AN INTRODUCTION TO MEDICAL IMAGE PROCESSING

BETHALA SHIRISHA
Assistant Professor, CSE, CMRIT,JNTUH
shirishasai34@gmail.com

KENANYA KUMAR K
Assistant Professor, M. Tech, Dept. of CSE, CMRIT, JNTUH
kenny.chowdary@gmail.com

Abstract

Biomedical image processing has experienced dramatic expansion, and has been an interdisciplinary research field attracting expertise from applied mathematics, computer sciences, engineering, statistics, physics, biology and medicine. Computer-aided diagnostic processing has already become an important part of clinical routine. Accompanied by a rush of new development of high technology and use of various imaging modalities, more challenges arise; for example, how to process and analyze a significant volume of images so that high quality information can be produced for disease diagnoses and treatment. The principal objectives of this course are to provide an introduction to basic concepts and techniques for medical image processing and to promote interests for further study and research in medical imaging processing. We will introduce the Medical Image Processing and summarize related research work in this area and describe recent state-of-the-art techniques.

Keywords: *Data Mining, Classification, Image Segmentation.*

1. Introduction

Medical image processing deals with the development of problem-specific approaches to the enhancement of raw medical image data for the purposes of selective visualization as well as further analysis. There are many topics in medical image processing: some emphasize general applicable theory and some focus on specific applications. We mostly focus on image segmentation and multi-spectral analysis.

Image segmentation: Image segmentation is defined as a partitioning of an image into regions that are meaningful for a specific task; it is a labeling problem. This may, for instance, involve the detection of a brain tumor from MR or CT images (Fig. 1). Segmentation is one of the first steps leading to image analysis and interpretation. The goal is easy to state, but difficult to achieve accurately

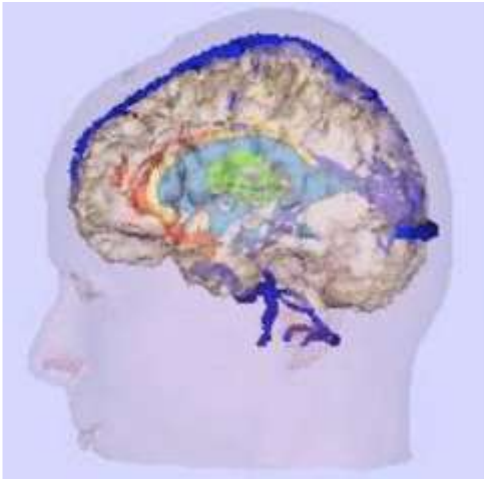

Figure 1: A 3D rendering of segmented skin surface (pink), brain tissue(brown), major blood vessels (navy-blue), and a tumor (green) from MRIvolume. This allows surgeons to visualize the actual location and to plan and simulate specific procedures.

2. Classification of Image Segmentation

Image segmentation approaches can be classified according to both the features and the type of techniques used. Features include pixel intensities, edge information, and texture, etc. Techniques based on these features can be broadly classified into structural and statistical methods.

2.1 Structural Methods

Structural methods are based on the spatial properties of the image, such as edges and regions. Various edge detection algorithms have been applied to extract boundaries between
different brain tissues. However such algorithms are sensitive to artifacts and noise. Region growing is another popular structural technique. In this approach, one begins by dividing an image into small regions, which can be considered as ``seeds''. Then, all boundaries between adjacent regions are examined. Strong boundaries (in terms of certain specific properties) are kept, while weak boundaries are rejected and the adjacent regions merged. The process is carried out iteratively until no boundaries are weak enough to be rejected. However, the performance of the method depends on seed selection and whether the regions are well defined, and therefore is also not considered robust.

2.2 Statistical Methods

Statistical methods label pixels according to probability values, which are determined based on the intensity distribution of the image. Gray-level thresholding is the simplest, yet often effective, segmentation method. In this approach, structures in the image are assigned a label by comparing their Gray-level value to one or more intensity thresholds. A single threshold serves to segment the image into only two regions, a background and a foreground. Sometimes the task of selecting a threshold is quite easy, when there is a clear difference between the Gray-levels of the objects we wish to segment

2.3 Mathematical Models

Mathematical models are the foundation of biomedical computing. Basing those models on data extracted from images continues to be a fundamental technique for achieving scientific progress in experimental, clinical, biomedical, and behavioral research. Today, medical images are acquired by a range of techniques across all biological scales, which go far beyond the visible light photographs and microscope images of the early 20th century. Modern medical images may be considered to be geometrically arranged arrays of data samples which quantify such diverse physical phenomena as the time variation of hemoglobin deoxygenating during neuronal metabolism, or the diffusion of water molecules through and within tissue. The broadening scope of imaging as a way to organize our observations of the biophysical world has led to a dramatic increase in our ability to apply new processing techniques and to combine multiple channels of data into sophisticated and complex mathematical models of physiological function and dysfunction.

3. Key Problems

In order to understand the extensive role of imaging in the therapeutic process, and to appreciate the current usage of images before, during, and after treatment, we focus our analysis on four main components of image-guided therapy

(IGT)and image-guided surgery (IGS): localization, targeting, monitoring, and control.

Specifically, in medical imaging we have four key problems:

1) Segmentation - automated methods that create patient-specific models of relevant anatomy from images;
2) Registration - automated methods that align multiple data sets with each other;
3) Visualization - the technological environment in which image-guided procedures can be displayed;
4) Simulation - software that can be used to rehearse and plan procedures, evaluate access strategies, and simulate planned treatments.

3.1 Imaging Modalities

Many different imaging techniques have been developed and are in clinical use.Inpractice they are complementary in that they offer different insights into the same underlying reality.

In medical imaging, these different imaging techniques are called modalities. Anatomical modalities provide insight into the anatomical morphology. They include radiography, ultrasonography or ultrasound (US), computed tomography (CT), magnetic resonance imagery (MRI). There are several derived modalities that sometimes appear under a different name, such as magnetic resonance angiography (MRA, from MRI), digital subtraction angiography (DSA, from X-rays), computed tomography angiography (CTA, from CT)etc.

Functional modalities, on the other hand, depict the metabolism of the underlyingtissues or organs. They include the three nuclear medicine modalities, namely, scintigraphy, single photon emission computed tomography (SPECT) and positron emission tomography (PET) as well as functional magnetic resonance imagery (FMRI). This list is not exhaustive, as new techniques are being added every few years as well. Almost all images are now acquired digitally and integrated in a computerized picture archiving and communication system (PACS).

3.2 Challenges in Medical Image Processing

There are a number of specific challenges in medical image processing. They are;

1) Image enhancement and restoration
2) Automated and accurate segmentation of features of interest
3) Automated and accurate registration and fusion of multimodality images
4) Classification of image features, namely characterization and typing of structures
5) Quantitative measurement of image features and an interpretation of the measurements
6) Development of integrated systems for the clinical sector

4. Research Areas

Focus is on developing novel computational methods, including image reconstruction analysis, in Medical Imaging. The research interesting include computational methods in medical imaging , multi modal imaging ,medical images Segmentation, computer aided detection/ diagnosis, physiological signal processing, Medical Image reconstruction techniques, different use of optical tomography, biomechanical modeling, computational methods in radiation therapy, and four dimensional imaging in diagnostic radiology and radiation oncology.

5. Conclusion

We hope that this paper may help us learn the fundamentals of medical image processing, experience it as a plastic blend of science and art, and most importantly understand the ultimate goal in medical image processing--helping patients. We summarized in this paper some important applications in medical image processing.

6. References

[1] DG Nishimura, Principles of Magnetic Resonance Imaging, April 1996.

[2] Z-P Liang and PC Lautenberg, Principles of Magnetic Resonance Imaging: a signal processing perspective, IEEE press series in biomedical engineering, 1999.

[3] F Bloch, "Nuclear induction," Phys. Rev. Vol 70, pp 460-474, 1946.

[4] N Bloembergen, EM Purcell, and RV Pound, "Relaxation effects in nuclear magnetic resonance absorption," Phys. Rev. Vol. 73, pp 679-712, 1948.

[5] Hornak's on-line MR manual, www.cis.rit.edu/htbooks/mri/inside.htm

[6] D Canet, Nuclear Magnetic Resonance: Concepts and Methods, John Wiley & Sons, New York, 1996

[7] RH Hashemi and WG Bradley, Jr., MRI: The Basics, Williams & Williams, Baltimore, MD, 1997

[8] M NessAiver, All You Really Need to Know about MRI Physics, Simply Physics,5816 Narcissus Ave, Baltimore, MD, 1997

[9] WJ Schempp, Magnetic Resonance Imaging: Mathematical Foundations and applications, John Wiley and Sons, New York, 1998