Managing and Viewing DICOM Images with ImageJ

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ABSTRACT

ImageJ is capable to read DICOM (Digital Imaging and Communication in Medicine)[3] images, the standard format in medical imaging. But this is not enough: to receive, to send, to compress, to decode, to compare or to search you need dedicated plugins. This paper reviews the ImageJ features related to DICOM and present the different existing ImageJ plugins that help to get the problem solved with ImageJ. The demonstration includes information on how to perform the most important tasks within DICOM Imagery and which commands and plugins to use. The weaknesses and limitations of ImageJ are discussed as well. The features of the TUDOR DICOM Tools, a collection of DICOM Plugins for ImageJ are shown including a presentation of the included DICOM Viewer.

Keywords: ImageJ, DICOM, medical image processing

1. INTRODUCTION

Over the last years the classical, analog medical imaging modalities are more and more replaced by digital image acquisition technologies. Today Computers have taken an important part in the diagnostic medical imaging. The mostly used format for storing, transferring and processing these digitalized medical images is the DICOM (Digital Imaging and Communication in Medicine) standard. The DICOM standard defines an image format as well as formats for sending, receiving and querying DICOM object (e.g. images) via network. The image format which does not only contain the pixel data of the acquired image, it also contains meta data about the patient, the used equipment and the acquisition parameters. This data is stored in tags in the so-called DICOM Header. Each tag contains a key in the form "0002,0010" and a corresponding value. When working with medical images, these Meta-data is nearly as important as the image itself to process, store and evaluate the image. Because of this, all software-solutions working with DICOM images, do allthough have to care about these stored meta-data.

ImageJ, a free Java based image processing software and library is capable of reading DICOM images and their header data.

This paper will give an overview of the built-in functionalities of ImageJ for working with medical images and how they can be extended by free available plugins. Afterwords we will show the TUDOR DICOM Tools, a set of Java libraries developed by our team containing ImageJ plugins and stand-alone applications for working with DICOM images. These tools combine a lot of needed features to an easy to use set of plugins or a base for own custom DICOM applications.

2. IMAGEJ BUILT IN FUNCTIONALITIES

ImageJ itself is capable of opening single DICOM images or image stacks from the local harddisk. It uses a build-in plugin, implemented in the ij.plugin.DICOM class to provide these features. Just like any other image format DICOM images can be loaded into ImageJ by using the open command (File $\Rightarrow$ Open) or just dropping the images onto the application. Image stacks can be loaded by using the import image sequence command (File $\Rightarrow$ Import $\Rightarrow$ Image Sequence). After choosing one of the stack images in a folder, ImageJ will import all images in this folder into one image stack. During the import you can filter these images by image name or image number and choose the starting image as well as the number of images to import. The meta-data of the images, the so-called DICOM-Header is written to the ImagePlus object and can be accessed via the show info command (Image $\Rightarrow$ Show.Info)

This built-in plugin is only capable of importing DICOM files with raw, uncompressed image data. Images with JPEG[4] or Lossless Run Length Encoding (RLE) can not be openend. In this case ImageJ will present an

error message while trying to open the image. The type of image compression that is used in the image is coded in the DICOM header field "Transfer Syntax UID" with code 0002,0010

By now, saving of DICOM images is not supported by ImageJ. The only way to save modified DICOM images is to export them as TIFF files. In this case ImageJ preserves the DICOM header information by writing it to the TIFF header.

3. EXISTING PLUGINS

As the built-in functionalities for working with DICOM images are limited, a number of plugins has been developed by the community to extend these functionalities. Most of these plugins can be found on the ImageJ homepage[1] or the ImageJ Documentation Wiki[2]

Import Dicom Sequence

Type: Input/Output
Authors: Anthony Padua, Duke University Medical Center, Department of Radiology, Daniel P. Barboriak, MD, Duke University Medical Center, Department of Radiology
Last Modification: 2005/11/15
Website: http://rsb.info.nih.gov/ij/plugins/import-dicom.html
License: none - Permission to copy, use, and modify for educational and research purposes

The Import Dicom Sequence plugins uses the image number from the DICOM header to sort the files importing an image stack. This might be necessary as the filesnames of the images are not allways sorted in the same way. If the images are named im1.dcm im2.dcm .... im10.dcm, without this plugin they will be loaded in the order the filesystem sorts them: im1.dcm, im10.dcm, im2.dcm ..... The functionality of this plugin has been integrated into ImageJ since version 1.34k which makes it obsolete to install it as a plugin in newer versions.

DICOM Directory Analyzer

Type: Input/Output
Authors: Dirk Scheffler Dep. of Radiooncology, Charite Hospital Humboldt University, Berlin
Last Modification: 2004/08/04
Website: http://rsb.info.nih.gov/ij/plugins/dicom-analyzer.html
License: none

The DICOM Directory Analyzer uses an JFileChooser with an image-preview window with multiselect to select the files to import. Images belonging to separate series are imported as separate image stacks in ImageJ. The plugin uses several tags, such as frame of reference UID, image orientation and image position to determine the stacks. These plugin is quite usefull because of the preview window, as most of the operating system file managers do not show image an preview for DICOM images.

DICOM Sort

Type: Input/Output
Authors: Thomas Stamm
Last Modification: 2004/05/13
Website: http://rsb.info.nih.gov/ij/plugins/dicom-sort.html
License: none

The DICOM Sort plugin allows the sorted loading of images by image number, image time or acquisition time, which are read from the DICOM header of the image. It can allthough be used to separate images from different patients, by using the information displayed log window when a series of images is openend. If a special way of sorting the images is needed, this plugin might be quite usefull.

DICOM Import and Export Plugins

Type: Input/Output
Authors: Thomas Hacklaender, MD, MSc, Institute for Telematic in Medicine.
Last Modification: 2002/08/22
Website: http://www.iftm.de/telemedizin/dcmimex.htm
License: GNU General Public License

The package contains plugins for importing and exporting DICOM images, as well as plugins for working with the header information. Images can not only be read or written to a folder on the local harddrive, the plugins are allthough capable of reading and writing DICOMDIR file-sets. These DICOMDIR file-sets are the common used format for DICOM CD's. Additional header information which is normally ignored by ImageJ is written to special properties of the created ImagePlus objects or stacks to make it accessable within other plugins or scripts. To archive all this functionality, the plugins make use of the dcm4che[5] project, which is a free available DICOM implementation written in Java. These usage makes the installation of the plugins a bit complicated, as the Java classpath need to be edited to load the libraries. As the last plugin version is from 2002, it uses the dcm4che version 1.2 libraries from 2002. Do not install this plugin in combination with the TUDOR DICOM Tools plugin, which uses current dcm4che 2.0 version. As this plugin is distributed under the GPL License, which will cause licensing problems if used in non-GPL projects.

LOCI Bio-Formats Library

Type: Input/Output
Authors: Curtis Rueden and Kevin Eliceiri
Last Modification: 2008/07
Website: http://www.loci.wisc.edu/ome/formats-imagej.html
License: GNU General Public License / commercial version available

The LOCI Bio-Formats are a Java library which was designed for reading several microscopy file formats. Besides these formats it is capable of opening DICOM files, even if they use run length encoding or JPEG compression. The library directly contains ImageJ plugins for opening single images or creating stacks from a directory full of images. For reading DICOM files with lossless JPEG compression the platform dependent version of the Java Advanced Imaging API (JAI)[6] library needs to be installed into the used Java runtime. As this plugin is distributed under the GPL License, which will cause licensing problems if used in non-GPL projects. A commercial version with other license is although available.

Query DICOM Header

Type: Utilities
Authors: Anthony Padua
Last Modification: 2003/05/12
Website: http://rsb.info.nih.gov/ij/plugins/query-header.html
License: none

The Query DICOM Header plugin queries the DICOM header of an opened ImagePlus and writes the header value of the given header tag field to the result window. As this plugin can be called within a macro, is can be used to manipulate the image depending on the value of one or more header tag value. E.g. run("Query Dicom Header", "0008,0060"); will retrieve the creation modality (CT, DR, NM) of the image.

DICOM Rewriter

Type: Utilities
Authors: Walter O'Dell PhD
Last Modification: 2003/09/23

Website: http://rsb.info.nih.gov/ij/plugins/dicom-rewriter.html
License: none

The DICOM Rewriter is a small utility implemented as an ImageJ plugin which allows the anonymization of DICOM files. After selecting one or more files from a directory, a dialog pops up in which the patient's name, patient-id and birthdate can be overwritten with new values. The values are changed directly in the original images files on the harddisk. The plugin is quite limited, as it is only capable of changing these three header tags with a maximum length of the original tag value.

4. THE TUDOR DICOM TOOLS

Type: Input/Output, Networking, Utilities, Viewing
Authors: Johannes Hermen, Christian Moll - Public Research Centre Henri Tudor, Luxembourg
Last Modification: 2008/10
Website: http://santec.tudor.lu/projects/optimage/dicomtools/
License: GNU Lesser General Public License (GNU LGPL)

The TUDOR DICOM Tools are a Java library to perform high-level DICOM operations. It is based on dcm4che version 2,[5] the Java Advanced Imaging API (JAI)[6] and ImageJ. The library includes stand-alone applications as well as ImageJ plugins. It can be used as a library in own custom applications as well. It offers functionality to read and write DICOM files from a disc or a DICOMDIR file-set (e.g. DICOM CD), work with the DICOM header, anonymize images and send, receive or query images from a Picture Archiving and Communication System (PACS) via network. The following DICOM network services are provided by the tools: C-ECHO-SCU/SCP, STORAGE-SCP, QUERY/RETRIEVE-SCU. Additionally it offers components to view DICOM images with features like windowing, zooming, shifting, measuring etc.. . The ImageJ plugin contains a small DICOM manager plugin which will open a small toolbar (fig:1) for an easy-access of all the included components. Most of the included functionalities can be used in ImageJ macros. You can explore how to use them by using the macro recorder of ImageJ.
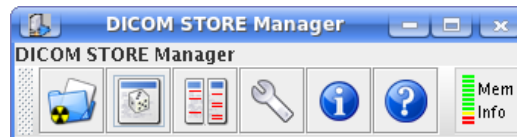

Figure 1. TUDOR DICOM Tools - Manager Window

4.1 Reading and writing DICOM Images

The tools offer an extended open dialog (fig:2), with a direct image and configurable header preview of the selected image. It is capable of reading image files from different sources. It has a built-in DICOM STORE to receive images via network, functionalities to query and move images from a PACS. The DICOM CD view will automatically search for valid CD's in the systems CD-ROM drives. The Image selector view can be used to filter images in a recursive directory structure by defining matching header tags. Most of the views show the files structured in patient/study/series to easily find images. Every view allows the selection of single images or whole series. This dialog is allthough used to manage the files in the local store or to send images from the local drive, store or CD to another PACS or DICOM entity. With a working version of the JAI framework[6] installed on your system, the plugin will allow you to open DICOM files with JPEG and RLE encoding.

When exporting ImagePlus objects to DICOM files from within ImageJ, the plugin writes the existing header metadata to the generated DICOM file. If the image does not contain a header, a new, default header will be created. During the export, the image can be anonymized and tags like patient name and id can be changed. By now the plugin only supports the creation of uncompressed DICOM files.
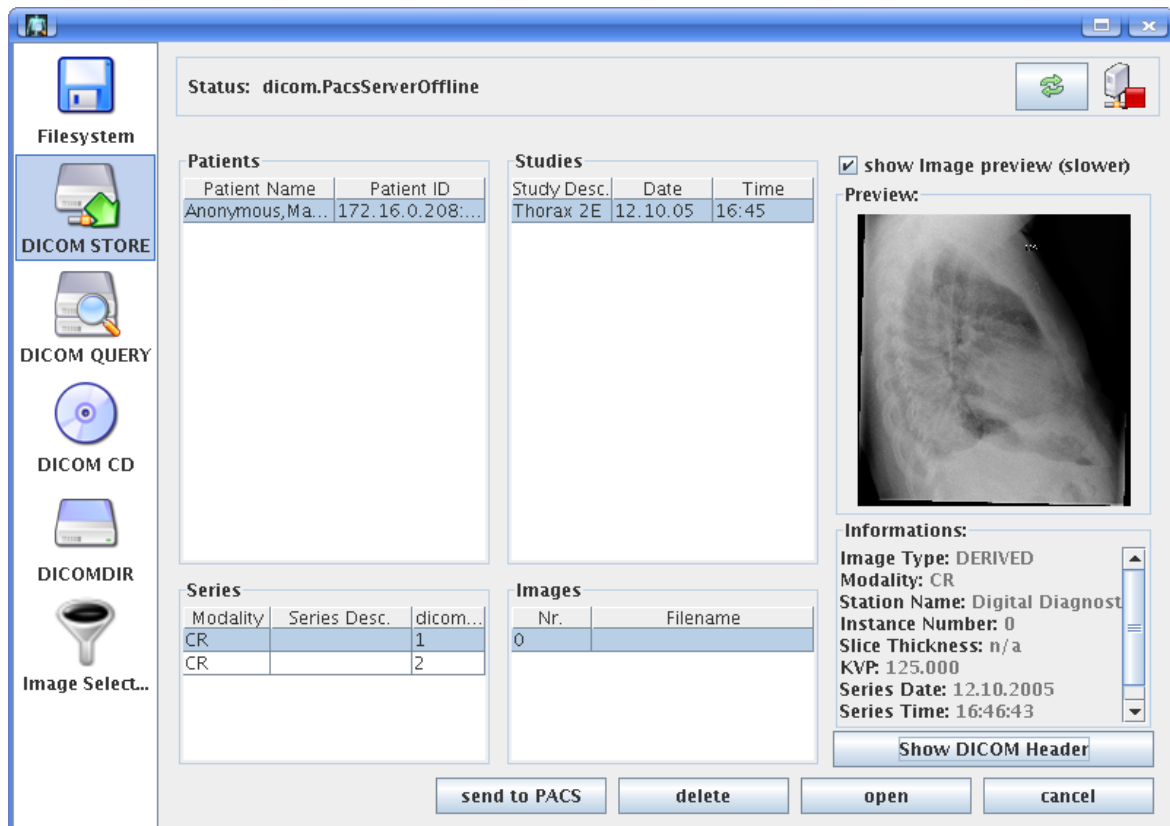
Figure 2. TUDOR DICOM Tools - Open Dialog

4.2 Working with the DICOM Header

The library loads the header of each DICOM file into a DicomHeader object, which makes it much easier to write back the header to exported DICOM files or to retrieve single fields and work with the header information. An advanced viewing component for the header allows the textual search in the header and the comparison of headers from different files. Complete directories of DICOM files can be anonymized by deleting the patient, hospital and/or manufacturer information from the file headers by using the provided anonymizer tool.

4.3 Viewing DICOM Images

The package contains components that offer advanced functionality for viewing DICOM images. While the ImageJ window needs dialogs and menu commands to window, zoom or shift the image, the DicomImagePanel uses the mouse-commands for all these things as most of the DICOM viewers do . The mouse-wheel can be used to run through a stack of images easily. Additionally important information such as patient name and birthday is extracted from the image header and shown as an overlay on top of the image.

4.4 TUDOR DICOM Viewer

The TUDOR DICOM Viewer started as a tech-demo of all features provided in the TUDOR DICOM Tools. With the time it evolved to an simple, but jet usefull DICOM viewing application. The viewer is able to display multiple images in several splitscreen or multi-monitor configurations. Multiple series can be loaded and managed in the viewer from different available sources. As the viewer allthough contains the complete DICOM open dialog with the integrated store and send functionalities it can be used not only to view images, but to retrieve images from one modality, store them into a DICOMDIR that can be burned as DICOM CD or send them to another DICOM capable modality.
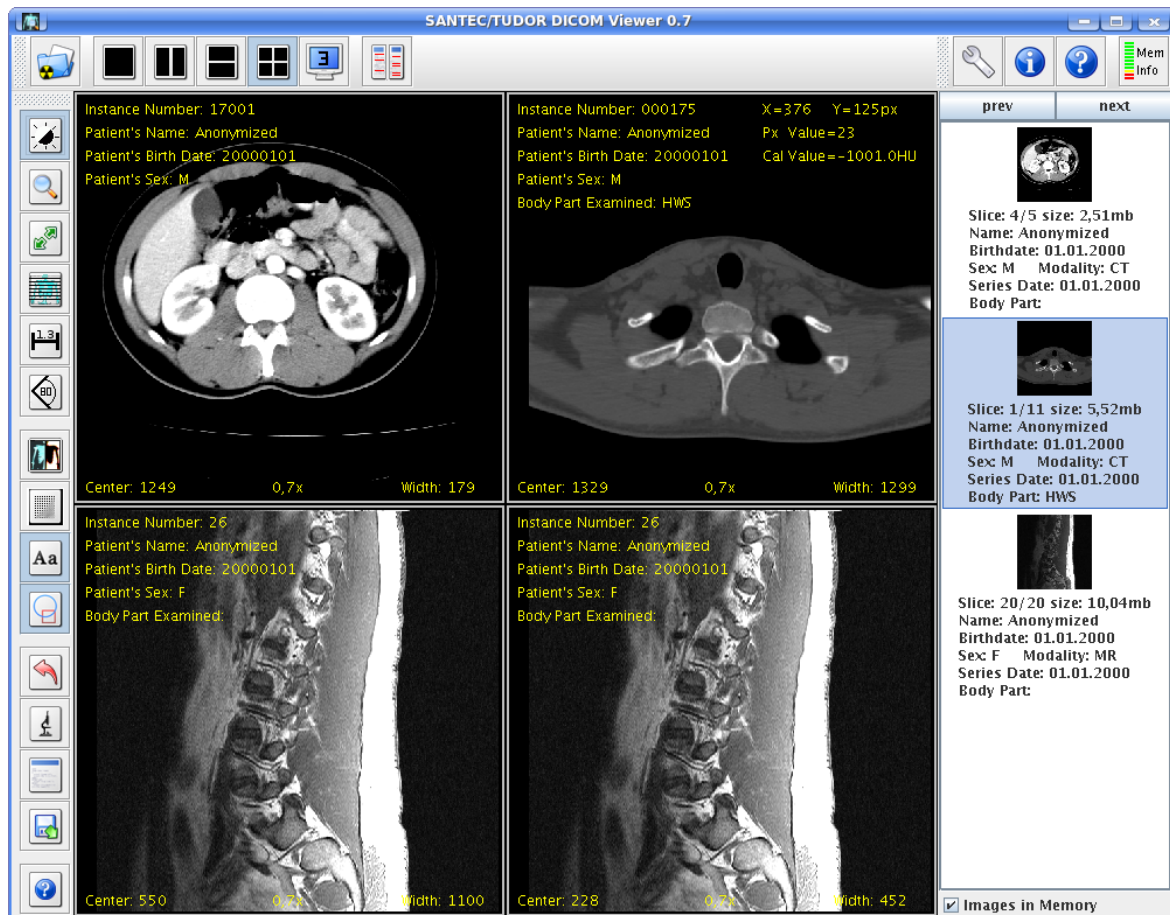
Figure 3. TUDOR DICOM Viewer

5. CONCLUSION

ImageJ is a very powerfull image procession solution. The out of the box DICOM support is quite limited. This issue can be bypassed by installing additional plugins for special needs and additional features. Most of the DICOM plugins on the ImageJ plugin page are very specific to dedicated problems and the developers have stopped working on them. Some plugins conflict with other because of external libraries they require. The TUDOR DICOM plugins groups most of the functionalities of the other plugins into one package and even offers a lot of additional features. With some of these plugins installed ImageJ can be used to easily solve specific problems in an hospital environment and to write custom application with full DICOM support.

REFERENCES

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