MEDICAL IMAGE ANALYSIS

Lab report 1: Image Modalities

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Objective:-

The objective of this lab-work was to get familiarized with different image modalities being used in medical imaging nowadays. Since, this was the first lab for medical imaging and none of us had any previous experience regarding the topic, this lab was dedicated to the basics in medical imaging. DICOM file structure was studied in detail and modality images were observed in different anatomical planes. This was followed by a basic application of transformations that convert a sample raw image from the medical imaging machines to presentable (informative) images for the doctor.

Introduction:-

Medical imaging is termed as the representation of the interior anatomy of a person for clinical analysis. Unfortunately, the images produced from the medical imaging machines are of low contrast (mainly black and white only) and it is very difficult for the doctor to make any sense out of them. So it is essential for these machines, to succeed, to have a system for transforming these raw images in order to get useful information from them.

Different medical imaging techniques have evolved over time like ultrasound, X-ray, MRI, mammography, SPECT, fluoroscopy etc. These machines are being developed by different companies. Due to competition, they all keep their systems confidential. It was seen in 1980's that it was very difficult for anyone, apart from the manufacturer's, to decode the images. This was a big problem for the radiologists who wanted to use these images for different purposes. So, it was decided to make a standard image format for these medical images. The format was called Digital Imaging and Communications in Medicine (DICOM). This file format includes communication protocols and format definition along with the image data. This format gained popularity and is now being used by almost all the manufacturers to store the images. Since this format is used as a standard by everyone and all the medical imaging modalities have different type of information in them, the DICOM format is complex with different types of definitions in the header that help to read the image data. Therefore, one of the main tasks of the lab was to understand the DICOM format and extract useful information from DICOM images produced by different modalities.

The medical imaging modalities are gaining popularity in different applications especially screening of people for different diseases. For this doctors have to process thousands of images in limited time, thus the need for automation of the process is increasing. Computer vision community is working on technique to automatically detect different features from these DICOM images in a reasonable amount of time. This has been the main focus of research in this area and it is important to develop efficient procees for these purposes.

Methodology & Experimental Results:-

The lab work was divided into two main parts: the first one was dedicated to understanding the DICOM image format and different anatomical plenary images, and the second one was dedicated to applying a transformation to a raw medical image in order to convert it to one used by doctors. Both of these tasks were implemented in MATLAB.

MATLAB has inbuilt functions for dealing with dicom files. We were provided with a set of images for three modalities: ultrasound, mammography and MRI. dicomread() was used to read the image data from the dicom files and dicominfo() was used to extra other information (header) from the dicom files. Some of the data extracted from the files in given in table 1.

Table 1: Information extracted from the DICOM header files

Modalities	Ultrasound	MRI	Mammography
Image name	ultrasound.DCM	MRI01.DCM	MAMMOGRAPHY_RAW.DCM
Patient Name	002	002	002
Patient ID	680710	680710	MOCKUPF032602
Patent DOB	19380722	19380722	00010101
Patient Sex	M	M	O
Patient Age	071Y	070Y	000Y
Patient Weight	-	66	-
File Size	256878	537512	27266052
Bit Depth	8	16	14
Width	564	512	3328
Height	452	512	4096
Rows	452	512	4096
Columns	564	512	3328
Pixel Spacing	-	0.3125	0.07
Slice Thickness	-	3	-

All the above mentioned information was stored in a structure class by the dicominfo() function. It is important to note that the patient information is kept anonymous here like the name and ID. However, since the patient sex, weight and age are of crucial importance in diagnosis, they have been kept non-anonymized. All the modalities have different type and quantity of data. Even the bit depths and dimensions are different. This is the main advantage of the dicom format that it accommodates all types of modalities by letting the header file indicate the type and size of information stored.

The images, read by the MATLAB inbuilt function, are displayed in figure 1.

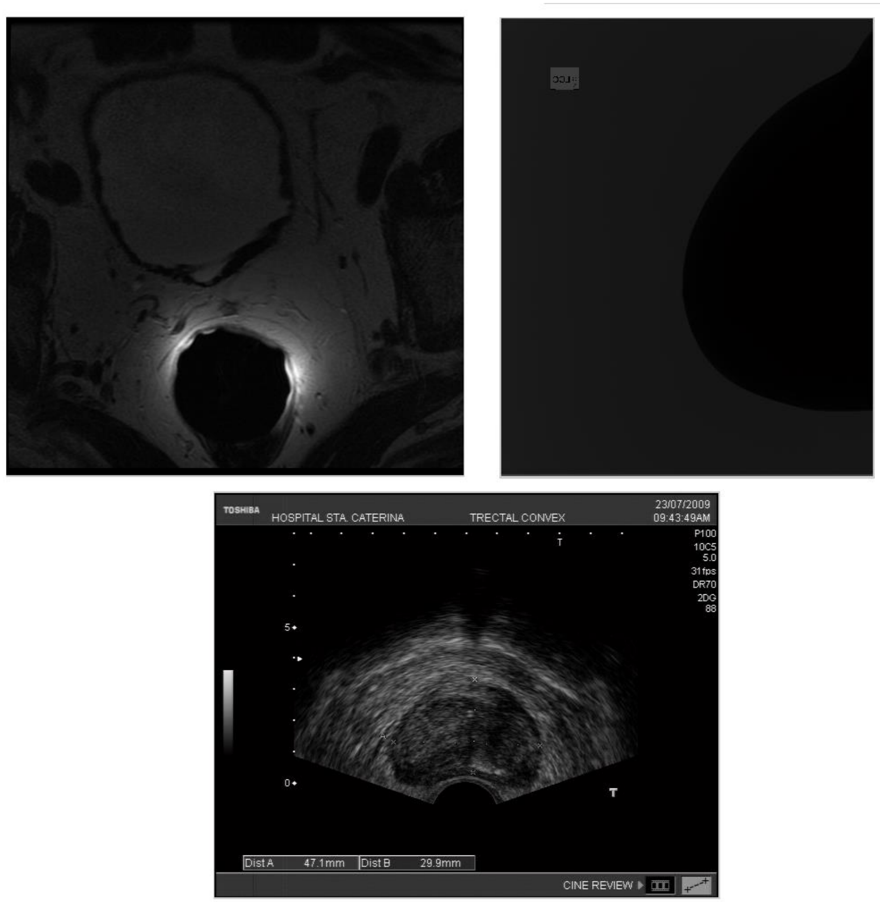

Figure 1: Medical Images of different modalities: MRI (a); Breast Mammaography (b); Ultrasound (c)

The MRI images were provided in a 3D set of 20 images in axial orientation. The next task was to produce the other two orientations from this set. This was easy because in MATLAB, we can extract parts of a bigger matrix. All the 20 images were read and stored in a 3D array and the appropriate dimensions were extracted to represent all the orientations: axial, sagittal and coronal. One slice of all the anatomical planes are shown in figure 2. Since the volume was of size 512x512x20, the coronal and sagittal images were too squeezed to visualize anything. This was also accredited to the fact that in medical images, voxels are used to represent the image whose size in all three dimensions is different. So, it is essential to display images with respect to their physical sizes. In order to accomplish this, scaling of the voxel in z-axis was done to resize the image for displaying.

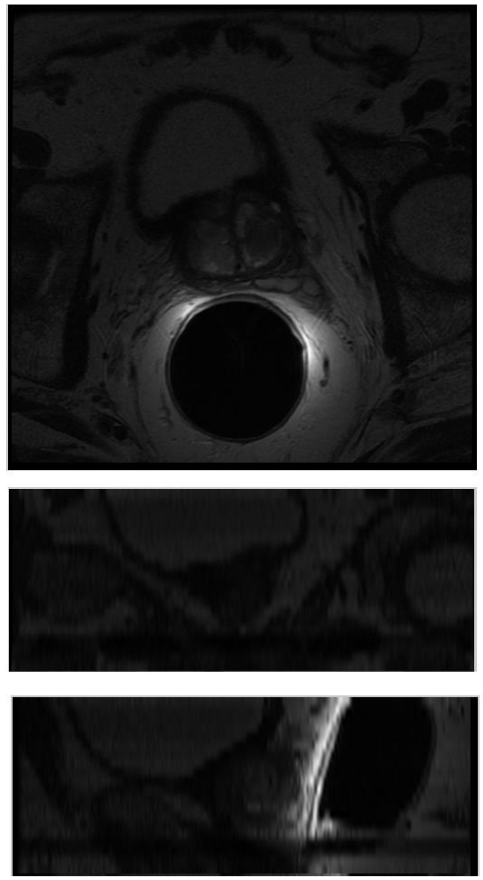

Figure 2: Anatomical Plane Images for MRI: Axial (a); Sagittal (b); Coronal (c)

The histogram of the entire volume of MRI images is shown in figure 3. Since the entire volume is being used here to represent the three-dimensional structures of the human anatomy, visualizing the histogram of the entire volume make more sense than that of a single image.

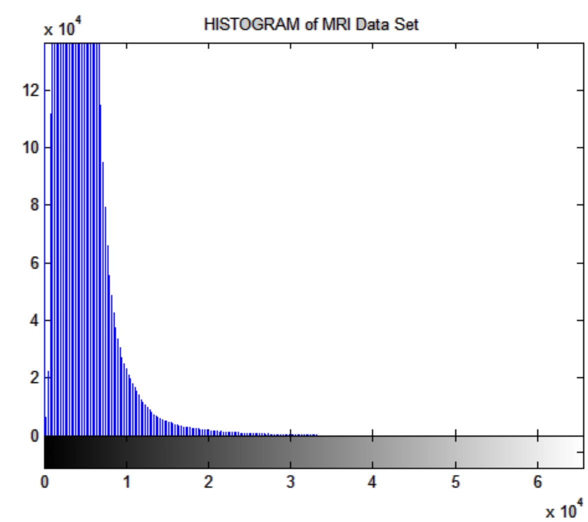

Figure 3: Histogram of the MRI image set

The next task was to read both the mammography images and figure out a transformation between the two. When we tried to display both of the images, they seemed to be different than the ones in the lab manual. So, a basic transformation was applied to both of the images to transform them to the appropriate representation. This transformation was just a contrast stretching for both. The raw image was in addition inverted.

Image processing is one of the crucial elements of digital mammography, now widely used to diagnose cancers, as the optimization of the mammography images may lead to more efficient diagnosis of the disease. The basic purpose of mammogram processing is to display all the information in the image with reasonable contrast that helps the doctor to better differentiate the structures in the image.

The raw images visually displayed the breast in white on a grey background. The structures within the breast were impossible to recognize as the contrast was very low. As this image is the one directly output from the machine and there are many factors involved in imaging, the intensities for different structures were almost the same in the image. On the contrary, the presentation image had distinctive differences between the structures within the breast. The outline of every structure was clear as opposed to a blob of single color in the raw image. In computer vision terms, the contrast between every surface was clearly distinguishable.

Next, we were to derive a transformation to convert the raw image into the presentation one. The basic objective was to enhance the contrast. The following transformations were applied:-

- A Gaussian kernel of 5x5 was created
- The kernel was applied to the image but not directly, but as an unsharp mask, for noise removal
- The intensities of the image was stretched to cover all the ranges
- Image adjust function of MATLAB was applied to the image
- Since, most of the pixels were in the dark region, a gamma transform was applied to enhance the whiter regions.
- An un-sharp mask was again applied.
- Adaptive histogram equalization was applied

The above mentioned transformations were applied to produce an image, resembling the presentation image. Parameters for the above transform were tuned to produce the best result. The result is shown in figure 4. However, two major differences are still present in the image. The inside structures of the breast were lighter (more white) and the outer boundary of the breast was very dull/blur. However, as discussed with the lab instructor, the image was considered satisfactory and the image used as the output of the system.

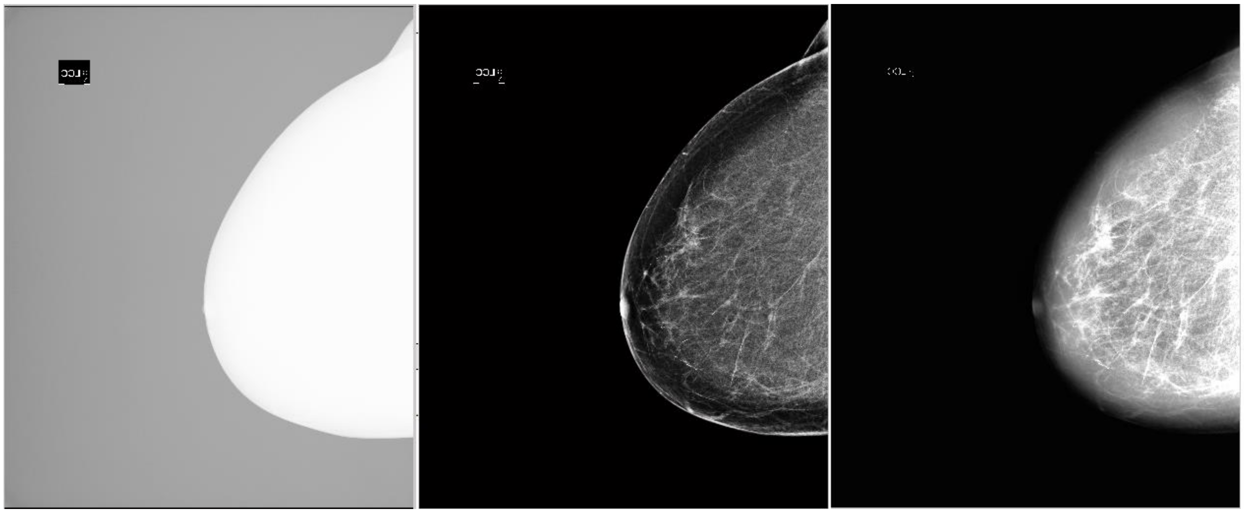

Figure 4: Image Transformation for Mammography images: Raw image (a); Presentation image (b); Transformed image (c)

Conclusion:-

Medical imaging is one of the fields gaining popularity throughout the world. Major advancements have been made. This lab work was dedicated to understanding the basics of this fields and playing with few of the basic transformations used in this field. Different modalities in the medical imaging world were also studied.