Application of Pattern Recognition in Medical Imaging and Computational Analytics for Cancer Detection.

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Medical imaging refers to the use of noninvasive techniques for observing the human body. This infers that the body need not be surgically opened to analyze the various organs or the tissues in the body. During the last few years, medical image processing has played a vital role in the early detection, diagnosis and treatment of various critical diseases. In most of the cases medical imaging act as the first step in preventing the spread of diseases. Computed Tomography scanning (CT), Magnetic Resonance image (MRI), Ultrasonography imaging (US) and X-ray imaging are all very common and important tools used in medical diagnosis [6]. Today the medical imaging has not just grown but has significantly evolved to a high level of maturity. Modern medical imaging includes not only image production but also the automated computational analysis for the accurate diagnosis [8]. Medical imaging has now become a multifaceted field with the combination of knowledge of various fields such as Computer Science, Physics, Mathematics and medicine. This article highlights various advanced aspects of medical imaging with respect to computational analytics for the automated diagnosis of cancer.

I. Introduction

Since the Discovery of the X-Rays in 1895, medical imaging has greatly contributed towards the progress in medicine. The Various image modalities developed during the years include Ultrasonography, Computed tomography (CT), Magnetic resonance imaging (MRI) and various other variants of MRI such as F-MRI etc. Over the past years, the medical images used to be produced through various modalities, then they were presented to a physician (radiologist) for interpretation and a subsequent diagnosis to infer at the medical condition of a patient. The diagnosis was the result of a decision making process done by the radiologist, who had some specialized medical knowledge. Thus, from a physician's point of view, image interpretation and decision making has been considered as the most critical and vital processes in diagnosis. Recently with the advent of various computational techniques the diagnosis results are considerably improving thus resulting into superior decision making by the physician.

Prostate cancer is one of the most widely occurring cancer among men in the world. It is heterogeneous disease, as the gland grows with the age [1] [2]. The occurrence of Prostate cancer is so high that it is most often considered as the normal age related phenomenon. Now in order to diagnose the patients, we require a non-invasive detection and staging as the invasive techniques are quite painful which involves the needle insertion to get the tissue (needle biopsy). Mortality in patients is often due to the spread of cancer from prostate to other parts which though happens only in a small number of patients. In fact, prostate cancer, if detected earlier can be controlled.

Magnetic Resonance Imaging (MRI) plays a vital role in diagnosis of prostate cancer. MRI scans is used for cell biopsies, radiation therapy treatment, or planning of surgeries. Automated analysis thus enhances the clinical workflow considerably.

This article walks through the various process in an automatic segmentation algorithm for prostate segmentation in MR images.

II. Magnetic Resonance Imaging

The Superconducting magnets are used in MRI systems to provide uniformly strong and steady magnetic fields. The superconducting magnetic coils are cooled to a temperature equivalent to a liquid helium and thus can produce very high magnetic fields. Different coil systems produce a time varying, controlled magnetic fields in different directions.

Figure 1.0 : Medical MRI Scanner.

The patient is kept in this gradient field space as shown in Fig. 1.0. There are also transmitting and receiving RF coils surrounding the site on which the image is to be formed [7]. By taking a series of projections at different gradient orientations using X, Y and Z gradient coils a 2 or 3-dimensional image can be obtained. The slice or the plane of the image depends upon the gradient or axis of magnetic field. The magnetic field is controlled by computer and the field can be positioned in three planes (X, Y and Z). The transmitter provides the RF signals. The received nuclear MR signal is picked up by the receiver coil and is fed into the receiver for signal processing.

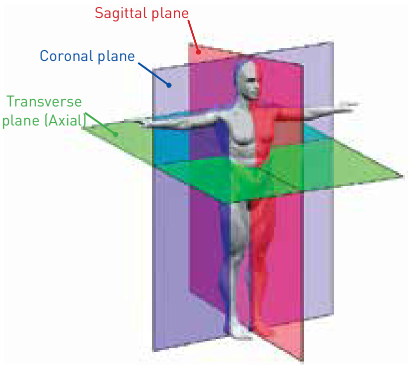


Fig. 2.0 : Axis of MRI images.

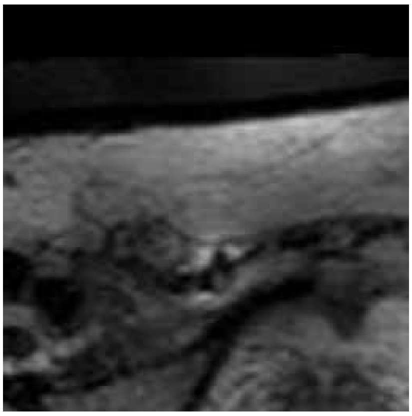
III. Steps in image processing

The Image processing steps for Prostate cancer detection
includes the below steps

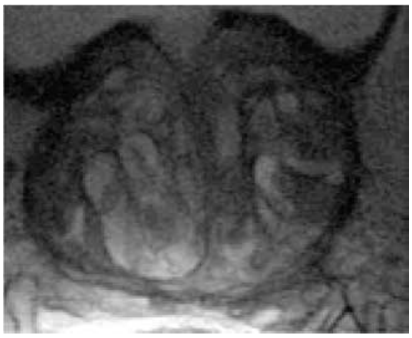
1. Image Formation
2. Image Enhancement
3. Visualization
4. Analysis.

A. Image Formation.

Image formation includes the acquisition of the medical image through use of various modalities. The acquired image is then processed through sampling to convert into a digital image. This process is known as Digitization [3]. The prostate MRI image is produced at this stage and is digitized using the above process.



a) Prostate Image



b) Prostate Image after Enhancement

Figure 3.0: Prostate MRI Image

B. Image Enhancement

Image Enhancement refers to techniques to be applied on the digital images formed earlier so that the impurities or the noise from the images can be removed. This process includes Calibration, Registration, Optimization and transformation, filtering. The digitized prostate image formed in the earlier stage is then enhanced to appropriate dimensions so that it can be further processed on visual aspect.

C. Image Visualization.

This process includes the enhancement with respect to the visual quality of the image. The images formed can have various intensity variation which might cause the computer programs to detect the region erroneously [3]. In order to avoid this normalization is used. It is often done by moving the mean intensity to zero and scaling the intensities so that standard deviation becomes equals to one. For effective normalization, we use the median intensity and the absolute median deviation as an estimate for mean and standard deviation, respectively.

The MRI image is normalized so that the noise is eliminated from the images and the intensities are normalized.

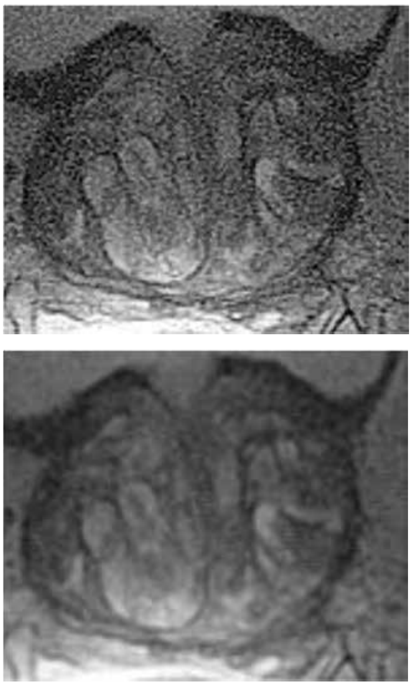


Fig. 4.0 : Images after Normalization.

D. Analysis

This phase includes the region of interest detection along with the feature extraction, segmentation and its classification. To identify the Prostate gland is the next task. In this method we slide the detection window of fixed size over the image and compute for each image defined by present detector position whether it contains the prostate gland. The tissue if found within the prostate's bounding box itself is relatively homogenous, thus we use a larger bounding box for the feature extraction [4]. The features in the form of the prostate volume vector is used to calculate density measure which then can be used as the input for the classifiers.

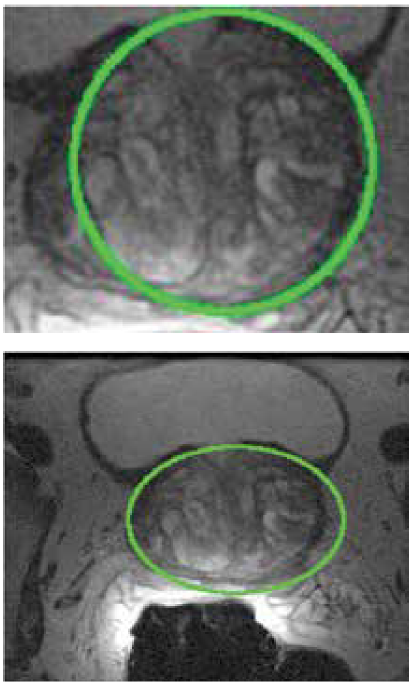


Fig. 5.0 : Prostate Detection

Classification.

Image classification aims to assign each pixel, or to each region of interest (ROI) obtained from image, a label associated with a class of object that is present in the analyzed section. During this phase, depending on the features extracted from the image the class labels are assigned which then helps in prediction of the appropriate results [5].

The advancement in computational analytics has increased the use of technique of classification such as Decision trees, Naïve Bias, and SVM's which helps in the near to accurate analysis of the image. When a prostate feature vector is classified using these algorithms, it can be assigned a suitable class label which in turn helps in the analysis of the results calculated.

IV. CONCLUSION

The medical imaging has thus resulted into fast and efficient diagnosis of various life threatening diseases. The Medical Imaging has provided a tool for the physician as well as the Computer researcher to construct efficient algorithms which can accurately assist in the prognosis of diseases in turn helping in the betterment of the society.

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