, sobel, Rober, Kirsch, Robinson, Marr-Hildreth, LoG, Canny etc.

Figure 3 shows image processing of human's brain CT-scan image. As per Kumar and Bhatia [26] and Dubey et al. [27], authors have implemented Gabor filter and edge detection technique to process the human brain CT-scan image in order to detect cancerous part of the brain. **Figure 3** is divided into 6 different sub-images as an output generated from the computerized digital image processing. In the first step original captured CT-scan image is fed to the system, image pre-processing and enhancement are conducted in the second step, edge detection using canny and prewitt method are done in the third step, fourth step focus on the Gabor filter in order to detect ROI, fifth step focuses on feature extraction using BLOB (binary large object) analysis and in the last that is step number 6 produces the final output image. Pseudocode of this process is given below:

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Pseudocode: Human's brain CT-Scan image processing
READ CT-Scan image
CONVERT an inputted image into gray scale image(If RGB)
DO Pre-Processing and Image Enhancement
Do Edge detection using canny & prewitt methods
APPLY Gabor filter to detect ROI
DETECT features using BLOB analysis
DISPLAY processed CT-Scan image as an output
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4. Conclusion and future attempts

X-Ray and CT-scan images is an important medical imaging component to detect bone related issues and diseases. Many researchers have shown their interest to work in the field of X-Ray image processing. The broad survey presented in the above section III proves that researchers have worked in features extraction from human being's X-Ray and CT-scan images. This research review is further useful for researchers to develop automatic application or decision support system to analyze human being's X-Ray and CT-scan images to detect bone related diseases such bone fracture identification, fatigue of knee joint, bone age assessment, lung module diagnoses, osteoporosis, arthritis, bone tumor, bone infection etc.

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