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Title

A Taxonomy and Evaluation of Free Non-Diagnostic DICOM Software Tools

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Principal Author's Biography

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Abstract Text (214 words)

A variety of software exists to interpret DICOM files and display them as individual images or volume rendered objects. Some of them offer further processing and analysis features. The surveys that have been published so far are not up-to-date anymore, and neither a detailed description of the software functions nor a comprehensive comparison is given. This survey aims at classification of freely available, non-diagnostic DICOM software into “volume renderer” and “image viewer”, and at comparison of software with respect to the following aspects:

1. Performance: such as data loading, transfer functions, sliced views, pre-built models for volume rendering, and viewing, exporting, and processing for image viewers;
2. Robustness: some software tools may misinterpret some datasets or, even worse, fail to read them, possibly resulting in program crash;
3. Usability: such as usage, documentation, and speed;
4. Portability: regarding the operation systems Windows, Unix, and Mac;
5. Miscellaneous: to describe other issues like source availability, support, etc.

Based on our study, a user who is not familiar with DICOM software can efficiently and effectively find that one most adequately addressing his needs. In this abstract, we reviewed five software packages exemplarily: Julius, 3D Slicer, DicomWorks, MIPAV and Osiris. On acceptance, the complete results on about twenty software tools will be provided in the full paper.

Expanded Summary

1. Purpose

After acquiring 3D medical datasets in DICOM format from MR, CT or PET scanners or equipment of other modalities, one often wants to view the data before starting to process them. To do so, DICOM software tools are needed which should meet certain requirements. There are many freely available DICOM software tools which are designated for quite different purposes. This paper presents a systematic taxonomy and evaluation of some freely available prominent non-diagnostic DICOM software tools. In an earlier survey in 2003, Horii [1] described some DICOM software tools, but on the one hand, some features of them may have been altered, and some are no longer available, on the other hand, in the mean time there are many new software tools. Furthermore, Horii explicitly states that he was not aiming at providing a comprehensive comparison of the software tools [1].

2. Methods

We have tested 20 GUI (Graphical User Interface) based DICOM software tools. Some of them are not restricted to function as DICOM viewer, but are much more powerful tools with many other features, such as 3D Slicer. Nevertheless, we mostly investigate those features which are related to viewing DICOM datasets. Performance, robustness, usability and portability are important issues. We use the terms “dataset”, “series” and “images” in the following way: a dataset can contain one or more series, a series is the result of a single scanning process and can contain several images.

First, we examine some general properties for all DICOM software tools. Second, we distinguish between two main classes of software tools, i.e. volume renderers and image viewers, and check the individual properties of each class separately.

In this paper, the term “software tool” refers always to both classes. We investigated 20 such tools: Julius, 3D Slicer, DicomWorks, MIPAV, Osiris, BioImage Suite, SyngoFastView, AMIDE, DicomScope, ImreadDicomViewer, FPIImage, MedImaView, EviewBox, ezDicom, TomoVision, Xmedon, UniPACS, JiveX, MicroView and ImageJ. The results of 5 prominent tools are presented exemplarily in this expanded summary: Julius, 3D Slicer as volume renderer and DicomWorks, MIPAV and Osiris as image viewers.

2.1 Classification

The volume renderers target mainly at volume rendering of datasets, while the image viewers aim at representing the datasets as individual images.

This classification does not mean that volume renderers are “better” than image viewers, because of the following:

1. volume renderers are more intuitive for human because the data is directly visualized in 3D, therefore one can gain much more spatial illusion than in 2D. However, volume rendering assumes that the data is sequentially sliced. This assumption is usually satisfied, but unfortunately not always. For instance, secondary reconstructed angiography of extremity can be stored radially and standard volume rendering is thus impossible. In this case, one has to fall back upon image viewers.

- some image viewers have very nice functionalities, for example for extracting images for archiving, and all of the volume renderers we tested have at most only rudimentary exporting functionality.

2.2 Comparison Criteria

2.2.1 General Comparison

First, the DICOM software tools are checked for the general properties, which are defined in the sequel. The left column is the abbreviate of the property which we will use later, its explanation is in the right column.

Performance In this criterion, we checked the basic general functionalities of the software tools.

Hdr	<p><i>Header:</i> the ability of the software tool to display DICOM header.</p> <ul style="list-style-type: none"> A: The software tool can display all available DICOM header in a dataset in a structured manner, i.e. the entries are grouped to “study information”, “image representation”, etc. B: The software tool can display the image related DICOM header entries, i.e. dimension of images, etc. C: The software tool can only display DICOM header minimally. <p>Since the number of header entries may vary strongly between individual datasets, it is difficult to give a quantitative evaluation.</p>
Dir View	<p><i>Directory Overview:</i> the software tool scans the directory recursively and provides an overview of all examinations in the directory and its subdirectories so that the user can select them easily.</p>

Robustness

Rob	<p><i>Robustness:</i> behavior of the program when loading errors occur, e.g. some files are missing.</p> <ul style="list-style-type: none"> A: the software tool works as usual with loadable files. B: the software tool crashes.
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Usability We checked the user-friendliness, documentation availability and efficiency. Some of these properties might be a little subjective as they result from the author’s own experience.

Usage	<p><i>Usage:</i> the ease of use.</p> <ul style="list-style-type: none"> A: The GUI is self-explanatory so that the software tool can be used in a very straightforward manner and the user does not need to read the manual at all. B: The usage is not very straightforward, user manual needed.
Docu	<p><i>Documentation:</i> the software tool has documentation/user manual which explains the functionalities of the GUI or provides concrete work flows.</p>
Start	<p><i>Start Speed:</i> time needed to start the program GUI. There are two cases: the software tool is already loaded into memory or not. For example, the result “3.0/10.0” would mean that if the software tool is already loaded in memory before (and then quitted), then the load time is 3.0 seconds, otherwise 10.0 seconds.</p>

Portability

Port	<p><i>Portability:</i> Operating systems on which the software tool runs (W = Windows, L = Linux, M = Mac).</p>
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Miscellaneous

Src	<p><i>Source:</i> the source code of the software tool is accessible. However, for this survey we have only used the pre-compiled versions.</p>
Support	<p><i>Further Support:</i> ways to get further information.</p>
Other	<p><i>Other</i> general comments.</p>

2.2.2. Volume Renderers

After that, the features of the two classes, i.e. volume renderers and image viewers, are compared separately. The properties for volume renderers are defined as:

Data Loading

Load	<p><i>Correct Loading:</i> the ability to load volume data correctly. According to our observations this is due to that the renderer sometimes cannot distinguish between volume data and the survey images, thus both of them are interpreted as volume data, resulting in incorrect rendering.</p>
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Transfer Function This function maps the iso-value of a voxel onto its opacity. We compare the GUI which allows one to configure the transfer function.

Mouse Based	<p><i>Mouse Based Configuration:</i> a GUI is provided such that the user can adjust the transfer function intuitively by moving the control points of the transfer function with the mouse.</p>
New CP	<p><i>New Control Point:</i> additional control points can be added to the transfer function to adapt individual datasets.</p>
Hist	<p><i>Histogram:</i> histogram is overlaid with the transfer function for easy comparison.</p>
Pre	<p><i>Preset Transfer Function:</i> the volume renderer has reasonably pre-configured transfer functions that can be used directly without having to adjust the control points first.</p>
Pse	<p><i>Pseudo-Color Rendering:</i> the volume renderer provides pseudo-color for the transfer functions instead of the conventional monochrome transfer function.</p>

Sliced View

Slices	<i>Slice Overlay</i> : the volume renderer can superimpose slices as overlay to the volume.
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Pre-built Model

Model	<i>Model Loading</i> : the volume renderer can load additional pre-built 3D models which are not generated from datasets using volume rendering and marching cubes.
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Additional Functionalities We only compare some simple operations which are related to data viewing.

MC	<i>Marching Cubes</i> : the volume renderer can perform marching cubes algorithm and visualize the result.
Seg	<i>Segmentation</i> : the volume renderer can perform segmentation for datasets.
Reg	<i>Registration</i> : the volume renderer can perform registration for datasets.

Other

Other	<i>Other</i> specific comments for volume renderers.
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2.2.3 Image Viewers

The properties for image viewers are defined as:

Image Viewing In this criterion, we check functionalities that allows to view images ergonomically.

Scroll	<i>Scrolling</i> : the user can scroll over all images in a series.
Info	<i>Information Overlay</i> : Information about the current image can be overlaid in the viewing window.
C/B	<i>Contrast and Brightness</i> : contrast and brightness of the images are adjustable.

Image Exporting

Fmt	<i>Formats</i> : The image formats in which the image viewer can export images. <ul style="list-style-type: none"> A: jpg, bmp, tiff, DICOM, pcx, png, wmf, tga, emf, pax, tla, psd B: jpg, tif, DICOM, png, psd, gif, pict C: bmp, tif, DICOM
Series	<i>Series Export</i> : the image viewer can export all images in an entire series once.
Dataset	<i>Dataset Export</i> : the image viewer can export all images in an entire dataset once.
Video	<i>Video Export</i> : the image viewer can export images in an series as video.
HTML	<i>HTML Gallery Export</i> : the image viewer can make an HTML gallery for images in the same series.

Image Processing We only compare some simple operations which are related to data viewing.

Ptr	<i>Painter</i> : painter-like functionalities such as drawing lines and inserting texts.
Seg	<i>Segmentation</i> : the image viewer can perform simple image segmentation such as thresholding.

Other

Other	<i>Other</i> specific comments for image viewers.
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2.3 Testing Data

We used 24 MR datasets to test the software tools. These datasets are listed below. Datasets 1-18 are acquired ourselves, dataset 19 comes with 3D Slicer and datasets 20-24 come with Julius.

Dataset no.	1	2	3	4	5	6	7	8	9	10	11	12
Manufacturer	Philips	Philips	Philips	Philips	Philips	Philips	Philips	Philips	Philips	Philips	Philips	Philips
Scanner Type	Gyrosan NT Intera	Gyrosan NT Intera	Achieva	Intera	Intera	Intera	Intera	Intera	Intera	Intera	Intera	Gyrosan Intera
No. Series	15	14	8	16	10	10	10	10	10	11	7	4
No. Images	515	475	316	638	667	687	665	671	676	752	281	184

Dataset no.	13	14	15	16	17	18	19	20	21	22	23	24
Manufacturer	Siemens	Siemens	Siemens	Siemens	Siemens	Siemens	GE	--	--	--	--	--
Scanner Type	TrioTim	TrioTim	TrioTim	TrioTim	Avanto	Symphony	Genesis Signa	--	--	--	--	--
No. Series	7	1	31	13	7	4	1	1	1	1	1	1
No. Images	204	39	945	1220	281	184	124	113	128	109	109	127

Abbreviates: Philips: Philips Medical Systems, Siemens: Siemens Medical Solutions, GE: General Electrics Medical Systems, "--" means the information is not available.

2.4 Testing Environment

The tests were all carried out on a Pentium IV 2.8 GHz machine with 512 MB memory, an nVidia FX5600XT video card (128 MB video memory), and an 80 GB hard disk. The operation system is Windows 2000.

2.5 Software Selection

The DICOM software tools tested for the summary are:

Name	Version	Class	Download URL
Julius	1.1	Volume renderer	http://www.julius.caesar.de/index.php/Julius_MV1
3D Slicer	2.7-opt	Volume renderer	http://www.na-mic.org/Slicer/Download/Release/
DicomWorks	1.3.5	Image viewer	http://dicom.online.fr/fr/donation.htm
MIPAV	3.1.6	Image viewer	http://mipav.cit.nih.gov/clickwrap.php
Osiris	4.19	Image viewer	http://www.sim.hcuge.ch/osiris/01_Osiris_Presentation_EN.htm

3. Results

The exemplary results based on five software tools are summarized in Tables 1, 2 and 3. The complete tables on all tools mentioned will be given in the full paper on acceptance.

Obviously, there is no all-round best software which outperforms all the others. Among volume renderers, 3D Slicer provides more processing functionalities than Julius, which is advantageous but not very relevant in this survey since we are mostly interested in the viewing functionalities. On the other hand, 3D Slicer is rather slow and can sometimes interpret the volume data incorrectly, whereas Julius does not suffer from these problems and is easy to use. Among image viewers, DicomWorks is user-friendly and has a strong performance, but it runs only on Windows. Furthermore, it is not very robust. MIPAV is platform independent but slow, and the usage is not straightforward. Osiris runs fast, but it can only show DICOM header entries minimally and does not run on Linux.

Also, the two classes, volume renderers and image viewers, are also quite complementary. For example, in order to view DICOM header entries, image viewers such as DicomWorks and MIPAV are superior to Julius and 3D Slicer, while the latter two can perform volume rendering well.

4. New or Breakthrough Work

Some web pages list many DICOM software tools, but describe them rather qualitatively and briefly. In 2003, an invited presentation was given at this conference, but most of the information is nowadays obsolete. Comparison categories have not yet been defined. In this paper, an complete and comprehensive overview of the functionalities of DICOM software is given by means of precisely defined evaluation criteria, which are applied to about twenty viewing and rendering tools.

5. Conclusion

The software tools that are available significantly differ regarding the defined criteria. Based on this survey, researchers can easily choose appropriate DICOM software best meeting their needs.

6. References

- [1] Horii SC. DICOM image viewers: A survey. Proceedings SPIE 2003; 5033: 251-9.
- [2] The University of Nottingham site: <http://www.sph.sc.edu/comd/rorden/dicom.html>
- [3] Dr. David Clunie's site: <http://www.dclunie.com/>
- [4] The University of Oldenburg site: http://dicom.offis.de/car97cd/car97_06.htm

Supplemental Information

Table 1: general property comparison

Software Tool	Property		Rob A-B	Usability			Port	Misc		
	General Performance			Usage A-B	Docu	Start (sec)		Src	Support	Other
Hdr A-C	Dir View									
Julius	B	No	A	A	Yes	3.10/11.20	WL	No	--	Used by author
3D Slicer	B	Yes	A	B	Yes	19.88/36.54	WL	Yes	Mailing List	--
DicomWorks	A	Yes	B	A	No	2.23/10.45	W	No	Forum	Used by author
MIPAV	A	Yes	A	B	Yes	7.321/13.39	WLM	No	Mailing List	Crash on memory shortage
Osiris	C	Yes	A	B	Yes	0.30/1.66	WM	Yes	--	Source is Mac only

Table 2: Volume renderer property comparison

Property Volume Renderer	Load	Transfer Function					Slices	Model	Additional Functionalities			Other
		Mouse Based	New CP	Hist	Pre	Pse			MC	Seg	Reg	
Julius	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	--
3D Slicer	No	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes	With many further processing functionalities

Table 3: image viewer property comparison

Property Image Viewer	Image Viewing			Image Exporting					Image Processing		Other
	Scroll	Info	C/B	Fmt A-C	Series	Dataset	Video	HTML	Ptr	Seg	
DicomWorks	Yes	Yes	Yes	A	Yes	Yes	Yes	Yes	No	No	--
MIPAV	Yes	No	Yes	B	Yes	No	Yes	No	No	Yes	Volume rendering will be added soon.
Osiris	Yes	Yes	Yes	C	Yes	No	Yes	No	Yes	Yes	Mac version (OsiriX) is much more powerful.