**Reading and Viewing Medical Images**

**Due:** At the beginning of the final exam (by 8:00 on Monday of Week 11)

**100 pts**

**Objective**

* To gain practical understanding of working with cell and structure arrays.
* To become familiar with one common biomedical/biomolecular application of structures.
* To get a first exposure to MATLAB image processing toolbox.

**Background**

Digital Image Communication in Medicine (DICOM) is a set of standards for storing, printing and transferring of medical information, the medical images in particular. The DICOM was developed by the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA), and was first published in 1985. Since then, it has become the most widely used medical imaging format, as it enables sharing of medical information and integration of different medical devices from different vendors, i.e. medical images acquired on the device of one manufacturer could be transferred to and easily accessed by the device of another manufacturer. Typically, all medical images acquired in hospitals and imaging centers are DICOM-compliant (i.e. their file format is compliant with the DICOM standards).

*DICOM file*

We typically refer to a DICOM-compliant imaging dataset as a DICOM file. The DICOM file consists of:

* Set of images – typically, uncompressed.
* DICOM header in the form of a structure array containing information about the patient, the procedure, the hospital, the imaging device, and the image itself. The information is organized in multiple fields, which include file size, file format, width and height of the image, imaging device and its manufacturer, the imaging modality (e.g. CT, MRI, PET) the patient’s name, age, gender, weight, and the reason for scanning, etc.

In this project, you will load, process, and display two medical images, and will extract patient and image-related information from their corresponding DICOM headers.

**Project Descriptions**

For this project, you are given one Computed Tomography (CT) image of the chest , and the MATLAB function *winwidth.m*, which can be downloaded from Blackboard.

* Computed Tomography (CT) image,***i97273.CTDC.78***, in standard DICOM format.
* MATLAB function ***winwidth.m***.

Write a MATLAB script file, *lastname\_image.m*, to do the following.

1. Load the CT image and the corresponding DICOM header. *Note:* the standard *load* command will not work here, as it cannot load DICOM files. Please see Table 1 for a list of useful functions.
2. It is a common practice to rescale medical images with the slope and intercept values provided in the DICOM header. The scaling is implemented to properly distribute the image data over the standard range of values, such that all anatomy (air to bone) could be visible in the image.
   * Evaluate the DICOM header fields for the given CT image and locate the fields containing the rescale slope and intercept. Extract the slope and intercept from their respective fields, and scale the CT image using the following linear equation, i.e. every value in the image array must undergo the transformation shown below. For full credit, use vectorized operations to do so.

* Display the rescale slope and intercept the image in the Command Window accompanied by an appropriate text. No variable names!

1. The MATLAB function *winwidth.m* was written to adjust the intensity of the image data to enhance the visualization of the lung anatomy in CT images. After rescaling, send the CT image data through this function to adjust its values for optimal visualization of the lungs and airways. You do not need to do anything other than send the image through that function, which would generate an image with optimal contrast. It is highly recommended, however, that you first open the function and evaluate its contents, so that you understand how it works.
2. Now that your image is adjusted for optimal contrast, you will filter the image generated in step 3 using a Sobel Edge filter. The Sobel Edge filter is to be implemented as a separate function *lastname\_sobel.m*. The input argument for the function should be the image from step 3, and the output argument should be the filtered image. The filtering operation is defined below.

*I* 🡪 input image

*If*🡪 filtered output image.

**\*** 🡪 **It is NOT multiplication but CONVOLUTION** operation, and is to be performed with the use of *conv2* function in MATLAB. For optimal performance, use vectorized operations!

1. In one figure with two subplots accompanied by the corresponding titles (no axis labels are needed), display the image generated in step 3 (after *winwidth.m* function), and the image generated in step 4 after *lastname\_sobel.m* filtering. Use *imagesc* function for image display. Set the color map of both images to GRAY.
2. Extract the following information regarding the image, the imaging device, and the patient from the original CT image. Display the information in the Command Window accompanied with the appropriate text. Make sure that the Command Window output is easy to read! I will take points off if I cannot easily read the information below for each image.
   * **CT Image**
     + Patient age
     + Study description
     + Hospital name
     + Imaging device manufacturer
     + Width and height of the image in pixels
3. Arrange the data extracted in step 6 into a cell array of size 6 x 2 of the following configuration. Name the cell array *outcell*.

|  |  |
| --- | --- |
| **Patient Age** |  |
| **Study Description** |  |
| **Hospital Name** |  |
| **Imaging Device/Manufacturer** |  |
| **Image Width** |  |
| **Image Height** |  |

1. Use the function *xlswrite.m* to save the array *outcell* into an Excel file named *Lastname\_Patient\_Out.xlsx* in the worksheet named “Patient Info”. To do that, investigate the implementation of the *xlswrite* function when saving a cell array. For this function to save successfully, it is important that each data entry, as well as the corresponding header, is placed into an individual cell within the *outcell* array. When executing the function, MATLAB will display a warning in the command window stating that the new worksheet in the xlsx file is being created. Find the way to suppress the display of this warning in your code.

**Table 1: Useful MATLAB Image Processing Toolbox Functions**

|  |  |
| --- | --- |
| **Function Name** | **Description** |
| dicomread | Loads DICOM image data |
| dicominfo | Loads DICOM header information |
| imagesc | Display image data in the figure |
| colormap | Sets the color map to the image in the figure |
| conv2 | 2-D convolution function to be used for filter implementation. |
| xlswrite | Saves data into MS Excel spreadsheet |

**What to Submit?**

* Electronic copy of the script and function files emailed to me.
  + When I run your program, the figures should be automatically generated, the Excel file should be automatically created, and all the DICOM information should be displayed in the command window.

**Grading Rubric**

The CT image is loaded correctly. The appropriate loading function was used.

1 2 3 4 5

The DICOM header for CT image was loaded correctly. The appropriate loading function was used.

1 2 3 4 5

The appropriate rescale intercepts and slopes were extracted from the CT image fields. The appropriate structure commands were used. The CT image was correctly rescaled using the slope and intercept data.

1 2 3 4 5 6 7 8 9 10

The CT image data were sent though *winwidth.m* function and the image data intensities were correctly adjusted to display the lung anatomy. The function handle was implemented correctly.

1 2 3 4 5 6 7 8 9 10

The *lastname\_sobel.m* function was correctly implemented. All input and output variables were correctly defined and used in the function. The filtering operations were correctly implemented. The code of the function was fully optimized. The function was correctly invoked from the script file, and the output argument was returned to the global workspace.

1 2 3 4 5 6 7 8 9 10

The CT images after *winwidth.m* and after *lastname\_sobel.m*  were displayed correctly in one figure with two subplots. The color maps were set correctly. The appropriate titles were included in the figure.

1 2 3 4 5 6 7 8 9 10

All required DICOM header information for CT image was displayed correctly in the Command Window. No variable names were used. The accompanied text was descriptive and legible. The Command Window output was organized effectively.

1 2 3 4 5 6 7 8 9 10

The patient information data were appropriately placed into an output cell array.

1 2 3 4 5 6 7 8 9 10

The output cell array was saved into an Excel file. The file itself and the data worksheet are named as specified. While executing the save, no warning messages was displayed to the user in the command window. The Excel file can be opened, and it contains all the required patient information. The arrangement of data within the Excel file is as specified.

1 2 3 4 5 6 7 8 9 10

The MATLAB script is well organized. The code is optimized. Vectorized operations were used whenever possible. The arrays were pre-allocated when needed. The structure commands were used correctly.

1 2 3 4 5 6 7 8 9 10

The code is properly documented.

1 2 3 4 5 6 7 8 9 10