User Manual

DICOMscope 3.5

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A Introduction

The NEMA Committee for the Advancement of DICOM and the European Congress of Radiology (ECR) hosted a demonstration of the proposed DICOM supplement 33 Grayscale Softcopy Presentation State Storage at the ECR 1999 in Vienna. After some minor corrections the supplement has been approved in September 1999 and is part of the DICOM standard since then.

For the annual meeting of the Radiology Society of North America (RSNA) 1999 in Chicago the demonstration was extended to support the DICOM Supplement 22 Presentation Look Up Table (LUT). By using this new service together with Grayscale Standard Display Function (part 14) the image appearance for both hardcopy (film) and softcopy (CRT) becomes comparable.

One year later "softcopy and hardcopy consistency" was added to the year 2 demonstration of the IHE (Integrating the Healthcare Enterprise), an initiative of HIMSS (Healthcare Information and Management Systems Society) and RSNA. In this context the application described in this manual was used as a tool to test the DICOM implementations of the participating vendors.

This application was extended for the RSNA 2000 and the ECR 2001 in order to support two of the new DICOM security extensions (TLS – Transport Layer Security, formerly known as supplement 31, and Digital Signatures which is described in supplement 41) together with DICOM Structured Reporting (supplement 23).

The purpose of Grayscale Softcopy Presentation States is the consistent appearance of images across a network, particularly in order to increase the quality and efficiency of softcopy reading. This new DICOM extension enables a workstation or modality to store any grayscale and spatial transformation as well as textual and graphical annotations and render them in the same way on different workstations. The Presentation LUT translates pixel values into device and vendor independent P-values, which facilitates perceptual linearization of grayscale images as specified in the DICOM Grayscale Standard Display Function. All parameters affecting the image rendering in a DICOM printer are transmitted as part of the DICOM print protocol.

The first security extension (TLS) introduces a secure transport connection which protects the data during transit, e. g. a DICOM image sent from one workstation to another over an unsecure network. The second security extension (Digital Signatures) provides lifetime integrity checks to any DICOM object. Further security extensions to the DICOM standard are currently being developed.
DICOM Structured Reporting (SR) provides a standardized way to store and exchange structured medical reports. An SR document might consist of a complete diagnostic report or the results of a particular examination. Like any other DICOM object SR documents or part of it can be digitally signed.

DICOMscope is a full DICOM viewer with a large number of features. It allows to process, transmit and receive DICOM studies, series, images as well as presentation states and structured reports over a DICOM network. Pre-formatted grayscale images with burned-in annotations can be assembled to a print job and sent to a DICOM printer. A fully functional print server is also included allowing to display the received print jobs on the screen.

The application is divided into four main parts: a study browser, a viewing component to display and process DICOM images, hardcopy grayscale images, presentation states and structured reports as well as a print manager and a logging component to display the status of the background processes. This manual describes all features of the application as demonstrated at RSNA 2000 / ECR 2001 and some previous shows.

For softcopy DICOMscope supports both high resolution (high resolution grayscale monitor with dedicated graphics adapter) and conventional consumer systems (color monitor with conventional VGA graphics adapter). For hardcopy it supports in principle all 8 bit and 12 bit DICOM printers since all relevant print parameters can be configured for each device individually.

B Installation and Getting Started

DICOMscope is known to run on both MS Windows (32 bit) and some Unix platforms (e. g. Solaris, Linux). Since the Windows version has been tested more intensively we have only created a binary installation package for this platform – this might change in the future. For other platforms we refer to chapter J where the compilation is described.

(Microsoft Windows Binary Version)

DICOMscope requires a Java 1.3 compatible system and a 32 bit version of MS Windows. Before installing the application, Java 2 SDK or Runtime Environment should be installed according to the setup instructions provided with the package. See chapter J for further details.

Thereafter start the setup program to install the DICOMscope software on your local disk. The setup will guide you through the installation process. Do not forget to modify the configuration file according to your system configuration (see I.1).

Following a successful installation DICOMscope can be started from the Windows "Start" menu or directly from the "DICOMscope 3.5" group window (fig. 1). The application will be loaded and initialized and the study browser will be displayed showing the contents of the local database.

Figure 1: DICOMscope Group Window

Click on the register tabs at the top of the main window to toggle between the four main components "Browser", "Viewer" , "Print" and "Process Log". A status bar at the bottom of the main window usually displays some helpful context information while using DICOMscope.

The deinstallation is very easy and works mainly automatically. Start the "Software" component from the Windows "Control Panel" and select "DICOMscope 3.5" to be removed. Of course, files which have been created or modified after the installation have to be removed manually. It is highly recommended to deinstall a previous version of DICOMscope before installing a new one.

C Browser

The "Browser" (fig. 2) lists all available images, hardcopy grayscale images, stored print objects, presentation states and structured reports[1] in a hierarchically tree (grouped by studies and series). An instance can be loaded from the local database and displayed in the "Viewer", as well as transmitted, printed, dumped, checked or deleted by selecting the corresponding entry. In analogy complete series and studies can be transmitted or deleted in a single step. DICOM images, presentation states and structured reports can also be loaded from file via a standard file open dialog.
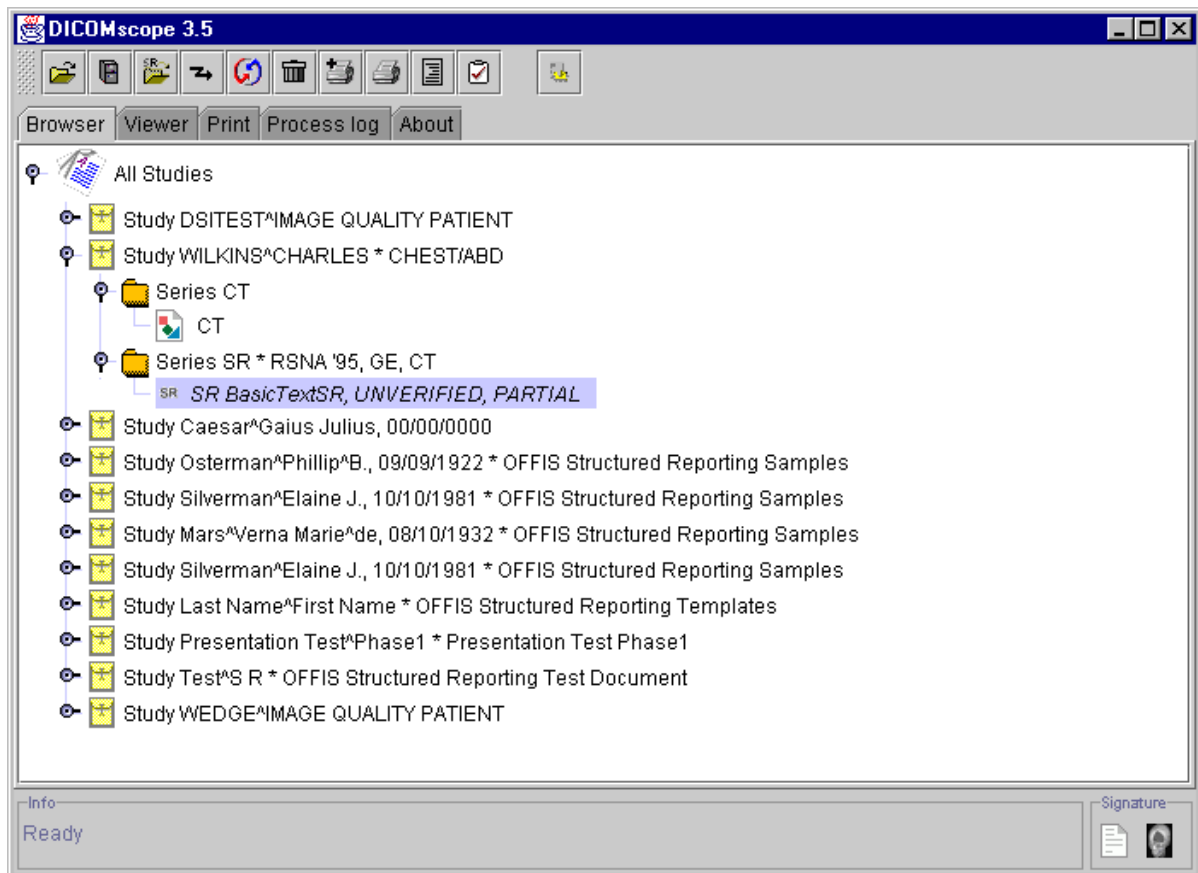
Figure 2: "Browser" Component

Initially only the studies currently available in the database are displayed in the browser. By clicking on the symbol left to the icon of a study or series the contents (series or instances) becomes visible. Doing this one can browse through the hierarchy of studies, series and instances. The top element of this tree ("All Studies") is always visible, even if no study is available.

Newly received instances (transmitted via network or stored from the application) are shown immediately in the tree; these instances are marked as "new" with corresponding icons until they have been displayed for the first time. Studies or series containing a mixture of "new" and "old" instances are indicated by a lighter "new" icon.

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[1] In the following the term "instance" is used when talking about images, hardcopy grayscale images, stored print objects, presentation states and structured reports.

C.1 Toolbar

At the top of the main window there is a toolbar with a number of icons representing the main functions of the "Browser" (fig. 3). The toolbar is moveable and can be docked to all borders of the main window or transformed to a "floating" window by means of "drag'n drop" (click on the left rastered part of the toolbar, move the mouse while pressing the left mouse button and drop the toolbar at the desired position).

Figure 3: "Browser" Toolbar

The toolbar icons in the "Browser" view have the following functions. Some of them are only available if a tree item is selected, some of them are only applicable to (specific) instances.

C.1.1   Load Image File

 Loads a DICOM image or hardcopy grayscale image from file. In the "Open File" dialog a valid DICOM image file has to be chosen. After the image has been successfully loaded it will be displayed in the "Image Viewer".

C.1.2   Open

 Loads the selected instance from the local database and displays it in the "Viewer". If an image is selected and presentation states are available for this image, a list will be shown to select the desired presentation state (fig. 4). By selecting the "<default>" entry the image is displayed without any presentation state (in fact, a new presentation state is created using the image settings as an initial state). Otherwise the selected presentation state is applied to the image and the resulting image will be displayed in the "Viewer".
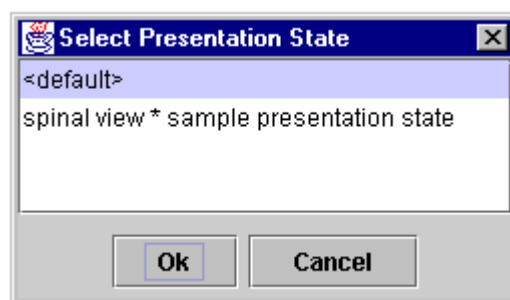
Figure 4: "Select Presentation State" Dialog

If a presentation state is selected from the "Browser" list the first referenced image is loaded (if available in the database) and the selected presentation state is applied to this image. The other referenced images are accessible via the "Navigation" toolbar (see D.1.3).

A new presentation state referencing more than one image can be created by selecting the images in the "Browser" (use "shift" and/or "ctrl" key for this purpose) and pressing the "Open" button. Then a presentation state is derived from the first image (see above) and applied to all referenced images which are then accessible via the "Navigation" toolbar.

C.1.3 Load SR File

Loads a DICOM structured report from a file. A valid DICOM structured report file has to be chosen from the "Open File" dialog. After the structured report has been successfully loaded, it will be displayed in the "Viewer".

C.1.4 Send

Transmits the selected study, series or instance to another workstation via network. The destination can be chosen from the displayed list (fig. 5). The available communication partners have to be added to the configuration file prior to the application start (see I.1). By pressing the "Details..." button some technical information about the selected peer is presented.
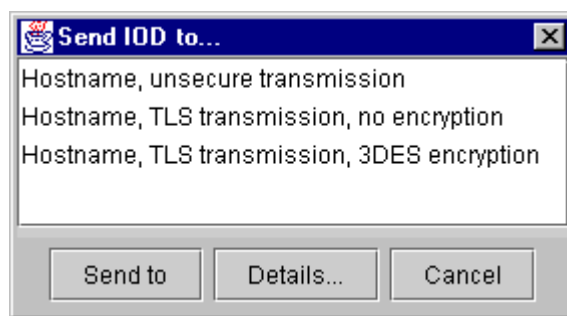
Figure 5: "Send IOD to..." Dialog

C.1.5 Refresh

Refreshes the "Browser" list after reloading all information from the local database. This function is very useful in case the automatic refresh is not working or disabled (see I.1).

C.1.6 Delete

Deletes the selected studies, series or instances. Multiple entries can be selected by using the "shift" and/or "ctrl" key. If the top element "All Studies" is selected all studies will be deleted. For instances the DICOM file stored in the same directory as the local database will also be deleted. Instances that are only "referenced" by the database (i. e. not stored in the database directory) are only removed from the list, the DICOM file is not deleted. A confirmation dialog is always displayed before deleting an entry.

C.1.7 Print Stored Print Object

Stored print objects and the referenced hardcopy grayscale images can be printed directly from the "Browser". If a stored print object is selected it will be sent to the current printer. Stored print objects are created and stored in the database either from the "Print" component or by the local print server (see I.1).

C.1.8   Add to Print

If a hardcopy grayscale image is selected it will be added to the current print job. Hardcopy grayscale images can be created from the "Image Viewer" by choosing "Add to Print" (see D.1.1.7) or by the print server extracting the images from the received print job. In both cases the hardcopy grayscale images are stored in the database.
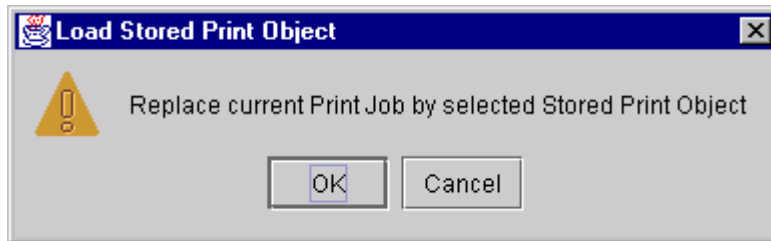
Figure 6: "Load Stored Print Object" Dialog

If a stored print object is selected and the dialog (fig. 6) is confirmed with "OK" the current print job will be deleted and replaced by the selected one. Stored print objects will be created and inserted automatically into the database by printing the current print job. The "Print" component is described in chapter E.

C.1.9   Create Dump

Creates a dump (textual, human readable version of the file contents) for the selected instance and displays it in a separate application. This requires the installation of the Tcl/Tk package (see chapter J) and probably some changes to the configuration file (see I.1).

The dump application supports syntax highlighting and a simple search and select function (fig. 7). Besides the explicit input of a search term a sequence of characters can also be selected by pressing the left mouse button first (while moving the mouse cursor) and then the right mouse button to start the search. A word can be selected by clicking the left mouse button twice, a whole line by pressing it three times.

Figure 7: Dump of a DICOM File

C.1.10 Check IOD

Checks the selected IOD (information object definition, called "instance" in this document) for conformance with the DICOM standard (correct value representation, value length etc., but the presence of mandatory attributes only for presentation states) and displays a report in a separate application. This requires the installation of the Tcl/Tk package (see chapter J) and probably some changes to the configuration file (see I.1).

The checking application supports syntax highlighting and a simple search and select function (fig. 8). Besides the explicit input of a search term a sequence of characters can also be selected by pressing the left mouse button first (while moving the mouse cursor) and then the right mouse button to start the search. A word can be selected by clicking the left mouse button twice, a whole line by pressing it three times.

DICOM PState Checker - mammo_identify_calcif.pres

Find | CS | Hits: 5

```
============================================================
Testing: mammo_identify_calcif.pres
============================================================


------------------------------------------------------------
Pass 1 - Inconsistencies between Meta-header and Data Set
------------------------------------------------------------


------------------------------------------------------------
Pass 2 - Inconsistencies between Data Dictionary and Data Set
------------------------------------------------------------

Error: Attribute value does not conform to data type definition.
    Affected attribute: GraphicLayer (0070,0002), Type CS
    Attribute value   : [calcifications 0]
    Expected format for each value: [0-9A-Z _]+

Error: Attribute value does not conform to data type definition.
    Affected attribute: GraphicLayer (0070,0002), Type CS
    Attribute value   : [calcifications 0]
    Expected format for each value: [0-9A-Z _]+

Error: Value Length too large.
    Affected length   : 23 bytes, should be 16 bytes maximum for CS.
    Affected attribute: (0070,0080) CS    [Indentify calcification]

Error: Attribute value does not conform to data type definition.
    Affected attribute: PresentationLabel (0070,0080), Type CS
    Attribute value   : [Indentify calcification]
    Expected format for each value: [0-9A-Z _]+


------------------------------------------------------------
Pass 3 - Semantic Check of Presentation State Object
------------------------------------------------------------

Test failed - one or more errors.
```

Figure 8: Check Report of a DICOM File

D Viewer

After successfully loading an instance DICOMscope automatically switches to the "Viewer" (fig. 9). Of course, the view can also be changed manually by clicking one of the five component tabs. The graphical user interface and the viewer's components depend on the configuration (see I.1) and the options (see H). The "Image Viewer" might be visible, as well as the "Structured Report Viewer", or even both at the same time. If a DICOM instance is loaded, the appendant viewer will open automatically.

D.1 Image Viewer

The "Image Viewer" itself is divided into different parts. On the right-hand side[2] the "Function" panel offers the main functionality of the "Image Viewer" (like windowing, zooming and rotating, as well as layer, annotation, shutter and presentation state management). On the left-hand side the current image is displayed. The "Navigation" toolbar (see D.1.3) at the top of the viewing area allows to choose the currently displayed image and frame referenced by the presentation state. This bar is only visible if more than one image, or an image with more than one frame, is loaded.

Figure 9: "Viewer" Component

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[2] Most of the positions described in the following are not fixed but can be configured (see chapter H and I).

The image can be scrolled by means of the scroll bars located at the right and bottom border. The current position of the displayed area (top left-hand corner and bottom right-hand corner) is always displayed in the status bar.

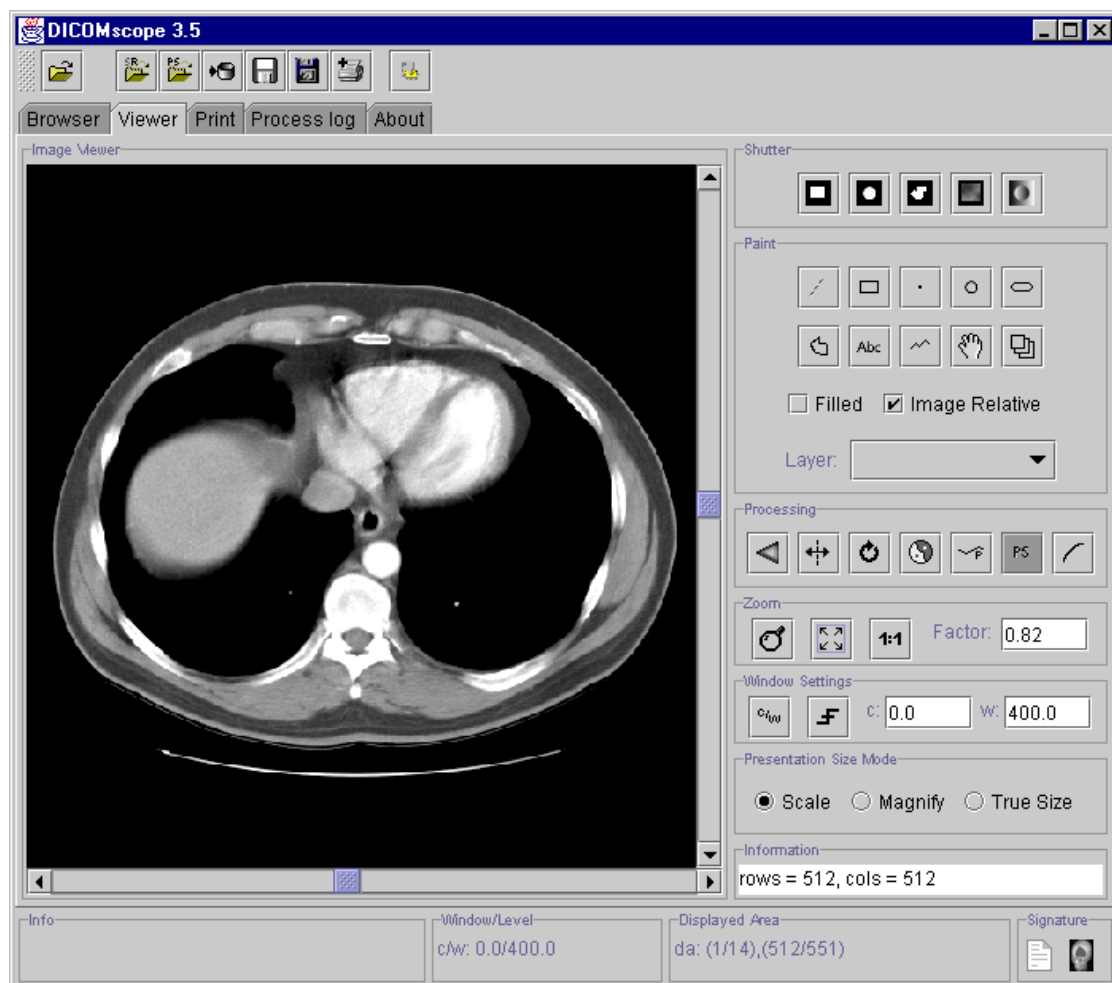Moving the mouse cursor while pressing the right mouse button changes the grayscale window settings. To start this interactive windowing the mouse cursor must be located inside the image area when pressing the right mouse button. The current window center and width values are always displayed in the status bar.

D.1.1   Toolbar

At the top of the main window there is a toolbar with a number of icons representing some general functions of the "Image Viewer" (fig. 10). A detailed description on how to place the toolbar within the application window can be found in section C.1.
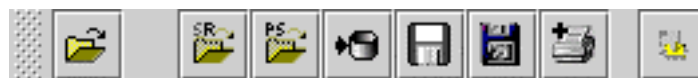
Figure 10: "Viewer" Toolbar

The "Image Viewer" toolbar icons have the following functions. Some of them are only available if an image is loaded.

D.1.1.1   Load Image File

Loads a DICOM image or hardcopy grayscale image from file. In the "Open File" dialog a valid DICOM image file has to be chosen. After the image has been successfully loaded it will be displayed in the "Image Viewer".

D.1.1.2   Load SR File

Loads a DICOM structured report from file. A valid DICOM structured report file has to be chosen from the "Open File" dialog. After the structured report has been successfully loaded, it will be displayed in the "Structured Report Viewer".

D.1.1.3   Apply Presentation State File

Loads a presentation state from file. In the "Open File" dialog a valid DICOM presentation state file has to be chosen. After the presentation state has been successfully loaded it will be applied to the current image. There is no check whether the presentation state refers to the image or not.

D.1.1.4   Save to Database

Stores the current presentation state in the local database. If the current image is not yet stored in the database (e. g. if the image was loaded from file) this image will also be stored.

In the "Save Presentation State to Database" Dialog (see fig. 11) the label and the creator of the presentation state can be entered. Furthermore, it can be chosen whether the displayed area of the presentation state should be set to the image size.
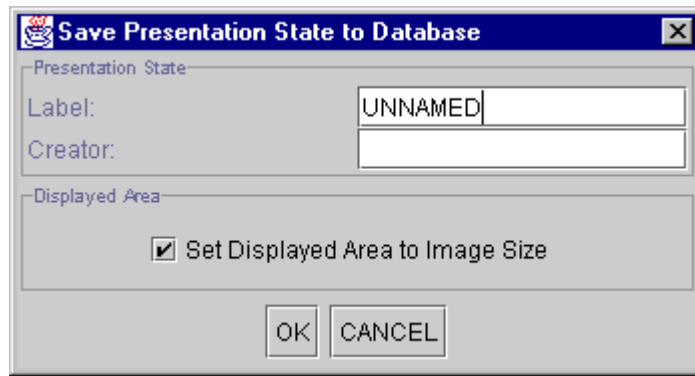
Figure 11: "Save Presentation State to Database" Dialog

D.1.1.5   Save to File

Saves the current presentation state and image to a DICOM file. The file name (without file extension) can be chosen or entered in the "Save File" dialog. The file extension is assigned automatically: ".dcm" is added to the image file name and ".pre" to the presentation state file name.

In the "Save Presentation State to File" Dialog (see fig. 12) the label and the creator of the presentation state can be entered. Furthermore, it can chosen whether the displayed area of the presentation state should be set to the image size. The DICOM files can be stored in little endian explicit or implicit format (big endian encoding is not supported).

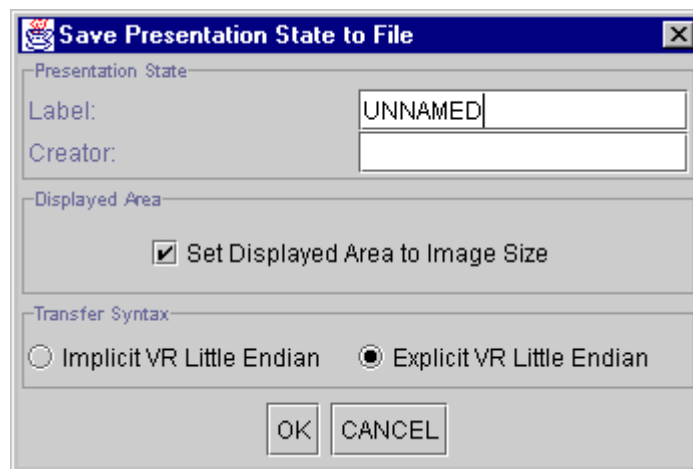**Figure 12: "Save Presentation State to File" Dialog**

D.1.1.6   Save Screen to File

Saves the currently displayed image / frame (including applied presentation state) to a secondary capture DICOM file. This function works like a screen capturing program. After choosing or entering the file name (with file extension) the transfer syntax (little endian explicit or implicit) has to be chosen.

D.1.1.7 Add to Print

Creates a hardcopy grayscale image, stores it in the local database and adds it to the print queue in the "Print" panel (see chapter E). The stored hardcopy grayscale image can be loaded from the "Browser" and displayed in the "Image Viewer" or re-added to the print queue.

There are two options to create a hardcopy grayscale image: if the answer to the question (fig. 13) is "Yes" the current displayed area is reset to the original image size, i. e. the whole image will be printed; if the answer is "No" the current displayed area (also printed in the status bar) will be used instead.
However, all transformations and annotations specified in the presentation state will be burned into the hardcopy grayscale image. The reason for this is that DICOM printers do not support presentation states but only pre-formatted grayscale images.
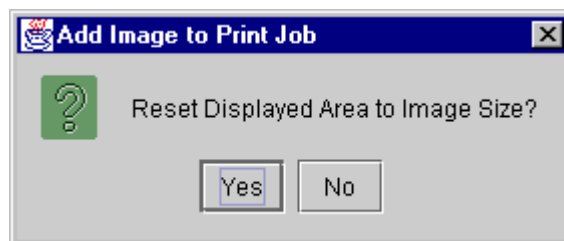
Figure 13: "Add Image to Print Job" Dialog

D.1.2 Status Bar

The status bar (fig. 14) at the bottom of the main window is divided into four sections. The first section contains some context dependent information to the user (e. g. what to do next with the mouse), the second section contains the current values for window center / width (or the name of the current VOI LUT) and the third one contains the coordinates of the current displayed area. The last section displays the status of digital signatures possibly contained in the loaded instances (see G).
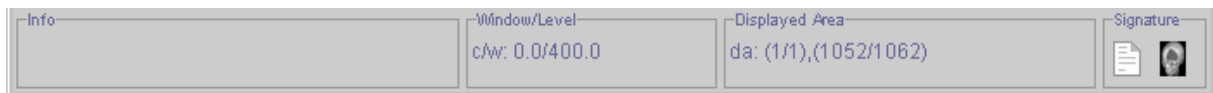
Figure 14: "Status Bar" Panel

D.1.3 Navigation Toolbar

The "Navigation" toolbar (fig. 15) at the top of the viewing area allows to choose the currently displayed image and frame referenced by the presentation state. Be aware that the navigation toolbar is visible only if more than one image is referred to or if an image with more than one frame is loaded. Furthermore, it can be specified whether certain image operations should be applied to all referenced images, only the current one or only the currently displayed frame.
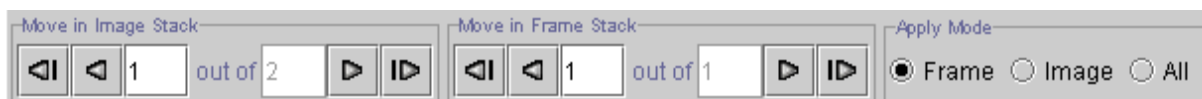
Figure 15: "Navigation" Toolbar

D.1.3.1 Image Stack

The "Move in Image Stack" Panel (see fig. 16) contains the functions for the navigation through the images referenced by the current presentation state. The first button (from left to right) allows to move to the first image, the second one to the previous, the third one to the next and the last button to the last image. The first text field always shows the number of the currently displayed image. By entering a valid number the corresponding image will be displayed directly. The second text field shows the number of images referenced by the current presentation state; it cannot be modified.
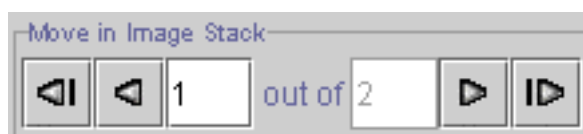
Figure 16: "Move in Image Stack" Panel

D.1.3.2 Frame Stack

The "Move in Frame Stack" Panel (fig. 17) contains the functions for the navigation through all frames of the currently selected image. The first button (from left to right) allows to move to the first frame, the second one to the previous, the third one to the next and the last button to the last frame. The first text field always shows the number of the currently displayed frame. By entering a valid number the corresponding frame will be displayed directly. The second text field shows the number of frame contained in the current image; it cannot be modified.
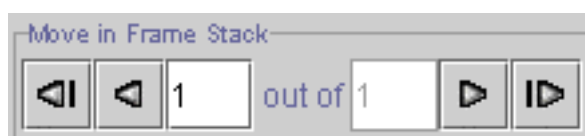
Figure 17: "Move in Frame Stack" Panel

D.1.3.3 Apply Mode

The "Apply Mode" (fig. 18) specifies whether the annotation related operations, the window settings and the displayed area related operations should be performed on all images in the presentation state, on the currently displayed image or on the currently displayed frame only.
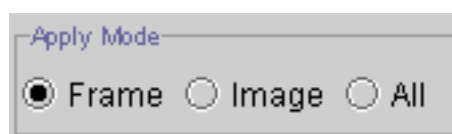
Figure 18: "Apply Mode" Panel

D.1.4 Shutter

The purpose of display shutters is to hide unwanted parts of an image (e. g. unexposed parts of X-ray images). The DICOM standard defines graphical shutters and bitmapped shutters (fig. 19) which are mutually exclusive. Graphical shutters have the shape rectangular, circular or polygonal. Each type of shutter may appear only once in a presentation state but the three graphical types can be combined to create a more complex shutter shape.

Figure 19: "Shutter" Panel

Bitmapped shutters cannot be created but displayed by the current release of the software. If more than one bitmapped shutter is available in a presentation state one (or none) of them has to be selected for display.

D.1.4.1 Rectangular Shutter

Rectangular shutters are created by specifying the top left-hand (TLHC) and bottom right-hand corner (BRHC) of the visible region. To do this press the left mouse button at the TLHC, move the mouse cursor to the BRHC (without pressing the mouse button) and press the left mouse button again to confirm the size. The order of specifying TLHC and BRHC is not significant.

The presence of a rectangular shutter is indicated by a dark gray background of the corresponding icon. By clicking the icon again the shutter will be removed.

D.1.4.2 Circular Shutter

Circular shutters are created by specifying the center and the radius of the visible region. To do this press the left mouse button at the center, move the mouse cursor to specify the radius (without pressing the mouse button) and press the left mouse button again to confirm the size.

The presence of a circular shutter is indicated by a dark gray background of the corresponding icon. By clicking the icon again the shutter will be removed.

D.1.4.3 Polygonal Shutter

Polygonal shutters are created by specifying the vertices of the visible region. To do this press the left mouse button at the starting point, move the mouse cursor to the next position (without pressing the mouse button), press the left button again to confirm the position, and so on. The polygon can be closed by choosing the corresponding entry from the context menu (press right mouse button to display this menu).

The presence of a polygonal shutter is indicated by a dark gray background of the corresponding icon. By clicking the icon again the shutter will be removed.

D.1.4.4   Bitmapped Shutter

The current release of this application does not support creating bitmapped shutters. However, bitmapped shutters stored in a presentation state can be activated as well as overlay planes having an appropriate size (i. e. same as image).

The presence of a polygonal shutter is indicated by a dark gray background of the corresponding icon. By clicking the icon again the shutter will be removed.

D.1.4.5   Shutter Color

The color used to replace those parts of the image occluded by the shutter can be changed in this dialog. All values between 0.0 (black) and 1.0 (white) are valid.

D.1.5   Layers

Layers group together annotations which are related. Each annotation has to be assigned to exactly one layer and is displayed in the color associated with this particular layer.

The "Layer Manager" (fig. 20) allows to add, delete and modify layers as well as to delete or move annotations to another layer.

The current layer can be changed by means of the combo box "Graphic Layer". The associated layer description and the annotations defined in this layer are displayed in the boxes below.

The layer "deactivate" is used to store overlay planes which have been deleted (directly or by deleting the associated layer). This allows to restore overlay planes (by moving the annotation from this special layer to another layer).
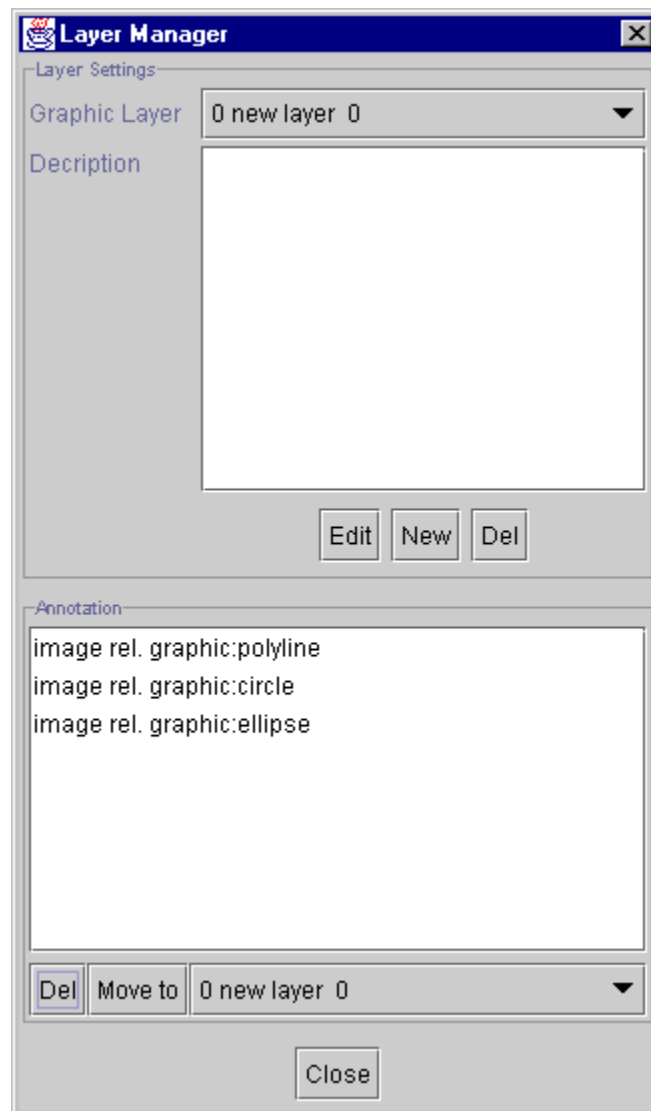
Figure 20: "Layer Manager" Dialog

D.1.5.1   Create

The "New" button in the "Layer Manager" creates a new layer with the specified name, color and description (fig. 21). "Color" is a value between 0.0 (black) and 1.0 (white). RGB colors are not supported yet by this application.

A layer will be created automatically (after confirming the corresponding dialog) for the first annotation if necessary.
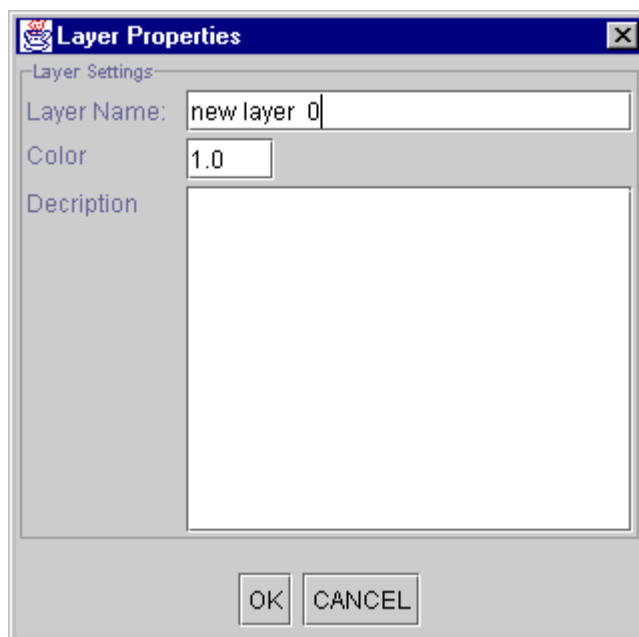
Figure 21: "Layer Properties" Dialog

D.1.5.2   Modify

The properties (name, color and description) of the current layer can be modified by pressing the "Edit" button (fig. 20 and 21).

D.1.5.3   Delete

The current layer can be deleted by pressing the "Del" button. All annotations associated with this layer will also be deleted without any warning. Overlay planes will be moved to the layer "deactivate" (see D.1.5).

D.1.6   Annotations

There are two types of annotations which can be created by the application and stored in a presentation state: graphical and textual annotations.

A new annotation is always associated with the current layer which can be changed in the „Paint" panel (fig. 22) or in the „Layer Manager" (see D.1.5). The color assigned to this layer is used to draw the annotation.

Annotations can be displayed "image relative" (coordinates are related to the underlying image) or "display relative" (coordinates are related to the displayed area). All annotation can be modified (moved, made image relative or display relative, etc.) after they have been created. For some types of annotations the modifications are limited (e. g. a rectangle cannot be resized).
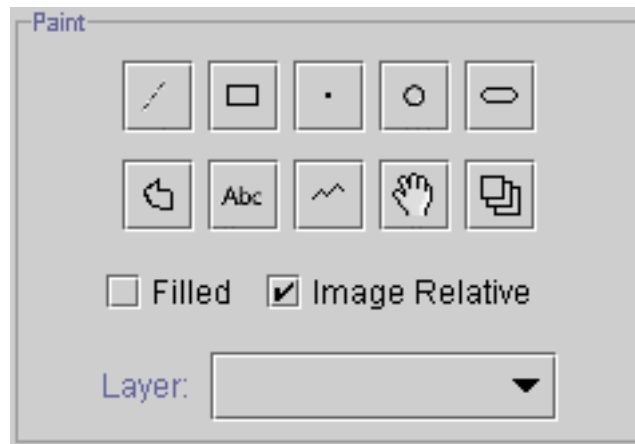
Figure 22: "Paint" Panel

D.1.6.1 Graphical Annotation

The DICOM standard only defines five types of graphical annotations: point, polyline, interpolated line, circle and ellipse. However, DICOMscope offers some additional types (line and rectangle) which are mapped to the standard types to facilitate the use of the application.

New graphical annotations are created according to the checkbox "filled" and "image relative" in the "Paint" panel.

D.1.6.1.1 Line

To create a line two points have to be specified. Press the left mouse button for the first point, move the mouse cursor (without pressing the mouse button) and press the button again for the second point.

The line is stored in the presentation state as a polyline with two points.

D.1.6.1.2 Rectangle

To create a rectangle the top left-hand corner (TLHC) and the bottom right-hand corner (BRHC) have to be specified. Press the left mouse button at the TLHC, move the mouse cursor (without pressing the mouse button) and press the left mouse button again at the BRHC to confirm the size. The order of specifying TLHC and BRHC is not significant.

The rectangle is stored in the presentation state as a polyline with four points.

D.1.6.1.3 Point

To create a point press the left mouse button at the desired position in the image.

D.1.6.1.4 Circle

To create a circle the center and the radius have to be specified. Press the left mouse button at the center, move the mouse cursor (without pressing the mouse button) to specify the radius and press the left mouse button again to confirm the size of the circle.

D.1.6.1.5 Ellipse

To create an ellipse the corners of the surrounding rectangle have to be specified. Press the left mouse button at the top left-hand corner, move the mouse cursor (without pressing the mouse button) and press the left mouse button again to specify the bottom right-hand corner.

D.1.6.1.6 Polyline

To create a polyline the vertices have to be specified. Press the left mouse button at the starting point, move the mouse cursor to the next position (without pressing the mouse button), press the left button again to confirm the position, and so on. The polyline can be closed by choosing the corresponding entry from the context menu (press right mouse button to display this menu). Open polylines can be created by choosing the "stop" entry from the context menu. Note that only closed polylines can be filled.

D.1.6.1.7 Interpolated Line

To create an interpolated line the vertices have to be specified. Press the left mouse button at the starting point, move the mouse cursor to the next position (without pressing the mouse button), press the left button again to confirm the position, and so on. Open interpolated lines can be created by choosing the "stop" entry from the context menu.

D.1.6.2 Textual Annotation

The DICOM standard defines a variety of options regarding textual annotations: bounding box and/or anchor point, support for multiple lines of text, horizontal text justification, etc. The font type/name and size are not defined in the DICOM standard. These properties are implementation dependent and can be configured for this application (see I.1).

Please note that international character sets are not supported by the current release of the software.

Pressing the icon shown on the left side a dialog for creating a new textual annotation (fig. 23) will appear. Type in the text and set the options you want. Start a new line by pressing Enter/Return. The "orientation" option is used to horizontally justify text of multiple lines.
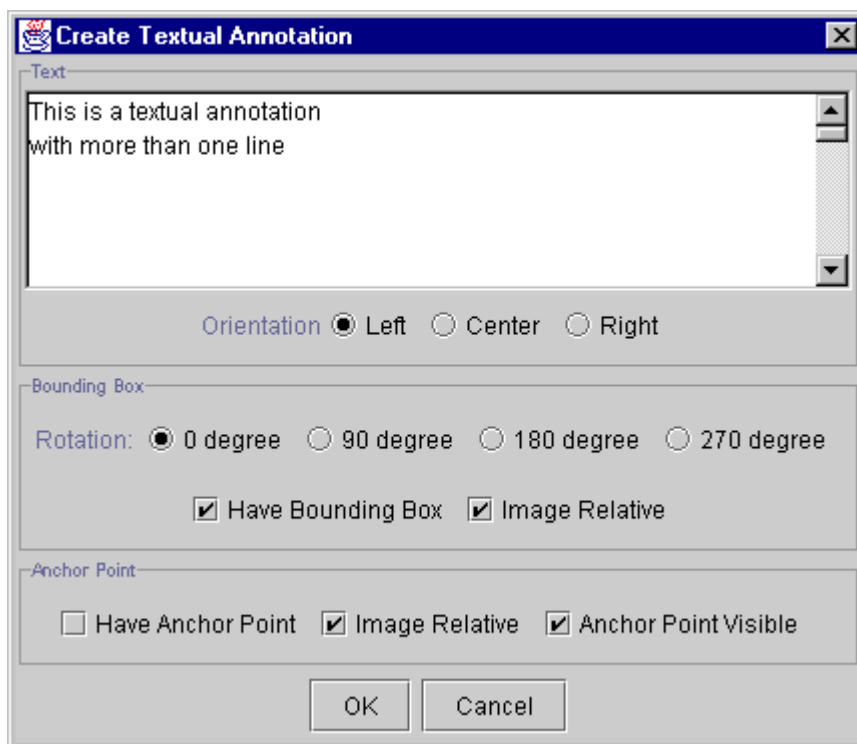
Figure 23: "Create Textual Annotation" Dialog

When the option "have bounding box" is activated the rotation of the text (in steps of 90 degrees) can be specified as well as whether the annotation should be displayed "image relative" or "display relative" (see D.1.6).

An anchor point refers to a specified point in the image. In this implementation a line is draw from the annotation to the point if the anchor point is made "visible". This point can also be specified "image relative" or "display relative" – independent from the bounding box. A good example for this is a display relative bounding box (e. g. in a corner of the image) with an image relative anchor point referring to a region of interest (ROI). When scrolling or zooming the image the textual annotation remains in the corner while the anchor point is moving with the image.

After setting all options the dialog is closed by pressing the "OK" button and the textual annotation can be placed in the image.

D.1.6.3   Edit

The properties of an annotation can be still modified after it has been created. By pressing the icon shown on the left side the "Edit" mode is activated. This is indicated by a "hand" cursor when moving the mouse cursor over the image.

Select the annotation to be modified first (by pressing the left mouse button) and then press the right mouse button to display a context menu. All annotations can be deleted and moved.

D.1.6.3.1   Graphical Annotation

For graphical annotations the additional options „filled" and „image relative" are available. If the option „image relative" is switched off the annotation is drawn „display relative".

D.1.6.3.2 Textual Annotation

For textual annotations a number of modifications are available. The text can be edited, the orientation of the bounding box can be changed, etc. (fig. 24). Furthermore, an anchor point can be moved, removed, added or made visible.
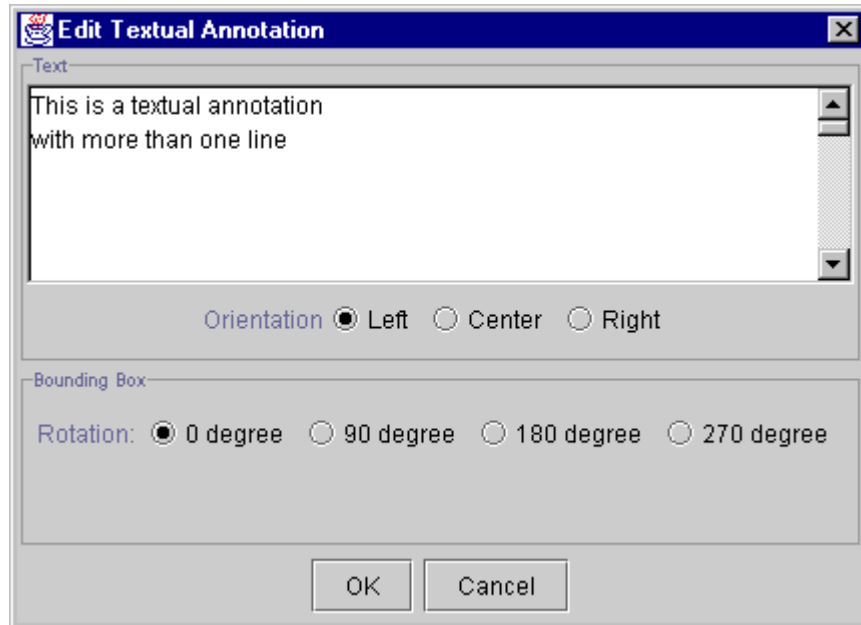
Figure 24: "Edit Textual Annotation" Dialog

D.1.6.3.3 Delete

There are two ways to delete an annotation. The first one has been described in the section "Modify an Annotation" (D.1.6.3). The second one is available via the "Layer Manager" (fig. 20, see D.1.5). Select the layer in which the annotation resides first. Then select the annotation itself and press the "Del" button.

D.1.6.4 Move to another Layer

An annotation is always bound to a specific layer which specifies the order and color in which the annotations are drawn. To move an annotation to another layer the annotation has to be selected in the "Layer Manager" (fig. 20, see D.1.5). Then the layer to which it should be moved has to be selected in the combo box next to the "move to" button and finally the button has to be pressed.

D.1.7   Image Processing Functions

A number of image processing functions is available in the "Processing" panel (fig. 25).

Figure 25: "Processing" Panel

D.1.7.1   Reset

Resets the current presentation state to its last saved state. All changes since then will be lost.

D.1.7.2   Flip

Flips the image horizontally. The current flip status is indicated by the background color of the icon. Mid gray means off, dark gray on.

D.1.7.3   Rotate

Rotates the image by steps of 90 degrees. The current rotation is indicated by the arrow in the icon.

D.1.7.4   Invert

Inverts all grayscale values of the image. If the background color of the icon is dark gray the image is inverted.

D.1.7.5   Presentation LUT

A predefined presentation LUT (for configuration see I.1) or the presentation LUT shape "Identity" can be chosen to be applied to the image. If the background color of the icon is dark gray a presentation LUT is currently selected.

D.1.7.6   GSDF / CIE-lab

Applies a correction curve to the image. Two correction curves are available: the Grayscale Standard Display Function (GSDF) defined in the DICOM standard and additionally the CIELAB curve. If the background color of the icon is dark gray one of the two correction curves is applied to the image.

A monitor characteristics file is required to perform the correction (see I.2). This function is not available on high resolution systems (see I.1).

D.1.7.7 Presentation State

Switches the presentation state on or off. If the background color of the icon is dark gray the presentation state is activated.

D.1.8 Zooming

The "Zoom" panel (fig. 26) provides a number of functions to zoom the image. The current zoom factor is always indicated in the text box on the right. The zoom factor can be entered directly into the text box or changed by using one of the following functions. The aspect ratio of the image is always maintained.

Figure 26: "Zoom" Panel

D.1.8.1 Zoom

The image can be magnified by selecting a rectangular area. The zoomed image usually does not exactly match with the selected area since the aspect ratio of the image is preserved. However, the selected area is always contained in the zoomed image.

D.1.8.2 Fit Image

Zooms the image to fit in the display ("Scale to Fit").

D.1.8.3 Zoom Image 1:1

The image is displayed with a zoom factor of 1. Each pixel value in the image is displayed as one pixel on the display ("1:1").

D.1.9 Window Settings

Images or presentation states may contain VOI LUTs, VOI windows, both or none of them. Per default the first VOI LUT will be selected. If there is no VOI LUT the first VOI window is selected if existing. Otherwise no windowing is performed on the image, i. e. the full range of pixel values is displayed on the screen.

If no VOI LUT is selected the window center and width can be modified by a number of ways. First, the values can be entered directly into the text boxes "c:" and "w:" in the "Window Settings" panel (fig. 27). Second, the window can be specified interactively by moving the mouse cursor over the image while pressing the right mouse button.
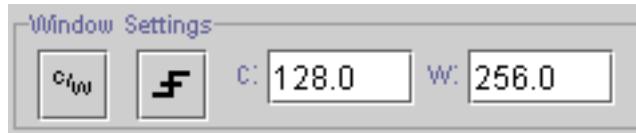
Figure 27: "Window Settings" Panel

D.1.9.1   Interactive

Especially on high resolution monitors the interactive windowing on the whole image might be too slow. Therefore, the windowing can be performed on a small preview image. The "Apply" button applies the current window settings to the whole image. "OK" does the same but also closes the "Preview Window" (fig. 28). Choosing "Cancel" aborts without changing the window center and width values of the original image.
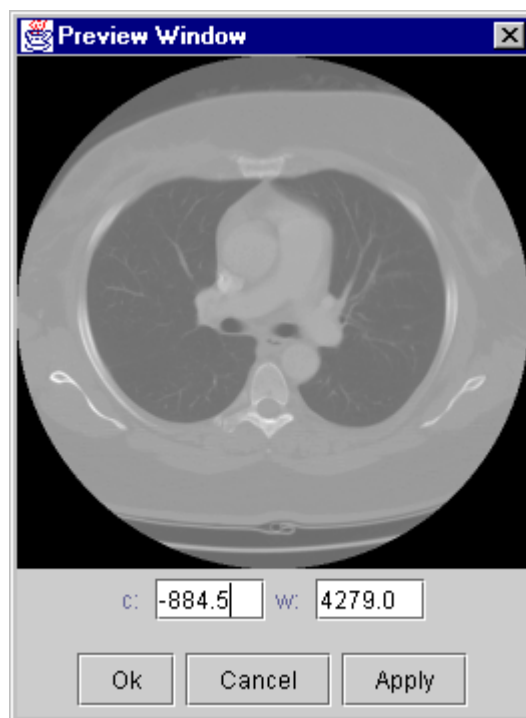
Figure 28: "Preview Window" Dialog

D.1.9.2   Presets

Modality specific presets (I.1), VOI windows or LUTs stored in the image can be selected from this context menu. Furthermore, two automatically computed window settings can be chosen which are always available: "min - max" sets window center and width according to the minimum and maximum pixel value actually existing in the image; "max range" sets the values according to the full pixel range (e. g. for 12 bit signed images to $c / w = 0 / 4096$).

A new VOI LUT with the shape of a gamma function can also be created. Just enter the gamma value into the dialog (fig. 29) and the current VOI settings are replaced by the new LUT.
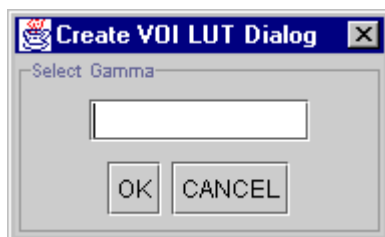
Figure 29: "Create VOI LUT" Dialog

The current VOI settings are permanently displayed in the second sector of the status bar ("VOI:", see D.1.2).

D.1.10 Presentation Size Mode

The "Presentation Size Mode" panel shows and allows to change the presentation size mode of the current image. According to the DICOM standard three different presentation size modes are available:

- **Scale to fit:** The specified displayed area shall be displayed as large as possible within the available area on the window, i. e. magnified or minified if necessary to fit the window space available.
  NB: Changing the presentation size mode to „Scale to fit" will not change the image on the display. This mode is only useful for transferring presentation states to another workstation where the available space to display the image might be different.

- **Magnify:** In this mode the factor that shall be used to spatially interpolate image pixels to create pixels on the display is defined.
  NB: Changing the presentation size mode to „Magnify" will not change the image on the display. This mode is only useful for transferring presentation states to another workstation where the available space to display the image might be different.

- **True Size:** The physical size of the rendered image pixels shall be the same on the screen as specified in the DICOM image or presentation state.
  To use this mode the physical size of the screen (i. e. the active area used for display) has to be defined in the configuration file (see I.1) or in the "Options" dialog (see H.2) and the pixel spacing attribute has to be stored in the DICOM file.

D.1.11 Presentation State Panel

The "Presentation State " panel shows and allows to modify the "Label" and the "Creator" of the current presentation state (fig. 30). It is important to enter at least a meaningful name (description) since this field is used to decided which presentation state should be applied to an image when loaded from the browser (see C.1.2, fig. 4).
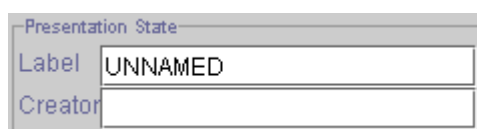
Figure 30: "Presentation State" Panel

D.1.12 Information Panel

The "Information" panel (fig. 31) shows additional information about the loaded presentation state and image, such as resolution of the image, presentation size mode, displayed area and pixel spacing.
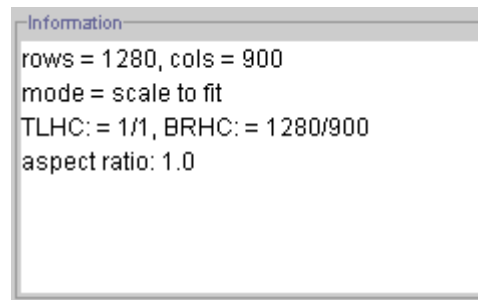
Figure 31: "Information" Panel

D.2 Structured Report

DICOMscope has a "Structured Report Viewer" (fig. 32) which is able to render DICOM Structured Reporting (SR) documents in a human readable HTML form. Images and presentation states referred to by the structured report can be visualized by the "Image Viewer". Furthermore, a user can edit this documents in a "Structured Report Editor". Though the current release of DICOMscope cannot create new reports.

Please note that we assume that the user has at least a basic understanding of DICOM Structured Reporting when using this part of the application.

D.2.1 Structured Report Viewer

The "Structured Report Viewer" (fig. 32) is able to render Structured Reports in a human readable HTML form. The viewer contains a HTML-viewer displaying the currently loaded structured report and a toolbar with various SR specific functions on the top.
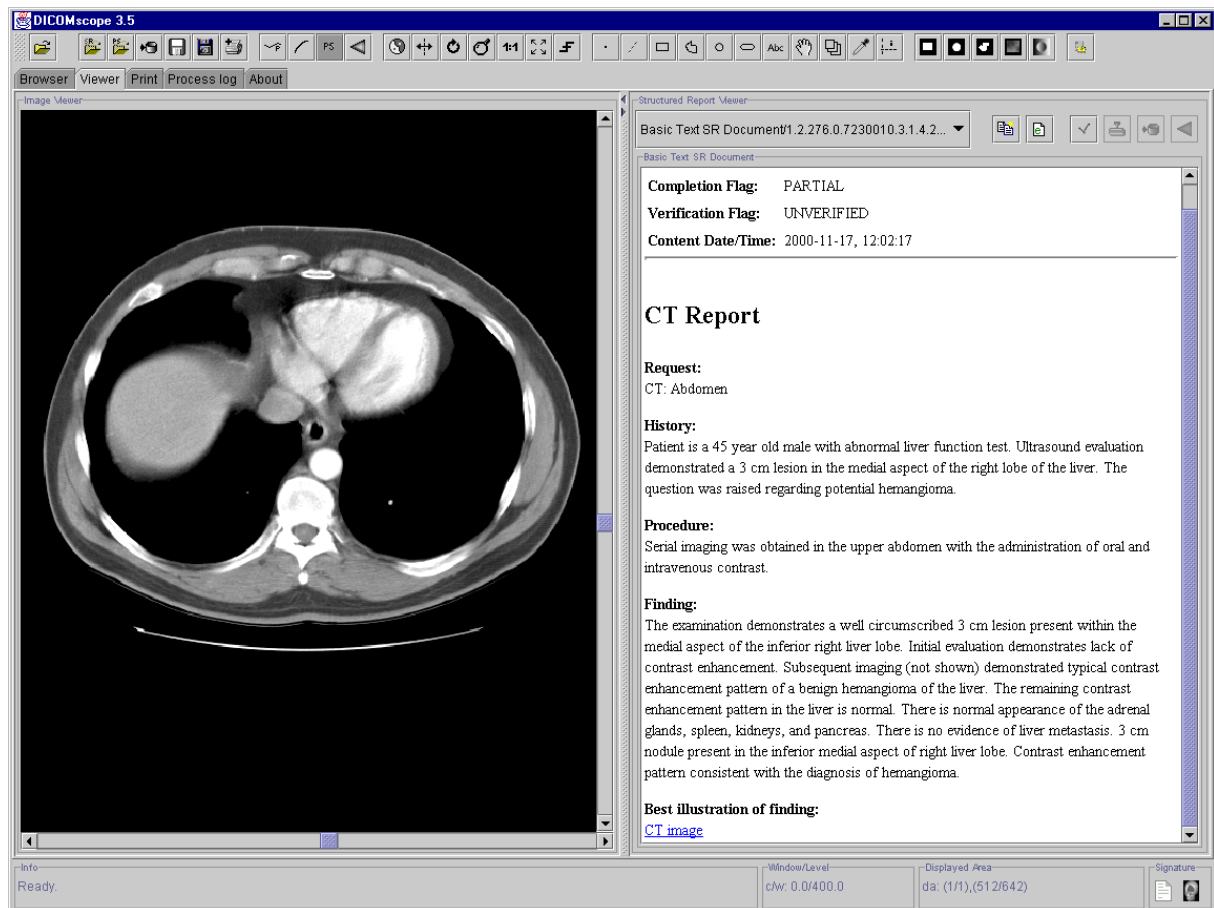
Figure 32: "Structured Report Viewer"

D.2.1.1   HTML Viewer

The "HTML Viewer" (fig. 33) displays the currently loaded structured report.   The first part of the document shows some general header information of the report.   Separated with a horizontal line the document content ("document tree") is rendered as plain HTML with captions, paragraphs and emphasized text blocks.   For a clear representation of the hierarchical structure of an SR document, internal hyperlinks are created automatically, referring to footnotes and annexes (and back to the reference source) when appropriate.
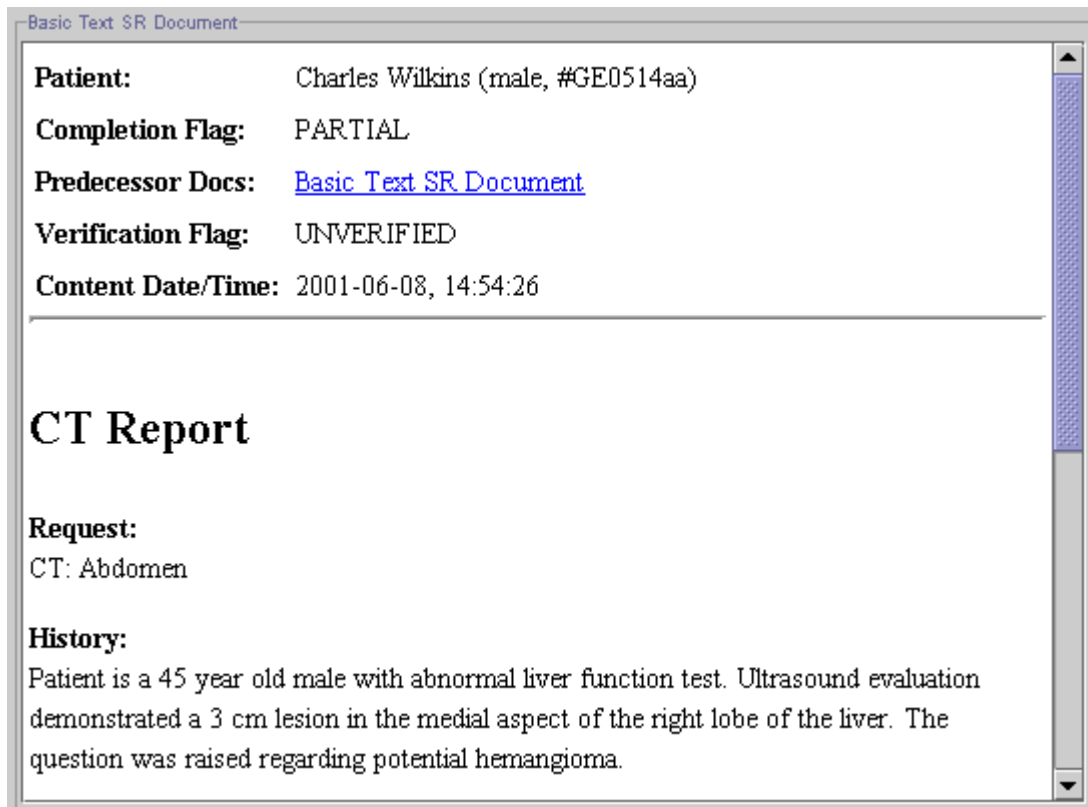
Figure 33: "HTML-Viewer"

References to external objects (COMPOSITE, IMAGE, WAVEFORM) are translated into HTML hyperlinks, but only references to uncompressed monochrome images, grayscale softcopy presentation states and structured reports can be resolved and visualized in the viewer.

The following header information is available:

Patient:	Patient's name, sex, birthdate and ID
Completion Flag:	Indicates when the document is COMPLETE or PARTIAL.
Predecessor Docs:	Contains a list of all the preceding documents (if any). Each document is referenced by means of a hyperlink. This allows to retrace the document history.
Verification Flag:	Indicates if the document is VERIFIED or UNVERIFIED. It also displays a list of all verifying observers (if any).
Content Date/Time:	Date and time of the document creation.

D.2.1.2 Toolbar

At the top there is a toolbar with a number of icons representing some general functions of the "Structured Report Viewer " (fig. 34).
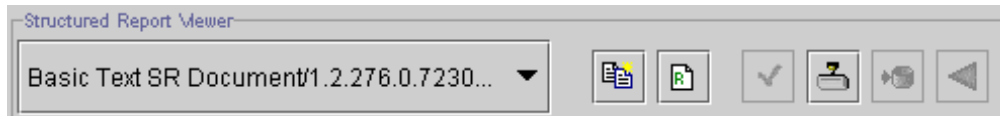
Figure 34: "Structured Report Viewer" Toolbar

In the combo box a reference to the currently loaded document and a list of all previously created versions is shown. Any previous document version can be reloaded via this combo box.

D.2.1.2.1 Copy to Clipboard

Copies the selected area in the "HTML Viewer" to the clipboard.

D.2.1.2.2 Revise

Creates a new revised structured report from the current document and displays it in the "Structured Report Editor". The completion flag of the new document is set to PARTIAL and the verification flag to UNVERIFIED. Furthermore, the list of verifying observers is cleared and all digital signatures (if any) are removed from the report. Finally a reference to the previous document version is added to the list of predecessor document. Please note that only COMPLETE reports can be revised.

D.2.1.2.3 Edit

Switches to the "Structured Report Editor". Please note that only PARTIAL reports can be modified – COMPLETE documents are "revised" instead.

D.2.1.2.4 Complete Document

Completes the current structured report. A "Complete Document" dialog appears where an optional description can be entered.

D.2.1.2.5 Verify Document

Verifies the current structured report and adds the selected person to the list of verifying observers. This function is available only if the structured report is COMPLETE. For more details on the verification of documents and a description of the "Verify Document" dialog see chapter G.

D.2.1.2.6 Save document to Database

Saves the current structured report to the database.

D.2.1.2.7 Reset Document

 Resets the structured report to last saved state.

D.2.2 Structured Report Editor

The "Structured Report Editor" (fig. 35) allows to modify DICOM Structured Reporting documents. It visualizes the document tree and has some functionality for manipulation.

Each time the editor is activated a new document instance is created.
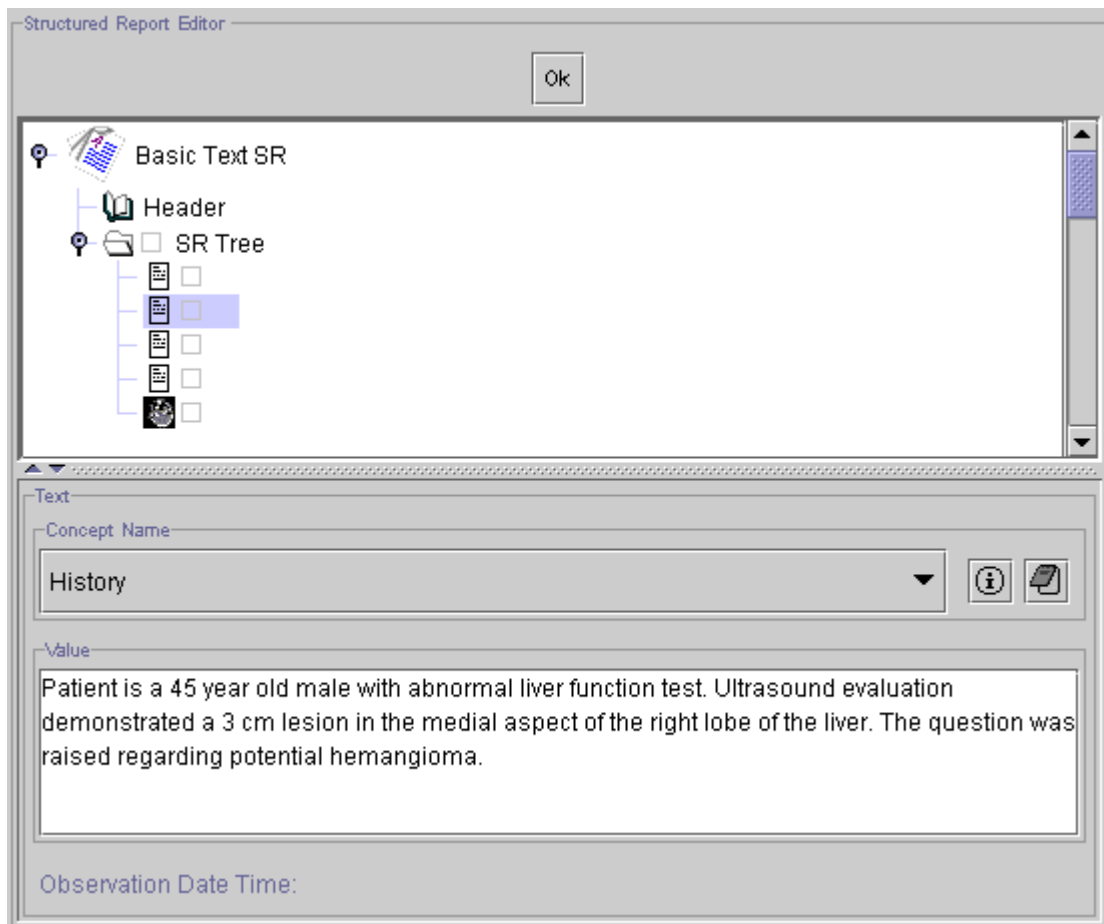
Figure 35: "Structured Report Editor"

D.2.2.1 Tree View

The document tree of a DICOM Structured Report is defined as an acyclic directed graph where the nodes are called "Content Items" and the edges symbolize "Relationships". The "Tree View" visualizes the structure of the report as a tree and allows both to delete and to insert content items into the document tree. The content / value of the currently selected content item is displayed in the "Item Editor" below the "Tree View".

The tree always consists of a root node labeled with the SOP Class name of the structured report (e. g. "Basic Text SR") and of at least two additional nodes. The first node, the "Header", allows to visualize and modify particular document header information (see D.2.2.2.2). The node "SR Tree" is the root container of the document and, therefore, always present. All other content items are child nodes of the "SR Tree".

Each node in the SR Tree consists of tree parts: An icon, identifying the (value) type of the content item, a small box and in some cases also a name representing the relationship between the connected content items. The small box indicates whether the content item is selected to be digitally signed (see G.3).

The following table shows all value types as defined in the DICOM standard (version 2000) and supported by this release of DICOMscope.

Icon	Value Type
📄	TEXT
123	NUM
🔤	CODE
🕐	DATETIME
17.	DATE
🕐	TIME
REF	UIDREF
👤	PNAME
🗂	COMPOSITE
🖼	IMAGE
⎷	WAVEFORM
📊	SCOORD
🔴	TCOORD
📁	CONTAINER

Table 1: "Value Types"

D.2.2.1.1 Insert Content Items

To insert a new content item into the document tree select a (source) node first and then click on the right mouse button. A popup menu appears (fig. 36). This menu contains the sub menus "Below", "Before" and "After" describing the position of the new content item in relation to the currently selected one ("Below" means to add a new child node, "Before" / "After" means to add a new sibling node directly before / after the current node). In each of these sub menus a combination of relationship types and (target) value types can be selected. Only combinations which are allowed according to the current SR document class are listed (see DICOM standard for details).
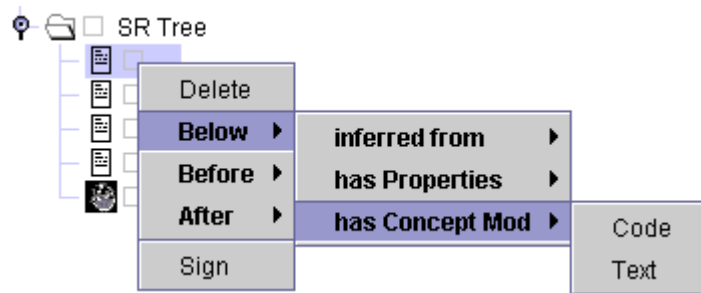
Figure 36: "Edit Tree" Menu

D.2.2.1.2 Delete Content Items

Apart from the three standard nodes (see above) each node in the tree can be deleted by selecting "Delete" from the popup menu.

D.2.2.1.3 Select Content Items to be Digitally Signed

The content items which are to be signed with a digital signature can be selected from the "Tree View". Use the entry "Sign" or "UnSign" respectively from the popup menu which appears by clicking the right mouse button. The small boxes in the tree indicate for each content item whether it will be digitally signed (green check mark) or not (empty gray box) when using the "Verify Document" function (see D.2.1.2.5).

If no content item is marked, the whole document (all content items) will be signed.

D.2.2.2 Item Editor

In the "Item Editor" the majority of value types and a selection of common header entries can be modified. When selecting a particular node from the tree the "Item Editor" changes its appearance depending on the value type of this content item. The editor component for each of the value types is described below.

The "Item Editor" itself consists of three parts (from top to bottom): the "Concept Name Editor", the editor component for the different value types and the observation date and time which cannot be modified.

D.2.2.2.1 Concept Name Editor

The "Concept Name Editor" (fig. 37) allows to modify the concept name of the currently selected content item. The current value (code meaning only) is displayed in the combo box. Additional predefined values can be selected from the list. The selection is "context group" dependent and can be extended by editing the simple text file"codes.dic" which is stored in the application folder.
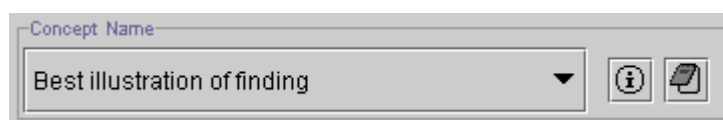
Figure 37: "Concept Name Editor"
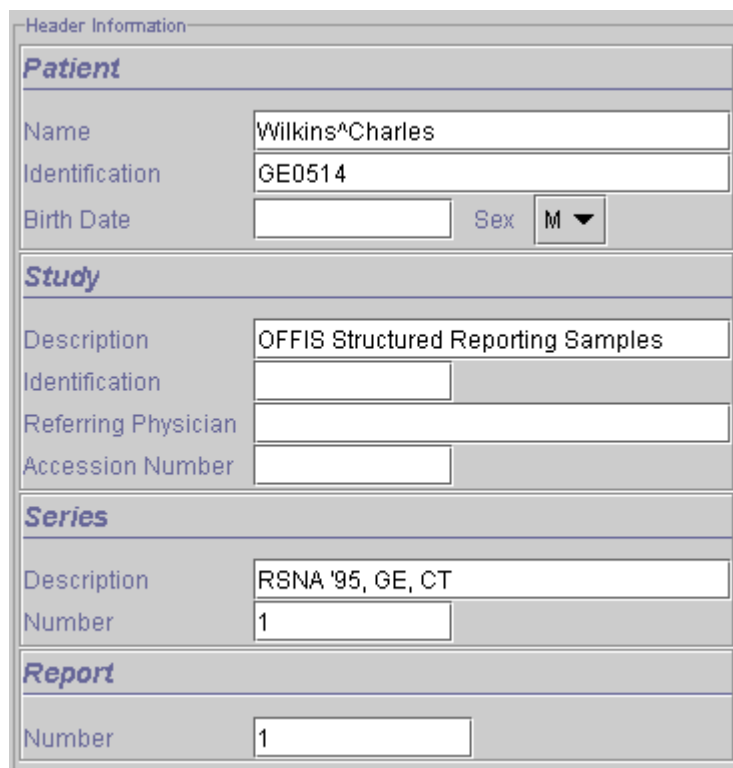
The following functions are also available:

Show Code. Displays the full information (code value, code meaning, coding scheme designator and coding scheme version) of the concept name code.

Insert Code. Add a new entry to the list of available codes (marked with a "*").

D.2.2.2.2   Header Information

The "Header Information" panel (fig. 38) shows a set of attributes which can be modified. The edit boxes automatically check for the DICOM value representation restrictions.

Figure 38: "Header Information" Panel

D.2.2.2.3 Edit TEXT

The panel for the value type TEXT (fig. 39) displays and allows to modify the textual value according to the DICOM value representation "UT".
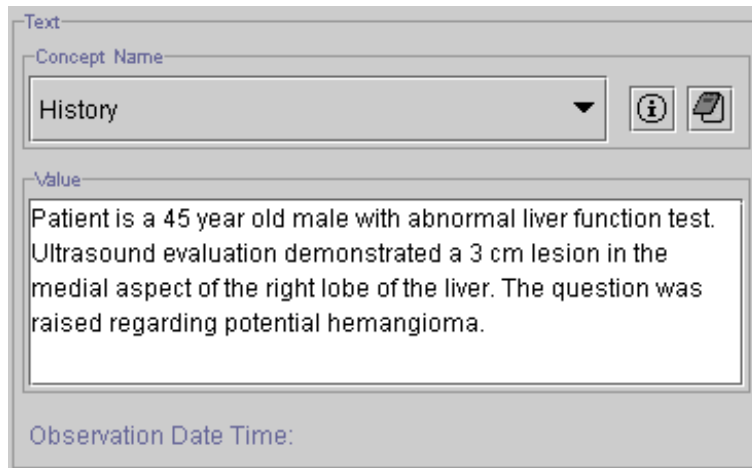
Figure 39: "Edit TEXT" Panel

D.2.2.2.4 Edit NUM

The panel for the value type NUM (fig. 40) displays the "Numeric Value" in a text box and the "Measurements Unit" as a code (similar to the "Concept Name Editor" as described in D.2.2.2.1). Both values can be modified. For the numeric value the corresponding DICOM value representation "DS" is checked.
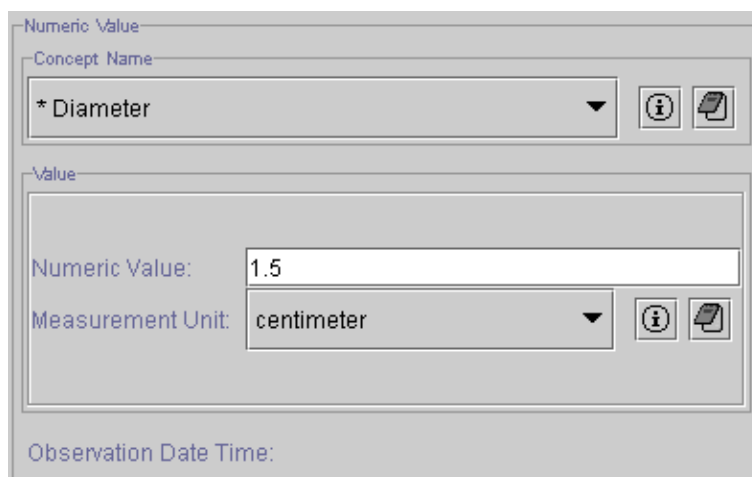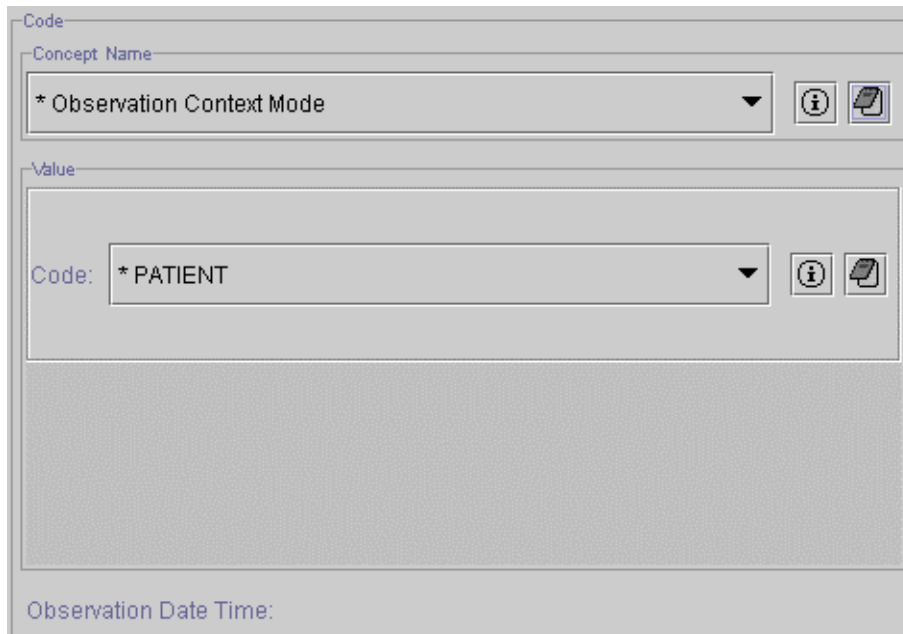
Figure 40: "Edit NUM" Panel

D.2.2.2.5 Edit CODE

The panel for the value type CODE (fig.41) works similar to the "Concept Name Editor" as described in D.2.2.2.1.
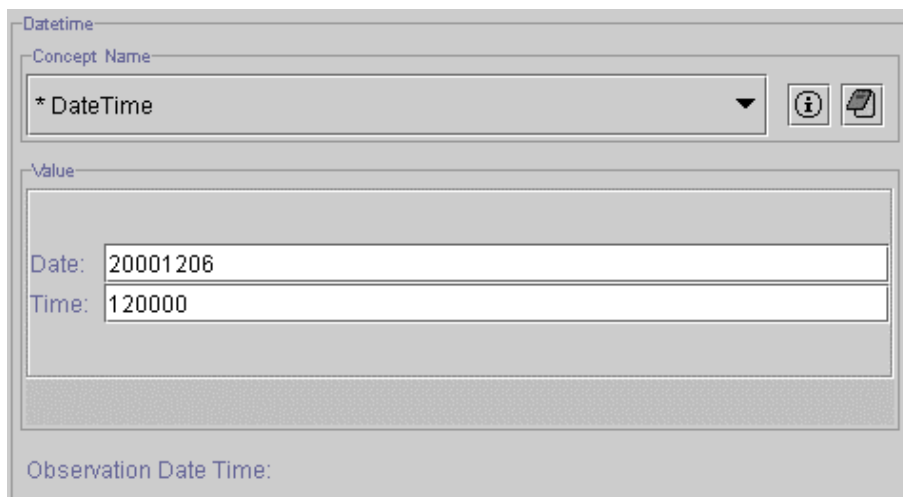
Figure 41: "Edit CODE" Panel

D.2.2.2.6 Edit DATETIME

The panel for the value type DATETIME (fig. 42) displays and allows to modify the numeric values for date and time according to the DICOM value representation "DT".
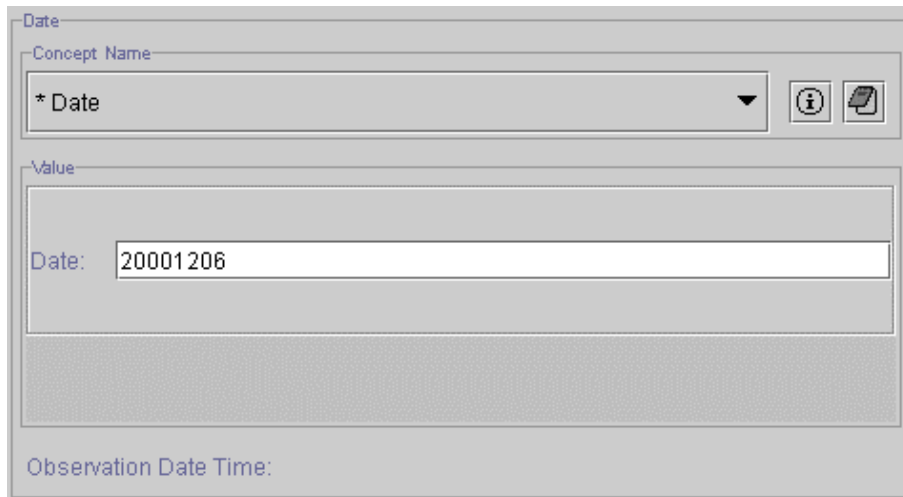
Figure 42: "Content Item DATETIME" Panel

D.2.2.2.7 Edit DATE

The panel for the value type DATE (fig. 43) displays and allows to modify the numeric value for the date according to the DICOM value representation "DA".
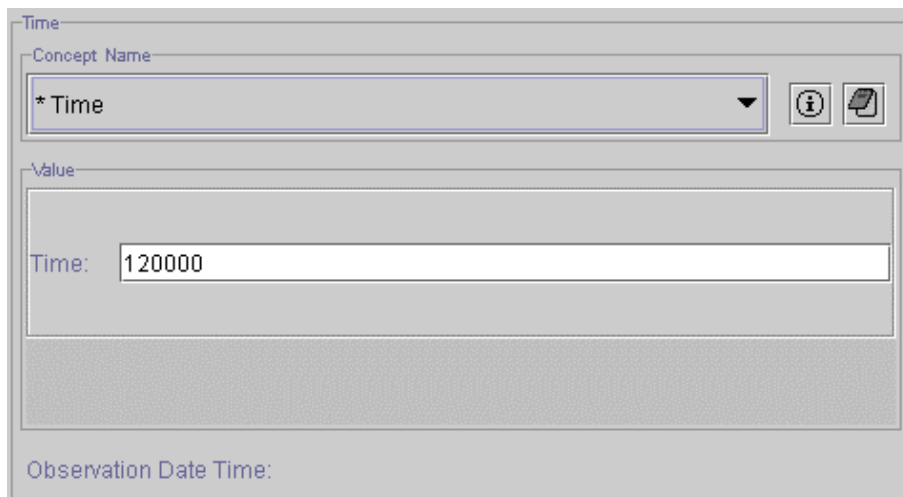
Figure 43: "Edit DATE" Panel

D.2.2.2.8 Edit TIME

The panel for the value type TIME (fig. 44) displays and allows to modify the numeric value for the time according to the DICOM value representation "TM".

Figure 44: "Edit TIME" Panel

D.2.2.2.9 Edit UIDREF

The panel for the value type UIDREF (fig. 45) displays and allows to modify the textual value for the unique identifier according to the DICOM value representation "UI".
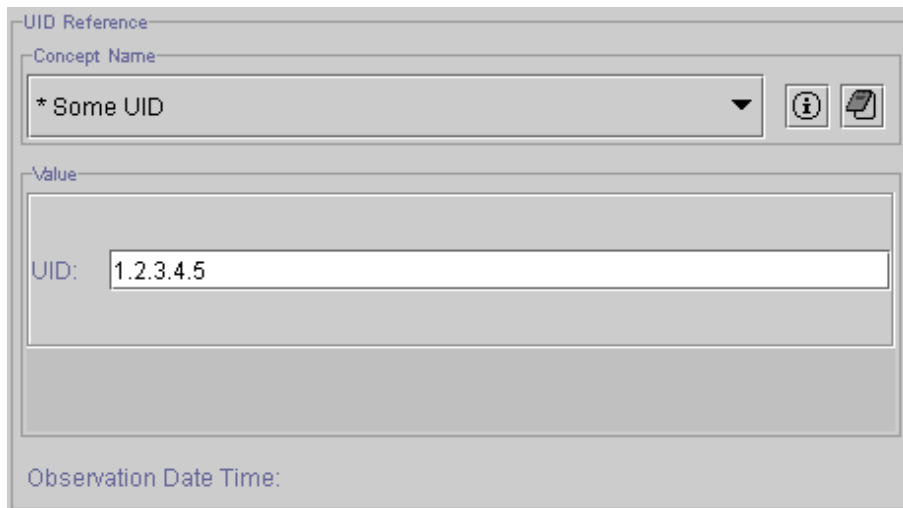
Figure 45: "Edit UIDREF" Panel

D.2.2.2.10 Edit PNAME

The panel for the value type PNAME (fig. 46) displays and allows to modify the textual value for the person name according to the DICOM value representation "PN".
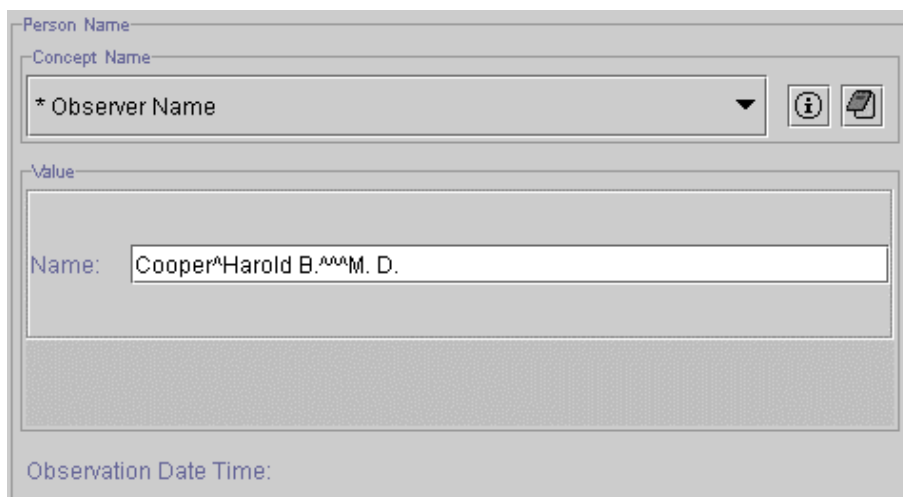
Figure 46: "Edit PNAME" Panel

D.2.2.2.11 Edit COMPOSITE

The panel for the value type COMPOSITE (fig. 47) displays the "SOP Class Name" and the "SOP Instance UID" of the referenced object. In the current release there is no possibility to modify the value on the user interface.

Figure 47: "Edit COMPOSITE" Panel

D.2.2.2.12 Edit IMAGE

The panel for the value type IMAGE (fig. 48) displays the "SOP Class Name" and the "SOP Instance UID" of the referenced image and the SOP instance UID of the associated presentation state (if any). The "Show " button loads the referenced image and displays it together with the associated presentation state (if available). "Set Image" sets the reference to the currently loaded image and "Set PState" sets the reference to both the currently loaded image and the active presentation state (which is automatically stored to the database).
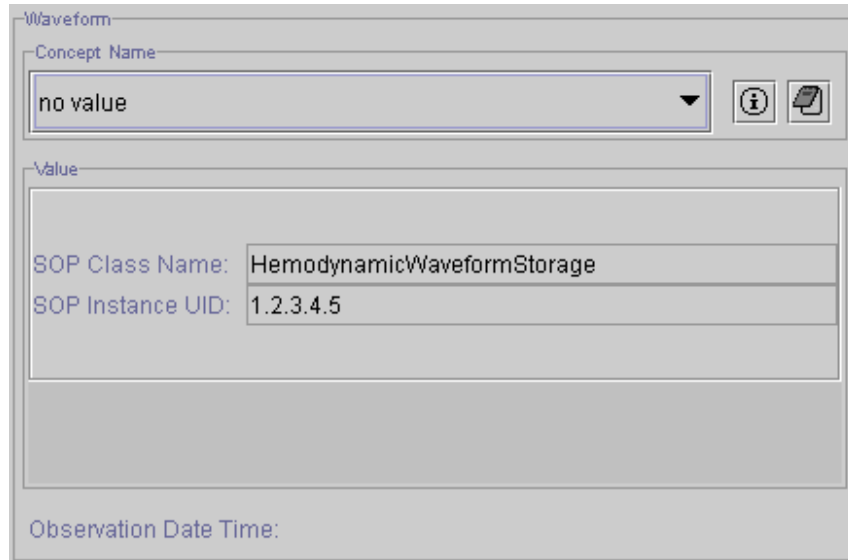
Figure 48: "Edit IMAGE" Panel

D.2.2.2.13 Edit WAVEFORM

The panel for the value type WAVEFORM (fig. 49) displays the "SOP Class Name" and the "SOP Instance UID" of the referenced waveform object. In the current release there is no possibility to modify the value on the user interface.
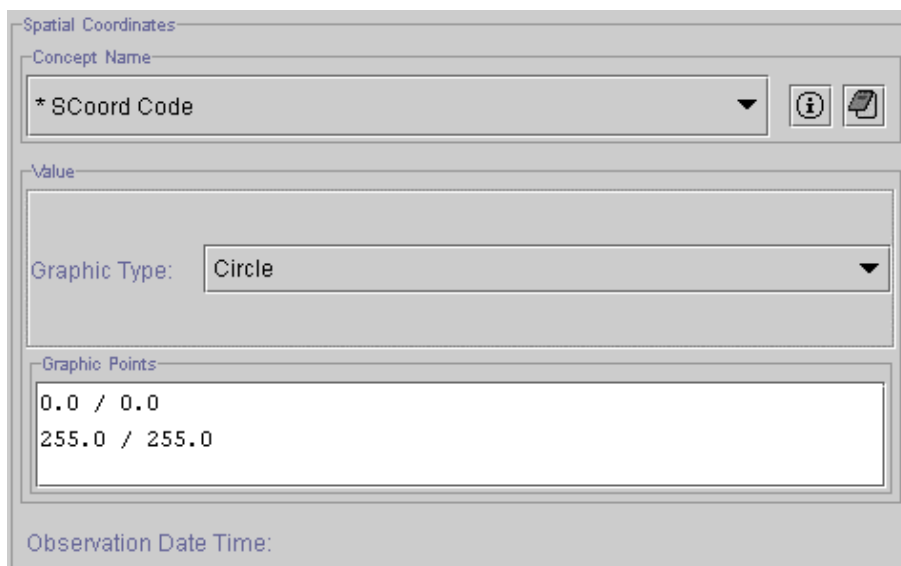
Figure 49: "Edit WAVEFORM" Panel

D.2.2.2.14 Edit SCOORD

The panel for the value type SCOORD (fig. 50) displays the "Graphic Type" in a combo box and the list of "Graphic Points" (spatial coordinates). In the current release the spatial coordinates cannot be modified and are not displayed in the "Image Viewer".

Figure 50: "Edit SCOORD" Panel

D.2.2.2.15 Edit TCOORD

The panel for the value type TCOORD (fig. 51) displays the "Temporal Range Type" in a combo box. The temporal coordinates are neither displayed nor alterable.

Figure 52: "Edit TCOORD" Panel

D.2.2.2.16 Edit CONTAINER

The panel for the value type CONTAINER (fig. 52) displays and allows to modify the value of the "Continuity of Content" flag which is SEPARATE or CONTINUOUS.

Figure 52: "Edit CONTAINER" Panel

D.2.3   Create Digital Signature

DICOMscope is able to create Digital Signatures on DICOM Structured Reports according to the proposed DICOM Supplement 41 (draft 09). The creation of signatures is implemented as part of the verification process. The reason for this is that the verification and the digital signing are complementary (in our opinion). When a document is verified the name of the verifying observer is added to the document. The digital signature makes this process secure by providing a lifetime integrity check for the document.

Only completed structured reports can be verified and signed. Only if a structured report is complete the "Verify" button in the "Structured Report Viewer" (see D.2.1) is enabled. The corresponding "Verify Document" dialog (fig. 53) lists all known users (see I.1 for configuration) and allows to select one of them. The "Verify" button invokes a "Login" dialog where the correct password[3] for the selected user has to be entered in order to proceed.
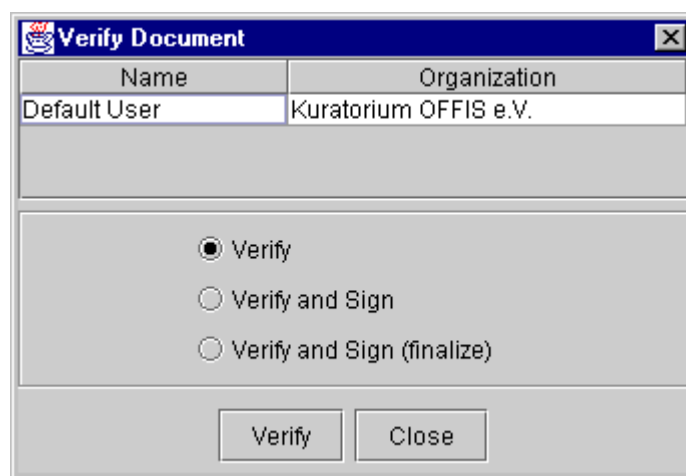
Figure 53: "Verify Document" Dialog

The following options are available:

- **Verify:** The structured report is verified, i. e. the verification flag is set to VERIFIED and the selected user is added to the list of verifying observers.

- **Verify and Sign:** In addition to the verification the document is also digitally signed. Only content items which are marked in the "Structured Report Editor" (see D.2.2.1.3) are signed. If no content item is marked all items are signed. A set of DICOM attributes (e. g. SOP instance UID) which is always modified when a new version of a report is created is never signed. This allows to verify and sign a document more than once.

- **Verify and Sign (finalize):** In contrast to the previous option the entire document is signed independent of any selection in the "Structured Report Editor". This operation can be applied to a structured report only once[4]. When trying it for the second time a warning dialog will be displayed.

---

[3] Leave the "Password" field blank when using the "Default User" as configured in the DICOMscope standard distribution.

[4] The reason for this is that the verification flag is part of the header information. If the entire structured report is signed, the verification flag is signed as well and cannot be changed any more.

E Print

The "Print" component (fig. 54) is used to manage all print related tasks. Hardcopy grayscale images added from the browser or the viewer are collected here in a print queue before being sent to a printer. The print queue consists of a number of pages. The first page is visualized using the selected layout and previews of the hardcopy images. When printing a stored print object is created and added to the database.

The "Print" component is divided into two parts. On the left side there is a preview of the first page in the print queue. New images are added to the end of the queue. On the right side there is a tabbed panel with two entries ("Main" and "Additional") allowing to modify the print related settings.

The "Print" component is also used to display the contents of a stored print object (and the hardcopy grayscale images referenced by it) loaded from the browser.
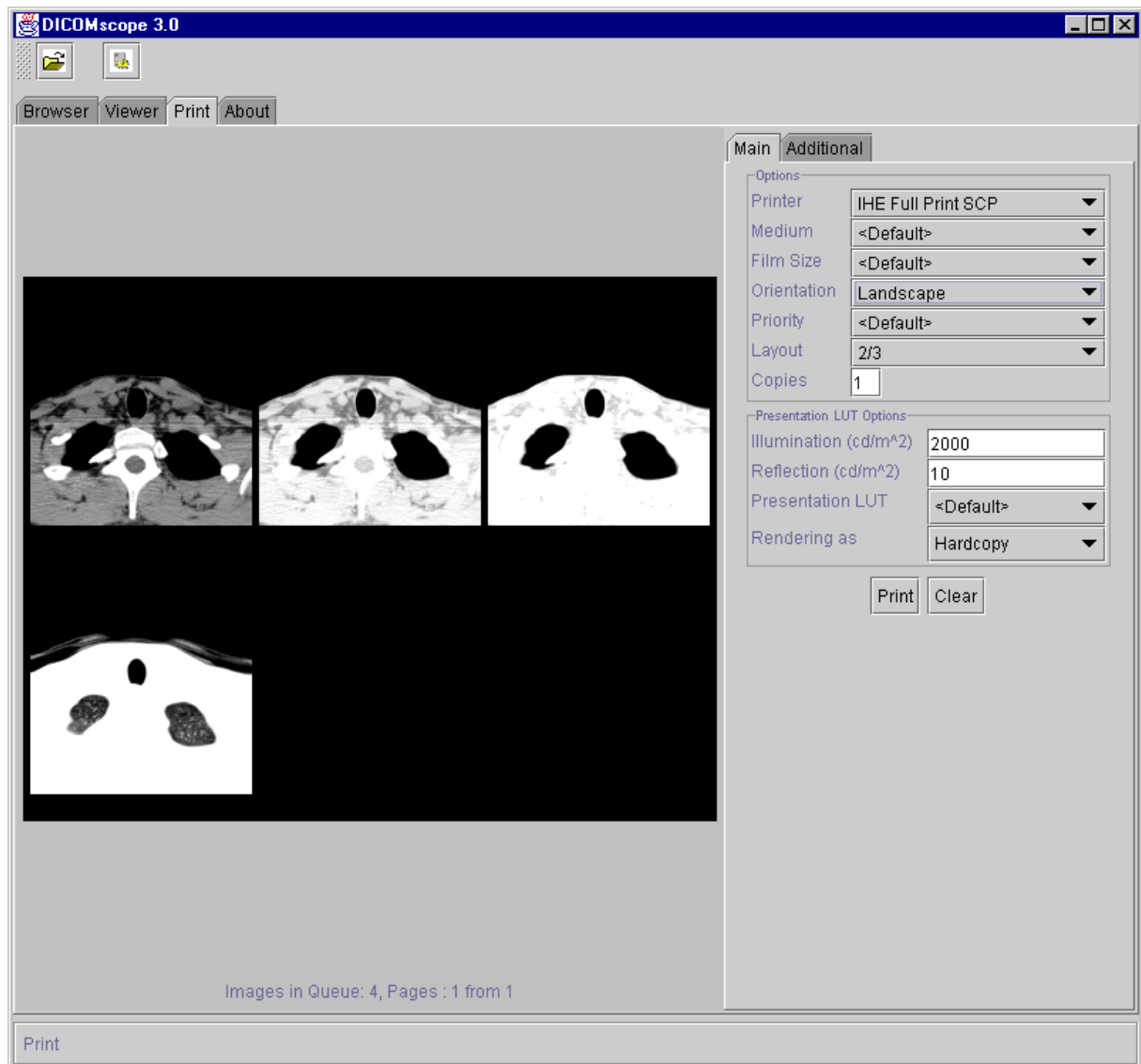
Figure 54: "Print" Component

E.1 Main Options

In this panel (fig. 55) the main printer options can be set (see table 1 for a description). Most of them are printer dependent and can be configured (see I.1). "<Default>" means that no value is sent to the printer.
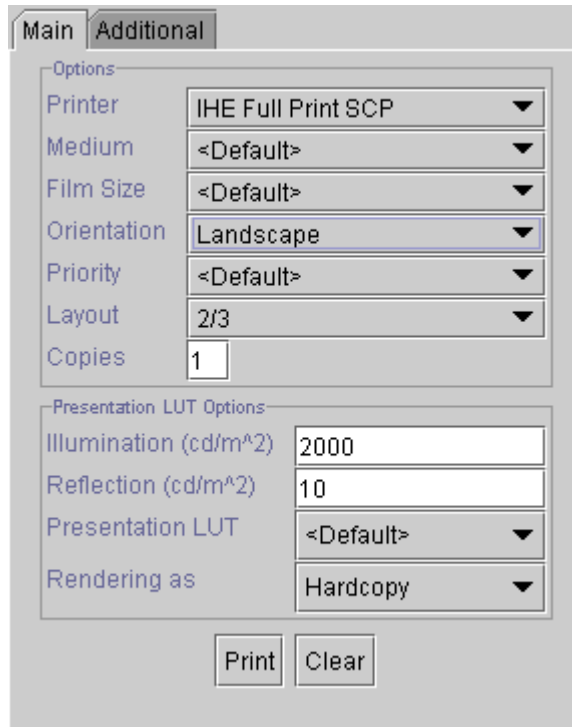
Figure 55: "Main" Print Options Panel

By pressing the "Print" button the first page of the print queue will be sent to the current printer using the currently selected options. By pressing the "Clear" button the current print queue will be cleared.

When loading a stored print object from the browser a new panel appears (fig. 56). Before it is possible to modify any setting and send the print job again a printer has to be selected.
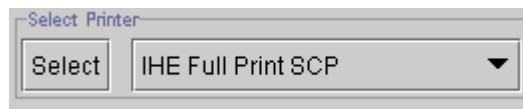
Figure 56: "Select Printer" Panel

E.2 Additional Options

In this panel (fig. 57) additional printer options can be set (see table 2 for a description, below the thick horizontal line). Most of them are printer dependent and can be configured (see I.1). "<Default>" means that no value is sent to the printer.

The attributes "Magnification", "Smoothing" and "Configuration" can also be changed for each image by double-clicking the corresponding preview image.
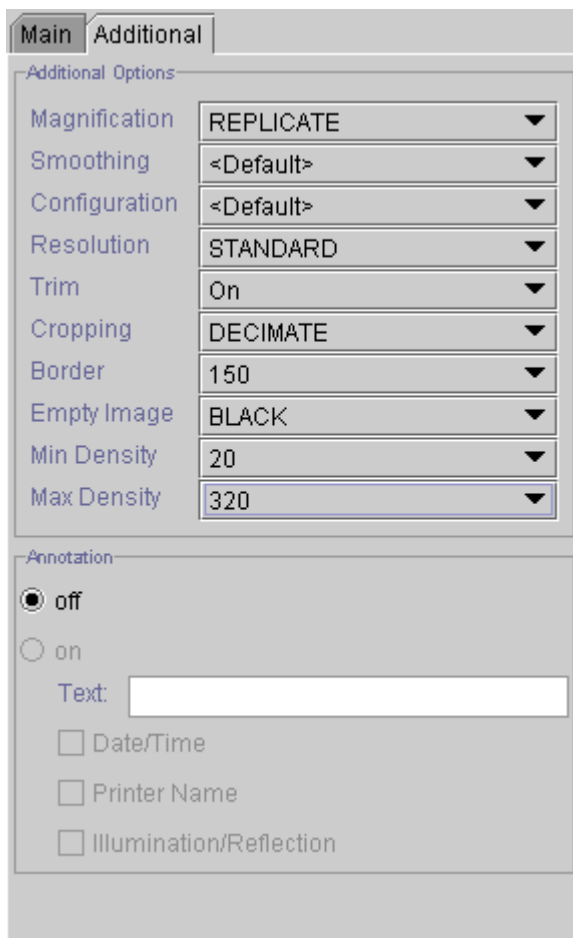
Figure 57: "Additional" Print Options Panel

Attribute	Description
Printer	All available printers (local and remote ones) are listed here. The first page of the print queue will be sent to the currently selected printer when pressing the "Print" button.
Medium	Medium Type identifiers supported by the current printer. Possible values are: "PAPER", "CLEAR FILM", etc.
Film Size	Film Size ID identifiers supported by the current printer. Possible values are: "14INx14IN", "17INx14IN", etc.
Orientation	Orientation of the film/paper. The following values are available: "PORTRAIT", "LANDSCAPE" and "<Default>".
Priority	Priority used by the printer to handle the print job. The following values are available: "HIGH", "MED", "LOW".
Layout	Layout of the current print page. Defined for portrait orientation. Possible values are: "1/1", "1/2", etc.
Copies	Number of copies to be printed .
Illumination	Illumination to be transmitted to the printer when using the Presentation LUT SOP Class.
Reflection	Reflected Ambient Light to be transmitted to the printer when using the Presentation LUT SOP Class.
Presentation LUT	Override the presentation LUT settings made for each image individually, "<Default>" means to use the individual settings.
Rendering as	The interpretation of presentation look-up tables is slightly different for softcopy (implicit scaling of the input width of the table) and hardcopy (no implicit scaling). Therefore, it is possible to choose.
Magnification	Magnification Type identifies supported by the current printer. Possible values are: "REPLICATE", "BILINEAR", "CUBIC", etc.
Smoothing	Smoothing Type identifies supported by the current printer.
Configuration	Configuration Information that can be sent to the current printer.
Resolution	Resolution identifies supported by the current printer. Possible values are: "STANDARD", "HIGH", etc.
Trim	If the current printer supports the Trim attribute then this attribute can be enabled or disabled.
Cropping	If the current printer supports the Cropping attribute then this attribute can be enabled or disabled.
Border	Border Density identifiers supported by the current printer. Possible values are: "BLACK", "WHITE", "20", etc.
Empty Image	Empty Image Density identifiers supported by the current printer. Possible values are: "BLACK", "WHITE", "20", etc.
Min Density	Min Density values supported by the current printer. Possible values are: "330", "290", etc.
Max Density	Max Density values supported by the current printer. Possible values are "20", "40", etc.
Annotation	Annotations added to the print out if supported by the current printer. Add the current date / time, the printer name and the Illumination / Reflection value by activating the corresponding checkboxes. Additionally a free text can be entered. NB: There is a limitation of the total length of such annotations for most printers.

Table 2: Printer Attributes

F Process Log

DICOMscope handles the transfer of DICOM instance in separate communication processes. This component logs information of the DICOM communication processes. The "Process Log" (fig. 58) consists of two parts. The "Process Table" contains general information about the status of each process. Below it there is an "Information Panel" available which displays detailed information about the selected entry in the "Process Table".
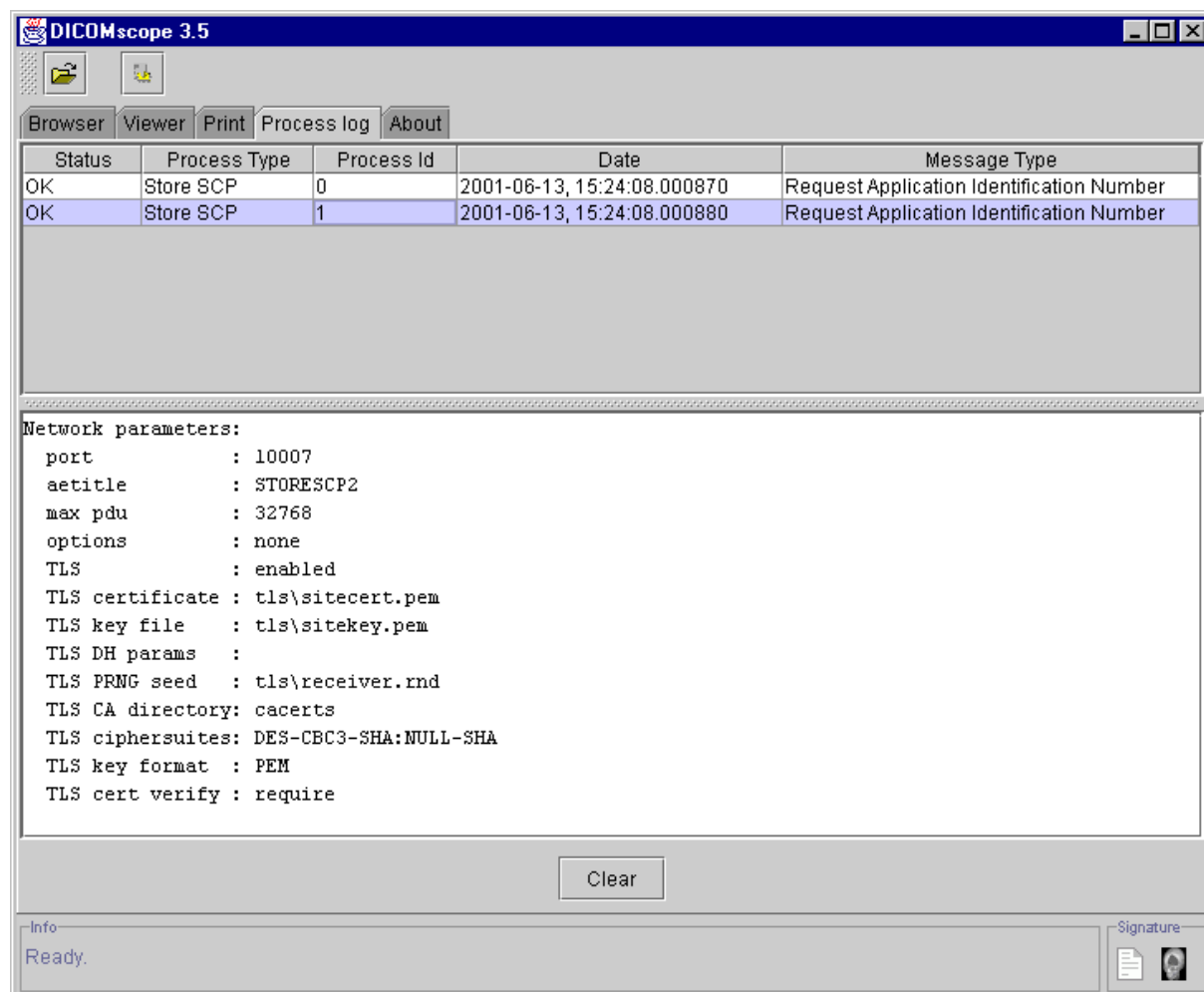
Figure 58: "Process Log" Component

F.1 Process Table

The "Process Table" contains general information about the status of each communication process. The process log contains the following columns:

Status	OK if the operation is completed successfully, ERROR otherwise.
Process Type	Type of the process. The following types are currently supported: Store SCU and Store SCP

Process ID	Integer value, unique identifier for each communication process. All the messages sent during one communication process share the same Process ID.
Date	Date and time when the message has been sent.
Message Type	REQUEST_APPLICATION_IDENTIFICATIONNUMBER This message appears after the communication process has started. Detailed information about this communication process can be displayed in the Information Panel.
	APPLICATION_TERMINATES This message appears after the communication process is terminated. In this case, all DICOM associations are terminated as well.
	RECEIVED_UNENCRYPTED_DICOM_CONNECTION This message appears after the communication process has received an unencrypted DICOM connection.
	RECEIVED_ENCRYPTED_DICOM_CONNECTION This message appears after the communication process has received an encrypted DICOM connection.
	DICOM_CONNECTION_CLOSED This message appears after a DICOM association has closed normally.
	DICOM_CONNECTION_ABORDED This message appears after the DICOM association has been aborted.
	REQUESTED_UNENCRYPTED_DICOM_CONNECTION This message appears after the communication process has requested an unencrypted DICOM connection.
	REQUESTED_ENCRYPTED_DICOM_CONNECTION This message appears after the communication process has requested an encrypted DICOM connection.
	RECEIVED_DICOM_OBJECT This message appears after a DICOM object has been received.
	SENT_DICOM_OBJECT This message appears after if a DICOM object has been sent.

F.2 Information Panel

The "Information Panel" displays detailed information about the selected row in the "Process Table". Use the "Clear" button when the list of processes becomes confusing.

G Digital Signatures

DICOMscope supports DICOM digital signatures according to the proposed supplement 41. Each time a new instance is loaded any[5] contained digital signature is checked and the status is displayed in the "Digital Signature" dialog (fig. 59).
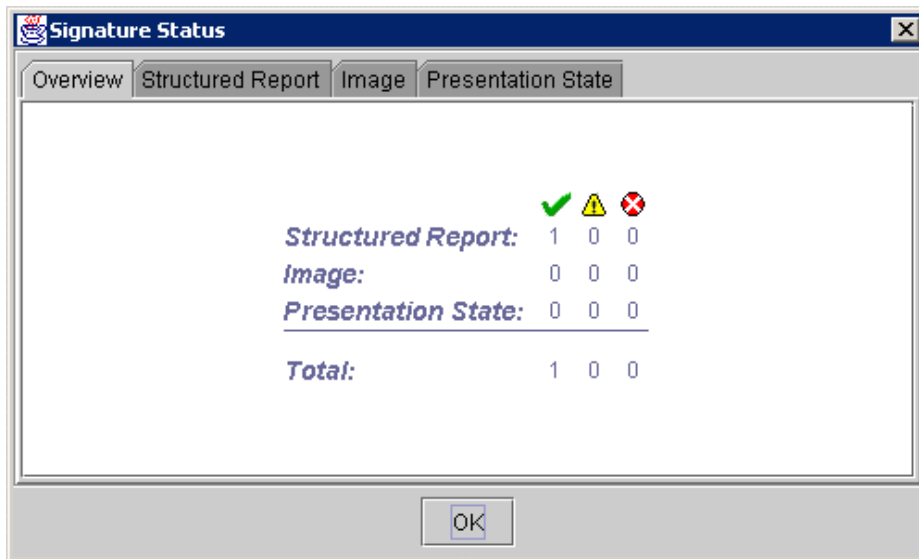
Figure 59: "Signature Status" Dialog

The application distinguishes the following status for digital signatures:

Valid	The verification of the digital signature is successful. An object has obtained this status if all digital signatures are valid.
Untrustworthy	The digital signature is valid but the certificate could not be verified. In this case, DICOMscope is unable to get the local issuer certificate. An object has obtained this status when all digital signatures are valid but when at least one digital signature is untrustworthy.
Invalid	The verification of the digital signature has failed. In this case, the signature is invalid and the document corrupted. An object has obtained this status if at least one digital signature is invalid.

---

[5] DICOM digital signatures can be applied to the whole object or to parts of it. There can be more than one signature in a DICOM object.

G.1 Signature Status Bar

The overall signature status of the currently loaded DICOM object is displayed in the "Signature Status" Bar (fig. 60), separated by report and image / presentation state. The same symbols as in the "Signature Status Overview" (fig. 59) are used to visualize whether the signatures are valid, untrustworthy or invalid.

Figure 60: "Signature Status" Bar

By clicking on one of the icons the "Signature Status" dialog is displayed with more detailed information about the signatures in the loaded objects (see below).

G.2 Signature Status Dialog

The "Signature Status" dialog (fig. 61) contains detailed information about the digital signatures in the loaded objects. The "Overview" panel shows the number of valid, invalid and untrustworthy digital signatures for each loaded object (see fig. 59). In addition each object type ("Structured Report", "Image" and "Presentation State") has its own panel containing the relevant signature information.
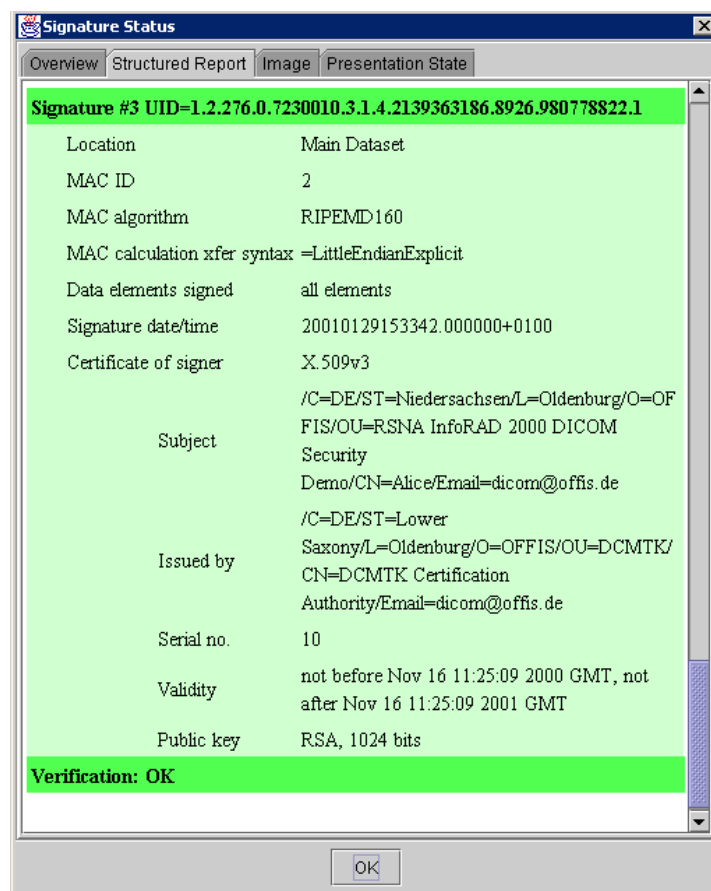
Figure 61: "Signature Status Overview" Panel

For each digital signature the following information is displayed:

Name	Description
Location	The location of the digital signature in the DICOM object. Digital signatures can be located at the "Main Dataset" or in any sequence.
MAC ID	A number used to identify the Message Authentication Code AC Parameters Sequence item.
MAC algorithm	The algorithm used in generating the Message Authentication Code to be encrypted to form the Digital Signature. Defined Terms: • RIPEMD160 • MD5 • SHA1
MAC calculation transfer syntax	The Transfer Syntax UID used to encode the values of the Data Elements included in the Message Authentication Code calculation. Only Transfer Syntaxes that explicitly include the VR and use Little Endian encoding will be used.
Data elements signed	Contains a list of all signed attributes. This can contain all attributes or only a part.
Signature date/time	Contains the date and the time on which the signature was created.
Certificate of signer	A certificate that holds the identity of the entity producing this Digital Signature, that entity's public key or key identifier, and the algorithm and associated parameters with which that public key is to be used
Subject	Identity of the user.
Issued by	Identify of the certification authority
Validity	Validity of the certificate
Public key	Message Authentication Code encoding algorithm and the associated parameters.

G.3 Create Signatures

The current release of DICOMscope is able to create DICOM digital signatures for structured reports only but not for images or presentation states. The creation of digital signatures is described in the "Structured Report" section (see D.2.3).

H Options

This icon is always available in the application toolbar. By pressing this button a dialog appears which allows to modify a number of application specific options which are divided into three groups.

H.1 General

In this register page (fig. 62) the general "Look and Feel" can be modified. Furthermore, a profile which compiles a predefined list of options can be selected.

The following profiles are available:

Image Profile	This configuration is optimized for image viewing on a landscape monitor.
Structured Report Profile	This profile is optimized for working with structured reports.
Configured Profile	This configuration contains all options as configured in the configuration file (see I.1).

If the user modifies any value in the "Options" dialog, the profile is changed to "User defined Profile" automatically.

Figure 62: "Options" Dialog – "General"

H.2 Viewer

In this register page (fig. 63) the placement of the "Function" panel in the "Viewer" can be changed. The "Image Processing", the "Navigation Panel" and the "Presentation State" panel can be switched on and off. Furthermore, the position of the "Paint" panel can chosen, integrated into the "Function" panel or into the "Toolbar" or disabled.

The "Ambient Light" value (measured in cd/m²) used for the correction curve (see D.1.7.6) can be modified here. The default value is taken from the monitor characteristics file (see I.2).

Finally, the physical size of a pixel as displayed on the screen can be defined. These values are used to display an image in the "True Size" mode. The default value is computed from the figures defined in the configuration file (see I.1).
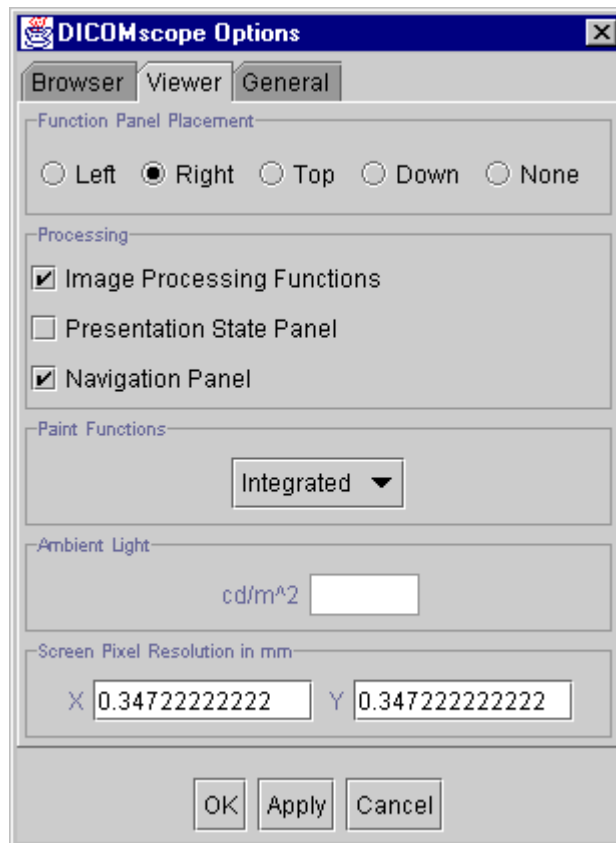
Figure 63: "Options" Dialog – "Viewer"

H.3 Browser

In the upper part of this register page (fig. 64) a number of attributes shown in the "Browser" list can be switched on and off. This allows to specify how many and which details are to be displayed:

UID	Toggles UID on/off (all layers)
Description	Toggles description (on study / instance layer) on/off
Patient Information	Toggles patient information on/off (on study layer)
Modality	Toggles modality on/off (on series layer)
Date & Time	Toggles date and time on/off (on study and series layer)
New Items	Shows new/received studies, series and instances with a "new" icon
Filename	Toggles the filename on/off (on instance layer)
Label	Toggles the label on/off (on instance layer)
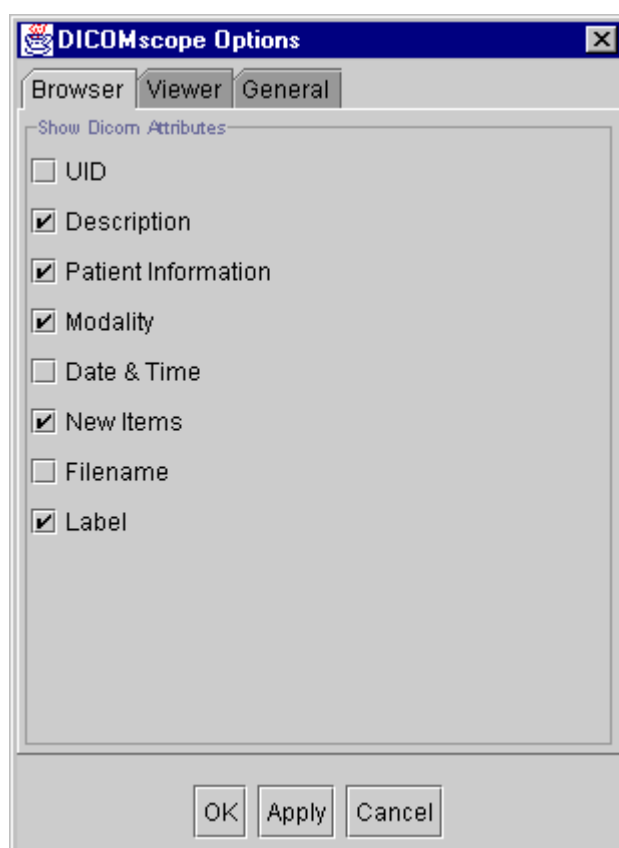
Figure 64: "Options" Dialog – "Browser"

I Configuration

I.1 Configuration File

All information DICOMscope needs to run proper on different systems and in different environments is stored in a single configuration file (`DICOMscope.cfg`). This text file is read only once during the application start-up process, i. e. if you have modified anything the application need to be restarted.

The configuration file consists of a number of entries which have the form

```
keyword = value
```

It is important that the keyword begins in the first column of a newline. Keywords are not case sensitive, but values are. Entries in the configuration file are grouped in a section, which is identified by a keyword in square brackets:

```
[section]
```

Multiple sections are grouped into a main section, which is identified by a keyword in double square brackets:

```
[[main_section]]
```

The first part of the configuration file for DICOMscope is identified by the main section heading `[[GENERAL]]`. This part defines the settings of the local system, e. g. database directory and local network characteristics. The following table describes the defined sections and entries:

Section	Keyword	Value	Description
Application	LogDirectory	directory	Directory in which log files are stored. Default: application root directory, for print: same as spool directory.
	LogFile	filename	Name of the file where the general log messages are stored. Default: no log file, i. e. do not write any log messages.

	LogLevel	identifier	Filter for the general log messages:
			  ERROR = only error messages
			  WARN = also warning messages (includes ERROR)
			  INFO = also informational messages (incl. WARN)
			  DEBUG = also debug messages (includes INFO)
			Default: no general log messages at all.

	MessagePort	1..65535	Port on which the GUI application accepts notification messages from the network processes. Default: 0 (no notifications sent).
	KeepMessagePort Open	true or false	Indicates whether client processes are allowed to keep their notification message port open during the lifetime of the process. Default: false.
Monitor	Characteristics	filename	Name of the monitor characteristics file. If omitted, no grayscale correction according to DICOM Part 14 (GSDF) or CIELAB is performed on consumer systems. See I.2 for further details on this file.
	Resolution	width\height	Screen resolution in pixels. Used for the "true size" presentation size mode.

	ScreenSize	width\height	Size of the visible screen area in mm. Used for the "true size" presentation size mode.
	PreviewSize	width\height	Size of the preview window in pixels. Used for the interactive windowing.
Print	Spooler	executable	Path to the DICOM print spooler (Print Management SCU) application to be used.
	Server	executable	Path to the DICOM print server (Print Management SCP) application to be used.
	Directory	directory	Directory in which spooled print jobs reside.
	DetailedLog	true or false	Log complete DICOM protocol (--dump --verbose) in print spooler / server. Default: false.
	BinaryLog	true or false	Log complete ACSE and DIMSE protocol in binary form (as DICOM file). This setting is independent from the DetailedLog setting and currently only implemented by the print server. Default: false.
	Sleep	double word	Time (in seconds) the print spooler should wait before polling (again) the spool directory. Default: use spooler default.
	MinPrintResolution	width\height	Minimum resolution for a print bitmap (width\height in pixel). If a bitmap to be printed is smaller than this, it is scaled up by an appropriate integer factor before burning in graphical annotations. This allows to have acceptable annotation visibility on low resolution bitmaps. Default: No lower limit for the print bitmap resolution.
	MaxPrintResolution	width\height	Maximum resolution for a print bitmap (width\height in pixel). If a bitmap to be printed is larger than this, it is scaled down by an appropriate integer factor before sent to the printer. This allows to reduce the amount of pixel data to be transferred. Default: No upper limit for the print bitmap resolution.
	DefaultIllumination	0..65535	Specifies the default value for the Illumination (in cd/m²) to be transmitted to the printer when using the Presentation LUT SOP Class. Default: 2000.
	DefaultReflection	0..65535	Specifies the default value for the Reflected Ambient Light (in cd/m²) to be transmitted to the printer when using the Presentation LUT SOP Class. Default: 10.
	DeletePrintJobs	true or false	Delete print job files from spool directory after processing. If false, spool jobs are renamed instead. Default: false.
	AlwaysDelete TerminateJobs	true or false	Always delete terminate job files from spool directory (these special print job files are created to inform the spool processes that the application has been terminated). If false, terminate jobs are handled like normal print jobs (see DeletePrintJobs). Default: false.
Database	Directory	directory	Directory in which the image database resides.
	Dump	executable	Path to the dump tool used to display the contents of DICOM files located in the database.
	Check	executable	Path to the check tool used to display the contents of DICOM files located in the database.
LUT	Directory	directory	Directory in which presentation LUT files reside.
Report	Directory	directory	Directory in which SR "template" files reside.
Network	Sender	executable	Path to the DICOM sender (Store SCU) application to be used. Should never be changed.
	Receiver	executable	Path to the DICOM receiver (Store SCP) application to be used. Should never be changed

	AEtitle	string	Application entity title sender processes use to identify themselves. Also used as default application entity title for the COMMUNICATION section. Max 16 uppercase characters.
TLS	TLSDirectory	directory	Directory in which TLS related files (certificates, keys, random data, Diffie-Hellman parameters etc.) are located. The content of this directory should be kept confidential because it may help an attacker to break the security of the TLS transmission.
	CACertificate Directory	directory	Directory in which certificates of the trusted Certification Authorities are located. During negotiation of a secure TLS connection, the remote site's certificate may be verified, depending on the settings for the sender or receiver process in the COMMUNICATION section. Verification checks if the certificate has been issued by one of the CAs located in this directory. This means that the content of this directory defines a simple means of access control for TLS communication. File names of certificates in this directory must have names derived from a hash key of the certificate DN, see -hash option of openssl x509 command.
	UserKeyDirectory	directory	Directory in which certificates and encrypted private keys of the known users are located. User certificates and keys are used for the verification of DICOM Structured Reports and for the creation of digital signatures.
	UsePEMFormat	true or false	DICOMscope allows to have certificates, keys and Diffie-Hellman parameters either in PEM ("privacy enhanced mail") format or in DER ("distinguished encoding rules") format. However, all files within one DICOMscope installation must use the same format, which is defined by this setting. True => PEM format, false => DER format. Default is PEM.
Query_ Retrieve	AutoCreateConfig File	true or false	Specifies whether the configuration file for the query/retrieve server is created automatically from the data contained in this file each time the server is started. Default is true.
	Server	executable	Path to the DICOM query/retrieve server (Q/R SCP) to be used. The configuration filename is created from this entry by adding the file extension ".cfg". Should never be changed
	Port	1..65535	IP Port number on which the receiver listens for new connections. On Unix platforms, the receiver must be started with setuid root if port numbers < 1024 (i. e. the standard DICOM port number 104) should be used.
	MaxPDU	8192..65536	Maximum PDU (protocol data unit) size to use when negotiating incoming connections. Must be between 4096 and 131072. Default: 16384.
	AEtitle	string	Application entity title with which both sender and receiver will identify themselves. Max 16 uppercase characters.
	MaxAssociations	1..65535	Maximum number of associations the server can handle at the same time. This is only applicable on Unix platforms, since Windows does not support the fork() command which is used for this purpose.

GUI	HighResolution Graphics	true or false	If this setting is true, we assume a system with very high resolution (2×2.5K) and a graphics board that performs calibration according to the DICOM GSDF in hardware. Therefore, we display much larger icons and disable rendering of the GSDF in software. This setting requires that a static 256 grayscale color palette is used by the operating system to access the graphics board.
	AutoUpdateStudy Browser	true or false	Starts the update thread for the study browser. Default: true.
	BackgroundColor	0..255/0..255/ 0..255	Sets the background color of the study manager as RGB color. Default: If HighResolutionGraphics is true, the default is 0\0\0, otherwise 255\255\255.
	FontSize	int	Sets the size of the fonts used in all GUI components. Default: If HighResolutionGraphics is true, the default is 30, otherwise 12.
	FontName	string	Sets the name of the fonts used in all GUI components. Default: SansSerif.
	FontSizeText	int	Sets the size of the fonts used for textual annotations. Default: If HighResolutionGraphics is true, the default is 48, otherwise 16.
	FontNameText	string	Sets the name of the fonts used for textual annotations. Default: SansSerif.
	TabPlacement	„North", „South", „East", „West".	Sets the placement of the main tab in the GUI. Valid values are: North, South, East, West. Default: North.
	FunctionPanel Placement	„North", „South", „East", „West". „None"	Sets the placement of the function panel in the Image Viewer. Valid values are: North, South, East, West, None. Default: If HighResolutionGraphics is true, the default is East otherwise South.
	PaintPanelPlacement	„North", „South", „East", „West". „None"; „Toolbar"; „Integrated"	Sets the placement of the paint function panel in the Image Viewer. Valid values are: North, South, East, West, None, Toolbar, Integrated. Default: Integrated.
	PSPanelOn	true or false	Checks if the presentation state information panel should be visible. Default: false.
	WarnUnsigned ObjectsInSR	true or false	Displays a warning message if an unsigned instance (report, presentation state, image) referenced from the current report is opened. Valid values are: true, false. Default: true.

The second part of the configuration file for DICOMscope is identified by the main section heading [[COMMUNICATION]]. This part defines the communication partners to which DICOM images and presentation states can be sent or printed to. For each communication partner, one section needs to be defined (i. e. [PEER_1].) The section heading is arbitrary but must be unique within the configuration file. It may only contain uppercase characters, numbers and underscore characters. The following table describes the entries for each communication partner:

Keyword	Value	Description
Type	identifier	The service type defines which DICOM services are offered by the peer described in this section. Four types of peers are supported: STORAGE – a DICOM Storage Service Class SCP. Entries of this type are shown as "send targets" in the DICOMscope browser GUI. An entry of this type is also required for each system that wants to download objects

		from the DICOMscope database using Query/Retrieve. The settings from this section are used to resolve an application entity title into the target hostname and IP port number. RECEIVER – a local DICOM Storage Service Class SCP which accepts incoming images and stores them in the local database. PRINTER – a remote DICOM Print Management Service Class SCP. For each entry of this type, a separate Print SCU ("spooler process") is started together with DICOMscope. Entries of this type are shown as printers in the DICOMscope print preview GUI.. LOCALPRINTER – a DICOM Print Management SCP that is running as part of the DICOMscope software on the local system. For each entry of this type a DICOM Print SCP is started together with DICOMscope. In addition, the entry is also shown as a printer in the DICOMscope print preview GUI – DICOMscope allows to print "to itself". Default value for this setting is: STORAGE.
Hostname	string	The IP number or domain name of the communication partner in conventional TCP/IP notation. For entries of type LOCALPRINTER this setting must have the value "localhost". This setting is mandatory, no default.
Port	1..65535	IP port number under which the communication partner receives DICOM associations.
Description	string	Human readable description of the communication partner. Used in the GUI to present the communication partner to the application user in selection boxes.
AEtitle	string	For outgoing connections (STORAGE, PRINTER) this setting contains the called application entity title of the communication partner. For incoming connections (RECEIVER, LOCALPRINTER) this setting contains the responding application entity used during association negotiation.
ImplicitOnly	true or false	Only negotiate the default Implicit VR Little Endian transfer syntax for all abstract syntaxes. This setting is useful if we're communicating with very old DICOM software which claims to support Explicit VR communication but fails to do so. Optional setting, default is: false.
DisableNewVRs	true or false	Do not create data types (VRs) that were defined in post-1993 editions of the DICOM standard when converting implicit VR files to explicit VR network transmission. Maybe necessary for old DICOM Store SCPs. Optional setting, default is: false.
MaxPDU	8192..65536	Maximum receive PDU (protocol data unit) size to use. Must be between 8192 and 65536. Default: 16384.
The following settings are only applicable to entries of type STORAGE and RECEIVER and have no meaning for PRINTER or LOCALPRINTER.		
BitPreserving Mode	true or false	Receive data in "bit preserving mode". In this mode, data is stored to file directly as read from network. Transfer syntax in file is identical to transfer syntax used for network transmission. If this mode is switched off (default), images are converted to explicit VR Little Endian format before storing in file, which makes it easier to burn images on CD-R in "General Purpose Image Exchange Profile" format. Optional entry, default is: false.
UseTLS	true or false	Use the Transport Layer Security (TLS) protocol for image transmission in accordance with the DICOM Security Enhancements One (Supplement 31). Optional setting, default is: false.
Certificate	filename	Filename of the X.509 certificate to be used for TLS authentication. The file should be located in the directory specified by GENERAL/TLS/ TLSDIRECTORY. Store SCP usage: The TLS protocol requires that a TLS server must have a certificate. Therefore, this parameter is mandatory. If absent, the certificate file is loaded from "sitecert.pem" in the TLS directory. Store SCU usage: For a TLS client the certificate is optional. Therefore, this setting is optional for Store SCUs. If absent, no TLS authentication is performed for the client. Warning: Anonymous TLS may be susceptible to man-in-the-middle attacks.

PrivateKey	filename	Filename of the private key "matching" the certificate, to be used for TLS authentication. The file should be located in the directory specified by GENERAL/TLS/TLSDIRECTORY. Store SCP usage: The TLS protocol requires that a TLS server must have a certificate. Therefore, this parameter is mandatory. If absent, the certificate file is loaded from "sitekey.pem" in the TLS directory. Store SCU usage: For a TLS client the certificate is optional. Therefore, this setting is optional for Store SCUs. If absent, no TLS authentication is performed for the client. Warning: Anonymous TLS may be susceptible to man-in-the-middle attacks.
PrivateKey Password	string	Private keys may be stored in encrypted form (e. g. 3DES), protected with a password. Since the DICOMscope Store SCU/SCP processes do not have any interaction with the user, they cannot request a password from the command line. Two options are available to the user: – the private key can be unencrypted. In this case this setting should be absent from the config file. Users should carefully adjust file system access rights to the private key file to make sure that the private key is not compromised (e. g. copied by an unauthorized used). – the private key can be encrypted, with the password in clear text in this configuration file. In this case, the DICOMscope configuration file must be protected from read access by unauthorized users, otherwise the private key may be compromised as well. A real secure approach would be to keep the private key in a safe place, e. g. in a microprocessor card, but this is not yet supported.

CipherSuites	string	Negotiate the following TLS ciphersuites when using TLS transmission. Ciphersuite names should have the format as defined in RFC 2246, e. g.:
		    TLS_RSA_WITH_RC4_128_SHA
		    TLS_RSA_WITH_IDEA_CBC_SHA
		    TLS_RSA_WITH_DES_CBC_SHA
		    TLS_RSA_WITH_3DES_EDE_CBC_SHA
		See the DCMTK documentation dcmtls/docs/ciphers.txt for a complete list of supported terms. Multiple terms should be separated by backslash characters.
		Optional setting, default is: TLS_RSA_WITH_3DES_EDE_CBC_SHA.

Peer Authentication	string	This setting defines the policy for handling the remote peer's TLS certificate. Known terms are:
		    REQUIRE: verify peer certificate, refuse transmission if absent
		    VERIFY: verify peer certificate if present
		    IGNORE: don't verify peer certificate
		Optional setting, default is: REQUIRE.

DiffieHellman Parameters	filename	File containing a set of random-generated Diffie-Hellman parameters as required for DH/DSS ciphersuites (but not for RSA ciphersuites). File should be located in the directory specified by GENERAL/TLS/TLSDIRECTORY in the format specified by GENERAL/TLS/USEPEMFORMAT. Optional setting, default is: no Diffie-Hellman parameters (which will cause TLS connection setup for DH/DSS ciphersuites to fail).
RandomSeed	filename	File containing random data which is used to initialize the pseudo-random generator. After transmission, a modified file is written back. The random seed file should be different for each send/receive target - see DCMTK documentation on random data for details. The file should be located in the directory specified by GENERAL/TLS/TLSDIRECTORY. Optional setting, default is: no random data (which may cause TLS connection setup to fail).
The following settings are only applicable to entries of type PRINTER and LOCALPRINTER and have no meaning for STORAGE or RECEIVER.		
Supports12Bit	true or false	*Print SCU usage:* assume that the Print SCP supports transmission of image pixel data with 12 bits/pixel in the Basic Grayscale Image Box SOP Class. *Print SCP usage:* accept image pixel data with 12 bits/pixel. Optional setting, default is: true.

Supports PresentationLUT	true or false	*Print SCU usage:* assume that the Print SCP supports the Presentation LUT SOP Class (Supplement 22) and attempt to negotiate it during association negotiation. *Print SCP usage:* activate support for the Presentation LUT SOP Class. Optional setting, default is: false.
PresentationLUT inFilmSession	true or false	The 1999 edition of the DICOM standard contains an inconsistency in the definition of the Presentation LUT SOP class. The attributes "Referenced Presentation LUT", "Illumination" and "Reflected Ambient Light" can either be part of the Basic Film Session or be part of the Basic Film Box. DICOM Correction Proposal CP 173 defines that these attributes have to be specified on Basic Film Box level. However, not all existing Print SCPs supporting the Presentation LUT SOP Class are implemented in accordance with CP 173. Both Print SCU and Print SCP can, therefore, be configured to use either Film Session or Film Box (but never both). *Print SCU usage:* If flag is true, transmit attributes in the Basic Film session instead of the Basic Film Box. *Print SCP usage:* If flag is true, attributes are accepted and returned in Basic Film Session instead of Basic Film Box. Optional setting, default is: false (which means that behavior will be consistent with CP 173.)
PresentationLUT MatchRequired	true or false	Some Print SCPs which support Presentation LUTs require that the number of entries in a Presentation LUT matches the bit depth of the image pixel data (4096 entries for 12 bit pixel data, 256 entries for 8 bit pixel data). *Print SCU usage:* If flag is true, assume that Print SCP requires match between Presentation LUT and image data. If for a given print job this match cannot be guaranteed, perform rendering of the Presentation LUT in the Print SCU and use an IDENTITY Presentation LUT shape in the Print SCP. *Print SCP usage:* If flag is true, enforce a matching rule as described above. All Presentation LUT N-CREATE or Basic Grayscale Image Box N-SET operations that would violate the rule will be refused. Optional setting, default is: true.
PresentationLUT PreferSCP Rendering	true or false	*Print SCU usage:* if the printer supports 12-bit image transmission and the film is to be printed with a Presentation LUT that could be rendered either in the print client or in the printer without loss of precision, prefer rendering in the printer. *Print SCP usage:* flag is ignored. Optional setting, default is: false.
SupportsImage Size	true or false	Some Print SCPs do not support the optional "Requested Image Size" attribute in Basic Grayscale Image Box N-SET operations. *Print SCU usage:* If flag is false, assume that the printer does not support requested image size, never send this attribute. *Print SCP usage:* If flag is true, support requested image size. Otherwise refuse N-SET operations containing a requested image size attribute. Optional setting, default is: false.
SupportsDecimate Crop	true or false	Some Print SCPs do not support the optional "Requested Decimate/Crop Behavior" attribute defined in Supplement 37 in Basic Grayscale Image Box N-SET operations. *Print SCU usage:* If flag is false, assume that the printer does not support requested decimate/crop behavior, never send this attribute. *Print SCP usage:* If flag is true, support requested decimate/crop behavior. Otherwise refuse N-SET operations containing this attribute. Optional setting, default is: false.
SupportsTrim	true or false	Some Print SCPs do not support the optional "Trim" attribute in Basic Film Box N-CREATE or N-SET operations. Print SCU usage: If flag is false, assume that the printer does not support trim, never send this attribute. Print SCP usage: If flag is true, support trim. Otherwise refuse N-CREATE or N-SET operations containing this attribute. Optional setting, default is: false.
DisplayFormat	int,int\...	*Print SCU usage:* this entry contains a list of all STANDARD\C,R column, row combinations supported as Image Display Format by the Print SCP for portrait orientation. Landscape image display formats are derived automatically by exchanging column and row for each format.

		Print SCP usage: this entry specifies all STANDARD\C,R image display formats accepted by the Print SCP for portrait orientation. Landscape image display formats are also derived automatically. This is a mandatory entry, no default.
FilmSizeID	string\...	Film Size ID identifiers supported by the printer for the Basic Film Box. Multiple values can be specified, must be separated by '\' characters. Print SCU usage: Optional setting, default: don't specify film size ID, use printer default. Print SCP usage: The first specified value is used as the default. This is a mandatory setting for entries of type LOCALPRINTER.
MediumType	string\...	Medium Type identifiers supported by the printer for the Basic Film Session. Multiple values can be specified, must be separated by '\' characters. *Print SCU usage:* Optional setting, default: don't specify medium type, use printer default. *Print SCP usage:* The first specified value is used as the default. This is a mandatory entry.
ResolutionID	string\...	Requested Resolution ID identifiers supported by the printer for the Basic Film Box (optional attribute defined in Supplement 37). Multiple values can be specified, must be separated by '\' characters. *Print SCU usage:* Optional setting, default: don't specify resolution ID, use printer default. *Print SCP usage:* The first specified value is used as the default. This is an optional entry. If omitted, the Print SCP does not support the attribute and rejects N-CREATE or N-SET requests containing the attribute.
Magnification Type	string\...	Magnification Type identifiers supported by the printer for the Basic Film Box or Basic Grayscale Image Box. Multiple values can be specified, must be separated by '\' characters. *Print SCU usage:* Optional setting, default: don't specify magnification type, use printer default. *Print SCP usage:* The first specified value is used as the default. This is a mandatory entry.
SmoothingType	string\...	Smoothing Type identifiers supported by the printer for the Basic Film Box or Image Box. Multiple values can be specified, must be separated by '\' characters. *Print SCU usage:* Optional setting, default: don't specify smoothing type, use printer default. *Print SCP usage:* The first specified value is used as the default. This is an optional entry. If omitted, the Print SCP does not support the attribute and rejects N-CREATE or N-SET requests containing the attribute.
BorderDensity	string\...	Border Density identifiers supported by the printer for the Basic Film Box. Multiple values can be specified, must be separated by '\' characters. *Print SCU usage:* Optional setting, default: don't specify border density, use printer default. *Print SCP usage:* If any of the identifiers is numeric, then all numbers are accepted. The first specified value is used as the default. This is an optional entry. If omitted, the Print SCP does not support the attribute and rejects N-CREATE or N-SET requests containing the attribute.
EmptyImage Density	string\...	Empty Image Density identifiers supported by the printer for the Basic Film Box. Multiple values can be specified, must be separated by '\' characters. *Print SCU usage:* Optional setting, default: don't specify empty image density, use printer default. *Print SCP usage:* If any of the identifiers is numeric, then all numbers are accepted. The first specified value is used as the default. This is an optional entry. If omitted, the Print SCP does not support the attribute and rejects N-CREATE or N-SET requests containing the attribute.

MaxDensity	string\...	*Print SCU usage:* Max Density values supported by the printer for the Basic Film Box. Multiple values can be specified, must be separated by '\' characters. Optional setting, default: don't specify max density, use printer default. *Print SCP usage:* only the first value is read and defines the default max density that is used when the Print SCU does not specify max density. This is a mandatory entry.
MinDensity	string\...	*Print SCU usage:* Min Density values supported by the printer for the Basic Film Box. Multiple values can be specified, must be separated by '\' characters. Optional setting, default: don't specify min density, use printer default. *Print SCP usage:* only the first value is read and defines the default min density that is used when the Print SCU does not specify min density. This is an optional entry. If omitted, the Print SCP does not support the attribute and rejects N-CREATE or N-SET requests containing the attribute.
Annotation	0..65535\ string	The DICOMscope application provides limited support for the Basic Annotation Box SOP Class. When printing on printers supporting Annotation, a single annotation can be specified for each print job. This setting defines the annotation display format ID and annotation position that are used when creating the annotation. *Print SCU usage:* Two values must be specified: First the Annotation Position, then the Annotation Display Format ID, separated by '\'. This is an optional setting, default is not to use Basic Annotation Box. *Print SCP usage:* The Print SCP component does not support the Basic Annotation Box SOP Class. This setting should be omitted for all entries of type LOCALPRINTER.
SessionLabel Annotation	true or false	Some printers use the Film Session Label as a replacement for annotations. *Print SCU usage:* If flag is true, any annotation defined in the user interface is replicated in the Film Session Label attribute of the Basic Film Session. This is an optional setting, default is: false. *Print SCP usage:* Ignored. This setting should be omitted for all entries of type LOCALPRINTER.
Configuration_N	string	Configuration Information that can be sent to the printer for the Basic Film Box or Image Box. Only a single value per entry can be specified because values may contain backslash characters. (VR=ST). Keywords are "Configuration_1", "Configuration_2", etc., without leading zeroes. *Print SCU usage:* These are optional settings, default is not to use configuration information. *Print SCP usage:* These are optional settings. If omitted, the Print SCP does not support the attribute and rejects N-CREATE or N-SET requests containing the attribute. The Print SCP default for Configuration Information is always an empty string.
FilmDestination	string	Film Destination identifiers supported by the Print SCP for the Basic Film Session. Multiple values can be specified, must be separated by '\' characters. *Print SCU usage:* ignored. *Print SCP usage:* The first specified value is used as the default. This is a mandatory entry.
OmitSOPClass UIDFromCreate Response	true or false	The Affected SOP Class UID attribute is optional in DIMSE N-CREATE-RSP messages but some clients rely on its presence. This setting can be used to test client behavior. *Print SCU usage:* ignored. *Print SCP usage:* Defines whether the Print SCP should include Affected SOP Class UID in DIMSE N-CREATE-RSP messages. This is an optional setting, default is false.

The third part of the configuration file is identified by the main section heading [[USERS]]. This part defines the logins and certificates which can be used from the application to verify and digitally sign structured reports. For each user, one section needs to be defined (i. e.

[USER_1].)   The section heading is arbitrary but must be unique within the configuration file. It may only contain uppercase characters, numbers and underscore characters.   The following table describes the entries for each user:

Keyword	Value	Description
Login	string	Login of user, must be unique. Required entry.
Name	string	Name of user in human readable form, must be unique (e. g. might be presented in combo box GUI). Required entry.
DicomName	string^...	Name of user in DICOM Person Name (PN) format. Used when creating a Verifying Observer Sequence in a DICOM SR document. Required entry.
Organization	string	Name of Organization for which this user is acting, in DICOM Long String (LO) format (i. e. max 64 characters). Used when creating a Verifying Observer Sequence in a DICOM SR document. Required entry.
Code	string\...	Code for identifying the user, with the entries required for the DICOM Code Sequence Macro (DICOM Part 3, Table 8.8-1). This is an optional entry that is used when creating a Verifying Observer Sequence in a DICOM SR document. If present, it must consist of four parts separated by backslash characters: – coding scheme designator, DICOM SH format (max. 16 characters) – coding scheme version (may be empty), DICOM SH format – code value, DICOM SH format – code meaning, DICOM LO format (max. 64 characters)
Certificate	filename	File containing the user's X.509 certificate for digital signature purposes. The certificate file must be located in directory defined in GENERAL/TLS/ USERKEYDIRECTORY. The file format is defined in GENERAL/TLS/ USEPEMFORMAT. This is a mandatory entry.
PrivateKey	filename	File containing the user's private key. The key is used during creation of digital signatures. The password with which the key is protected (when stored in PEM format) is also used to authenticate a user when a DICOM Structured Report is to be verified by a "Verifying Observer". The key file must be located in directory defined in GENERAL/TLS/ USERKEYDIRECTORY. The file format is defined in GENERAL/TLS/ USEPEMFORMAT. It is strongly recommended to keep the files in PEM format which (unlike DER) allows 3DES encryption of private keys! This is a mandatory entry.

The fourth part of the configuration file is identified by the main section heading [[LUT]]. This part defines the presentation look-up tables (LUT) which can be used from the application. For each LUT, one section needs to be defined (i. e. [LUT_1].)   The section heading is arbitrary but must be unique within the configuration file. It may only contain uppercase characters, numbers and underscore characters. The following table describes the entries for each LUT:

Keyword	Value	Description
Description	string	Description of the LUT. Used in the GUI to present the selectable LUTs to the application user.
Filename	filename	Filename of the LUT file, should reside in LUT directory (see above).

The fifth part of the configuration file is identified by the main section heading [[VOI]]. This part defines the window level/width presets which can be used from the DICOMscope application. For each VOI (value of interest) preset, one section needs to be defined (i. e. [VOI_1].) The section heading is arbitrary but must be unique within the configuration file. It may only contain uppercase characters, numbers and underscore characters. The following table describes the entries for each VOI preset:

Keyword	Value	Description
Description	string	Description of the preset. Used in the GUI to present the selectable VOIs.
Modality	string	Modality to which this preset applies. Must be one of the DICOM defined terms for element (0008,0060) Modality, see PS3.3 C.7.3.1.1.1 in DICOM standard.
Center	float	Value for window center.
Width	float	Value for window width.

The sixth part of the configuration file is identified by the main section heading `[[REPORT]]`. This part defines the structured reporting "templates" which can be taken from the application. For each report "template", one section needs to be defined (i. e. `[REPORT_1]`.) The section heading is arbitrary but must be unique within the configuration file. It may only contain uppercase characters, numbers and underscore characters. The following table describes the entries for each report "template":

Keyword	Value	Description
Description	string	Description of the report. Used in the GUI to present the selectable SR "template" to the application user.
Filename	filename	Filename of the SR "template" file, should reside in REPORT\DIRECTORY.

Note: The report "templates" are not yet used by the current release of DICOMscope.

I.2   Monitor Characteristics File

To perform the GSDF/CIELAB transform you need a text file describing the characteristic curve of your display device (monitor). This file can be created automatically by using a calibration tool like VeriLUM (from IMAGE Smiths) and converting its output to a more common format which can be read by DICOMscope[6]. You can also try to adapt the sample file (`monitor.lut`) which is part of this distribution manually by editing the luminance values for each DDL (device driving level).

---

[6] This conversion can be done by the console application `dconvlum` from the DCMTK package (see `dcmtk/dcmimgle/docs/dconvlum.txt` for further details).

I.3   Registering DICOM Instances in the Database

DICOM instances (images, presentation states, structured reports, etc.) can be registered directly in the database. Only references to the instances are stored in the database file `index.dat`, i. e. no images or other large objects are copied. For this purpose the command line tool `dbregimg` is typically contained in the tools sub directory. If not it can be created from the dcmtk source (see chapter J).

Assuming the current path is DICOMscope and the instances you want to register are stored in the sub directory images just type

```
tools\dbregimg -v database images\*.*
```

if you are on a Windows system. The references are then added to the database file `database\index.dat`. If the database file has been deleted a new one is created automatically. Please note that the format of the database files is system dependent.

Windows users can also copy all files to be registered to the database folder and then start the make_db.bat batch file from the tools sub directory which registers all DICOM instances contained in the database folder.

A detailed description on `dbregimg` can be found in `dcmtk/imagectn/docs/ dbregimg.txt`.

I.4   Log Files

Not only for debugging purposes DICOMscope typically writes a number of log files which can be found in the log sub directory (see I.1 for details).

The main application log file is called "general.log" and contains mainly start / terminate process and I/O error messages (such as "Load failed ..."). The messages are divided into different log levels which can be used to filter the output (see entry "APPLICATION / LogFilter" in the config file).

The other log files are created by the print spooler (filename starting with a long number) and local print server (filename starting with "PrintSCP_"). The level of verboseness can be specified by means of the entry "PRINT / DetailedLog" in the config file. For the print server it also possible to log the complete ACSE and DIMSE protocol in binary form (as DICOM file).

J Compilation

This section describes how to build DICOMscope from the source code. This might be of interest to users who wish to modify the application to fit their needs. We recommend that you install a binary distribution of DICOMscope first to see which files are expected in which sub directory.

J.1 Microsoft Windows

J.1.1   Requirements

DICOMscope for Windows requires a 32 bit version of Microsoft Windows. It has been tested successfully with Windows 95, 98, NT 4.0 and Windows 2000 Professional. Other versions might also work.

Please note that the full compilation of the source code requires typically around 100 MB of disk space. Further requirements for running the software are mentioned in chapter K.

J.1.1.1   Tools

The following tools are required in order to compile the DICOMscope source code:

- Tool to unzip the source code (e. g. WinZIP, available from http://www.winzip.com/)
- C++ Compiler with support for C++ templates: tested successfully with MS Visual C++ 5.0 and 6.0
- OpenSSL 0.9.6a (other versions might also work), available from http://www.openssl.org/
- Java 2 SDK v1.3 or newer, available from http://java.sun.com/j2se/
- Tcl/Tk is not required for compiling the application, but it is required if you want to use the "Create Dump" (see C.1.9) or "Check IOD" (see C.1.10) function from the user interface. It is available from http://tcl.activestate.com/software/tcltk/.

J.1.1.2   Sources

The following source code packages have to be downloaded:

- dcmtk 3.5.0: ftp://dicom.offis.uni-oldenburg.de/pub/dicom/offis/software/dcmtk350.zip
- dsgui 3.5: ftp://dicom.offis.uni-oldenburg.de/pub/dicom/offis/software/dscope/dsgui35.zip

The files are also available at http://www.microtherapy.de/e/imt/fi/medinf/download/.

J.1.2   Preparations

- Install WinZIP, Java 2 SDK and Tcl/Tk if necessary.
- Unpack the dsgui (Java) source code package to your local drive and make sure that the stored directory structure is restored correctly.
- Unpack the dcmtk (C/C++) source code package to the dsgui35 directory extracted from the dsgui archive and make also sure that the stored directory structure is restored.
- Compile and/or install OpenSSL according to the instructions shipped with this package. The dcmtk package expects the files in the directoty dsgui35\openssl-0.9.6a.

J.1.3 Compilation

J.1.3.1 C++ Code

When using a Microsoft Visual C++ (MSVC 5.0 and above) compiler the existing project files can be used to compile the C/C++ part of the source code.

- Open the workspace file `dcmtk.dsw` (stored in the dcmtk sub directory) and compile all sub projects as "OpenSSL" versions.
- Open the workspace file `jInterface.dsw` (stored in the interface sub directory) and compile the project as "OpenSSL" version as well. Since the project file refers to the include directory of the installed Java 2 SDK package it might be necessary to adjust it (default: \jdk1.3.1\include\...).
- After a successful compilation the DLL (Dynamic Link Library) and the command line tools should be copied to the DICOMscope application folder by starting the `copy_bin.bat` batch file from the main directory. This only works for the "OpenSSL" version but the same result can be achieved by copying the files manually.

If not using a Microsoft Visual C++ compiler you have to create the project make files for your own. Be sure to compile all C/C++ modules in multi-threaded mode. At least the Microsoft compilers have problems when mixing multi-threaded and single-threaded code or single-threaded C/C++ code with Java.

J.1.3.2 Java Code

Open a command prompt window, change the directory to tkgui and type

```
javac -d ..\DICOMscope DICOMscope.java
```

If the `bin` directory of the Java 2 SDK is not part of your search path you have to use the explicit path to the Java compiler (e. g. \jdk1.3.1\bin\javac ...).

Change the directory to DICOMscope and type

```
java DICOMscope
```

to start the application or use the explicit path to `java` if necessary. Do not forget to adjust the configuration file before starting the application for the first time (see I.1).

For a description on how to create a single Java archive ".jar" from the compiled ".class" files we refer to the Java documentation.

J.2 Unix

J.2.1   Requirements

J.2.1.1   Tools

- A reasonably modern C++ Compiler with support for C++ templates. GNU gcc 2.95 and egcs 1.1.2 are known to work. Earlier releases of GNU gcc are likely not to work. We have also successfully compiled with the Sun Workshop Compilers 4.x for Solaris.
- Tar and gzip (gzip, gunzip or zcat):
  - Tar should be available on all modern Unix installations.
  - Gzip is available at http://www.gzip.org/ and most GNU mirror sites
  - Tool to unzip the Java source code (e. g. Info-ZIP from http://www.info-zip.org/pub/infozip/)
- OpenSSL 0.9.6 (other versions might also work), available from http://www.openssl.org/
- Java 2 SDK v1.3 or newer, available from http://java.sun.com/j2se/
- Tcl/Tk is not required for compiling the application, but it is required if you want to use the "Create Dump" (see C.1.9) or "Check IOD" (see C.1.10) function from the user interface. It is available from http://tcl.activestate.com/software/tcltk/.

J.2.1.2   Sources

The following source code packages have to be downloaded:

- dcmtk 3.5.0: ftp://dicom.offis.uni-oldenburg.de/pub/dicom/offis/software/dcmtk350.tar.gz
- dsgui 3.5: ftp://dicom.offis.uni-oldenburg.de/pub/dicom/offis/software/dscope/dsgui35.zip

The files are also available at http://www.microtherapy.de/e/imt/fi/medinf/download/.

J.2.2   Preparations

- Install infozip, gzip, Java 2 SDK and Tcl/Tk if necessary.
- Unpack the dsgui35.zip package.
- Unpack the dcmtk350.tar.gz package to the dsgui35 directory, e. g. by typing
    ```
    zcat dcmtk350.tar.gz | tar xvf -
    ```
- You might need to consult the manual pages for tar and gzip (or zcat) if this does not work.
- Compile and/or install OpenSSL according to the instructions shipped with this package.

J.2.3   Compilation

J.2.3.1   C++ Code

- *Important:* Read the compilation instructions for the DCMTK package (file "INSTALL").
- Run "rootconf" and "configure" according to the instructions. The flag `--with-openssl` is required for configure; use `--with-opensslinc` to specify the OpenSSL directory if necessary. If you don't want the DCMTK tools to be installed in /usr/local/dicom, remember to use the `--prefix` option for configure.
- *Before* compiling the toolkit, edit the file `config/Makefile.def`. Add the compiler flags required for multi-thread support and position independent code to the `CXXFLAGS`

variable. For GNU gcc on most platforms, this means adding `-D_REENTRANT -fPIC`. For the Sun Workshop Compilers on Solaris, add `-D_REENTRANT -PIC`. We also recommend that you switch on the optimizer, e. g. `-O2` for GNU gcc or `-fast` for the Sun Workshop Compilers.

- Compile and install the DCMTK package according to the installation instructions. It is important that at least the DCMTK data dictionary file "dicom.dic" is installed in the default location (if you prefer to have the data dictionary built-in into the applications, read the DCMTK FAQ which is included in the package on how to achieve that).

- Copy all C++ class ("cpp") files and header files (".h") from the dsgui35 package into the dcmpstat/jni sub directory of DCMTK. You will need to rename the file extension to ".cc" for all class files.

- Edit dcmpstat/jni/Makefile. Adjust the following settings:
  - `javainc` must point to the include directories for your Java 2 SDK installation, e. g. `javainc=-I/usr/java1.3/include -I/usr/java1.3/include/solaris`
  - `soflags` must contain the compiler flag telling the compiler to produce a shared object instead of a standard executable. For GNU gcc, this is `-shared`, for the Sun Workshop Compilers it is `-G`.
  - solibs may optionally contain additional libraries that must be linked to the shared object. For GNU gcc, this is normally not required. For the Sun Workshop Compilers, use `-lC`.

- Build the shared object `libjInterface.so` by running "make" in the dcmpstat/jni directory.

- Copy the required binaries into the DICOMscope installation directory. libjInterface.so is located in dcmpstat/jni, the tools dcmprscp, dcmprscu, dcmpschk, dcmpsrcv and dcmpssnd are located in dcmpstat/apps, dcmpschk.tcl in dcmpstat/tests. The tool dcmdump is located in dcmdata/apps, dcmpsdmp.tcl in dcmdata/tests. The tool imagectn is located in imagectn/apps.

- *Warning:* the database index file used by DICOMscope has a different format on different operating systems and *must not* be copied e. g. from the Windows version into a Linux or Solaris installation. See the documentation for the "dbregimg" tool in DCMTK's imagectn/docs directory on how to rebuild an index file.

J.2.3.2   Java Code

Change the directory to tkgui and type

```
javac -classpath . -d ../DICOMscope DICOMscope.java
```

If the `bin` directory of the Java 2 SDK is not part of your search path you have to use the explicit path to the Java compiler (e. g. /usr/java1.3/bin/javac ...).

Change the directory to DICOMscope and type

```
java -classpath . DICOMscope
```

to start the application or use the explicit path to `java` if necessary. Do not forget to adjust the configuration file before starting the application for the first time (see I.1). It might also be necessary to add the current working directory (".") to the library path (LD_LIBRARY_ PATH).

For a description on how to create a single Java archive ".jar" from the compiled ".class" files we refer to the Java documentation.

K System Requirements

(Microsoft Windows Binary Version)

Minimum / recommended system requirements for hardware and software.

Consumer System:

- PC with Pentium 200 MHz (Pentium II, 266 MHz ore more recommended)
- Microsoft Windows (32 bit), tested with Windows 95, 98, NT 4.0 and 2000 Professional
- Java 2 Runtime Environment (also known as JRE 1.3) / Sun Microsystems
- 64 MB memory (128 MB or more recommended)
- VGA graphics adapter with true color support (1024×768 pixel ore more recommended)
- Mouse recommended
- TCP/IP network recommended

High Resolution System:

- PC with Pentium II, 333 MHz or above
- Microsoft Windows (32 bit), tested with Windows 95, 98, NT 4.0 and 2000 Professional
- Java 2 Runtime Environment (also known as JRE 1.3) / Sun Microsystems
- 256 MB memory or more
- High resolution grayscale monitor with dedicated graphics adapter
  (tested with Siemens/Dome and Barco/Metheus)
- Mouse recommended
- TCP/IP network recommended

Disk Space:

- 21 MB for Java 2 Runtime Environment (for version 1.3)
- 11 MB for DICOMscope (standard installation)

L About the Project

The project team for the implementation consists of:

OTech Inc.: Main contractor and project management
Kuratorium OFFIS e.V.: Implementation of the DICOM toolkit software
Institute for Microtherapy; University of Witten/Herdecke: Graphical User Interface

This software is available in the public domain at:

http://www.microtherapy.de/go/dicomscope/
http://www.offis.de/projekte/dicom/

The DICOM standard is available at:

http://medical.nema.org/dicom.html

The demonstrations at ECR '99, RSNA '99, RSNA 2000 and ECR 2001 were made possible by:

- NEMA – National Electrical Manufacturers Association (http://www.nema.org/)
- ECR – European Congress of Radiology (http://www.ecr.org/)
- RSNA – Radiological Society of North America (http://www.rsna.org/)

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- Agfa-Gevaert N.V.
- Aycan Digitalsysteme GmbH
- Barco Display System Inc. / Metheus
- Cedara Software Corporation (formerly: ISG technologies)
- CEMAX-ICON, A Kodak Company
- Clinton Electronics Corporation
- Compaq Computer Corporation
- DOME imaging systems Inc.
- Eastman Kodak Company
- GE Medical Systems
- Gossen Foto und Lichtmesstechnik
- IMAGE Smiths Inc.
- Imation Enterprises Corporation
- Marconi Medical Systems
- Merge Technologies Inc.
- Philips Medical Systems
- Quintiles Intelligent Images
- Siemens Medical Systems
- Sun Microsystems Inc.

IHE (Integrating the Healthcare Enterprise) is an initiative of HIMSS (Healthcare Information and Management Systems Society) and RSNA (Radiological Society of North America). More information is available at http://www.rsna.org/IHE/.

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OTech Inc.
2001 East Oakshores Drive
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TX 76227 (USA)
http://www.otechimg.com/

M References

A number of documents on the new DICOM extensions and the experiences gained from the demonstrations at ECR '99, RSNA '99, RSNA 2000 and ECR 2001 as well as from the work for IHE Year 2 have been published by the project team so far:

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