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A study on Medical Image Processing Methodologies

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Abstract—Medical images are at the core of medical science and an enormous source of information that need to be utilized. Image processing techniques in biomedical images are generally either used for the retrieval of images (Content Based Image Retrieval) or for analysis. Various applications of image processing in the medical field are existing and enormous work is being done now a days. In this paper we have studies the current state of medical image digitization, representation, limitation of current image storing techniques and the future trends.

Keywords— medical science, digital image processing, Fourier transform, multimedia database, MRI

I. INTRODUCTION

Medical images are at the core of medical science and an enormous source of information that need to be utilized. Image processing techniques in biomedical images are generally either used for the retrieval of images (Content Based Image Retrieval) or for analysis. Today digital image processing techniques are used to solve a variety of problems. These techniques are used in two major application areas and they are a) Improvement of pictorial information for human interpretational and b) processing of scene of data for autonomous machine perception. In medicine, the digital image processing techniques are used to enhance the contrast or transform the intensity levels into colour for easier interpretation of X-rays, MRI and other bio-medical images.

The organization of paper is as follows Section II describes the fundamental steps in medical image processing, in Section III we have discussed the visualization and perception sub systems, in section IV various image representation and description techniques have been described, in section V we have discussed the limitations of existing methodologies and in section VI we have concluded our study.

II. FUNDAMENTAL STEPS IN MEDICAL IMAGE PROCESSING

A. Image Grabbing or Acquisition

In the image acquisition step using the suitable camera, the image of the component is acquired and then subjected to digitization. A physical device sensitive to a band in the electromagnetic energy spectrum is required. This device converts the light (X-rays ultraviolet, visible, or infrared) information in to corresponding, electrical signal.

B. Pre-processing

The key function of pre-processing is to improve image such that it increases the chances for success of other processes. It can be used for enhancing t electrical signal.

Segmentation is a process in which the given input image is partitioned into its constituent parts or objects. The output of the segmentation stage usually consists of either boundary of the region or all parts in the region itself.

C. Representation and feature extraction

Representation deals with properly transformation of data obtained from segmentation into a suitable form for further computer processing. The feature selection deals with extracting salient features from the object representation in order to distinguish one class of object from another.

D. Recognition and Interpretation

Recognition process assigns a label to an object based on the information provided by the feature selection. The process of interpretation assigns a meaning to the recognized object.

III. VISUALIZATION AND PERCEPTION SUB SYSTEM

While designing a digital image processing system understanding the human vision system and the underlying perceptual system plays the major role. The aim of the image processing and analysis techniques are to built a system that has similar capabilities as the human vision system. Many interesting studies have been carried out and the subject of visual perception has grown over centuries. In this section we describe the elements of human visual systems like brightness perception, contour detection and pattern discrimination ability. These concepts are useful in designing algorithms as well as image processing systems

A. Brightness Adaptation and Contrast

Brightness is a psycho-visual concept and can be defined as a sensation to the light intensity, Contrast may be defined as the difference in perceived brightness. As in a MRI scan detection of a bright spot depend not only on the brightness, size and duration (in time), but also on the contrast between the spot and the background.

B. Acuity and Contour

The ability of human visual system to detect fine spectral details is known as acuity. Human vision system response to stimuli such as points, lines, edges or sinusoids, and the response to sinusoids is particularly important because it is associated with resolution. Resolution may be defined in terms of modulation transfer function which exhibits the characteristics of a bandpass filter for a wide range of background luminances.

C. Texture and Pattern Discrimination

Texture refers to coarseness of a surface [Brodatz(1966)].Visual texture is usually defined as repetitive arrangement of some basic pattern, where the repetition may not be random. Whereas, a texture pattern normally has some degree of randomness. To quantify texture, the randomness is measured by a small rectangular region called *window*.

D. Shape Detection and Recognition

Human eye formes a shape of pattern by grouping different regions in the visual field [Hochberg (1964), Nevatia (1982)]. Many different arrangement of objects in a three-dimensional scene produce same two dimensional image in the eye. The detection, classification and recognition process require no only the visual system but also the memory process. The stored information and structural description are used as prototypes or ideal objects.

IV. IMAGE REPRESENTATION AND DESCRIPTION

Image analysis and image understanding are two important systems that constitute a computer vision system. The first step in image analysis system is segmentation. This step is followed by representation and description schemes. After segmentation the boundary pixels of object is received, now for analysis of shape the proper representation of this boundary is very important. Generally the representation schemes are carried out in two ways : first by using external characteristics of the object in the region, second by using the internal feature. Various representations and description schemes are being used in image processing system.

A. Boundary Representation Using Chain Codes

The chain code technique is simple and effectively used to represent the boundary of an object. Two approaches are being used in first one four directions are used and in second approach eight directions are used.

B. Boundary Representation Using line Segment

Straight – line segments give simple approximations of curve boundaries. In this approach the end points of a line segments are joined, and if the distance from the farthest curve point to the line segment is greater than the predetermined quantity the curve point will be joined with two end points. This process is continued till the desired accuracy is reached.

C. Boundary Representation Using Signature

Signature of any boundary is a one dimensional function, which can be generated in different ways. For example, on any elliptical boundary a line will be drawn from one point on the curve to the origin and the distance and Ɵ will be measured. The process will be repeated and the curve will be drawn.

D. Fourier Descriptors

When a continuous boundary is digitized and represented as a digital boundary, that will have few points for example N, each point can be represented as a spatial coordinate pair (X_0, Y_0) (X_1, Y_1) (X_2, Y_2).....(X_{N-1}, Y_{N-1}). All these coordinates can be expressed as a sequence, which can be represented in the form of equation :

$$P(l) = [X(l), Y(l)] \text{ where } l=0,1,2.....N-1$$

These coordinates pair can be represented in the complex number :

$P(l) = X(l) + j\,Y(l)$ for $l=0,1,2.....N-1$. By using the complex number representations, the boundary will not be changed, but the discrete Fourier transforms P(l) can be defined .

$$A(u) = \frac{1}{N}\sum_{l=0}^{N-1} P(l)e^{\frac{-j2\pi ul}{N}} \quad for\ u = 1,2,3,\ldots\ldots N-1$$

The complex coefficient A(u) are called the Fourier descriptors of the given boundary.

E. Moments

The boundary shapes can be well described quantitatively by using moments. In general, only first few moments are required to differentiate between boundaries of different shapes. A significant approach for motion-based segmentation is change detection. Change detection is based on identifying the set of pixels that are significantly different between a pair of images of the same scene, taken at two different times.

VI. IMAGE RETREIVAL TECHNIQUES

A. Content based Indexing

Some automatic image indexing methods have been proposed, based on shape [8, 9, 11, 15, 14], color [7, 9,16] , or combinations of such indices [12]. The general approach is to calculate some approximate invariant statistic like a color histogram, invariants of shape moments, parametric curve distance, or frequency subband decomposition, and use these to categorize the image database.

B . Metadata Indexing

In order to retrieve image from database systems, one needs a mapping between textual terms and semantic entities stored in a knowledge base.[18]. In medical science the machine from which the imaging is done is also a key role player while diagnosis a disease, storing the information in separate file and mapping the technical terms with the medical terms provides a solution for better end user centric retrieval.

VI. LIMITATIONS OF EXISTING IMAGE STORAGE TECHNIQUES

However the extraction of low level features form a medical image has achieved a significant level, the indexing on those features still needs improveent. Some automatic image indexing methods have been proposed, based on shape, colour or combinations of such indices. But none of the algorithm provides a generalized indexing scheme. While checking the similarity between the two images maximum algorithms are based on textual annotations rather than visual properties of image. Queries like "find the patient having similar stage of tumour", is still solved with the help of textual annotations or metadata. IBM's Query By Image Content system(QBIC) [12], one of the most advanced 2D image database systems to date, usescolor, texture, and shape of image objects and regions. Unfortunately, these methods lack effectivemodels that are robust to noise, scale, and sampling, and models that roughly correspond to a human's notion of perceptual similarity.[17]

VI. CONCLUSION

Each of the five approaches that we have discussed for medical image representation, in few cases only one technique will be sufficient while in few cases combination of two approaches would be beneficial. During our study we have realized that applying different approach for representing the image features and indexing does not provide the desired result at the time of retrieval. We suggest that image representation techniques should be combined with image indexing techniques to achieve automatic indexing. Second we suggest that for semantic representation and retrieval of medical images intelligent user interface should be defined by using AI and HCI algorithms.

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