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Image Processing in Medical Applications

Asma Yasrib[1] & Mohd Adam Suhaimi[2]
International Islamic University Malaysia
Malaysia

Abstract

In this article a number of recent developments in medical imaging are outlined, with the focus being on the application of image processing techniques. Medical images are at the core of medical science and an enormous source of information that need to be utilized. Image processing techniques with regards to biomedical images are generally either used for the retrieval of images (Content Based Image Retrieval) or for analysis and modification of images. In this article we give a description of the different applications of image processing in the medical field.

Keywords: Image Processing, Biomedical Images, Healthcare Informatics

Introduction

Information Technology (IT) has traversed all aspects of human life, and the past few decades have seen the influence of this technology in the field of healthcare and medicine. At the core of medical science are biomedical images – images of the human body that help in the understanding of the nature of human biological systems. These images may be at the molecular level or images of complete organs, organ systems, and body parts. These images are enormous sources of information and like any other source of information need to be tapped and analysed to pave the way for better understanding.

In understanding and gathering information from these images, the technique of image processing is of utmost importance. Image Processing is the process of modifying or interpreting existing pictures, such as photographs. (Hearn & Baker, 1997). This paper studies the current state of technology and outlines the major areas in which image processing techniques are used with regards to medical science. It also looks at the current research work being done all around the world in the field.

Biomedical Images and IT

From the discovery of X-ray by Roentgen in 1895, to the present day imaging tools like Magnetic Res0onance Imaging (MRI) and Computed Tomography (CT), the technology has progressed much. The advances in t he imaging technology will continue as time progresses. However, today the focus of systems is shifting from medical imaging focus from the generation and acquisition

of images to post processing and management of image data. (Wong & Tjandra, 1999). This is stimulated by the need to make efficient use of the data that already exists.

Recent progress in imaging research have shown the potential the technology can have to improve and transform many aspects of clinical medicine. Figure 1 shows the linkage between the various research areas in Biomedical Imaging Systems. Within the area of biomedical image processing we see research currently being done on two major frontiers:

a) Image Retrieval

Image retrieval techniques refer to the tools employed to search for a particular image from a set of images which are usually stored in a database. The mechanism used is either text based or based on content of the image, as will be discussed shortly.

b) Image Processing.

Once the image has been retrieved, methods can be used to enhance, reconstruct, or allow automated analysis so as to highlight or point out areas that may be of interest to the user. These will also be discussed here.

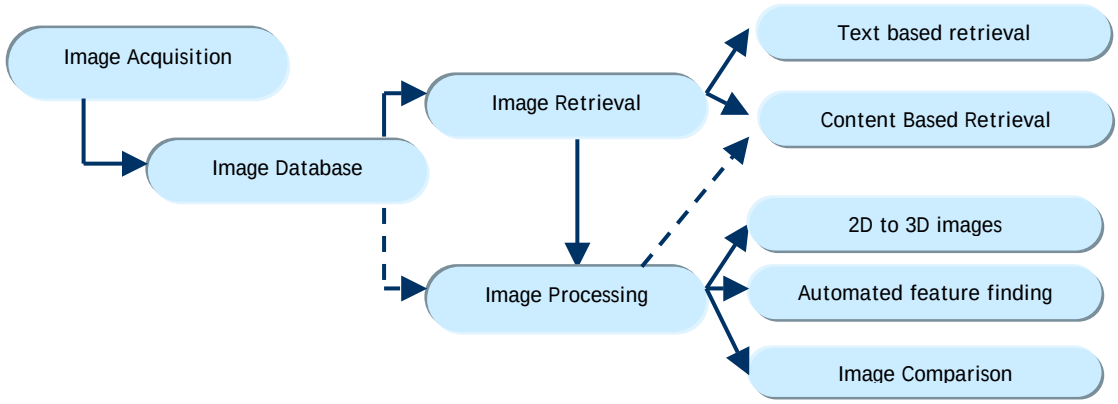

Figure 1. Main Research Areas in Biomedical Imaging Systems

Image Retrieval

Research on biomedical imaging systems has it roots in early 1970s. The research was focused on developing systems that would enable image retrieval based on textual information about the image. Biomedical imaging systems developed over time to be text-based. A very popular framework of Image Retrieval was to first annotate the images by text, then use a text-based Database Management System to do the retrieval. Different representations of this were developed, and Picture Archiving and Communication Systems (PACS) found its place in many medical centres. However, as Yong Rui et. al (1998) pointed out, there exist two major difficulties in this approach, especially when the size of image collections is large (tens or

hundreds of thousands of images). The first problem has to deal the vast labour required to manually annotate the images. The second difficulty is a result of the subjectivity in human perception – meaning different people may see things differently. This perceptual subjectivity may cause mismatches during retrieval.

As large scale image collections emerged, the two difficulties faced by manual annotation became more and more acute. As a solution to this researchers started looking into image-based solutions. The most often referred to as content-based image retrieval (CBIR). Instead of manual annotation of images by text-based keywords, images would be indexed by their own visual content, such as colour, shape and texture which can be extracted from the images themselves. Another system QBIC™, described by Flickner et. al (1995) retrieves images based on their visual image content combined with text and keyword predicates. Another system which retrieves images based on their perceptual content is SURFIMAGE.

Many techniques in this research direction have been developed and many image retrieval systems have been built – both for research and for commercial usage.

Systems have also been developed that allow users to submit shapes as queries. The first system developed to submit shapes as queries on the internet is Shape Queries Using Image Databases (SQUID), developed at University of Surrey. Such techniques could be useful in the medical field as well. Systems allowing retrieval based on both semantic as well as visual properties have been developed, for example the VHD-MMS Agent Retriever. Use of statistical learning process, as well as Artificial intelligence agents has been studied to ensure easy retrieval of images.

James Z. Wang (2000) of Stanford University writes about a multiresolution based retrieval system called SIMPLIcity that not only reduces the need for textual information but also, can handle, quickly and efficiently, the approximately one billion images that can be found on the internet. Much progress has been seen in the field of image retrieval – with various techniques studied and applied – generally in the context of the World Wide Web. These techniques can be modified and used to serve the medical community.

Image Processing

In the development of biomedical imaging systems, the idea of image retrieval goes hand in hand with the need for digital image processing. There are three primary application areas: firstly, image restoration, secondly, the processing of data for autonomous machines perception and finally the processing of images for improvement in human perception for example comparison or feature extraction.

The field of image processing has seen much research and advance since 1964, when the pictures of the moon transmitted by Ranger 7 were processed by a computer to correct various types of image distortions (Gonzales and Woods, 1993). The application of the image processing techniques has seen its place in often unrelated problems, since they require the same underlying technology. In medicine, image processing techniques have been used for assisting in diagnosis and research.

Various techniques for image improvement like image enhancement and image restoration are used. Image analysis techniques including morphological image processing, edge detection, image feature extraction, image segmentation, shape analysis find much use in the medical field. More specifically, much research is being done to change the 2-dimensional images to provide a 3-Dimensional image structure, automated detection of certain specific features – which largely depends on what kind of images are being processed, and automated comparison of images to show the differences among them.

Image processing techniques are also employed for image retrieval in case of content based image retrieval as has been pointed out earlier in this article. However, in this section we will look specifically at attempts made to process images once the retrieval process has been done.

The three different methods used to segment biomedical images have been described in a paper by S. Vitulano, C.Di Ruberto and M. Nappi (1997). These three techniques are based on Entropy, Fuzzy Entropy and the Least Square Method. These methods are used to extract the components of an image.

Ronald M. Summers (2002) provides a review of the current concepts in computer-aided diagnosis for CT colonography. The methods employed depend extensively on image processing. The challenges faced at current are the determination of useful features and improvement in classification strategies.

Many systems have been developed for the manipulation of biomedical images – both commercial as well as public domain software. Open software systems include I4 developed by Eric Butterworth(1998) which explicitly supports the three spatial dimensions and the time dimension which is required for MRI and PET. disNei, as described by Carlos Alberola et.al (2000) is a graphical tool for image analysis and visualization allows a number of users to simultaneous and coordinatedly analyse medical images, create graphical models, navigate through them and superimpose raw data onto the models.

Mayo Clinic (Robb & Hanson, 1996) has been involved in the design and implementation of computer-based techniques for comprehensive and fully interactive display and analysis of biomedical images since 1970s. The algorithms and programs that Mayo Clinic has developed have been integrated into a software system called Analyze, which allows detailed investigation of 3-D and 4-D biomedical images. The clinic also developed an extensible library of over 500 optimised image processing functions, called AVW for A Visualisation Workshop. The centre has designed the “Virtual Reality Assisted Surgery Program (VRASP)” which takes image processing to another milestone in allowing surgeons to see 3D renderings of CT and MRO data and permit interactive virtual display manipulation.

Conclusion

The future holds many prospects for the field of medicine from the applications that can be offered using the image processing technology. Much research is being carried out all around the globe and it takes only a couple of keyword searches to bring about a plethora of courses and research being done in the field. As time progresses, we need to consolidate our level of

technological advancement so that it can be usefully implemented – this needs cooperation among people with different backgrounds – with a common aim of working for the benefit of mankind.

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[1] Ms. Asma Yasrib is a graduate student of Management Information Systems at the International Islamic University Malaysia. She can be reached at Kulliyyah of Information Communication Technology, International Islamic University Malaysia, Jalan Gombak. 53100, Kuala Lumpur, Malaysia. E-mail: asmayasrib@yahoo.com.

[2] Dr. Mohd Adam Suhaimi is Assistant Professor and Dean of the School of Information Communication Technology at the International Islamic University Malaysia. He can be reached at Kulliyyah of Information Communication Technology, International Islamic University Malaysia , Jalan Gombak 53100, Kuala Lumpur, Malaysia. E-mail: adam@iiu.edu.my, Phone: (603) 2056 5152.