

VGStudio 1.1

User's Manual



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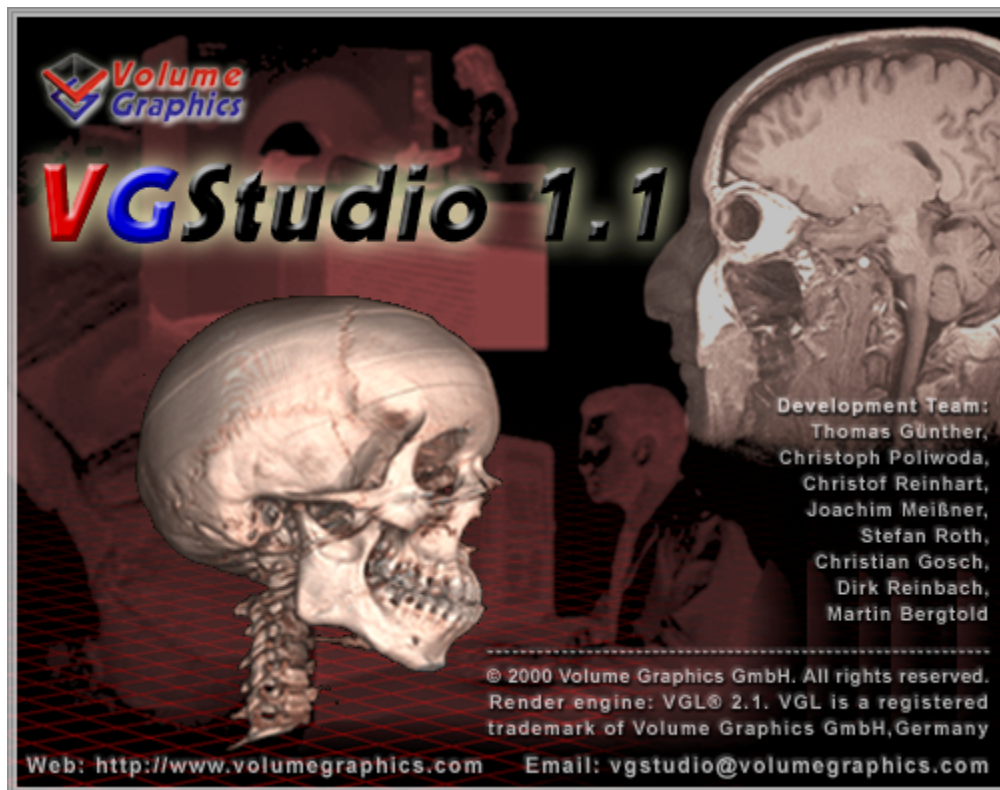
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User's Manual



Solutions about Voxels

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WELCOME TO VGSTUDIO 1.1 USER'S MANUAL

VGStudio 1.1 is a highly sophisticated image analysis and visualization software and was developed to provide the user with a powerful but easy-to-use interface to process and visualize voxel/volume data with high-performance analyzing and volume rendering algorithms. It uses an intuitive graphical user interface (GUI) with standard functions which are well known by most users from many other software packages. Apart from volume data analysis, VGStudio 1.1 may also be used for documentation and presentation purposes. You may render high quality images of the data set under investigation.

We hope you enjoy working with VGStudio 1.1!

All terms you might be unfamiliar with here will be explained throughout this manual.

Medical Use Restrictions

We wish to thank you for your past support and continued usage of the VGStudio voxel data visualization and analysis program. We have many future plans for the product, and we will advise you through the appropriate channels as these enhancements become available.

At the same time, however, we wish to remind you that the VGStudio products are "for research use only" or "for investigational use only." The Department of Health and Human Services (DHHS) National Institute of Health (NIH) defines "research" as...

" ... a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge..." (Cf. 45 CFR 46.102(d))

The "human subject" in research is...

" ... a living individual about whom an investigator... conducting research obtains (1) data through intervention or interaction with the individual, or (2) identifiable private information. Intervention includes both physical procedures by which data are gathered and manipulations of the subject or the subject's environment that are performed for research purposes. Interaction includes communication or interpersonal contact between the investigator and subject..." (Cf. 45 CFR 46.102(f))

Similarly, the DHHS Food and Drug Administration (FDA) defines an "investigation" as... "... a clinical investigation or research involving one or more subjects to determine the safety or effectiveness of a device..." (Cf. 21 CFR 812.3(h))

The FDA definition of a "subject" is...

" ... a human who participates in an investigation, either as an individual on whom... an investigational device is used or as a control. A subject may be in normal health or may have a medical condition or disease..." (Cf. 21CFR.812.3(p))

Within this regulatory framework, then, a clinical investigation can be argued to be a more restrictive form of research, in which the data and information collected are intended to be used to support the claims of a device's safety or effectiveness (the FDA regards software used in medical applications to be a medical device).

At the present time, Volume Graphics makes no representation that the VGStudio product is either safe or effective for any intended use for which research may currently be performed.

If you are conducting research or clinical investigations, by law, you are required to obtain prior Investigational Review Board (IRB) approval of

the clinical study protocol and of the patient informed consent documents, and to provide each patient/subject with a copy of the completed informed consent document. Similarly, if you are conducting research or clinical investigations using animal subjects, you are obligated to follow Good Laboratory Practices, and to observe the ethical treatment of the animals. If your facility or academic institution receives funding from NIH, or if your IRB has DHHS- approved assurances on-file, then you are obligated to follow the NIH rules, in addition to the FDA rules.

As a consequence of the regulatory status of the VGStudio products, you are reminded of the Login Acceptance Screen, reprinted below, in which you acknowledge the regulatory status of the product prior to using its functionality:

Disclaimer: VGStudio IS NOT FOR CLINICAL USE

VGStudio or data derived from VGStudio may be used only for research and may not under any circumstances be used for clinical purposes. Pressing the 'Accept' during the VGStudio installation procedure indicates your consent NOT to use VGStudio for anything other than research purposes.

You are encouraged to contact your governing IRB or clinical risk manager should you have any additional questions or concerns. We hope that this information clarifies your understanding of the regulatory status of the VGStudio product, and look forward to continued dialog with you.

To acknowledge the conditions regulating the use of VGStudio, please sign this letter in the space provided below and fax a copy of page 8 and 9 to us at +49 621 181 2634.

We wish you continued success in your research activities.

—
Volume Graphics GmbH

I agree to the above restrictions on the use of VGStudio.

Customer's Signature

Customer's Name (Printed)

Organization

1 Introduction to VGStudio 1.1

This chapter will help the user in getting accustomed with the program and its functions, and gives an overview of some basic concepts the user should keep in mind when using the program.

This chapter covers the following topics:

- Volume graphics and VGStudio
- About this manual
- Conventions used in this manual
- Where to get additional help
- Where to send feedback

1.1 Volume Graphics and VGStudio 1.1

Volume rendering or, to use a more general term, volume graphics, is a sub-specialty of 3D computer graphics which deals with the discrete representation and visualization of objects represented as sampled data in three or more dimensions. Volume graphics differs from traditional 3D graphics in that 3D graphics primarily deals with the representation of object surfaces, whereas volume graphics deals with the representation of both object surfaces and interiors. In volume graphics, for example, sample points such as CT or MRI scans are taken from the real world, assigned color and transparency levels, and are then projected directly onto the computer screen.

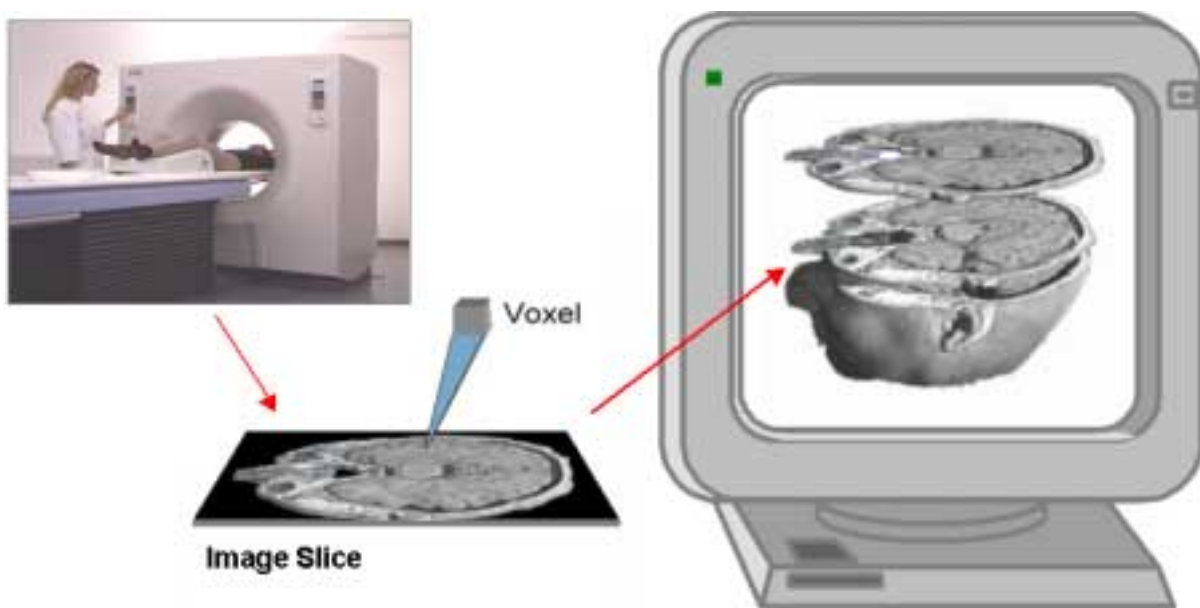


Fig. 1 Color and transparency levels are assigned to CT or MRI scans and are then projected directly onto the computer screen.

In recent years, the popularity of volume graphics has grown considerably. A few years ago, volume graphics was still limited by the large amount of computational power and memory required for real-time volume rendering. In contrast to classical or advanced 2D image processing, volume visualization and analysis produces huge amounts of data, so that memory, processor performances and algorithms are critical. Due to the highly sophisticated algorithms used in VGStudio 1.1 and the increase in PC computing power, volume graphics and volume analysis became accessible to everybody as the program runs on a standard PC. The adoption of efficient solutions in VGStudio 1.1, e.g. the multiprocessor (SMP) capable implementation of nearly every VGStudio 1.1 feature, allows the user to apply a trial and error approach to the analysis of 3D data; the user can apply an operation or a transformation to the data and control the result in an interactive and real-time environment, and may thus select the best suited operation for his/her needs. By using VGStudio 1.1, everybody can take advantage of volume graphics technology which has inherent advantages for applications that need visualization of irregular objects, or where the interior structure and a high-quality detail representation are essential, e.g. representations of the human body.

1.2 Example Images Rendered by VGStudio 1.1 Users



Fig. 2 Here are example images rendered by VGStudio users.

1.3 About this Manual

VGStudio has been designed to be as intuitive as possible, but as it is a sophisticated program, you might need help from time to time. In this case, you should refer to this manual which includes a comprehensive table of contents and an index to help you find the information you need.

This manual assumes that you are familiar with the Unix or Windows operating systems. If you need help with features specific to either system, please refer to the documentation supplied with your computer.

1.4 Conventions Used in this Manual

This manual uses the following conventions to identify information:

- Whenever you must execute a command by clicking the mouse, the command will be displayed in **bold** text (for example, click **OK** to continue).
- Menu items and buttons also appear in **bold** text for easy identification (for example, the **File** menu or the **Save** button).
- You will find the following icons throughout the manual. The icons indicate which mouse button you should press to execute the appropriate action.

Press left mouse button



Press middle mouse button



Press right mouse button



- Throughout the manual, you will find **Reminder** icons. They indicate important facts and exceptions.



- Chapter cross references are displayed in *italics* (for example, *Chapter 1, Introduction*).
- This manual combines Windows and Unix instructions. In most cases, they overlap, but in those instances when there are differences (most often with key commands), the manual will list both commands.

1.5 Where to Get Additional Help

Check the table of contents or the index whenever you need to locate information on a particular function. If you cannot find the information, there are other ways to get help. Please also refer to *Chapter 2.5 Registering VGStudio 1.1*.

- **Installation & Information Card**—Provides latest information on the current VGStudio 1.1 release and information on the installation procedure for your operating system.
- **Volume Graphics Web Site**—The Internet is a quick way to get answers to your questions. You can use the Volume Graphics web site at www.volumegraphics.com as a technical support resource.
- **E-Mail**— Send an e-mail to Volume Graphics at vgstudio@volumegraphics.com
- **Volume Graphics Technical Support**—If none of the resources mentioned above provides the answer, you can contact the Volume Graphics technical support by sending an e-mail to vgstudio@volumegraphics.com or one of our sales representatives. Please be at your computer and have your registration number available when you call.
- **Volume Graphics Sales**—Our friendly and knowledgeable sales personnel can answer basic questions about product capabilities and give information on other Volume Graphics products which may fit your needs. You may contact our sales department by sending an e-mail to info@volumegraphics.com or one of our sales representatives.

1.6 Feedback

We are very interested in your comments on VGStudio. Many of VGStudio's changes and improvements over the years were based upon user requests and input. If you have comments or feature requests, please send them to us via the World Wide Web:

<http://www.volumegraphics.com>

e-mail: vgstudio@volumegraphics.com

You may also send a letter or fax to the following address / fax number:

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2 Installation

This chapter gives general information on installation requirements and on the installation itself. Each section provides the users with instructions for both Windows and Unix operating systems. Find the section that is appropriate for your operating system.

This chapter covers the following topics:

- System requirements
- Installation instructions
- Registering VGStudio

2.1 System Requirements

This section lists the minimum system requirements for Windows and Unix users. Refer to the section that is appropriate for you. Also, see the section on VGStudio and memory usage in the *Appendix*.

Windows

Microsoft Windows™ 9x, Windows NT 4.0 or Windows 2000 operating system

Pentium III or higher or equivalent CPU

64 MB RAM (128 MB or more recommended)

Super VGA display (17" or larger recommended) with 800x600 resolution and 256 colors (1280x1024 at High Color recommended)

CD-ROM drive

Unix

Linux 2.0 (other Unix OS on request) operating system

64 MB available RAM (128 MB or more recommended)

Super VGA display (17" or larger recommended) with 800x600 resolution and 256 colors (1280x1024 at High Color recommended)

CD-ROM drive

2.2 VGStudio 1.1 on Multiprocessor Hardware

Almost all features included in VGStudio 1.1 are implemented multithreaded so that VGStudio 1.1 takes full advantage of modern processor technologies. Especially on multiprocessor (SMP) hardware, VGStudio 1.1 delivers an almost linear speedup proportional to the number of processors in use. VGStudio 1.1 utilizes the full memory bandwidth of today's and upcoming system designs to provide its users with an optimal performance.

By default VGStudio 1.1 utilizes all processors available in a system. The user may limit the number of processors used by VGStudio 1.1 by applying the environment variable **PROCESSORS** with the appropriate number of processors.

Adding environment variables on a Windows NT 4.0 / 2000 System

Step 1: Choose **Settings** in the Program Manager **Start** menu.

Step 2: Choose **Control Panel** from the **Settings** menu.

Step 3: Double-click the **System** icon to display **System Properties**.

Step 4: On the **Environment** index card, click any existing variable name in the list you want to add the variable to.

Step 5: Type in the name of the new variable in the **Variable** box.

Step 6: Type in the value in the **Value** box.

Step 7: Click **Set**.

Notes:

If you are not an administrator, you may add variables only to the **User Variables** list. Windows NT will save changes in the registry so that they will be available automatically the next time you start your computer. Changes will not affect programs that are running, and will only be effective once you have restarted your computer.

Adding environment variables on a Unix system

Examples for utilization of 2 processors.

For tcsh users type:

```
setenv PROCESSORS 2
```

For bash users type:

```
export PROCESSORS=2
```

2. Installation

Notes:

Ask your system administrator for help if you are not familiar with modifying system or environment variables. To modify your PATH variable, type in one of the following commands depending on what shell you use and where you have installed the software. Include the corresponding line into your `.cshrc` or your `.bashrc` file if you do not want to modify your environment variables every time you log into your system.

2.3 Installation Instructions

Please refer to the **Installation & Information Card** which is supplied with your VGStudio 1.1 software package for up-to-date and detailed information on the installation procedure for your operating system. It also provides you with the latest information on the current VGStudio 1.1 release.

2.4 VGStudio 1.1 License

The VGStudio 1.1 **License update** window will pop up when you start VGStudio 1.1 for the first time or when no valid license was found on your system. Enter your name or the name of your company and the license key which is included in your VGStudio 1.1 software package and click **OK**. You may also ask the Volume Graphics support for a trial license at vgstudio@volumegraphics.com. To do so press the **Create registration form button**, fill in the required information and send the registration form to Volume Graphics. See *Chapter 1.6 Feedback* for more information on how to contact Volume Graphics directly.

Update node locked license

License

To order full or trial license, please create registration form, fill out form and send the fully filled out form to Volume Graphics!

Create registration form

Licensed to:

Dr. GUENNE

Hardware ID:

Q C9EBD8FA416350728DAF9CBE05271436

License key:

Expiry Data (mm-dd-yyyy):

OK Exit Cancel

Fig. 3 The License update window where you enter your name and license key.

2.5 Registering VGStudio 1.1

To be eligible for technical support, as well as receive information on bug-fix updates and feature upgrades, you must register your copy of VGStudio. To register press the **Create registration form** button in the License dialog (please refer to *Chapter 4.3.8 Help Menu License update*), fill in the required information and send the registration form to Volume Graphics either by fax, mail, or e-mail. If you change your address after registering, you may call or e-mail us so we can update your record, or send us a standard post office change of address notice. See *Chapter 1.6 Feedback* for more information on how to contact Volume Graphics directly.

3 Getting Started

This chapter explains how to get started using VGStudio by introducing some basic program concepts. It covers the following topics:

- Launching the program
- First steps with VGStudio
- Exiting VGStudio
- Image quality versus speed

3.1 Launching the Program

To launch VGStudio MAX 1.0 for Windows open the **Start** menu. Select the option **Programs / Volume Graphics / VGStudio 1.1**. You may also **double-click** on a vgi-File e.g. in your Windows Explorer to start VGStudio 1.1. You may drag a vgi file on the VGStudio 1.1 icon to start VGStudio 1.1 with the appropriate file loaded automatically.

To launch VGStudio 1.1 for Linux/Unix enter the command **vgstudiomax** at the command prompt. You may add a vgi file as command line option to start VGStudio MAX with the appropriate file loaded automatically.

```
C:\>vgstudiomax [vgi-file]
```

Example: C:\>vgstudiomax demo.vgi

You may drag a vgi file on the VGStudio icon to start VGStudio with the appropriate file loaded automatically.



Reminder: When starting the program for the first time you have to enter your name and the license key. For more information on the installation procedure, see *Chapter 2 Installation*.

After having launched the program, the VGStudio application will appear on your screen with its startup screen. The startup screen will disappear after a few seconds or upon pressing a key on your keyboard or a mouse button. The VGStudio interface consists of seven main elements:

- Title bar
- Menu bar
- Icon bar
- Slice windows
- 3D window
- Tool box
- Status bar

3.1 Launching the Program

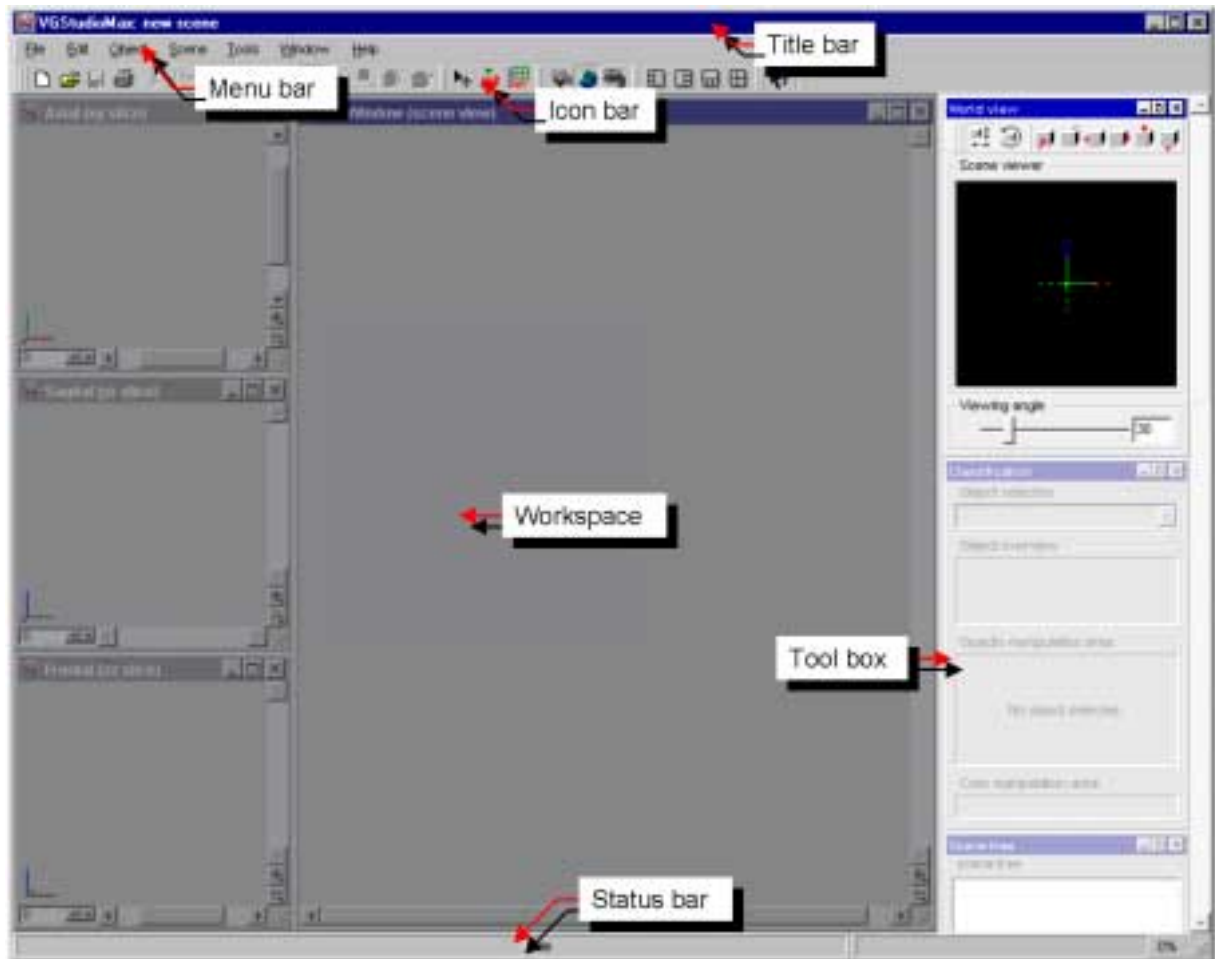


Fig. 4 The VGStudio interface after startup.

All the functions included in VGStudio are accessed either by selecting options in the main menu, by clicking buttons in the icon bar, by using the tools in the toolbox, or via context menus which you open by clicking into an element with the right mouse button.

3.1.1 Keyboard Usage

Most VGStudio functions that are accessed via the menu may also be activated by using keyboard shortcuts. If keyboard shortcuts exist, they are displayed next to the entries in the pulldown menus. This can be seen in the following image where the **Edit** menu is shown as an example.

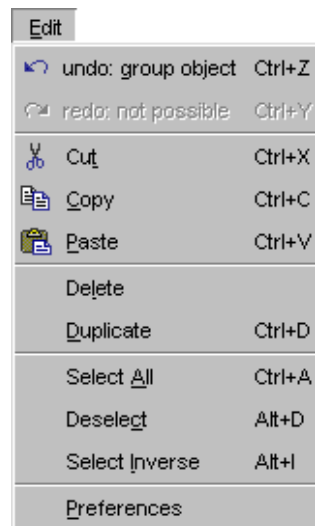


Fig. 5 The keyboard shortcuts are displayed next to the menu entries.

List of Keyboard Shortcuts

Command	Keyboard Shortcut
---------	-------------------

File Menu

New	Ctrl + N
Open	Ctrl + O
Save	Ctrl + S
Save As	F12
Quit	Alt + F4

Object Menu

Move	Shift + Ctrl + M
Rotate	Shift + Ctrl + R
Scale	Shift + Ctrl + S
Clipbox	Shift + Ctrl + B
Clipplane	Shift + Ctrl + C
Group	Ctrl + G
Ungroup	Ctrl + U

Edit Menu

Undo	Ctrl + Z
Redo	Ctrl + Y
Cut	Ctrl + X
Copy	Ctrl + C
Paste	Ctrl + V
Delete	Del
Duplicate	Ctrl + D
Select All	Ctrl + A
Deselect	Alt + D
Select Inverse	Alt + I

3.1.2 Mouse Usage

VGStudio is designed to work with a mouse with either two or three buttons. If you are using a two-button mouse, the third (middle) mouse button is emulated by simultaneously pressing the **Alt** key on your keyboard and the left mouse button. In conjunction with certain window managers, the **Alt + left mouse button** combination is already in use. A second alternative to emulate the middle mouse button when using a two-button mouse is to use the combination **Shift + Ctrl + left mouse button**.

Throughout the manual, you will find the following icons. The icons indicate which mouse button you should press to perform the appropriate action.

Press left mouse button	Press middle mouse button	Press right mouse button
		

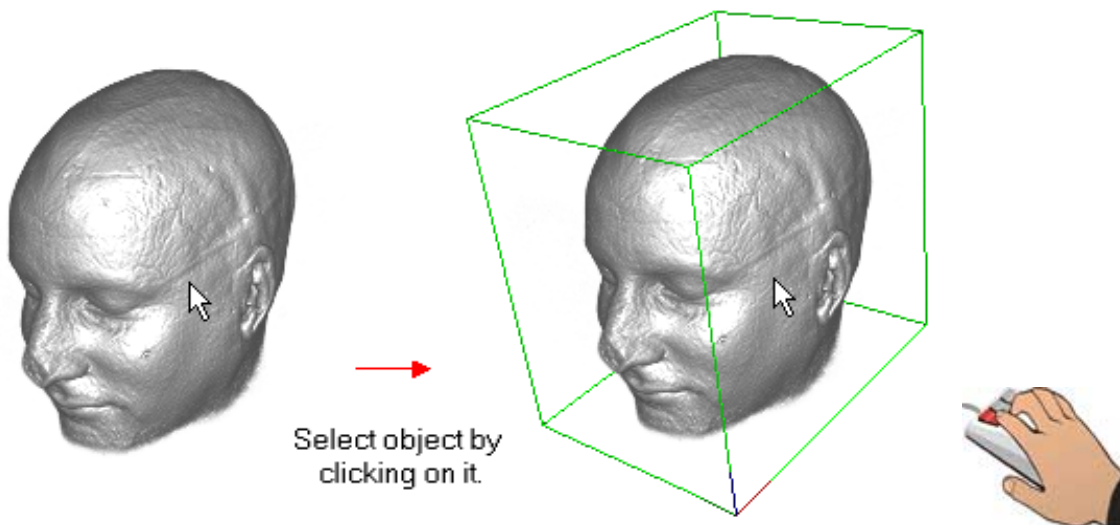


Fig. 6 When clicking an object with the left mouse button you select or activate it. This is indicated by a bounding box around the object.

By clicking an object with the left mouse button, you select or activate an object. You may also select several objects at once by clicking into a window with the left mouse button and then dragging a frame over the objects while the left mouse button is pressed or by using the shortcut **Ctrl + A** (when using this shortcut, **all** objects currently displayed in the scene will be selected). You may deselect one or several objects by clicking outside the bounding box of any object. The box around any object will disappear.

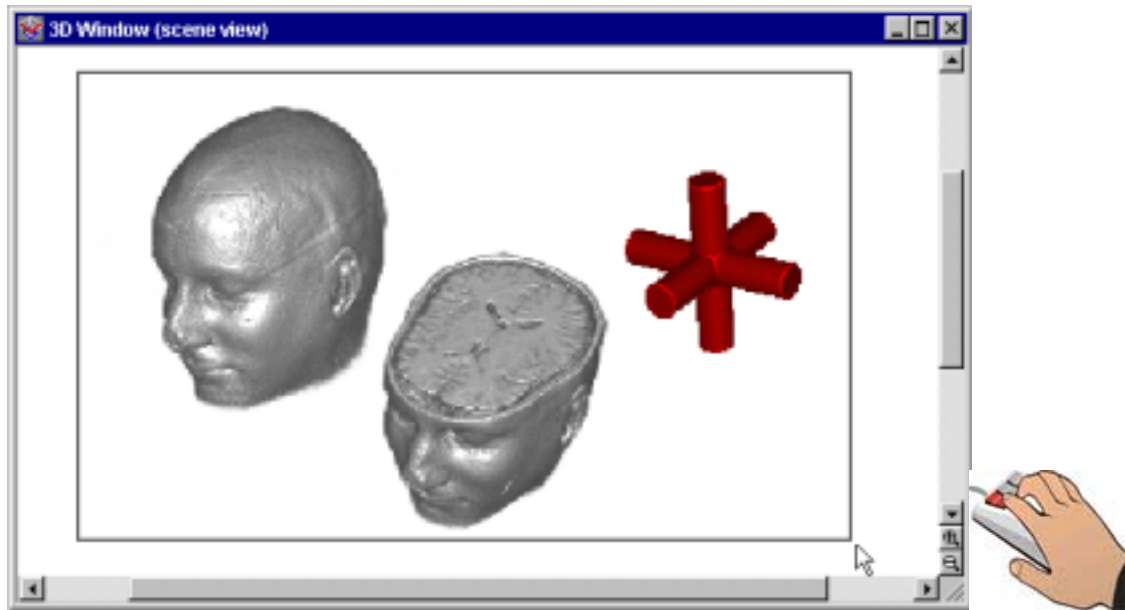


Fig. 7 Select several objects by dragging a frame over the objects while the left mouse button is pressed.

To select more than one object (but not **all** objects of the scene), keep the **Ctrl** key pressed while clicking the objects to be selected. A bounding box will appear around the selected, active objects. To deselect an object, press the **Ctrl** key and click the selected object. The bounding box will then disappear.

For different actions such as positioning, rotating, clipping, or scaling, the bounding boxes around the objects will be displayed in different colors (see table below). These bounding boxes also include **active areas**. The mouse cursor has to be moved into an active area before an action can be applied to the object. In positioning, rotation, and clipplane mode, the whole bounding box is the active area. In clipbox mode (see figure below) or scale mode, squared handles on each side of the bounding box indicate the active areas.

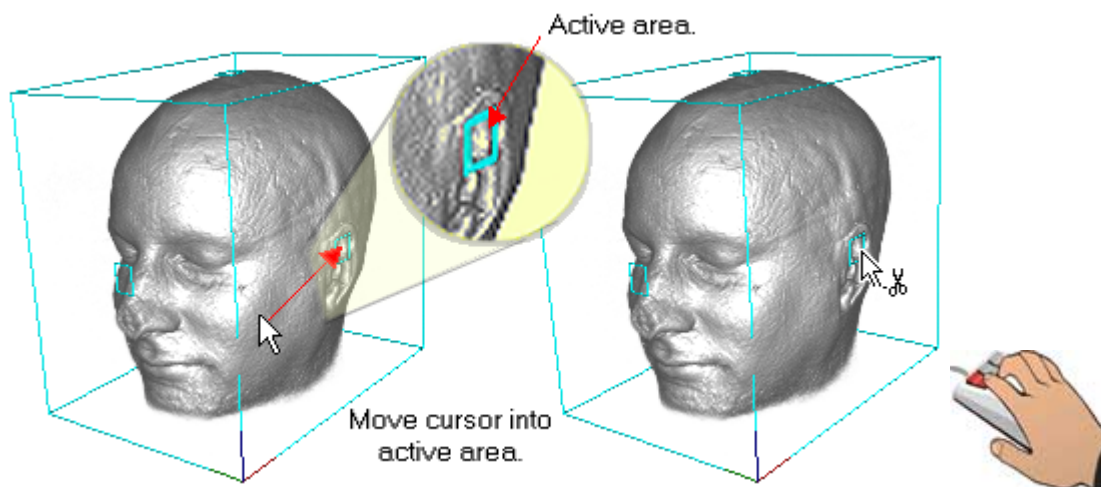


Fig. 8 Move the cursor into the active area to perform an action.

3.1 Launching the Program

The mouse cursor will change as soon as the mouse is moved into an active area, which indicates that an action can now be performed. The following table shows the colors of the bounding boxes and the shape of the cursor when a certain mode is selected.

Action	Color of bounding box	Default cursor	Cursor on active area
Positioning	green		
Rotate	red		
Clipbox / Clipplane	cyan		
Scale	blue		

VGStudio 1.1 Magellan® / SPACE MOUSE support

VGStudio 1.1 is designed to work with the LogiCad Inc./GmbH Magellan® / SPACE MOUSE. To use VGStudio 1.1 in combination with a LogiCad Spacemouse start the Space Mouse driver before starting VGStudio 1.1.



Fig. 9 The Space Mouse

The Space Mouse may be used to steer the six degrees of freedom of the currently selected object. The Magellan® / SPACE MOUSE allows you to control "flying objects" spatially without strain. In a similar way, you may also "fly" through virtual voxel worlds.

Information on the LogiCad Inc./GmbH Magellan® / SPACE MOUSE can be found under the internet address <http://www.spacemouse.com>.

3.2 First Steps with VGStudio

This section will explain your first steps when using VGStudio and will guide you through the most important steps of the program. A data set of a human jaw which was scanned with a CT scanner is used to show some of the basic functions of VGStudio. This chapter will not go into detail, i.e. describe all the options and alternatives available. Each tool introduced in this chapter will be described in more detail in the following chapters.



Reminder: Some of the settings discussed here will only be valid for CT data!

Start the VGStudio application. An empty scene will be displayed, i.e. the slice windows and the 3D window will be empty. Select the **Open** command in the **File** menu. In the **Open info file** dialog select the file **jaw.vgi** by clicking it and pressing **Open** or by simply double-clicking the file. The file extension **.vgi** stands for **V**olume **G**raphics **I**nterface file. The data is loaded into VGStudio and images will appear in the four windows of the workspace as shown below.

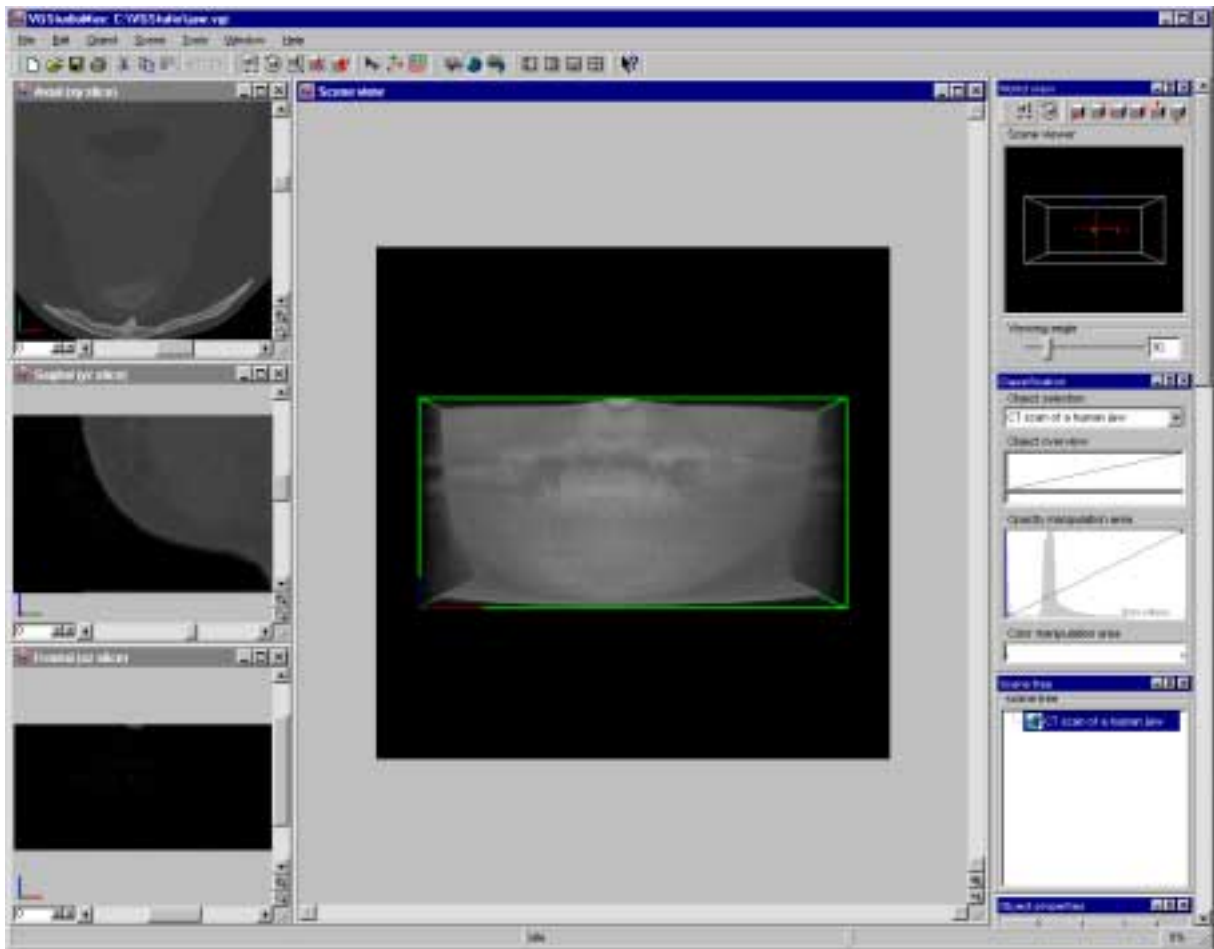


Fig. 10 The VGStudio screen after a file has been loaded. Here, the Move mode is activated, which is indicated by the green bounding box.

The jaw data set is loaded into the scene. Around the jaw, a green bounding box will appear. The green box indicates that the object is the currently selected object and that the **Move** mode (indicated by the green box around the jaw data set) is activated. An action can be applied to the selected object only. Click with the left mouse button into the 3D view window outside the green bounding box to deselect the object. The bounding box will disappear. Click the jaw again to select the object. The green bounding box will reappear. Now move the object by clicking into the green bounding box with the left mouse button and dragging the mouse while the left mouse button is pressed.

To activate the **Rotate** mode, press the **Rotate** icon in the icon bar.



The bounding box around the jaw will appear now in red color, which indicates that the **Rotate** mode is active. Rotate the jaw by clicking into the red bounding box with the left mouse button and dragging the mouse while the left mouse button is pressed. The jaw can be rotated in any direction.

3. Getting Started

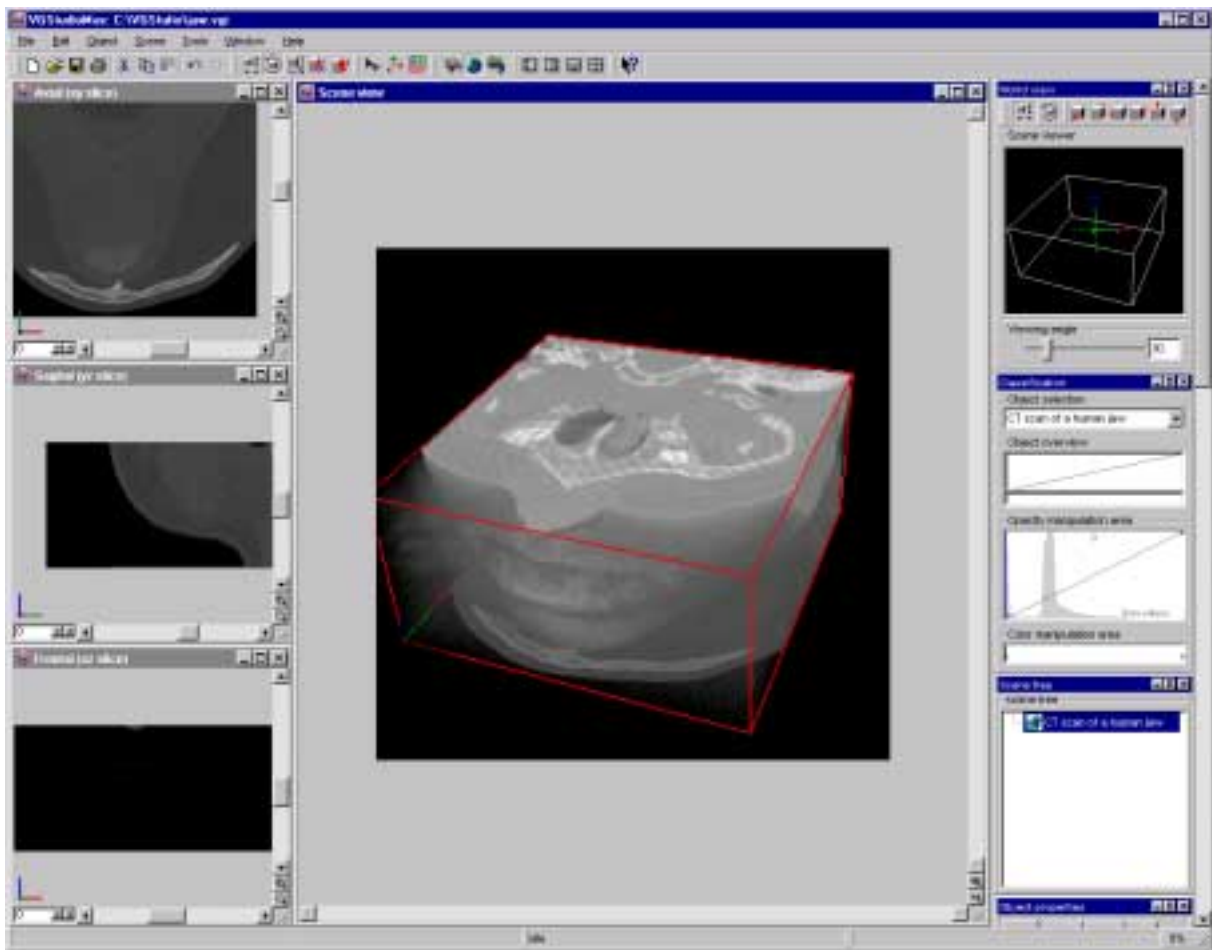


Fig. 11 The red bounding box indicates that the Rotate mode is active. Rotate the image by clicking into the bounding box and dragging the mouse while the left mouse button is pressed.

One of the most powerful tools of volume graphics is the possibility to map any grayvalue of the original data to any arbitrary opacity. This functionality is handled by the **Classification** tool.

In the main part of the **Classification** tool you find the **Opacity manipulation area**. It shows a function which maps any grayvalue (abscissa) to any opacity value (ordinate). It also shows a histogram of the frequency of occurrence of the different grayvalues in the background. The grayvalues are applied to the abscissa of the plot, the opacity values are applied to the ordinate. The line running from the lower left corner to the upper right corner is the default opacity function running from dark transparent voxels to bright opaque voxels. An arbitrary function may be applied to the data by inserting new handles to the function and moving these handles.

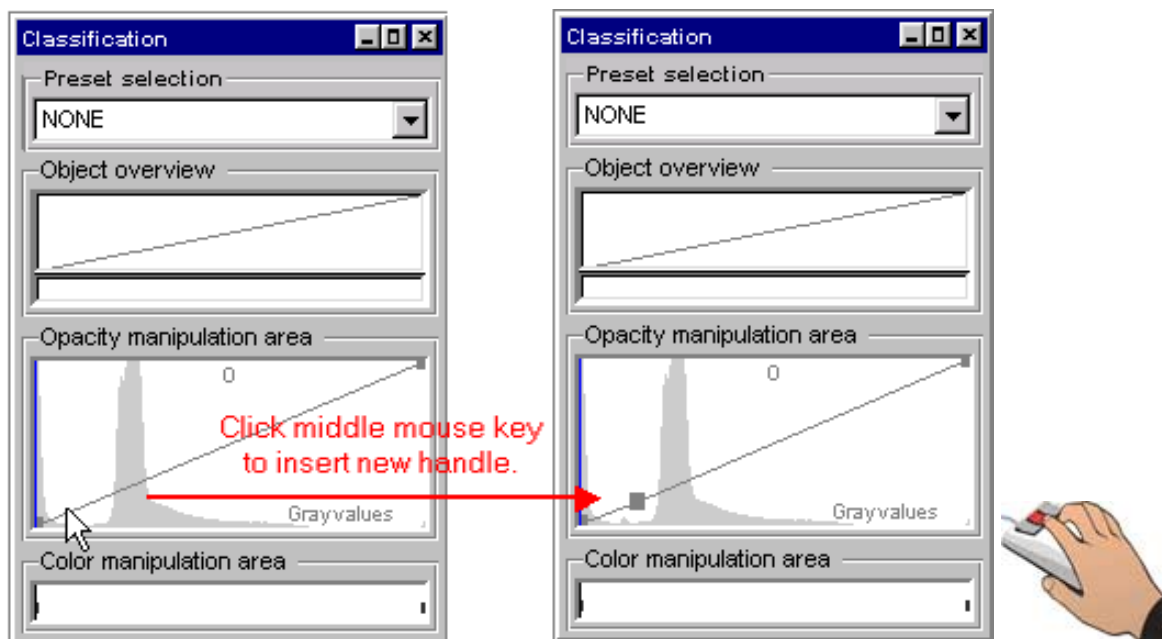


Fig. 12 To insert a new handle or to remove an existing handle in the Opacity manipulation area, click the desired position with the middle mouse button.

To manipulate the opacity function place the mouse into the **Classification** tool's **Opacity manipulation area** as shown above. Click the middle mouse button (or the left mouse button while the **Alt** key is pressed) to insert a new handle or remove an existing handle on the opacity function's line. Click the new handle with the left mouse button and drag it down to zero opacity. The opacity function should now look like the following example:

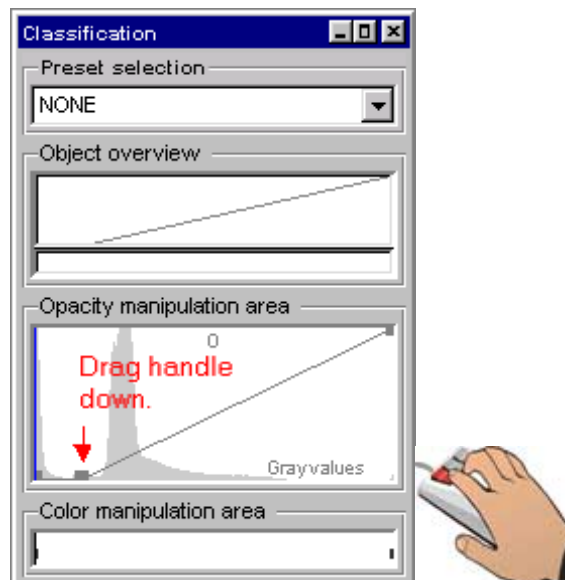


Fig. 13 The opacity function after a new handle has been inserted.

3. Getting Started

The resulting 3D image will appear much clearer since all the noise included in the lowest (the left side) grayvalues is now set to zero opacity and is therefore invisible.

For another step grab the new handle by clicking it with the left mouse button and drag it to the right while the left mouse button is pressed. Keep the handle on the base line, zero opacity, as shown in the following example. Drag it to the right-hand side of the gray peak displayed in the histogram of the **Opacity manipulation area**.

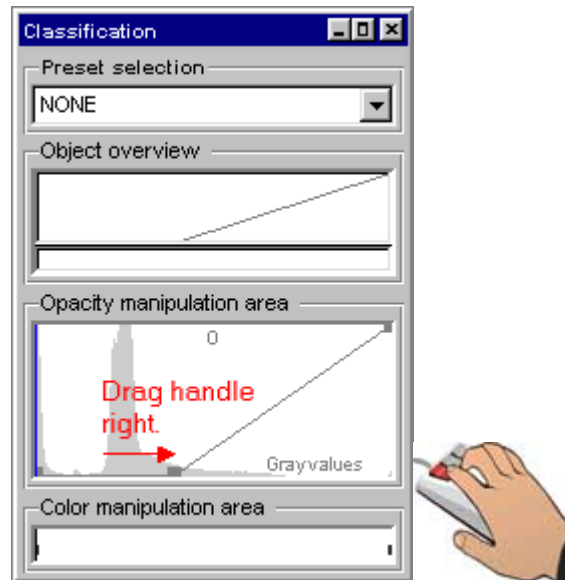


Fig. 14 Drag the new handle to the right to make soft tissue invisible in the 3D image.

The resulting 3D image should look like it is shown in the following figure. Only the bone structure, the teeth, and the braces are visible, the noise/air and the soft tissue are invisible.

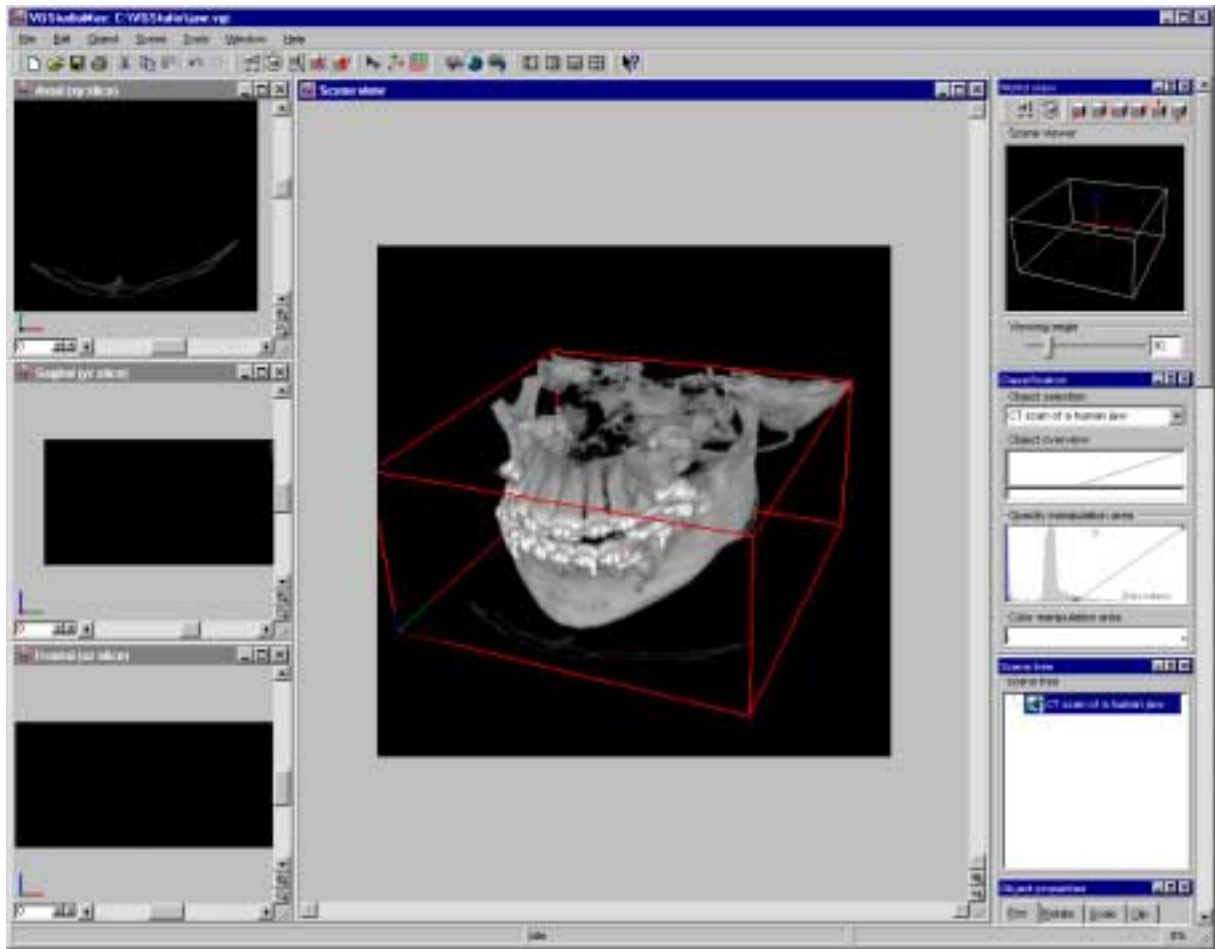


Fig. 15 The 3D image after noise/air and soft tissue have been removed. Only the bone structures, the teeth and metal parts are now visible.

The reason for this is explained in the following picture.

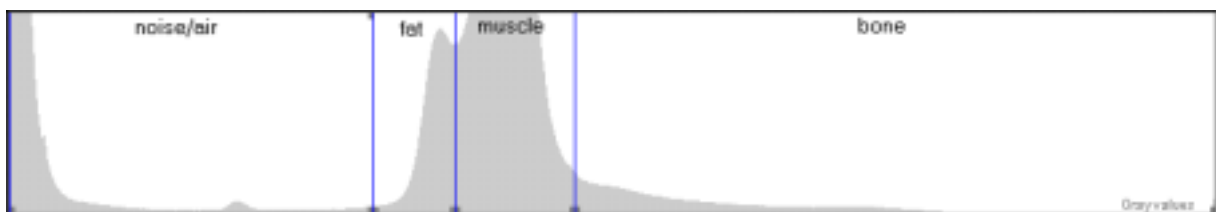


Fig. 16 From left to right, the grayvalues of the different structures are displayed, i.e. noise/air, fat, muscle, and bone structures.

Noise and air will appear on the left-hand side of the **Opacity manipulation area**. The next tissues which appear towards brighter grayvalues are fat and muscles. The brightest tissue is the bone structure, teeth and metal braces which appear on the right-hand side of the **Opacity manipulation area**. If all the grayvalues of tissues such as air/noise, fat and muscle are set to zero opacity, only the bone structure, teeth, and metal will remain visible.

3. Getting Started

To enhance the 3D perception of the image activate the **Shadow light source**.

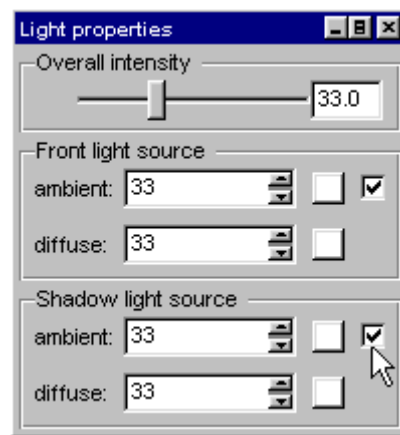


Fig. 17 The Light properties dialog.

To activate the shadow light source click the checkbox in the **Shadow light source** section of the **Light properties** dialog.

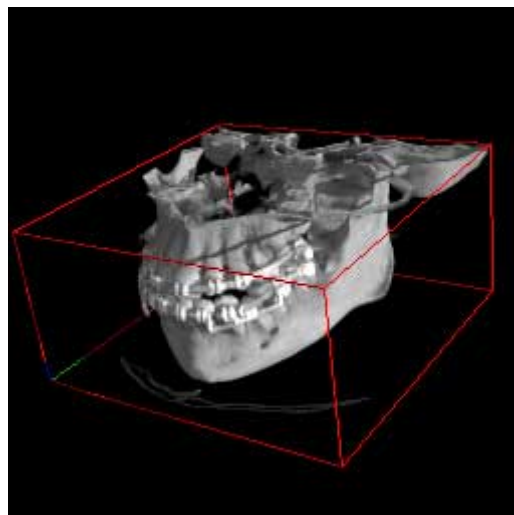


Fig. 18 The 3D image after having activated the Shadow light source.

The jaw will now appear with realistic shadowing.

Another very powerful function of the **Classification** tool is the grayvalue segmentation. To demonstrate this feature we will first reset the **Classification** tool. To do so click into the **Object** overview section with the right mouse button and click **Delete all segments** as shown in the following figure.

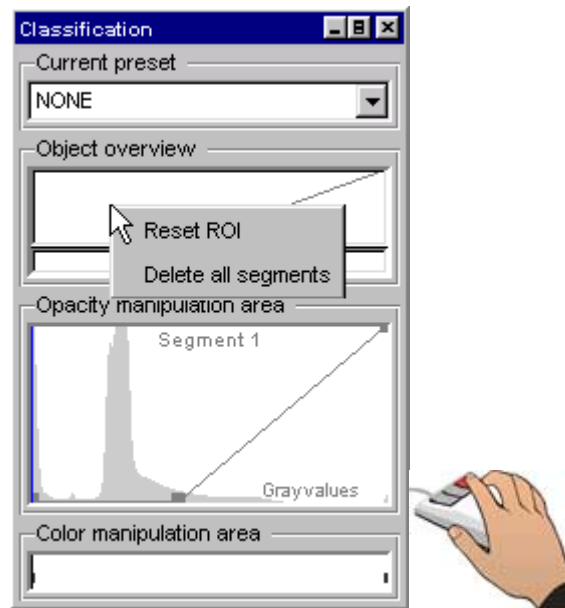


Fig. 19 Click Delete all segments to reset the Classification tool to its default values.

Then move the mouse cursor to the right border of the **Opacity manipulation area**.

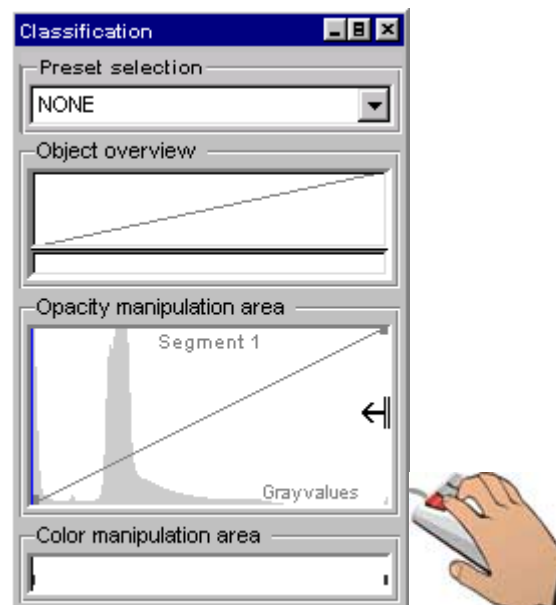


Fig. 20 For grayvalue segmentation, move the cursor to the right side of the Opacity manipulation area and drag the blue line.

The shape of the cursor will change as shown in the figure above. Drag the blue line which appears on the left-hand side of the **Opacity manipulation area** while keeping the left mouse button pressed. The grayvalues to the left and right of the blue line will be displayed while dragging the line. Drag the line to a grayvalue between 1300 and 1400. You can always move the line by dragging it to the left or right while keeping the left mouse button pressed.

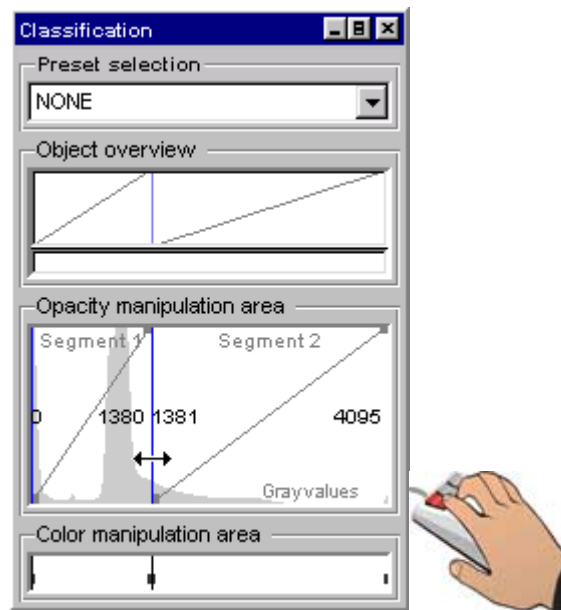


Fig. 21 The blue line marks the border between two grayvalue segments.

The blue line will mark the border between two grayvalue segments. Two segments have been created. The left segment includes the noise/air, fat, and muscle grayvalues, the right segment includes the bone structure and metal objects. To reduce the noise, add a new handle in the left segment as you did before by using the middle mouse button. The classification tool should now look like the following figure.

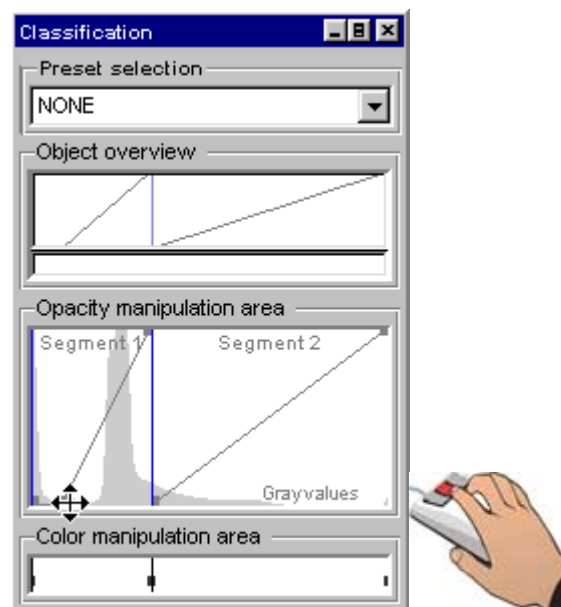


Fig. 22 Reduce the noise by inserting a new handle and dragging it down to zero position.

3.2 First Steps with VGStudio

Click with the right mouse button into the left segment's section of the **Color manipulation area**. The following menu will pop up.

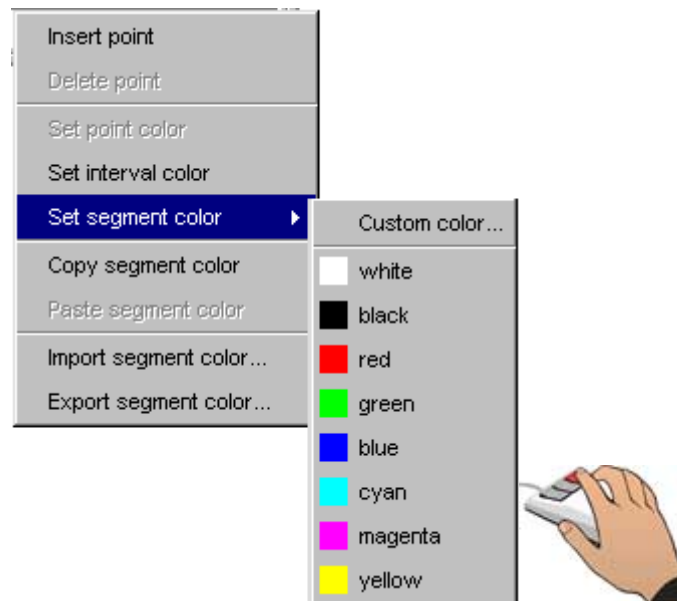


Fig. 23 Select a color for the different segments.

Click **Set segment color** and select a color for the left segment, the soft tissue, by clicking one of the default colors or using the **Custom color** option to select a user-defined color. After you have done so, the **Classification** tool will look as follows.

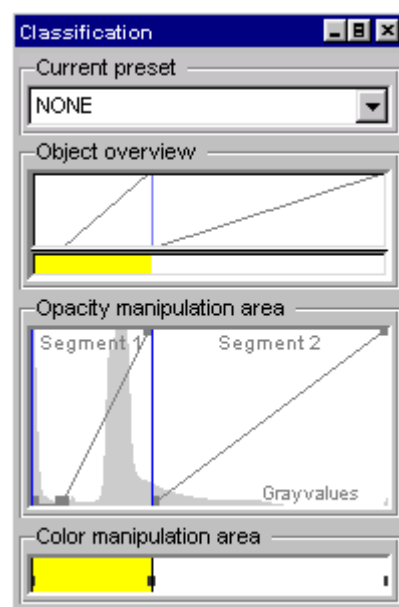


Fig. 24 The Classification tool after you have selected a color for the segments.

The jaw in the 3D image will then look like in the figure below. Soft tissue is displayed in yellow, the bone tissue in white.

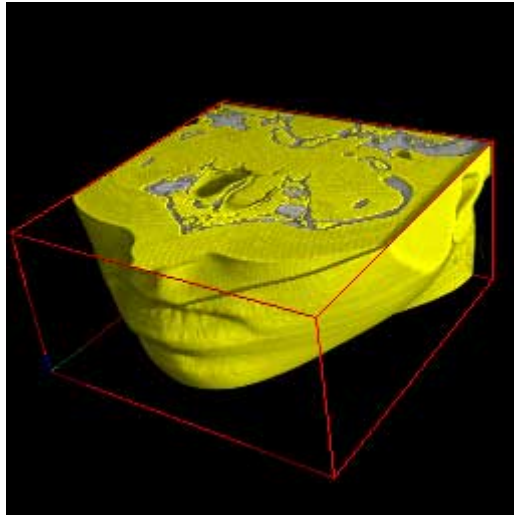


Fig. 25 The 3D image after a color has been assigned to one of the segments.

The grayvalue segmentation allows to set up independent grayvalue ranges where opacity and color can be customized without affecting other segments. A single segment may, for example, be extracted (see *Chapter 4.6.1 Classification Tool*), disabled, or enabled by clicking with the right mouse button into segment 1 shown in the **Opacity manipulation area**. A context menu will then open where you may, for example, select **Disable segment** to disable segment 1.

The next functions explained here are the **Clipbox** and **Clipplane** functions. Rotate the jaw into a position as shown in the following figure.

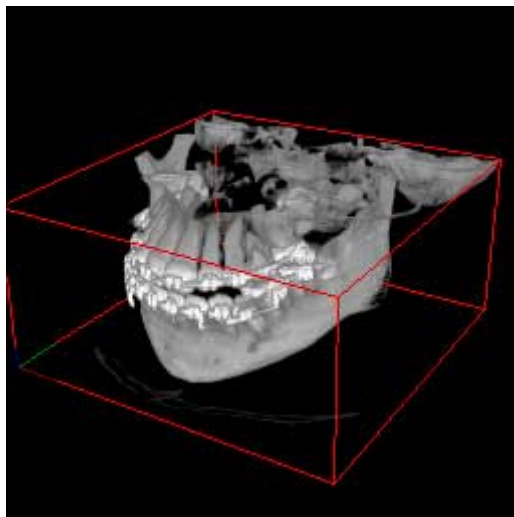


Fig. 26 The 3D image in Rotate mode indicated by the red frame.

Click the **Clipbox** icon in the icon bar.



The **Clipbox** mode is characterized by the cyan bounding box with squared handles, i.e. active areas on each side of the selected object or group of objects. When moving the cursor into the active area, a scissors will appear next to the cursor, as it is shown in the figures below. Clip the object by clicking the active area on one side of the bounding box and dragging the mouse inward while keeping the left mouse button pressed.

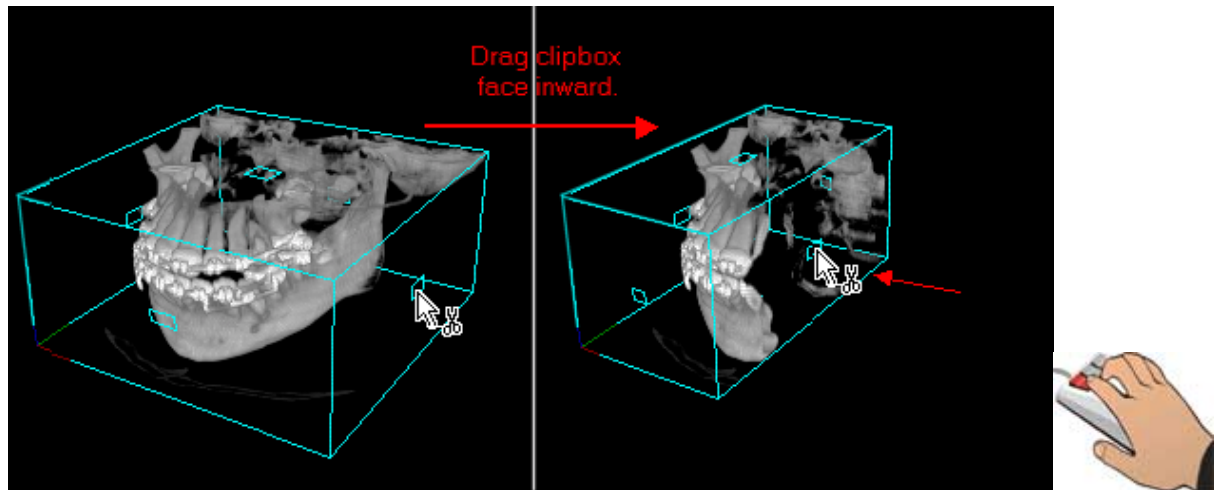


Fig. 27 The 3D window in Clipbox mode indicated by the cyan bounding box and the scissors displayed next to the cursor when moving it into an active area.

Remove the clipping by dragging the handles outward or by clicking the **Undo** button.



Most features included in VGStudio 1.1 can be undone! After you have removed the clipping, the 3D image should look like the following image.

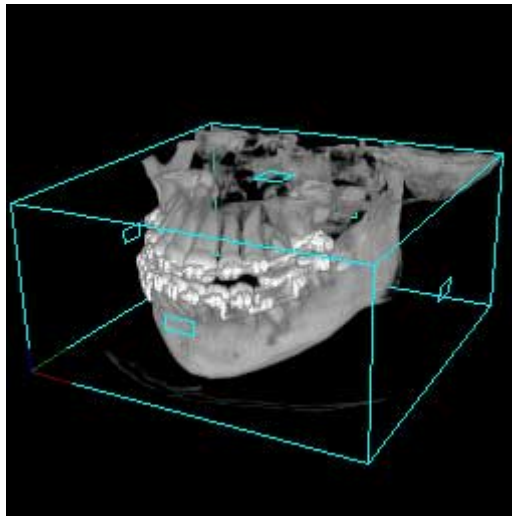


Fig. 28 The 3D view in Clipbox mode after the previous clipping has been undone.

Click the **Clipplane** icon to activate the **Clipplane** mode.



The **Clipplane** mode is characterized by the cyan bounding box with a normal vector on one side of the currently selected object. When moving the cursor into the bounding box, a scissors will appear next to the cursor. The object may be clipped along an arbitrary clipplane by dragging the mouse up and down while the **middle mouse button** (or the **Alt** key and the left mouse button) is pressed. Press the middle mouse button while positioning the mouse inside the active area and drag the mouse down to move the clipplane inward. Drag the mouse inside the active area while keeping the left mouse button pressed to rotate the clipplane in any arbitrary direction.

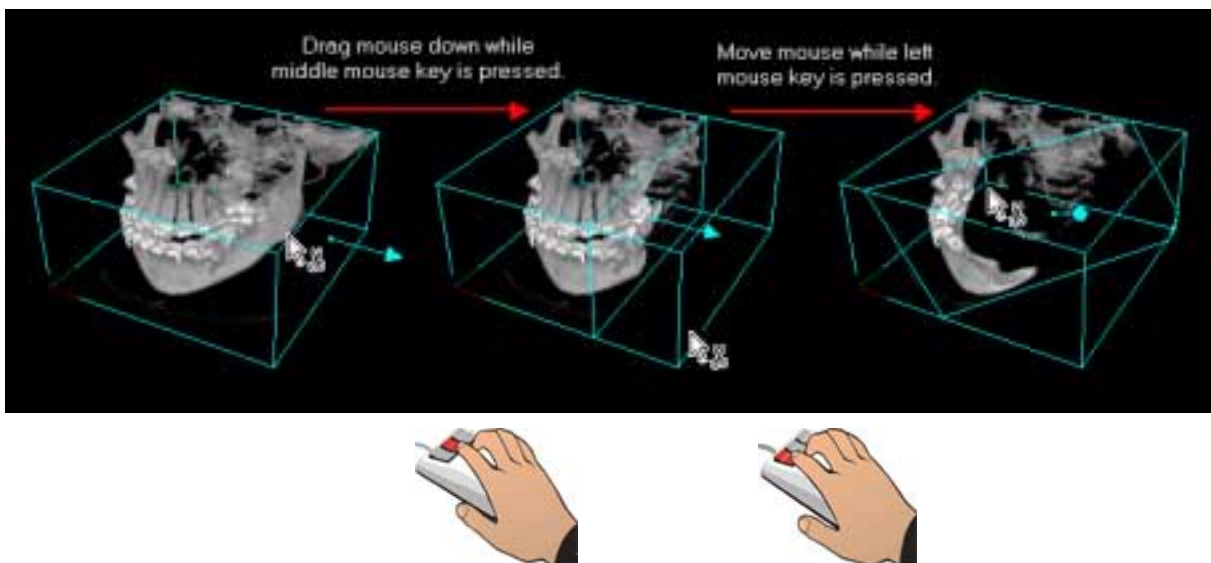


Fig. 29 Move the object along an arbitrary clipplane by dragging the mouse up or down while the middle mouse button is pressed. By dragging the mouse inside the active area while the left mouse button is pressed, the clipplane will be rotated in any arbitrary direction.

You may save your current work at any time by using the **Save** or **Save as** option in the **File** menu. As an example, use the **Save as** option and name the scene **jaw1** (the original file will then not be overwritten). The file extension **.vgi** (**V**olume **G**raphics **I**nfo file) will be added automatically and therefore has not to be added by you. To reload the current scene, you may use the **Open** option in the **File** menu.

A single image such as the rendered 3D image or one of the slice images may be saved by selecting the appropriate image window and using the **Save image** option in the **File** menu.

3.2.1 Voxel Objects, Polygon Objects, and Scenes

All objects loaded into VGStudio will be placed into “**the Scene**”. The scene is the virtual space displayed in VGStudio’s 3D window. By default, the scene coordinate axes will be displayed on your screen as shown in the following figure.

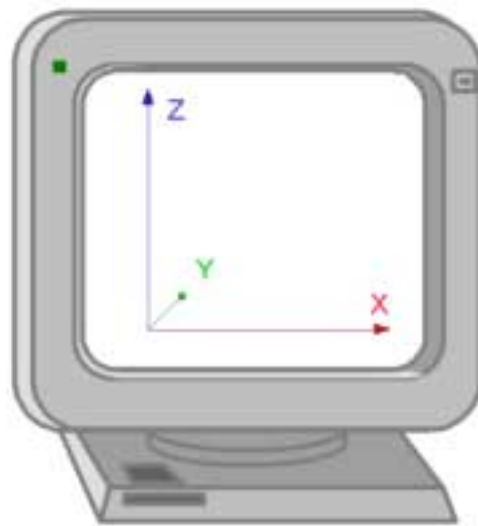


Fig. 30 The VGStudio scene coordinate system.

The default coordinate system used by VGStudio is right-handed, with the coordinate origin in the lower left corner. The coordinate origin is on the left side of a body (x), at the front (y), and at the feet (z). By default, the positive x-direction in the scene runs from left to right. The positive y-direction in the scene runs from the front to the back of the screen plane. The positive z-direction in the scene runs from the bottom upwards. However, these orientations represent the default settings. The whole scene may be rotated or moved with help of the **World view** tool. All axes or planes orthogonal to the axes in VGStudio have a consistent color coding. The x-axis and planes orthogonal to the x-axis are displayed in red, the y-axis and planes orthogonal to the y-axis in green, and the z-axis and planes orthogonal to the z-axis in blue. For easy identification, all sections in the windows of the tool box related to the coordinate axes are also marked according to this color scheme.

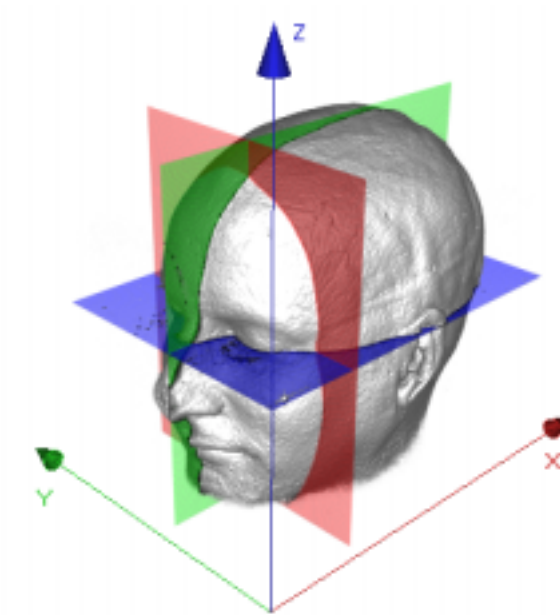


Fig. 31 Color coding of axes and orthogonal planes.

However the user may change the coordinate system used to display slice images in the three orthogonal slice windows to a left handed coordinate system. Left handed coordinate systems are mainly used by medical applications. Please refer to *Chapter 4.3.3 Setting Preferences*.

An object loaded into a scene will be placed in the scene's origin (0,0,0) with its center, not with its origin. An object may be moved or rotated arbitrarily within the scene as shown in the following example:

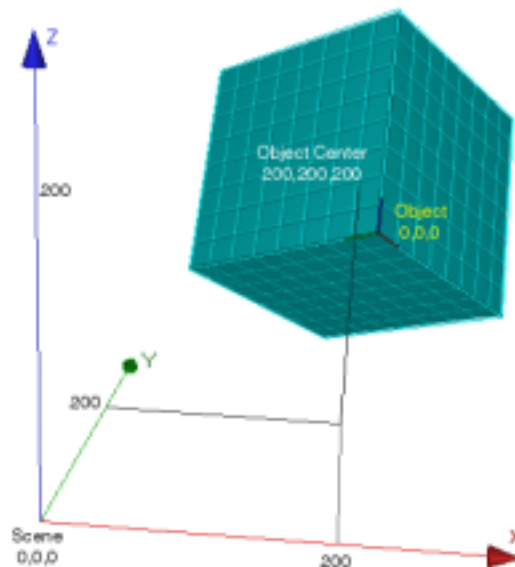


Fig. 32 An arbitrarily rotated object is moved to scene position 200,200,200.

3.2 First Steps with VGStudio

VGStudio is able to handle and render objects or data sets in voxel and polygonal representation. In traditional 3D graphics (polygon graphics), objects are represented as mathematical models. Surfaces are subdivided into many small triangles or polygons, which are assigned colors, textures, and levels of transparency or opacity.

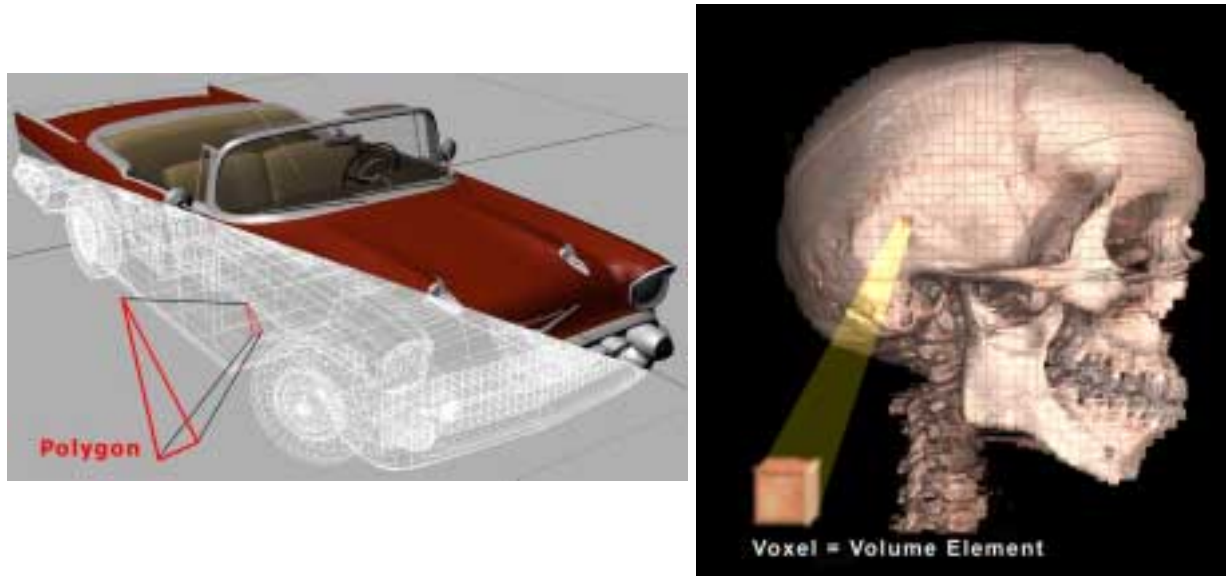


Fig. 33 Objects in polygonal representation (left) and voxel representation (right).

Volume graphics is a sub-specialty of 3D computer graphics. It deals with the discrete representation and visualization of objects represented as sampled data in three or more dimensions. A volume/voxel data set is a three-dimensional array of voxels. The term *voxel* is used to characterize a volume element; it is a generalization of the notion of *pixel* that stands for a picture element. A volume data set usually contains values that have been obtained by some type of 3D scanning or sampling device or by a simulation process. Typical sampling devices are x-ray, CAT, MNR, PET, SPECT, and Confocal Laser microscopy. Each voxel consists of a position and a value. The voxel position is a three-tuple that specifies a position within the three-dimensional voxel array. The origin of the volume data set is considered to be the center of the first voxel (i.e., the voxel with coordinates (0,0,0)). The first coordinate of the voxel position represents the column, the second coordinate represents the row, and the third coordinate represents the image (or slice). Columns, rows, and images are numbered starting from 0. The voxel in the 8th column, 1st row, and 2nd image would then have the position (7,0,1).

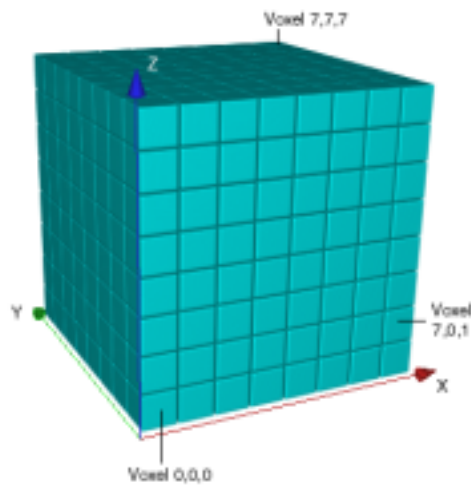


Fig. 34 A schematic Voxel data set.

3.2.2 The Illumination Model

VGStudio supports an illumination of the scene by two light sources with parallel light. You may adjust the light settings in the **Light properties** dialog (for more information on the **Light properties** dialog, please refer to *Chapter 4.6.4 Light Properties*).

The **Front light source** is positioned in 0° , i.e. in the eye of the observer, the **Shadow light source** is positioned in 45° , to the right of the observer. The light sources are located at fixed positions relative to the observer.

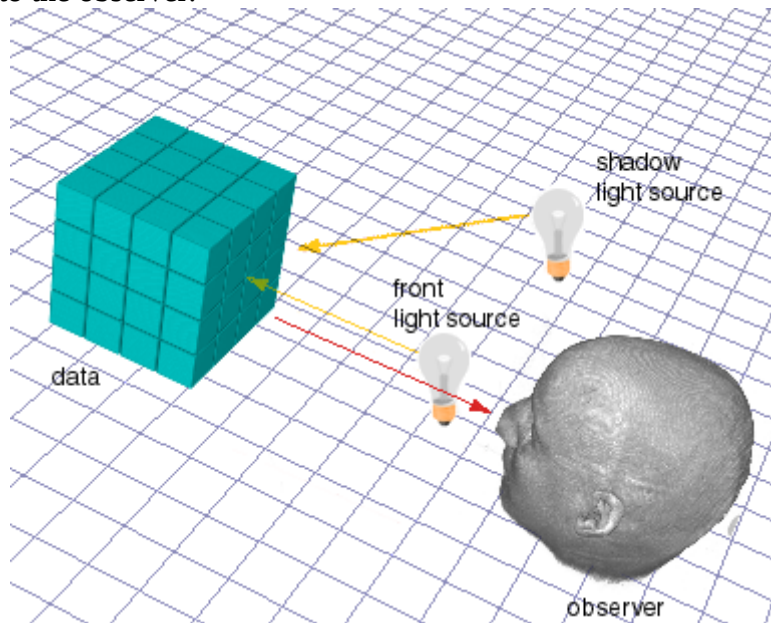


Fig. 35 Usage of the light sources in VGStudio will enhance the 3D perception of an image.

Activating the shadow light source will considerably enhance the 3D perception of an image.

3.2.3 VGStudio Clipboard

VGStudio has its own clipboard and does NOT use the standard clipboards of your operating system since these clipboards are not capable to handle the different data used by VGStudio. Due to this you will not be able to use the cut, copy, and paste commands to copy data or images into other applications or from other applications into VGStudio. Use the **Save Image** command to export rendered 3D images or slice images in standard image files.

3.3 Exiting VGStudio

To exit VGStudio, click **File** in the menu bar and select **Quit**. If there are any unsaved scenes, VGStudio will ask you whether you want to save them before exiting. You may also exit VGStudio by clicking the **Close Window** button in the upper right corner of the window.

3.4 Image Quality versus Speed

With every decision you make in VGStudio, you make a trade-off between rendering speed and image quality. As a rule of thumb, the higher the quality of the rendered images, the slower the rendering speed. Additional lights or many semitransparent structures in the image will increase the rendering time.

As you go through the scene creation process, you will probably want to keep the rendering quality low in order to increase the rendering speed.

When you are satisfied with your scene, you may increase the rendering quality to see what the scene looks like in its final form.

Here are some hints on how to adjust parameters in order to achieve optimal settings for performance or quality.

Optimal settings for performance:

- Use the Scatter HQ algorithm,
- use small result image sizes, e.g. 256x256,
- use only front light and disable shadow light source,
- use oversampling factor of 1.0,
- deactivate color rendering,
- use opaque data structures and avoid transparent data.

Optimal settings for image quality:

- Use the Scatter HQ or Scatter + Gradients algorithms,
- use large result image sizes,
- use oversampling factor of 3.0 or more,
- activate color rendering.

4 VGStudio Interface & Tools

This chapter will guide you through the various functions of VGStudio. Before you actually start working with the program, you should familiarize yourself with the various parts of the interface. In this chapter, the following parts of the interface will be explained in detail:

- Menu bar
- Tool bar
- Tool box
- Slice windows
- 3D window
- Status bar

4.1 Basic Concepts of the VGStudio User Interface

4.1.1 2D slices and 3D images

In the past, working with volume or voxel data meant working with stacks of 2D image slices. Radiologists got tenths of images from a CT scanner and viewed them slice by slice along the scan axis to get a 3D impression of the data. Thanks to the upcoming computer technology, radiologists now have the possibility to use MPR (Multi Planar Reconstruction) image slices, which means that they can view image stacks not only along the scan axis but also along all three axes of a voxel data set. VGStudio overcomes the limitations of simple 2D image viewing. It provides full 3D visualization and analysis functionality. In addition, VGStudio supports the MPR technology. The VGStudio user interface includes a 3D view window as well as the 2D image viewing windows with the three orthogonal cross sections axial, frontal, and sagittal.

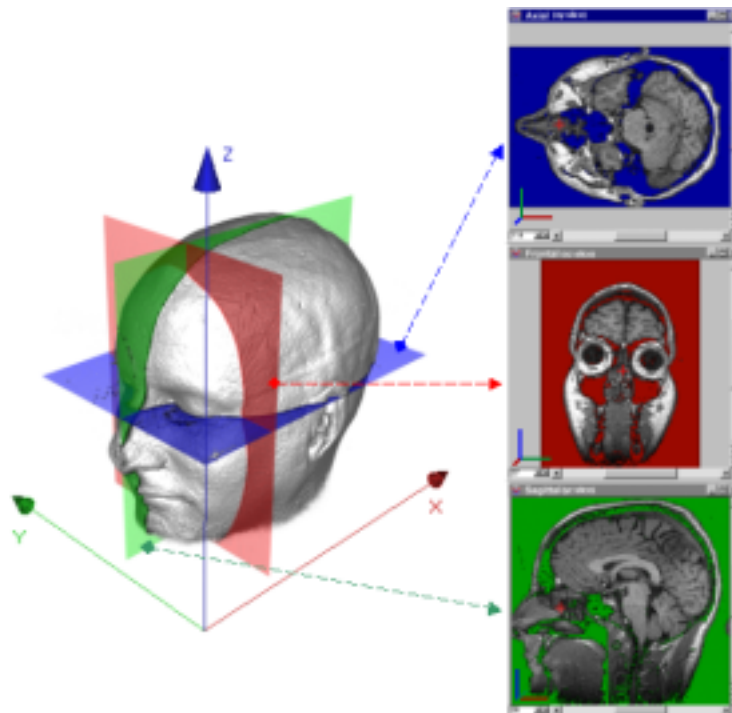


Fig. 36 In addition to the 3D view window, VGStudio also displays 2D image viewing windows with the three orthogonal cross sections axial, frontal, and sagittal.

4.1.2 VGStudio Color Coding

The x-, y-, and z-axes and the planes orthogonal to these axes are coded by a color scheme throughout the whole VGStudio user interface. The x-axis and image planes orthogonal to the x-axis are displayed in red, the y-axis and image planes orthogonal to the y-axis in green, and the

z-axis and image planes orthogonal to the z-axis in blue. In the three slice windows, a small colored tripod is displayed in the lower left corner, which shows the orientation of the respective image in the 3D data set. Labels in tools as well as scene axes or grids are displayed in the same colors.

The bounding box of an object includes a colored tripod at voxel position (0,0,0). The axes are colored in the same scheme, i.e. the x-axis is red, the y-axis is green, and the z-axis is blue.

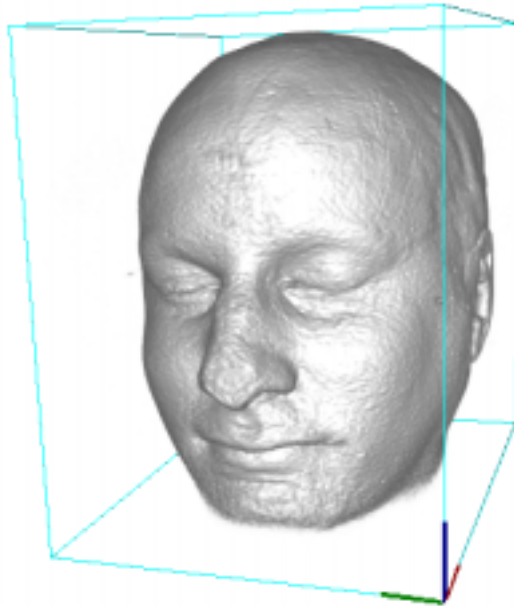


Fig. 37 A tripod colored according to the VGStudio color scheme is displayed at voxel position (0,0,0).

4.1.3 Tool tips

A tool tip will pop up and display the function of an element of the VGStudio user interface when the mouse pointer is placed on an element, e.g. buttons or tools.

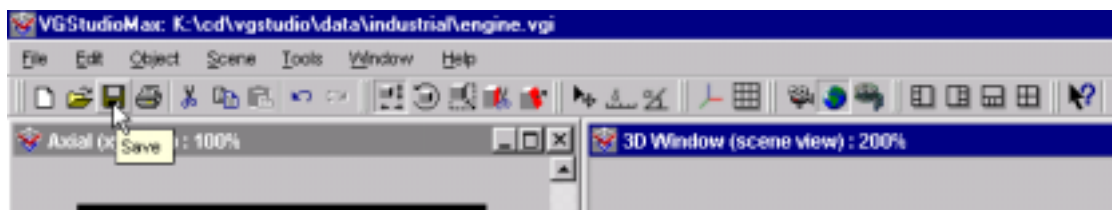


Fig. 38 Tool tips will pop up when the mouse pointer rests on an icon.

4.2 Title Bar Elements

Title bar

In the title bar, "VGStudio" and the filename of the current scene are displayed.

Control icon

In the left corner of the title bar you find the **Control** icon, which is used to access the **Control** menu (see following section). Double-clicking the **Control** icon will close VGStudio.

Control menu

You open the **Control** menu by clicking the **Control** icon with the left mouse button. You can use the **Control** menu to position the main window or to exit VGStudio.

Window buttons

The window buttons can be found in the right corner of the title bar. You can use the buttons to position the main window or to exit VGStudio.

4.3 Menu Bar

The **Menu** bar displays VGStudio's menu titles. Each menu lists a group of entries, and with each entry, a specific action is performed.

Menus or menu items that are not available are disabled.

Using the menus

1. You open a menu by clicking it, or by pressing <Alt> plus the letter that is underlined in the menu's title. For example, to open the **File** menu, you press <Alt> + <F>.
2. Once you have opened a menu, you choose a menu item by clicking it, by pressing the underlined letter, or by using the cursor keys to highlight it and then pressing <Enter>. Menu items that appear in gray are currently not available.

In the following sections, you will find a description of each of these menus in the order in which they appear in the menu bar.

4.3.1 File Menu

Click **File** to open a pulldown menu containing the following entries:

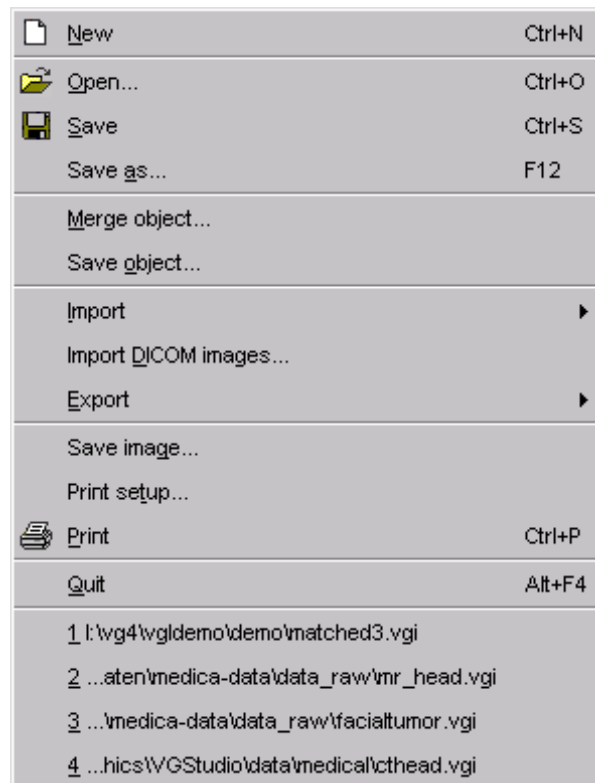


Fig. 39 The File menu.

- **New**—Select this command to create a new scene. Note that selecting this entry will close the scene you are currently working on. After you have created a scene, you can save it by using the **Save** command. The scene can be accessed again using the **Open** command. Both commands are described below. You may also use the keyboard shortcut **Ctrl+N** to create a new scene.
- **Open**—Select this command to open an existing scene. You may load Volume Graphics Info files (.vgi extension) as well as old info files (.info extension) by selecting the desired file and clicking **Open** or by simply double-clicking the file in the **Open info file** window. You may also use the keyboard shortcut **Ctrl+O** to open an existing scene.
- **Save**—Select this command to save your work. You should save your work frequently throughout the scene creation process. Saving a scene with **Save** or **Save as** will generate a Volume Graphics Info file (.vgi extension). The *.vgi file includes data-relevant information such as the file name and path, data type, file type, file size, and data mapping as well as scene-relevant information such as light settings, rendering algorithm, or background color. You may also use the keyboard shortcut **Ctrl+S** to save a scene.
- **Save As**—Select this command to save the current scene under a different name. You could use this, for example, to save the current scene to a different drive or to save the changes under a different name, thereby keeping the original scene intact. You may also use the **F12** key on your keyboard to save a scene under a different name.
- **Merge Object**—Select this command to load additional objects into the active scene. To merge objects, select a *.vgi file and click **Open**. If the *.vgi file includes more than one object, a dialog box will open where you may select one or several of the included objects that are to be loaded into the active scene. All object properties of the merged object such as position and rotation will remain unchanged during a merge process. The scene properties of the active scene, e.g. background color or illumination, will also remain unchanged.

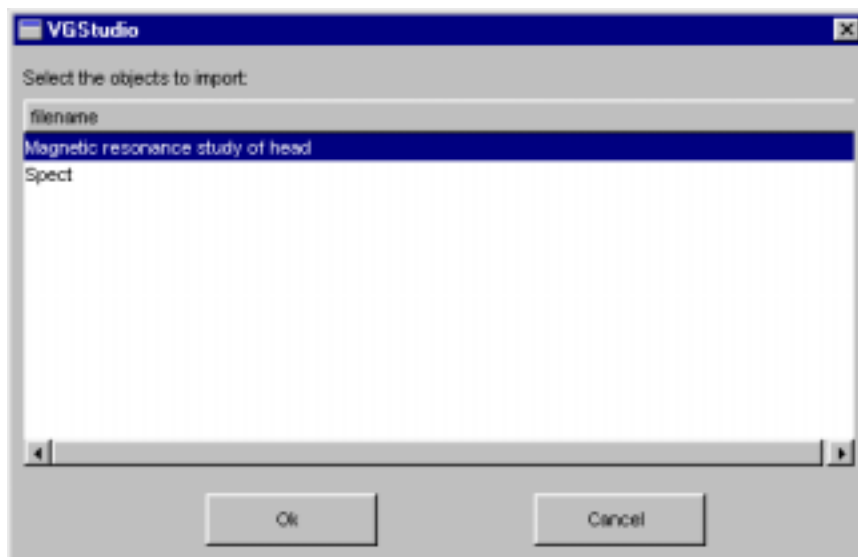


Fig. 40 Select the objects to be imported and click OK.

- **Save Object**—Select this command to save the currently selected object only. The object will be saved in its default settings; no scene-relevant settings such as position, rotation, or clipping will be saved with the object. Only the object's voxel resolution will be saved. Use the **Save** or **Save As** command to save an object with all scene parameters.
- **Import**—Select this command to import objects and data of different data types into VGStudio. VGStudio supports image stacks of TIFF, JPEG, BMP, PPM, DICOM, and RAW Images as well as RAW data volumes (un-/signed 8, 16, 32 bit Integer, 32 bit Floating Point and 32 bit RGBA), HDF volumes, Analyze volumes, and DICOM data. Polygonal data can be imported in OFF file format. For more information on how to import images, please refer to *Chapter 5.1 Importing Data*.
- **Import DICOM images**—Select this command to import DICOM volume data or image files into VGStudio. Use the file dialog to select one or several data files. For more information on how to import images, please refer to *Chapter 5.1.6 Importing DICOM Data*.
- **Export**—Select this command to export the currently selected object. For more information on how to import images, please refer to *Chapter 5.2 Exporting Data*.
- **Save Image**—Select this command to save a rendered image or a slice image to a file. Supported file formats are TIFF, JPEG, BMP, or PPM. The rendered 3D image or one of the three slice images may be saved. To save an image, select one of the four windows in the workspace by clicking into the image (**View** window, **3D Scene** view, **Camera** view or one of the three slice windows) and then selecting **Save Image** in the **File** menu.



Reminder: The size, width, and height in pixels of a saved image is independent of the applied zoom factor in the 3D or slice windows.

The size of a saved slice image is the original size of the cross section of the volume data set. When saving a slice image, only the cross section of the actual volume data set will be saved. No bounding box cross sections or instruments will be saved in the image.

The size of a saved 3D image is the size (width and height) which is adjusted in the **Render properties** tool. When saving a 3D image, the full scene as shown in the 3D window will be saved, including all instruments, active bounding boxes, coordinate axes, or grids. To remove the bounding box of an object use the **Deselect** option in the **Edit** menu.

- **Print Setup**—Select this command to access the standard print options dialog box.
- **Print**—Select this command to print the active window. You may select one of the three slice windows or the 3D window as the active window by clicking the title bar or into one of the windows. You may also use the keyboard shortcut **Ctrl+P** to print the active window.



Reminder: The **Print** option will scale the printed image so that it fits best to the page.

When printing a slice image, only the cross section of the actual volume data set will be printed. No bounding box cross sections or instruments will be printed.

When printing a 3D image, the full scene as it is shown in the 3D window will be printed, including all instruments, active bounding boxes, coordinate axes, or grids. To remove the bounding box of an object use the **Deselect** option in the **Edit** menu.

- **Quit**—Select this command to exit VGStudio. Note that if there is an open scene that you have not yet saved, VGStudio will ask you whether you want to save your changes prior to exiting. You may also use the keyboard shortcut **Alt+F4** to exit VGStudio.
- List of the last four edited scenes.

4.3.2 Edit Menu

Click **Edit** to open a pulldown menu containing the following entries:

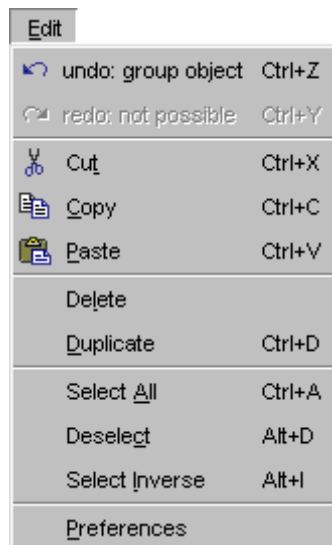


Fig. 41 The Edit menu.

- **Undo**—Select this command to undo your previous action. This menu item changes depending on the action you last performed. For instance, if you have pasted an object into your scene, the text reads **undo: paste object** and the object will be removed from the scene when you select this command. You may also use the keyboard shortcut **Ctrl+Z** to undo your last command. You may undo the last 100 actions and commands. Only one exception will destroy the undo history.



Reminder: The undo history will be **destroyed** in case of deleting an object. You have to select the undo command **immediately** after having deleted the object.

- **Redo**—Select this command to redo your previous **Undo** action. This menu item changes depending on the **Undo** action you last performed. For instance, if you have undone the pasting of an object, the text reads **redo: paste object** and the object will be pasted into the scene again when you select this command. You may also use the keyboard shortcut **Ctrl+Y** to redo your last **Undo** command.
- **Cut**—Select this command to cut objects within a scene in VGStudio. The cut objects will remain in the VGStudio clipboard. When you cut objects, you cut all related information such as opacity and color along with whatever you cut. Note that VGStudio objects cannot be pasted into another program. You may also use the keyboard shortcut **Ctrl+X** to cut objects.
- **Copy**—Select this command to copy selected objects into the VGStudio clipboard. When you copy objects, you copy all related information such as opacity and color along with whatever you copy. Note that VGStudio objects cannot be copied into another program. You may also use the keyboard shortcut **Ctrl+C** to copy objects.
- **Paste**—Select this command to paste previously copied or cut objects into a scene. You may also use the keyboard shortcut **Ctrl+V** to paste objects.
- **Delete**—Select this command to delete any selected object in the scene. Note that you can undo this action by using the **Undo** command explained above. You must, however, undo your action **immediately** after having deleted the object. You may also use the **Del** key to delete an object.
- **Duplicate**—The **Duplicate** option is the fastest possibility to generate and use a copy of an object. You may also use the keyboard shortcut **Ctrl+D** to duplicate objects. In contrast to the **Copy** and **Paste** command the duplicate command does not use the clipboard. The copied object will be placed directly into the scene where it can be used immediately. When duplicating an object, VGStudio places the object directly above the original object. The relative position will be used as default offset. If the new object is moved, its offset to the original object is used as offset for every new duplication process. This procedure is called smart duplicate.



Reminder: The offset adjusted during a smart duplicate will be set to its default value (zero) as soon as the duplicated object is deselected or another object is selected.

- **Select All**—Select this command to select all objects in the scene. You may also use the keyboard shortcut **Ctrl+A** to select all objects.
- **Deselect**—Select this command to deselect all selected objects in the scene. You may also

use the keyboard shortcut **Alt+D** to deselect all objects.

- **Select Inverse**—Select this command to invert the active objects in the scene. You may also use the keyboard shortcut **Alt+I** to generate an inverse selection.
- **Preferences**—Select this command to access the **Preferences** dialog box where you can set VGStudio preferences. For more information on this dialog please refer to *Chapter 4.3.3 Setting Preferences*.

4.3.3 Setting Preferences

Numerous program settings are stored in the preferences file (vgstudio.cfg), located in the VGStudio application folder. The settings stored in this file include general appearance options, directory information, tool options, and options such as time periods for auto-saving the scenes you are currently working on. In the **Preferences** dialog, you may adjust the settings for **Directory** information and other **Options** such as auto-saving. Preference settings are saved each time you exit VGStudio.

To open the **Preferences** dialog box select **Preferences** in the **Edit** menu. Then choose the desired preference index card by clicking it.

The index card **Directories** is used to set up where VGStudio should look up or save different kinds of files. Enter the appropriate path or click the **Browse** button to select a directory in the **Find Directory** dialog box.

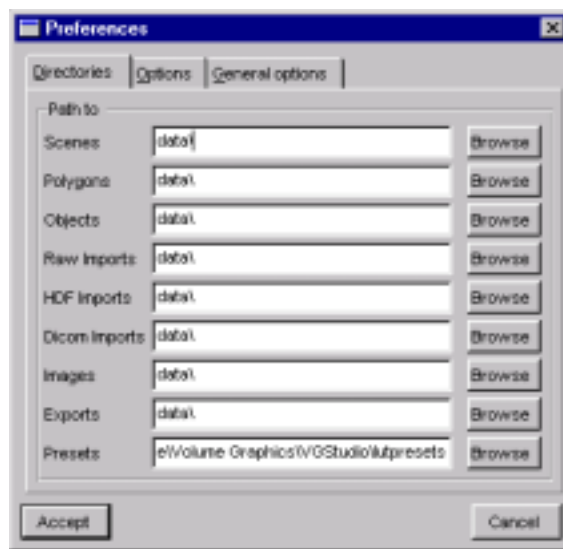


Fig. 42 The Preferences dialog box with the Directories index card selected.

- The **Scenes** path is the default directory where the **Open** file dialog looks up scene files saved as Volume Graphics Info files (.vgi).

- The **Polygons** path is the default directory where the **Import - Polygon** file dialog looks up polygonal data files (.off).
- The **Objects** path is the default directory where the **Merge object** file dialog looks up Volume Graphics Info files (.vgi).
- The **Raw Imports** path is the default directory where the **Import - Raw volume** import wizard looks up raw data files.
- The **HDF Imports** path is the default directory where the **Import - HDF volume** file dialog looks up Hierarchical Data Format files (.hdf).
- The **Dicom Imports** path is the default directory where the **Import - DICOM image series** file dialog looks up Dicom and Papyrus files.
- The **Images** path is the default directory where the **Save image** file dialog saves image files.
- The **Exports** path is the default directory where the **Save data** file dialog saves data files.
- The **Presets** path defines where the VGStudio Classification tool presets where located. Refer to *Chapter 4.6.1 Classification Tool*.

The index card **Options** is used to apply several parameters to VGStudio.

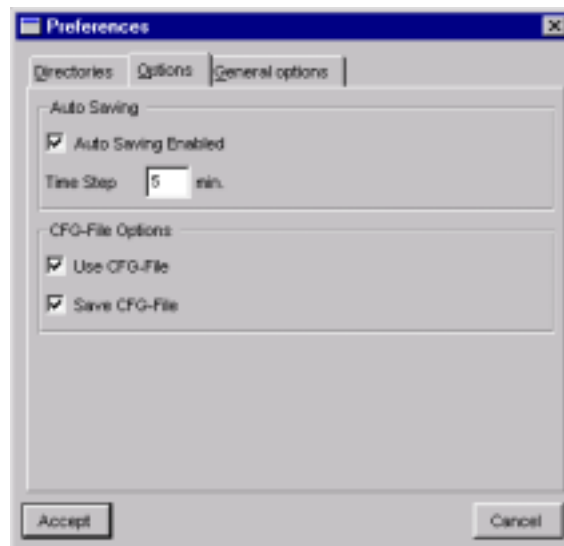


Fig. 43 The index card Options in the Preferences dialog box.

- **Auto Saving** – Click the **Auto Saving Enabled** checkbox and enter the **Time Step** in minutes, i.e. the regular interval when VGStudio should auto-save the scene you are currently working on. A file named #last.vgi will then be saved. You may use this file to restore your work after e.g. a system crash by loading it using the **Open** command in the **File** menu.

- **CFG-File Options** – If the checkbox **Use CFG-File** is activated VGStudio will load the application settings from the `vgstudio.cfg` file in your VGStudio application folder at every startup. If the option **Use CFG-File** is disabled, VGStudio will start with its default settings. If the checkbox **Save CFG-File** is activated VGStudio will save the application settings to the `vgstudio.cfg` file in your VGStudio application folder every time you exit VGStudio. If **Save CFG-File** is disabled VGStudio will not save any new application settings and will use the last `vgstudio.cfg` configuration file at every startup.



Reminder: To restore all preferences to their default settings open the VGStudio application folder and rename or delete the VGStudio 1.1 configuration file (`vgstudio.cfg`). New default preferences files will be created the next time you start VGStudio.

The index card **General options** is used to apply several parameters which define the appearance of VGStudio.

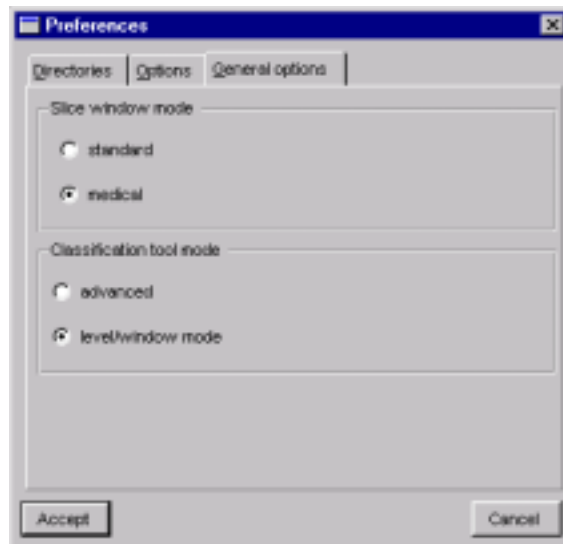


Fig. 44 The Preferences dialog box with the General options index card selected.

- **Slice window mode** – The three orthogonal slice windows (see *Chapter 4.5.1 Slice Windows and Multiplanar Reformatting*) will show the slices in a right handed coordinate system if the Slice window mode is set to standard. The three orthogonal slice windows will show the slices in a medical style if set to medical mode. Most medical applications use left handed coordinate systems to present slice data to the users.
- **Classification tool mode** – VGStudio will startup either with the default Classification tool or in Window/Level mode depending on which mode is set in this dialog.

4.3.4 Object Menu

Click **Object** to open a pulldown menu containing the following entries:

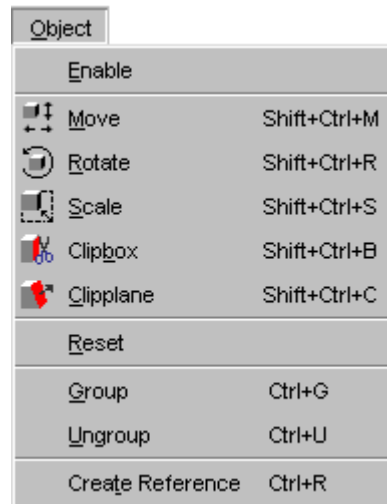


Fig. 45 The Object menu.

- **Disable**—Select this command to disable an object or object group. A disabled object will not be displayed in the scene. No action can be applied to a disabled object; you first have to enable it again. To do so, select the object in the **Scene tree** tool by clicking it and then selecting the **Enable** option in the **Object** menu. The **Enable** and **Disable** menu options will toggle in the object menu, i.e. will only be visible one at a time.
- **Enable**—Select this command to enable a previously disabled object or object group. To enable an object, select a disabled object in the **Scene tree** tool by clicking it and then selecting the **Enable** option in the **Object** menu. The **Enable** and **Disable** menu options will toggle in the object menu, i.e. will only be visible one at a time.
- **Move**—Select this command to move the selected object or object group. The **Move** mode is characterized by the green bounding box around the selected object or group of objects. When moving the cursor into the bounding box, it will take the shape of one vertical and one horizontal arrow (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be moved in the image plane by clicking into the bounding box and dragging the mouse while the left mouse button is pressed. The object may be moved forwards or backwards (and thus will be enlarged or reduced) by clicking into the bounding box and dragging the mouse while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. The whole bounding box may be used as active area to apply the appropriate action. For more information on the **Move** mode, please refer to *Chapter 4.6.7 Object Properties*.
- **Rotate**—Select this command to rotate the selected object or object group. The **Rotate** mode is characterized by the red bounding box around the selected object or group of objects. When moving the cursor into the bounding box, it will take the shape of one vertical and one horizontal circular arrow (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be rotated around the x- or y-axes of the image plane by clicking into the bounding box and dragging the mouse while the left mouse button is pressed. The object may be rotated around

the viewing direction by clicking into the bounding box and dragging the mouse while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. The whole bounding box may be used as active area to apply the appropriate action. For more information on the **Rotate** mode, see also *Chapter 4.6.7 Object Properties*.

- **Scale** —Select this command to scale the selected object or object group. The **Scale** mode is characterized by the dark blue bounding box with squared handles, i.e. active areas on each side of the selected object or group of objects. A rectangular shape will appear next to the cursor when moving it into the active area (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be scaled along the x-, y-, or z-axes by clicking the handle, i.e. the active area on one side of the bounding box and dragging the mouse while the left mouse button is pressed. Isotropic scaling may be performed by clicking into the bounding box and moving the mouse up or down while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. When several objects are selected, only isotropic scaling is supported. Group the objects first if you need to perform unisotropic scaling for several objects at a time. For more information on the **Scale** mode, see also *Chapter 4.6.7 Object Properties*.
- **Clipbox** —Select this command to box clip the selected object or object group along the axes of its bounding box. The **Clipbox** mode is characterized by the cyan bounding box with squared handles, i.e. active areas on each side of the selected object or group of objects. When moving the cursor into the active area, a scissors will appear next to the cursor (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be clipped by clicking one of the handles of the bounding box and dragging the mouse along the desired clip direction while the left mouse button is pressed. Group the objects first if you want to clip several objects at a time. For more information on the **Clipbox** mode, see also *Chapter 4.6.7 Object Properties*.
- **Clipplane** —Select this command to clip the selected object or object group by an arbitrary clipplane. The **Clipplane** mode is characterized by the cyan bounding box with a normal vector on one side of the currently selected object. When moving the cursor into the bounding box, a scissors will appear next to the cursor (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be clipped along an arbitrary clipplane by moving the mouse up and down while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. To rotate the clipplane around the origin of the clipplane's normal vector click into the clipplane and drag the mouse while the left mouse button is pressed. The origin of the clipplane's normal vector may be moved to any arbitrary position on the clipplane by clicking the clipplane's normal vector origin with the left mouse button and dragging the mouse while the left mouse button is pressed. The clipplane will be disabled if several objects are selected. Group the objects first if you want to clip several objects with one clipplane at a time. For more information on the **Clipplane** mode, see also *Chapter 4.6.7 Object Properties*.
- **Reset** —Select this command to reset actions of all categories applied to the selected object such as translation, rotation, clipping, and scaling to their default values. Reset single categories of actions in the **Object properties** tool. For more information see also *Chapter 4.6.7 Object Properties*.
- **Group** —Select this command to combine the current selection of objects or groups to a single group. A group of objects can be handled like a single object. The **Group** command remains disabled until more than one object is selected. Several objects can be selected by dragging a frame over the objects in the 3D view window, by clicking the objects with the

left mouse button while the **Ctrl** key is pressed or by clicking the object's name in the **Scene tree** tool with the left mouse button while pressing the **Ctrl** or the **Shift** key. The bounding boxes of each selected object will be visible when several objects have been selected. After grouping, a single bounding box around all the selected objects will be displayed. You may also use the keyboard shortcut **Ctrl+G** to group the objects. For more information see also *Chapter 4.6.7 Object Properties*.

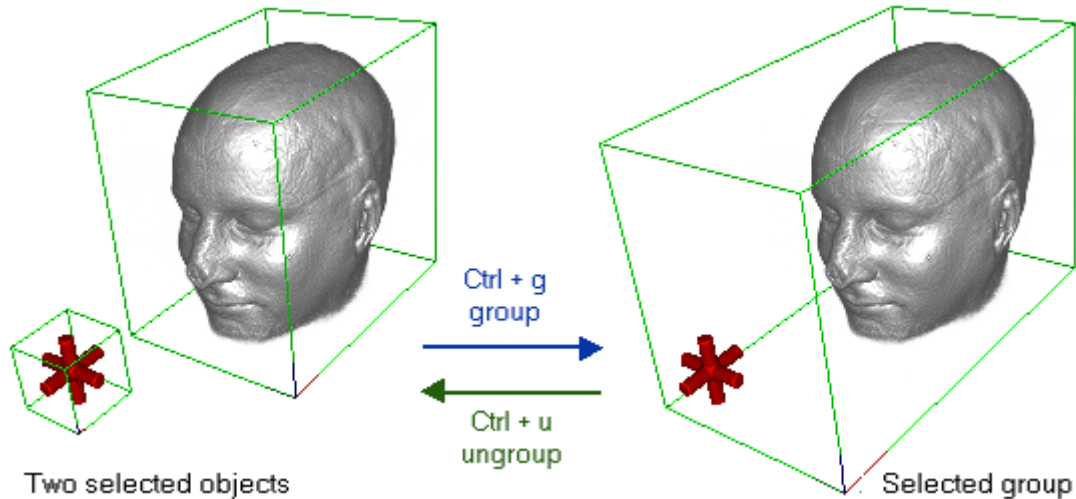


Fig. 46 Use the keyboard shortcut Ctrl + G to group two or more objects. After having grouped the objects, a single bounding box will be displayed around the selected objects. Press Ctrl + U to ungroup the objects again.

- **Ungroup** —Select this command to ungroup an object group previously created with the **Group** command. The **Ungroup** command remains disabled until an object group is selected. You may also use the keyboard shortcut **Ctrl+U** to ungroup objects. For more information see also *Chapter 4.6.7 Object Properties*.



Reminder: The clipping of an object group will be reset as soon as you ungroup the object group.

- **Create reference** —Select this command to create a reference of an object. A reference is a copy of an object which uses the same classification tool settings (color and opacity settings) as the original object. Due to this special property, a reference needs hardly any additional system memory. Therefore, a reference is a memory-saving possibility to copy objects. You may also use the keyboard shortcut **Ctrl+R** to create a reference. In the **Scene tree** tool, a small arrow will appear in the symbol displayed on the left-hand side of the scene name  and next to the scene name, the text **reference: #** will appear. Applying the **Create reference** command to a polygon object will result in a “normal” copy of the object. Creating a reference includes a smart placement functionality. An example: select an object and click **Create reference** in the **Object** menu or press **Ctrl+R**. The new referenced object will appear as the currently selected object. Move the reference to a new position in the scene. Select **Create**

Reference in the **Object** menu or press **Ctrl+R** once again. The second referenced object will appear in the same relative position as in the first reference.



Reminder: The new offsets of the smart create reference procedure will be reset to their default values as soon as you deselect the object.

4.3.5 Scene Menu

Click **Scene** to open a pulldown menu containing the following entries:



Fig. 47 The scene menu.

- **Camera mode / World view mode**—Select this command to switch between **Camera mode** and **World view mode**. These options are toggles, i.e. only visible one at a time depending on the mode you are currently working in. If you are working in **World view mode** (indicated in the 3D view window with the text **scene view**), you may switch to **Camera mode** and vice versa.
- **Axis**—Select this command to activate or deactivate the axes within a scene. A small check mark in front of the menu item indicates that the axes are activated. The axes can be customized within the **Grid, Axes & Instrument properties** dialog which you open by clicking **Properties** in the **Scene** menu (see below).
- **Grid**—Select this command to activate or deactivate the grid within a scene. A small check mark in front of the menu item indicates that the grid is activated. The grid can be customized within the **Grid, Axes & Instrument properties** dialog which you open by clicking **Properties** in the **Scene** menu (see below).
- **Instrument**—Select this command to activate or deactivate the 3D cursor within a scene. A small check mark in front of the menu item indicates that the instrument is activated. You can move the cursor around in the three slice windows. The cursor position and the appropriate gray or color values are displayed in the status line of the VGStudio user interface. The instrument can be customized within the **Grid, Axes & Instrument properties** dialog which you open by clicking **Properties** in the **Scene** menu (see below).

- **Properties** —Select this command to open the **Grid, Axes & Instrument properties** dialog where you may adjust the display of the grid, axes, and instrument.

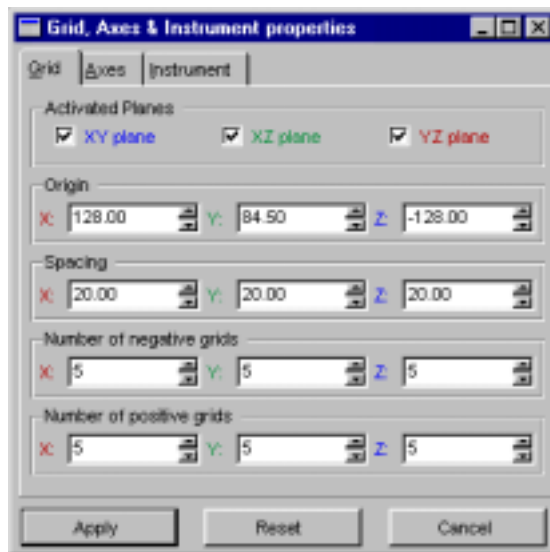


Fig. 48 The Grid, Axes & Instrument properties dialog where you may adjust the display of the grid, axes and instrument. Here, the index card Grid is displayed.

Every single grid plane may be enabled or disabled by clicking the checkbox in front of it. The grids' origins can be defined in scene coordinates. The spacing of a single grid cell can be adjusted independently for every direction. The number of grid cells in positive and negative direction can also be adjusted separately for each axis. Click **Apply** to accept the new settings. To reset the values to their default, simply click **Reset**. If you want to quit the dialog without accepting the new settings, click **Cancel**.

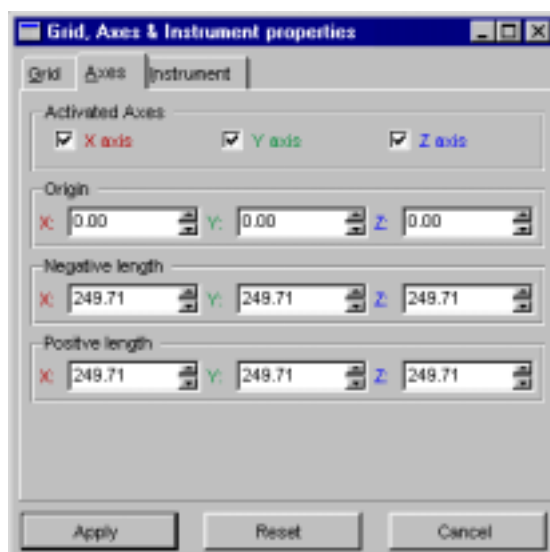


Fig. 49 The Axes index card in the Grid, Axes & Instrument properties dialog.

Every single coordinate axis can be enabled or disabled by clicking the checkbox in front of it. The coordinate system's origin can be defined in scene coordinates. The length of each axis in positive and negative direction can be adjusted separately for each axis. Click **Apply** to accept the new settings. To reset the values to their default, simply click **Reset**. If you want to quit the dialog without accepting the new settings, click **Cancel**.

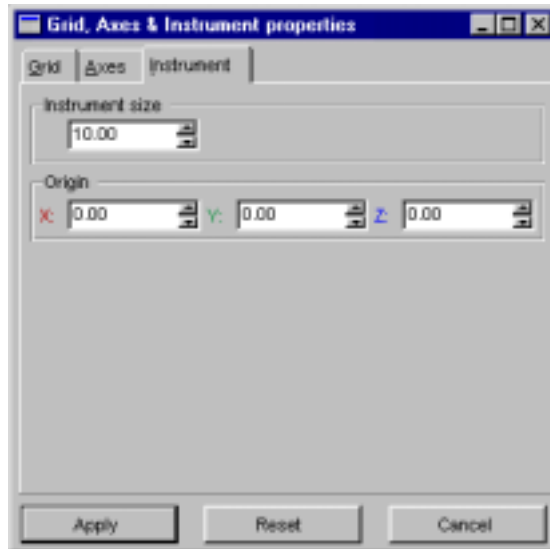


Fig. 50 The Instrument index card in the Grid, Axes & Instrument properties dialog.

Use the dialog shown in Fig. 50 to adjust the instrument position in scene coordinates. The size of the instrument can also be adjusted. Click **Apply** to accept the new settings. To reset the values to their default, simply click **Reset**. If you want to quit the dialog without accepting the new settings, click **Cancel**.

All labels related to axes or planes orthogonal to the appropriate axis are colored according to the VGStudio color scheme, i.e. all labels related to the x-axis are displayed in red, all labels related to the y-axis in green, and all labels related to the z-axis in blue.

- **Background color** —Select this command to choose a background color for the current scene. Select one of the default colors from the menu shown in the figure below.

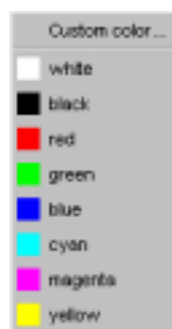


Fig. 51 Choose one of the default colors as background color for the current scene.

4.3 Menu Bar

You may also select **Custom color** to activate a color selection tool shown in Fig. 52.

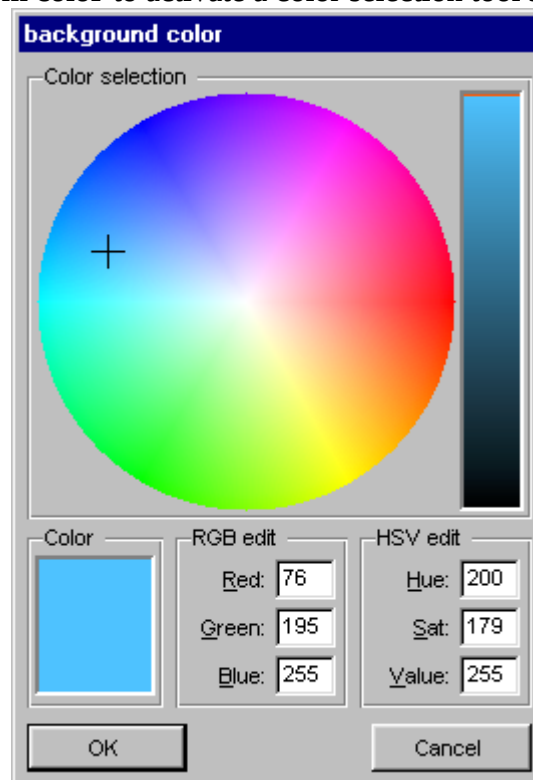


Fig. 52 In the background color window you may define a background color for the active scene.

4.3.6 Tools Menu

Click **Tool** to open a pulldown menu containing the following entries:

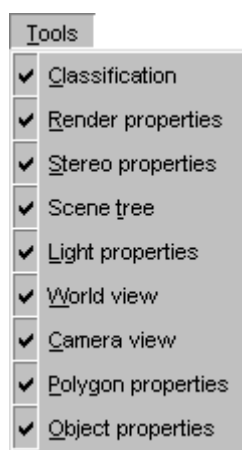


Fig. 53 The Tools menu.

Use the **Tools** menu to activate or deactivate the various tools of VGStudio. A check mark in

front of each entry indicates that a tool is activated.

- **Classification**—Select this command to activate or deactivate the **Classification** tool. For more information on the **Classification** tool please refer to *Chapter 4.6.1*.
- **Render properties**—Select this command to activate or deactivate the **Render properties** tool. For more information on the **Render properties** tool, please refer to *Chapter 4.6.3*.
- **Stereo properties**—Select this command to activate or deactivate the **Stereo properties** tool. For more information on the **Stereo properties** tool, please refer to *Chapter 4.6.5*.
- **Scene tree**—Select this command to activate or deactivate the **Scene tree** tool. For more information on the **Scene tree** tool, please refer to *Chapter 4.6.2*.
- **Light properties**—Select this command to activate or deactivate the **Light properties** tool. For more information on the **Light properties** tool, please refer to *Chapter 4.6.4*.
- **World view**—Select this command to activate or deactivate the **World view** tool. For more information on the **World view** tool, please refer to *Chapter 4.6.8*.
- **Camera view**—Select this command to activate or deactivate the **Camera view** tool. For more information on the **Camera view** tool, please refer to *Chapter 4.6.9*.
- **Polygon properties**—Select this command to activate or deactivate the **Polygon properties** tool. For more information on the **Polygon properties** tool, please refer to *Chapter 4.6.6*.
- **Object properties**—Select this command to activate or deactivate the **Object properties** tool. For more information on the **Object properties** tool, please refer to *Chapter 4.6.7*.

4.3.7 Window Menu

Click **Window** to open a pulldown menu containing the following entries:

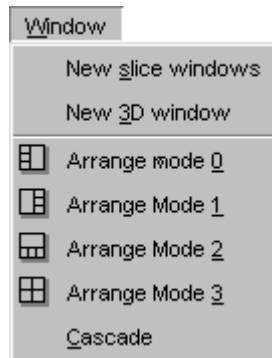


Fig. 54 The Window menu.

- **New slice windows**—Select this command to open the three slice windows within VGStudio's workspace. The menu entry remains disabled as long as these windows are open in the workspace.
- **New 3D window**—Select this command to open the 3D window within VGStudio's workspace. The menu entry remains disabled as long as these windows are open in the workspace.
- **Arrange modes** and **Cascade**—Click one of the **Arrange modes** 0 to 3 to choose a predefined layout for the windows within the workspace. VGStudio uses a Multiple Document Interface (MDI). The 3D window and the three slice windows may also be arranged arbitrarily within the workspace by clicking into the title bar of the corresponding window with the left mouse button and dragging the window to the desired position. The arbitrarily arranged windows may be rearranged by one of the **Arrange modes** or by the **Cascade** option.

4.3.8 Help Menu

Click **Help** to open a pulldown menu containing the following entries:

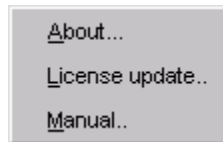


Fig. 55 The Help menu.

- **About**—Select this command to open a window with information on your VGStudio release.

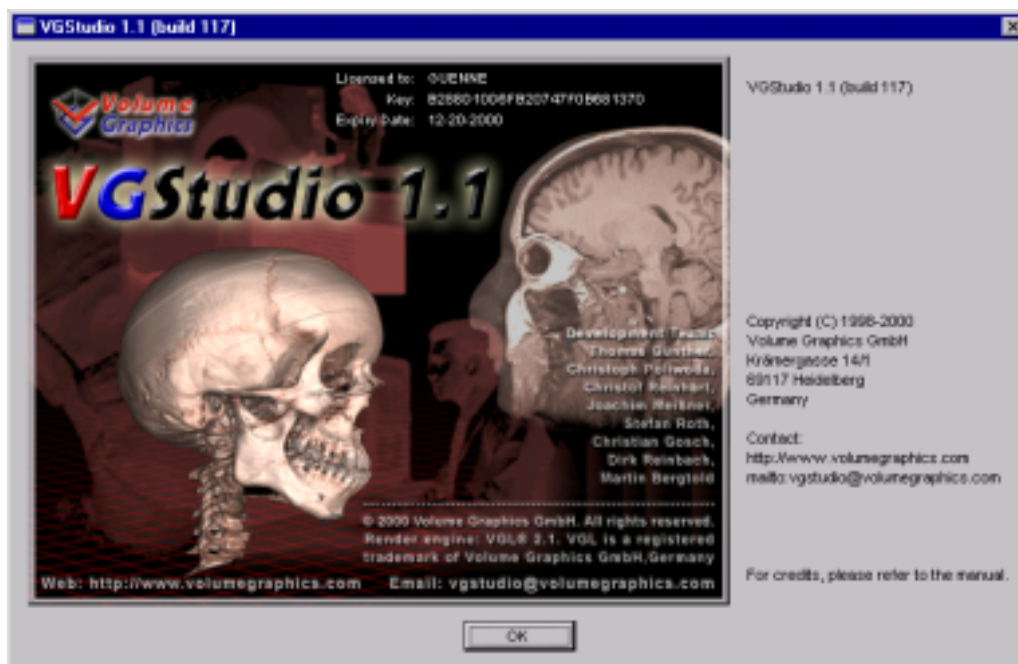


Fig. 56 In this window, you will find information on your VGStudio release.

- **License update**—Select this command to open VGStudio's **License update** window.

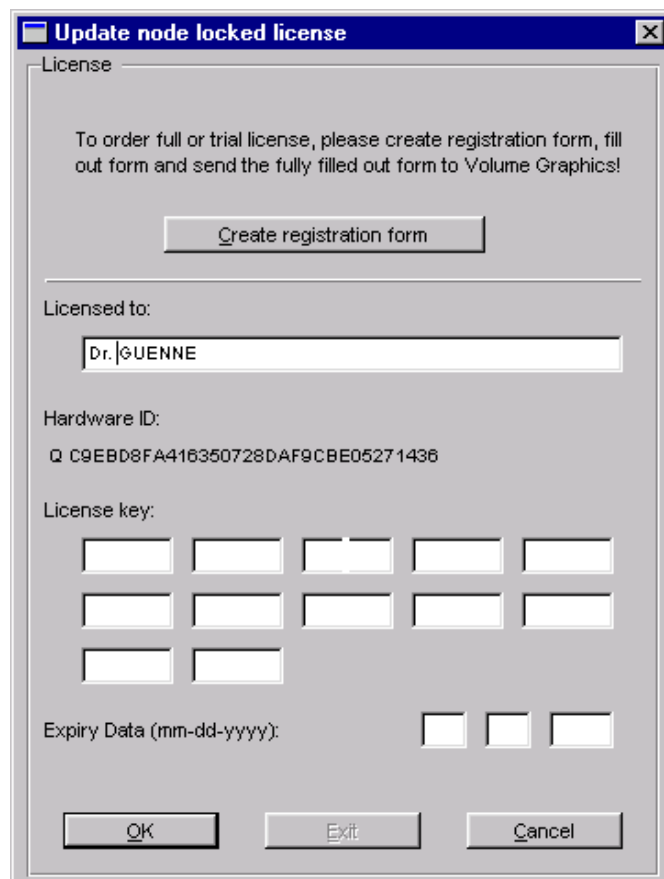


Fig. 57 VGStudio's License update window.

- **Manual**—Select this command to open VGStudio's **Manual**. Please keep in mind that the Adobe Acrobat Reader has to be installed on your computer to be able to open up the manual.

4.4 Icon Bar



Fig. 58 The VGStudio icon bar.

The tools in the icon bar provide quick access to many common VGStudio functions. When placing the cursor on an icon, a tooltip will appear which shows the function of the icon. The tools are divided into five main categories:

Standard icon section



Object manipulation section



Scene utilities section



View selection section



Window layout tools section



What's this section



4.4.1 Standard Icon Section

New



New—Click this icon to create a new scene. Note that selecting this command will close the scene you are currently working on. After you have created a scene, you can save it by using the **Save** command. The scene can be accessed again using the **Open** command. Both commands are described below. You may also use the keyboard shortcut **Ctrl+N** to create a new scene.

Open



Open—Click this icon to open an existing scene. You may load Volume Graphics Info files (.vgi extension) as well as old info files (.info extension) by selecting the desired file and clicking **Open** or by simply double-clicking the file in the **Open info file** dialog. You may also use the keyboard shortcut **Ctrl+O** to open an existing scene.

Save



Save—Click this icon to save your work. You should save your work frequently throughout the scene creation process. Saving a scene will generate a Volume Graphics Info file (.vgi extension). The *.vgi file includes data-relevant information such as the file name and path, data type, file type, file size, and data mapping as well as scene-relevant information such as light settings, rendering algorithm, or background color. You may also use the keyboard shortcut **Ctrl+S** to save a scene.

Print



Print—Click this icon to print the active window. You may select either one of the three slice windows or the 3D window as the active window by clicking the title bar or into one of the windows. You may also use the keyboard shortcut **Ctrl+P** to print the active window.

Cut



Cut—Click this icon to cut objects within a scene in VGStudio. The cut objects will remain in the VGStudio clipboard. When you cut objects, you cut all related information such as opacity and color along with whatever you cut. Note that VGStudio objects cannot be pasted into another program. You may also use the keyboard shortcut **Ctrl+X** to cut objects.

Copy



Copy—Click this icon to copy selected objects into the VGStudio clipboard. When you copy objects, you copy all related information such as opacity and color along with whatever you copy. Note that VGStudio objects cannot be copied into another program. You may also use the keyboard shortcut **Ctrl+C** to copy objects.

Paste



Paste—Click this icon to paste previously copied or cut objects into a scene. You may also use the keyboard shortcut **Ctrl+V** to paste objects.

Undo



- **Undo**—Click this icon to undo your previous action. This menu item changes depending on the action you last performed. For instance, if you have pasted an object into your scene, the text reads **undo: paste object** and the object will be removed from the scene when you select this command. You may undo the last 100 actions and commands. Only one exception will destroy the undo history. You may also use the keyboard shortcut **Ctrl+Z** to undo your last command.



Reminder: The undo history will be **destroyed** in case of deleting an object. You have to select the undo command **immediately** after the delete command to undo a delete process.

Redo



Redo—Click this icon to redo your previous **Undo** action. This menu item changes depending on the last **Undo** action. For instance, if you have undone the pasting of an object, the text reads **redo: paste object** and the object will be pasted into the scene again when you select this command. You may also use the keyboard shortcut **Ctrl+Y** to redo your last **Undo** command.

4.4.2 Object Manipulation Section

VGStudio provides five object manipulation modes: translation, rotation, scaling, clipbox, and clipplane. All five modes allow interactive object manipulation. The mode can be selected by clicking the icons in the icon bar after you have selected an object.



Object manipulation can also be applied by using the **Object properties** tool which allows the user to type in exact translation, rotation, clipping, and scaling values. For more information on the **Object properties** tool, please refer to *Chapter 4.6.7*.

Object Selection and Deselection

Before any object manipulation can be applied, you have to select an object or a group of objects. A bounding box around an object will indicate that the object is selected. This means that the object is the active object to which actions may be applied. When loading an object into VGStudio, the object will automatically be the active object, indicated by a green bounding box around the object. You may deselect an object by selecting another object, by clicking into the scene outside an object's bounding box, or by clicking **Deselect** in the **Edit** menu (alternatively, you may also use the keyboard shortcut **Alt+D**).

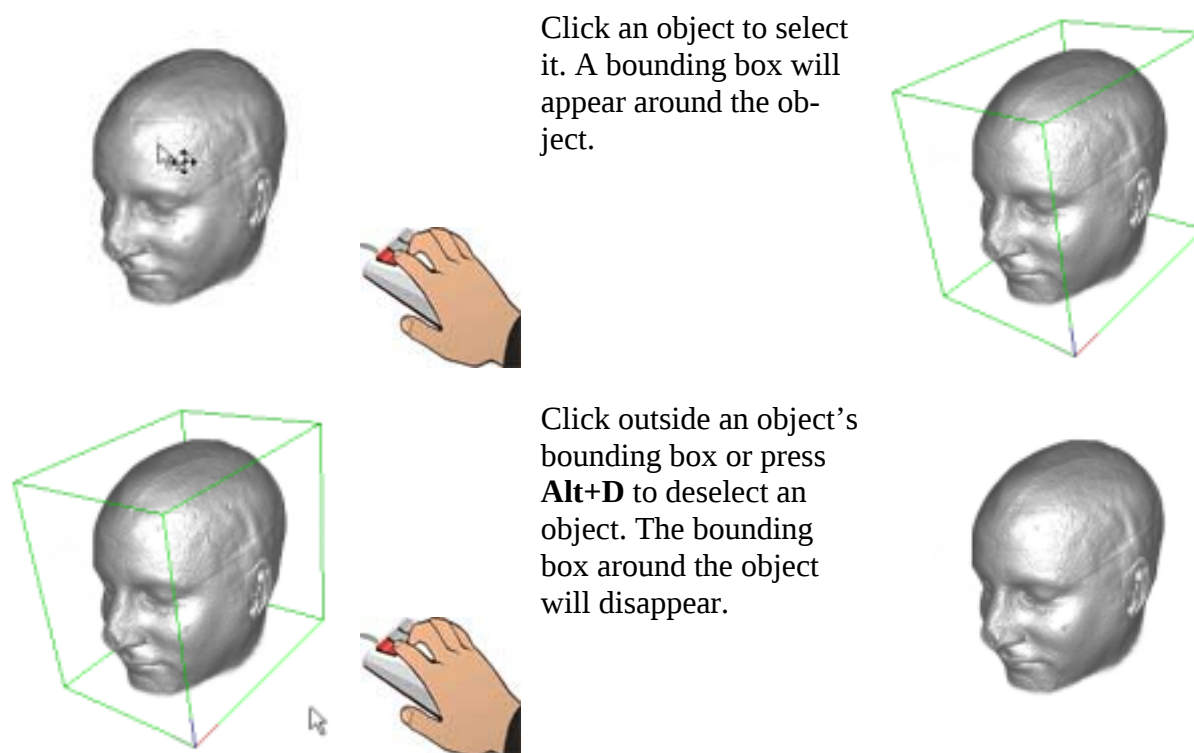


Fig. 59 Select or deselect an object. A bounding box around the object indicates that an object is selected.

Move



Click this icon to move the selected object or object group. The **Move** mode is characterized by the green bounding box around the selected object or group of objects. When moving the cursor into the bounding box, it will take the shape of one vertical and one horizontal arrow (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be moved in the image plane by clicking into the bounding box and dragging the mouse while the left mouse button is pressed. The whole bounding box may be used as active area to apply the appropriate action. The object may be moved forwards or backwards (and thus will be enlarged or reduced) by clicking into the bounding box and dragging the mouse while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. The whole bounding box may be used as active area to apply the appropriate action. Using the **Shift** modifier in **Move** mode allows you to move the object along either the vertical or horizontal direction of the 3D window image plane. For more information on the **Move** mode, please refer to *Chapter 4.6.7 Object Properties*.

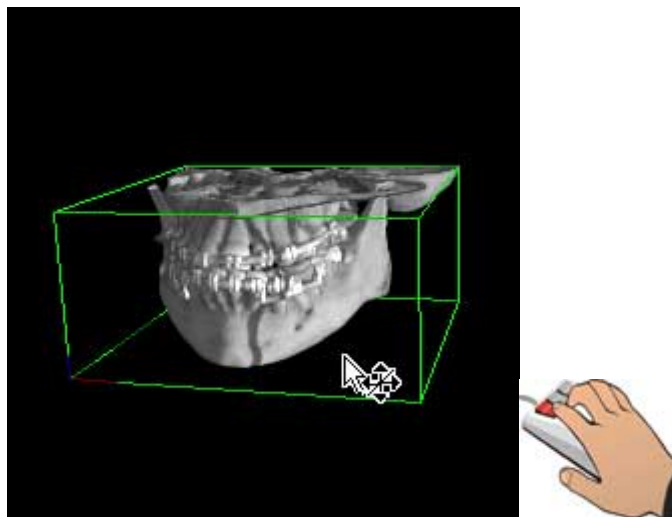


Fig. 60 The 3D window in Move mode indicated by the green bounding box and the tripod displayed next to the cursor when moving it into an active area..

Rotation



Click this icon to rotate the selected object or object group. The **Rotate** mode is characterized by the red bounding box around the selected object or group of objects. When moving the cursor into the bounding box, it will take the shape of one vertical and one horizontal circular arrow (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be rotated around the x- or y-axes of the image plane by clicking into the bounding box and dragging the mouse while the left mouse button is pressed. The object may be rotated around the viewing direction by clicking into the bounding box and dragging the mouse while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. The whole bounding box may be used as active area to apply the appropriate action. Using the **Shift** modifier in **Rotate** mode allows you to rotate the object either around the vertical or horizontal axes of the 3D window image plane. For more information on the **Rotate** mode, please refer to *Chapter 4.6.7 Object Properties*.

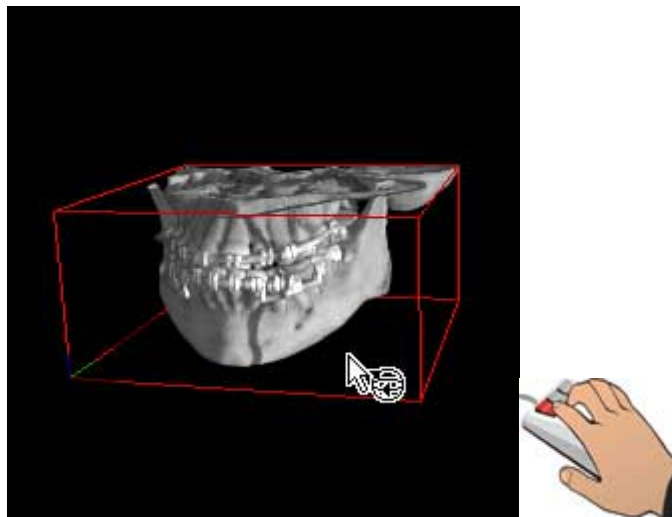


Fig. 61 The 3D window in Rotate mode indicated by the red bounding box and the ball with arrows displayed next to the cursor when moving it into an active area..

Scaling



Click this icon to scale the selected object or object group. The **Scale** mode is characterized by the dark blue bounding box with squared handles, i.e. active areas on each side of the selected object or group of objects. A rectangular shape will appear next to the cursor when moving it into the active area (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be scaled along its x-, y-, or z-axes by clicking the handle, i.e. the active area, of one side of the bounding box and dragging the mouse while the left mouse button is pressed. Isotropic scaling may be performed by clicking into the bounding box and moving the mouse up or down while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. When several objects are selected, only isotropic scaling is supported. Group the objects first if you need to perform uni-isotropic scaling for several objects at a time. For more information on the **Scale** mode, please refer to *Chapter 4.6.7 Object Properties*.

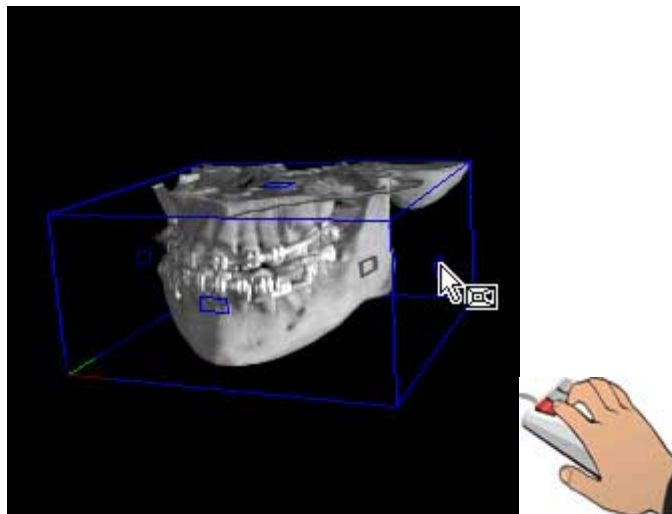


Fig. 62 The 3D window in Scale mode indicated by the blue bounding box and the perspective box displayed next to the cursor when moving it into an active area..

Clipbox



Click this icon to box clip the selected object or object group along the axes of its bounding box. The **Clipbox** mode is characterized by the cyan bounding box with squared handles, i.e. active areas on each side of the selected object or group of objects. When moving the cursor into the active area, a scissors will appear next to the cursor (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be clipped by clicking one of the handles of the bounding box and dragging the mouse along the desired clip direction while the left mouse button is pressed. The box clipping will be disabled if several objects were selected. Group the objects first if you want to clip several objects at a time. For more information on the **Clipbox** mode, please refer to *Chapter 4.6.7 Object Properties*.

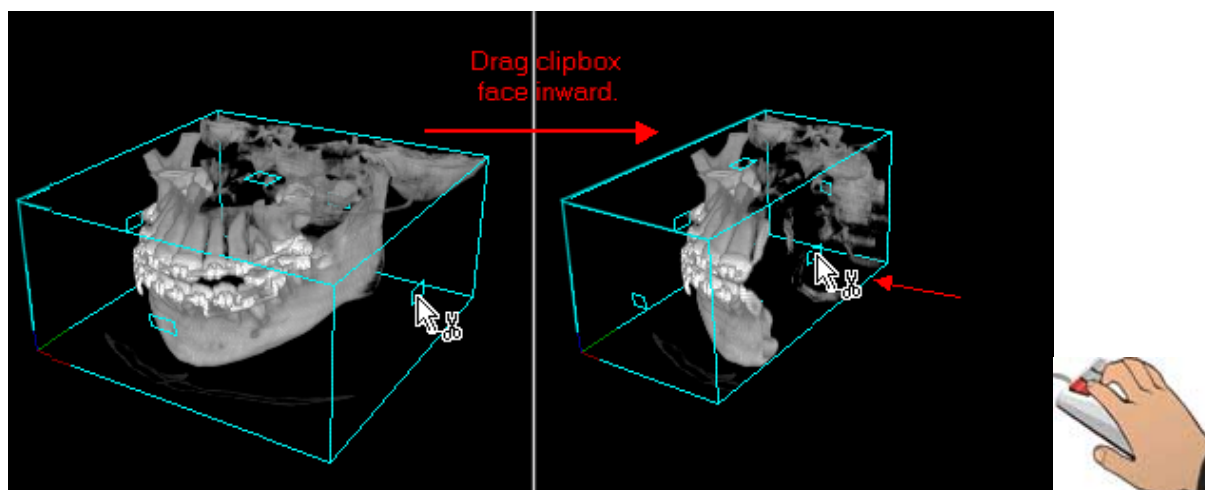


Fig. 63 The 3D window in Clipbox mode indicated by the cyan bounding box and the scissors displayed next to the cursor when moving it into an active area.

Clipplane



Click this icon to clip the selected object or object group by an arbitrary clipplane. The **Clipplane** mode is characterized by the cyan bounding box with a normal vector on one side of the active object. When moving the cursor into the bounding box, a scissors will appear next to the cursor (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be clipped along an arbitrary clipplane by moving the mouse up and down while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. To rotate the clipplane around the origin of the clipplane's

normal vector click into the clipplane and drag the mouse while the left mouse button is pressed. The origin of the clipplane's normal vector may be moved to any arbitrary position on the clipplane by clicking the clipplane's normal vector origin with the left mouse button and dragging the mouse while the left mouse button is pressed. The clipplane will be disabled if several objects are selected. Group the objects first if you want to clip several objects with one clipplane at a time. For more information on the **Clipplane** mode, please refer to *Chapter 4.6.7 Object Properties*.

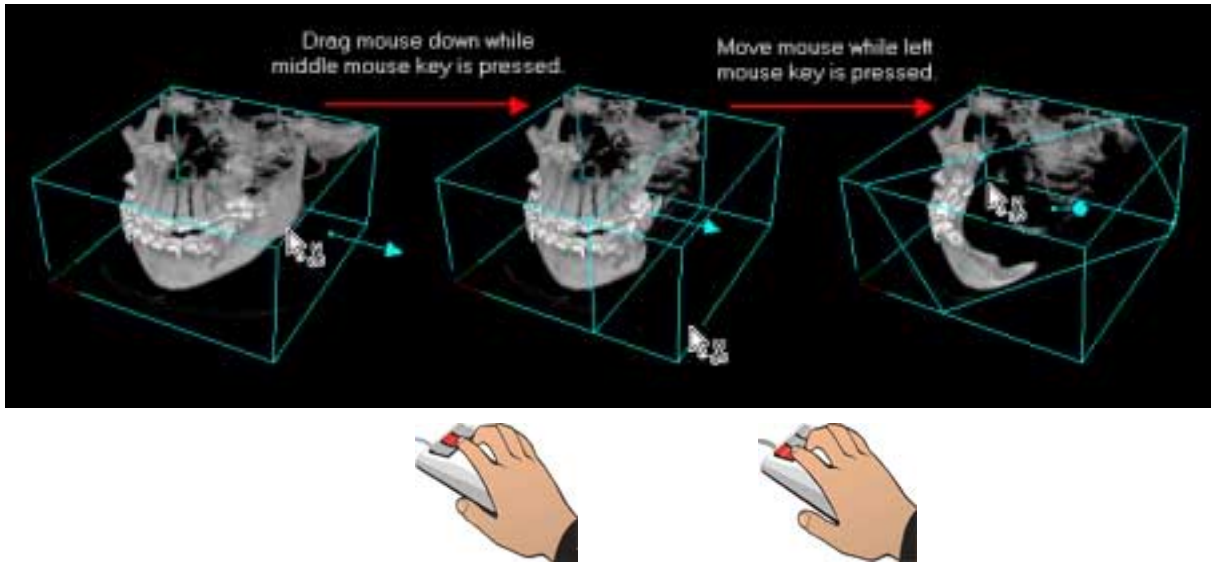


Fig. 64 Clip the object along an arbitrary clipplane by dragging the mouse up or down while the middle mouse button is pressed. By dragging the mouse inside the active area while the left mouse button is pressed, the clipplane will be rotated in any arbitrary direction.

4.4.3 Scene Utilities

Three different utilities may be activated for data analysis and evaluation or better orientation in the scene.

Activate the utilities by clicking one of the three icons in the icon bar



or by using the **Instrument**, **Axis** and **Grid** options in the **Scene** menu.

3D instrument



Click this icon to activate or deactivate the 3D instrument in the scene. A small cross will appear in each slice window as well as in the 3D Window. The 3D instrument can be positioned anywhere in the scene or an object within the three slice windows. The scene coordinates and the gray and color values of the 3D instrument will be displayed in the status bar.

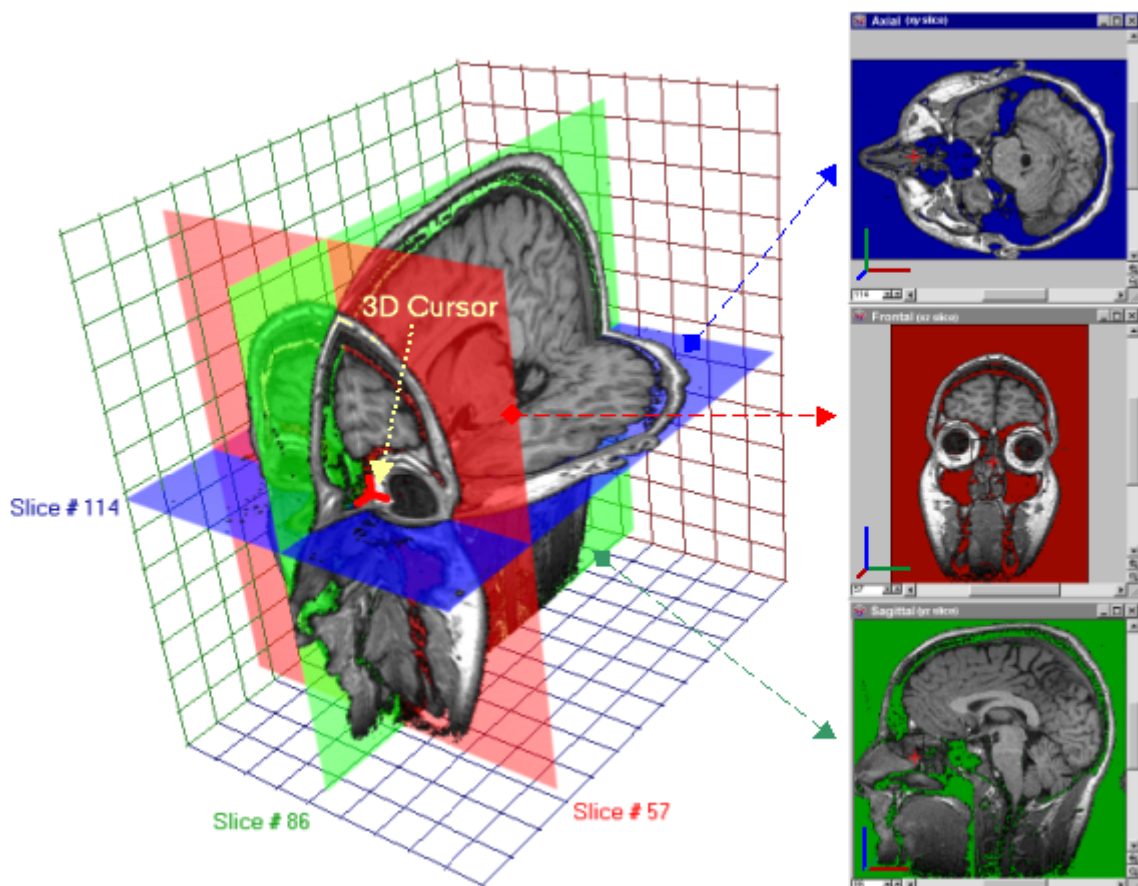


Fig. 65 The 3D instrument is displayed as a small cross in the slice windows and the 3D window.

When moving the cursor in the slice windows, the three cross sections through the volume data will be displayed with the 3D instrument in the center of the three sections. You may use the 3D instrument to scroll through the volume data set in the slice windows in two directions simultaneously by clicking it with the left mouse button and then dragging the mouse while the left mouse button is pressed.

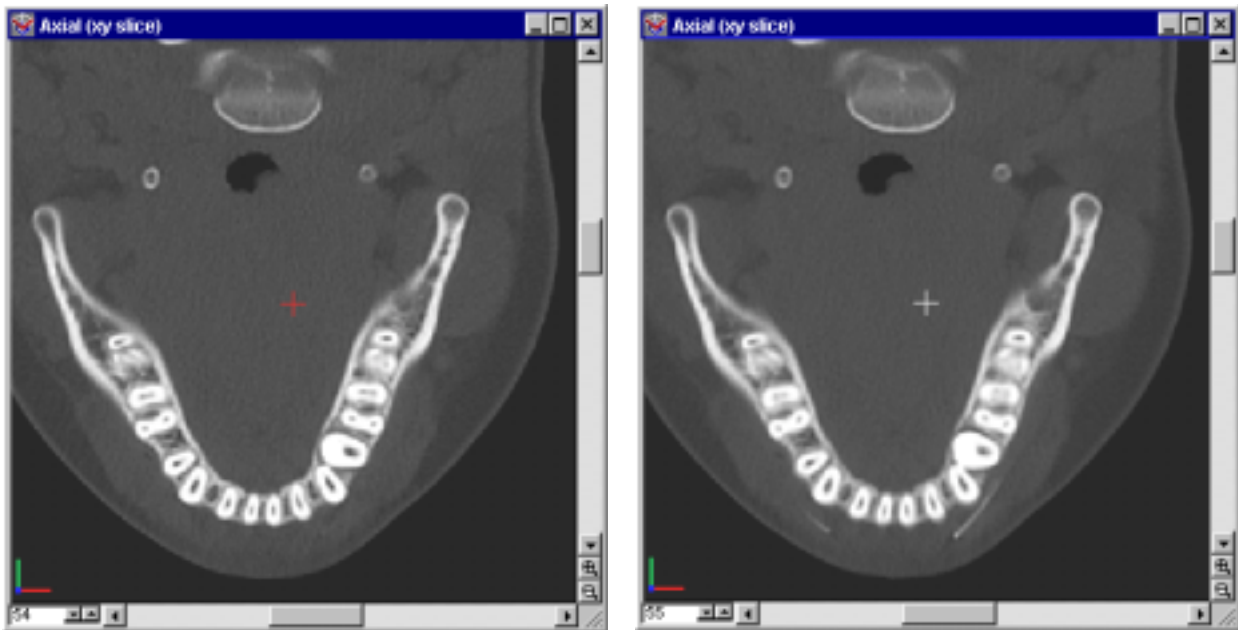


Fig. 66 The 3D instrument will be displayed in red when the cursor is located in the currently selected slice.

In a slice image, the cursor will appear in red when the cursor is located in the slice that is currently selected. It will appear in white as soon as the displayed slice is another one than the one in which the cursor is positioned at the moment. In the example shown in Fig. 66, the cursor is located in slice # 54 and the cursor in the left image slice # 54 is displayed in red. In the right image, slice # 55 is shown and the cursor is displayed in white.

If the cursor is placed outside the selected voxel data set or if the active object is a polygon object, only a red bounding box will appear in the slice windows (see figure below).



Fig. 67 A red bounding box will be displayed when the cursor is placed outside the selected voxel data set.

Scene Axes



Click this icon to activate the scene coordinate axes. The display of the axes can be customized in the **Properties** dialog which you open via the **Scene** menu.

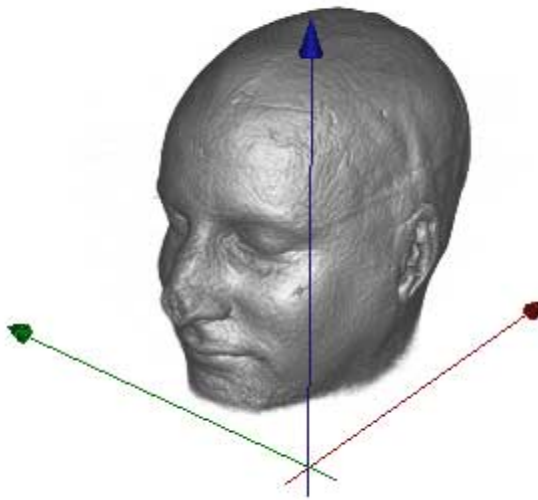


Fig. 68 The coordinate axes are displayed.

Scene Grid



Click this icon to activate a grid in the scene. The display of the grid can be customized in the **Properties** dialog in the **Scene** menu.

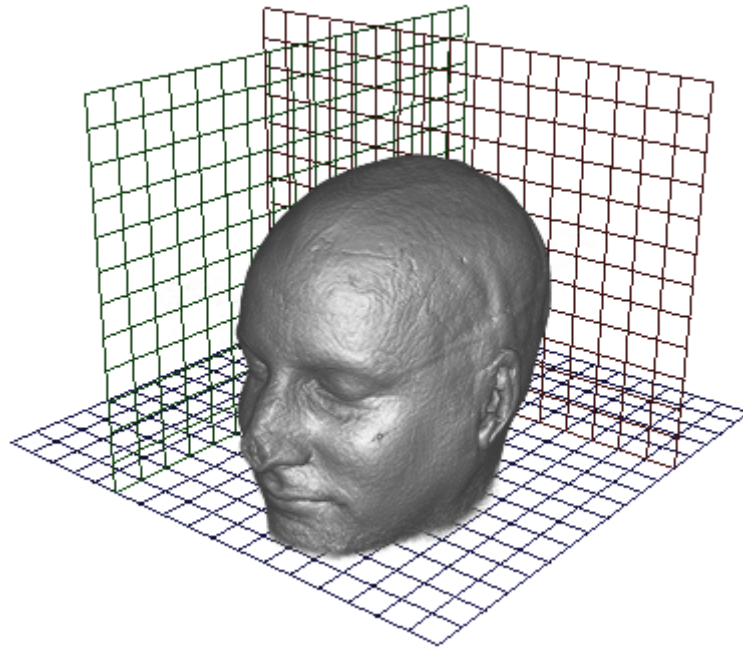


Fig. 69 The grid is activated in the scene.

4.4.4 View Selection

The **3D view** window supports two different viewing modes (for more information on the **3D view**, please refer to *Chapter 4.5.2*). Click the **View selection** buttons to activate the appropriate mode.



Camera View



Use this button to activate the **Camera** mode. For more information on the **Camera** mode, please refer to *Chapter 4.6.9*.

World View



Use this button to activate the **World View** mode. For more information on the **World view** mode, please refer to *Chapter 4.6.8*.

4.4.5 Window Layout Section



Click one of these icons to select a predefined layout for the windows within the workspace. VGStudio uses a Multiple Document Interface (MDI). The 3D window and the three slice windows may also be arranged arbitrarily within the workspace by clicking into the title bar of the window and dragging the window to the desired position. The arbitrarily arranged windows may be rearranged by clicking one of the window layout buttons.

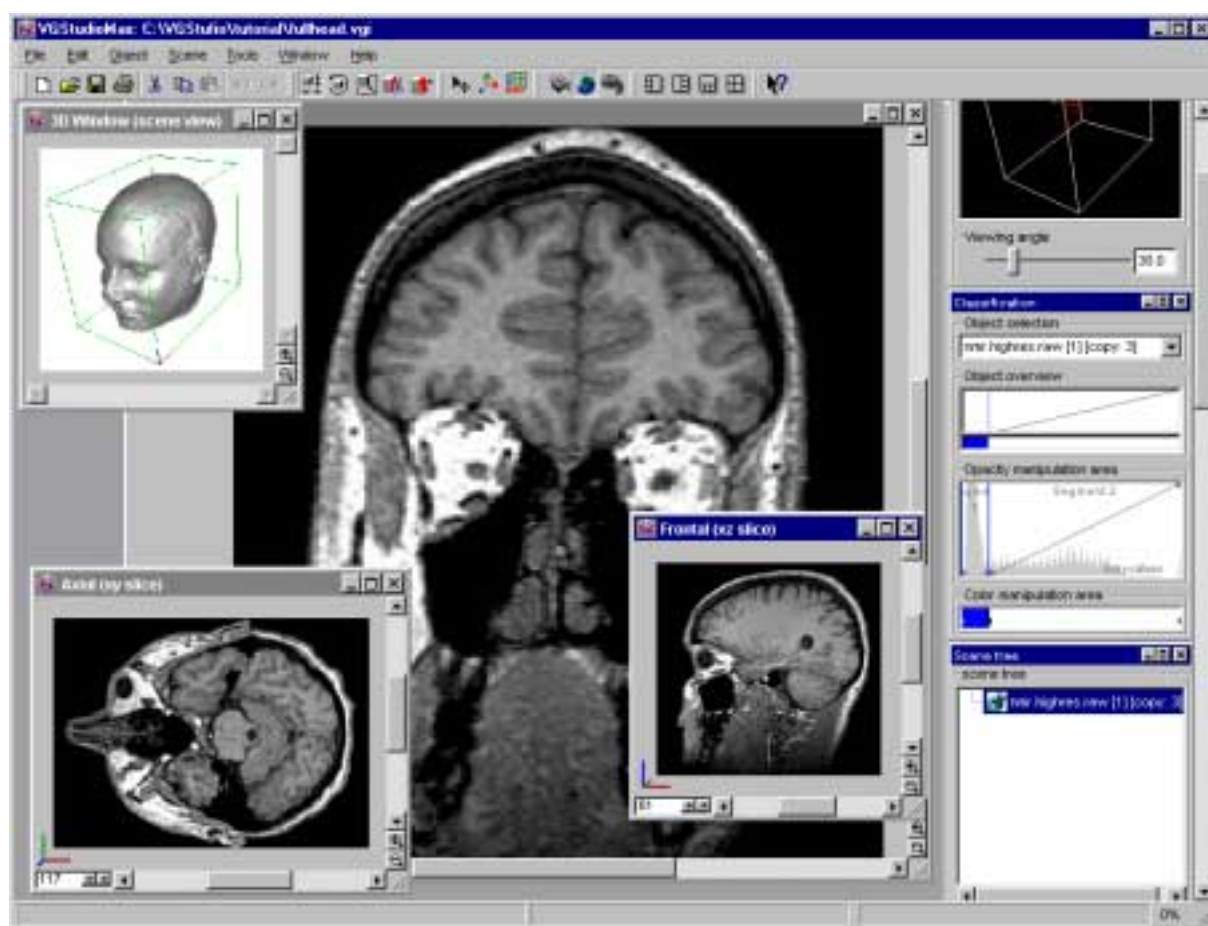


Fig. 70 The VGStudio interface with arbitrarily arranged windows.

You may also arrange the windows by using the options of the **Window** menu (see *Chapter 4.3.7*).

4.4.6 “What’s this” Section



Click this icon to change into “What’s this” mode. A question mark will then be displayed next to the cursor. If you need help or information on a certain function simply click into a window or on a component of the user interface; a popup window containing online help topics about the selected component will then appear. There you will find short information on the functions and also on where to find the information in the User’s Manual.

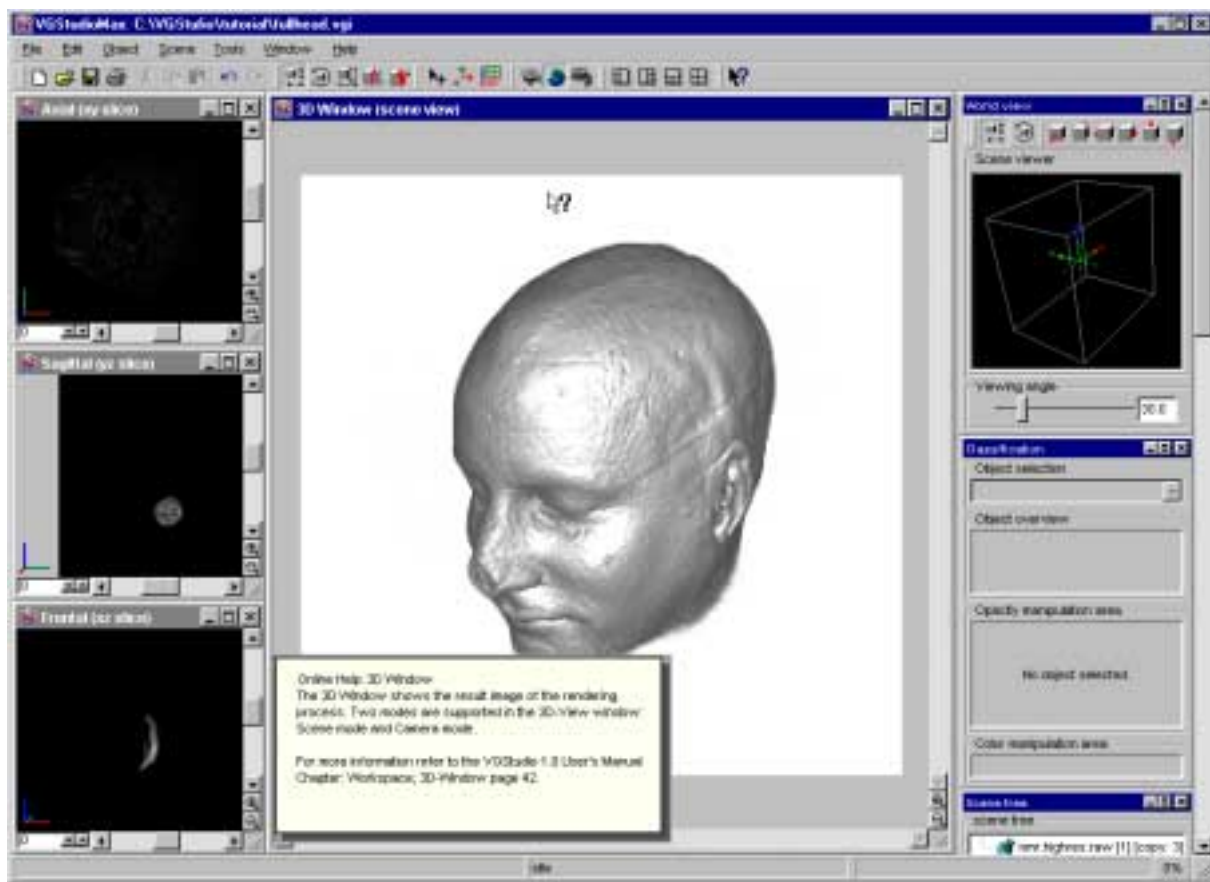


Fig. 71 VGStudio’s online help.

4.5 The Workspace

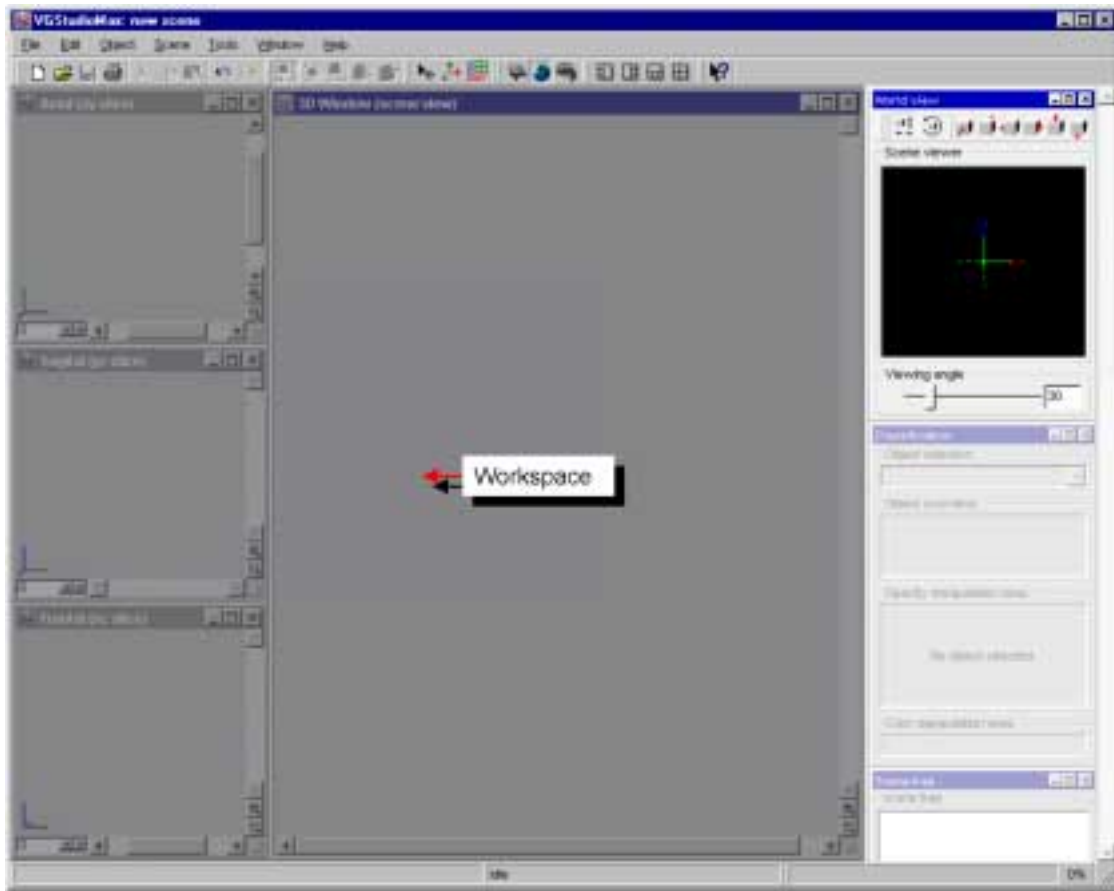


Fig. 72 Default layout screen after VGStudio has been started.

The VGStudio workspace includes four elements, i.e. the 3D window and the three slice windows. The 3D window and the slice windows may be activated or deactivated by simply clicking into the title bar or into the windows. The three slice windows form one entity which means that they can only be opened or closed all together and not separately. To close one of the two parts, click the **Close**  button in the upper right corner of the window. To activate a disabled window again use the **Window** menu and select **New slice windows** or **New 3D window**. For more information on how to work with the windows, see also *Chapter 4.3.7 Window Menu*.

The layout of the windows in the workspace can also be adjusted arbitrarily by simply clicking into the title bar with the left mouse button and dragging the window to the desired position. Each window can be positioned or enlarged independently from the other windows.

You may use the **Window** menu or the window icons to enlarge, minimize, or close a window.

Use the **Minimize** button  to minimize a window within the workspace.

Use the **Maximize** button  to maximize a window within the workspace.

4.5.1 Slice Windows and Multiplanar Reformatting

The slice windows provide the VGStudio user with full Multi Planar Reconstruction (MPR) functionality for voxel data sets. In the slice windows, three perpendicularly oriented cross sections (axial, sagittal, and frontal) of the currently selected object are displayed. The projection of the data sets origin is always displayed as a colored tripod in the lower left corner of the window. The coordinate system used in the slice images is either the object coordinate system (object relative mode) of the currently selected object or the scene coordinate system (scene coordinate system). The slice images show in both modes perpendicular cross sections through the selected data set. In object coordinate system Axial slices are perpendicular to the z-axis, frontal slices are perpendicular to the y-axis, and sagittal slices are perpendicular to the x-axis.

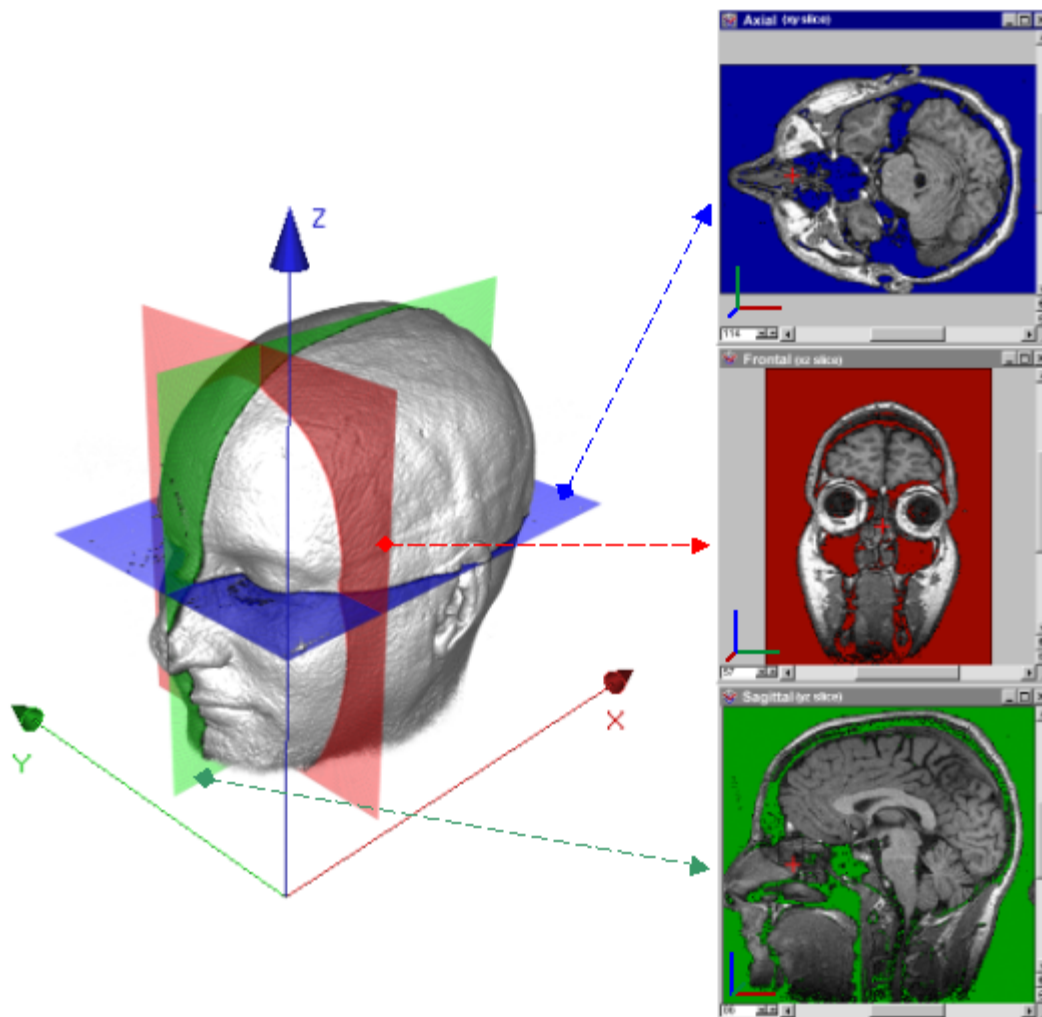


Fig. 73 In the three slice windows of VGStudio, the cross sections axial, frontal, and sagittal are displayed.



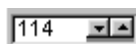
Fig. 74 VGStudio's frontal view window.

In the title bar of the slice windows, the orientation (i.e. axial, sagittal, or frontal) and the image planes (i.e. the xy, yz, and xz planes) are displayed. In the left corner of the title bar you find the **Control** icon, which you use to access the **Control** menu. Double-clicking this icon will close all three slice windows. You can use the **Control** menu to maximize or minimize the slice windows or to close them. The window buttons can be found in the right corner of the title bar. These buttons can also be used to maximize, minimize, or close the slice windows.

In each slice window you will also find two scrollbars to pan large images as well as two **zoom** buttons and one slice selection box. In the lower left corner of each slice window a small tripod colored in the VGStudio color scheme will be displayed, which shows the orientation of the corresponding slice in the object coordinate system.



Use the slice selection box in the lower left corner of the slice windows to scroll through the image stack by clicking the up and down arrows or to select a specific slice by typing in the slice number and then clicking into another window. The selected slice will then be displayed.



Use the **zoom in** and **zoom out** buttons in the lower right corner of the slice windows to zoom in on an image (i.e. enlarge the image) or to zoom out (i.e. reduce the image). The images will then be enlarged or reduced by a preset zoom factor.



When clicking into a slice window with the right mouse button, a context menu will be opened.

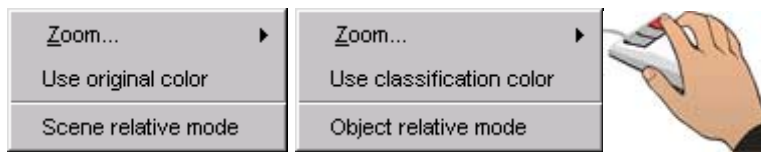


Fig. 75 A context menu will be opened when clicking into one of the slice windows with the right mouse button.

- **Zoom**—Select this command to open the **Zoom** menu.

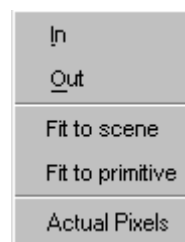


Fig. 76 The Zoom menu of the slice images.

The slice window may be zoomed in (enlarged) or zoomed out (reduced). These functions may also be applied by using the zoom buttons in the lower right corner of the slice windows. The images will then be enlarged or reduced by a preset zoom factor. The **Fit to scene** option will zoom the slice window so that all objects included in the scene may be seen. The **Fit to object** option allows to zoom the active object so that it is displayed with maximum zoom factor. The **Actual Pixels** option applies a zoom factor so that one pixel in the image of the slice window will be one pixel on your screen.

- **Use original color**—Select this command to display the slice images in its original color, brightness, and contrast settings.
- **Use classification color**—Select this command to apply the color, brightness, and contrast settings of the classification tool to the slice images.

- **Object relative mode**— Select this command to switch the three orthogonal slice windows into Object relative mode. The object will be sliced along the axes of the object coordinate system. The originally scanned slice data will be displayed in this case.

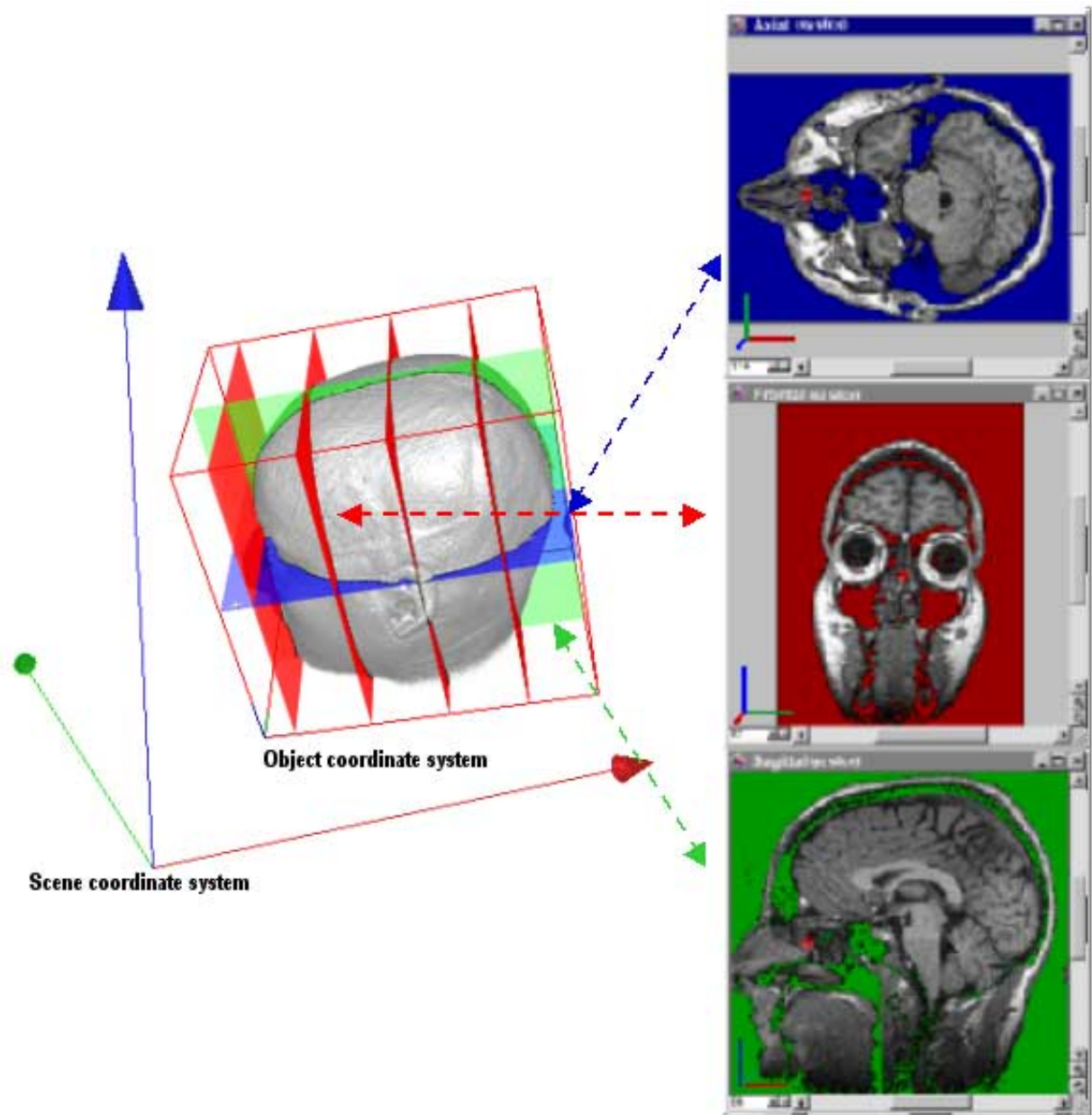


Fig. 77 MRI scan sliced in object relative.

- Scene relative mode**—Select this command to switch the three orthogonal slice windows into Scene relative mode. The object will be sliced along the axes of the scene coordinate system. This mode allows the user to slice the object along any arbitrary axis. To define the slicing orientation rotate the object against the scene coordinate system. Select the rotate mode in the 3D window and rotate the object against the scene coordinate system. The scene coordinate system can be seen when activating the Axis in the 3D window.

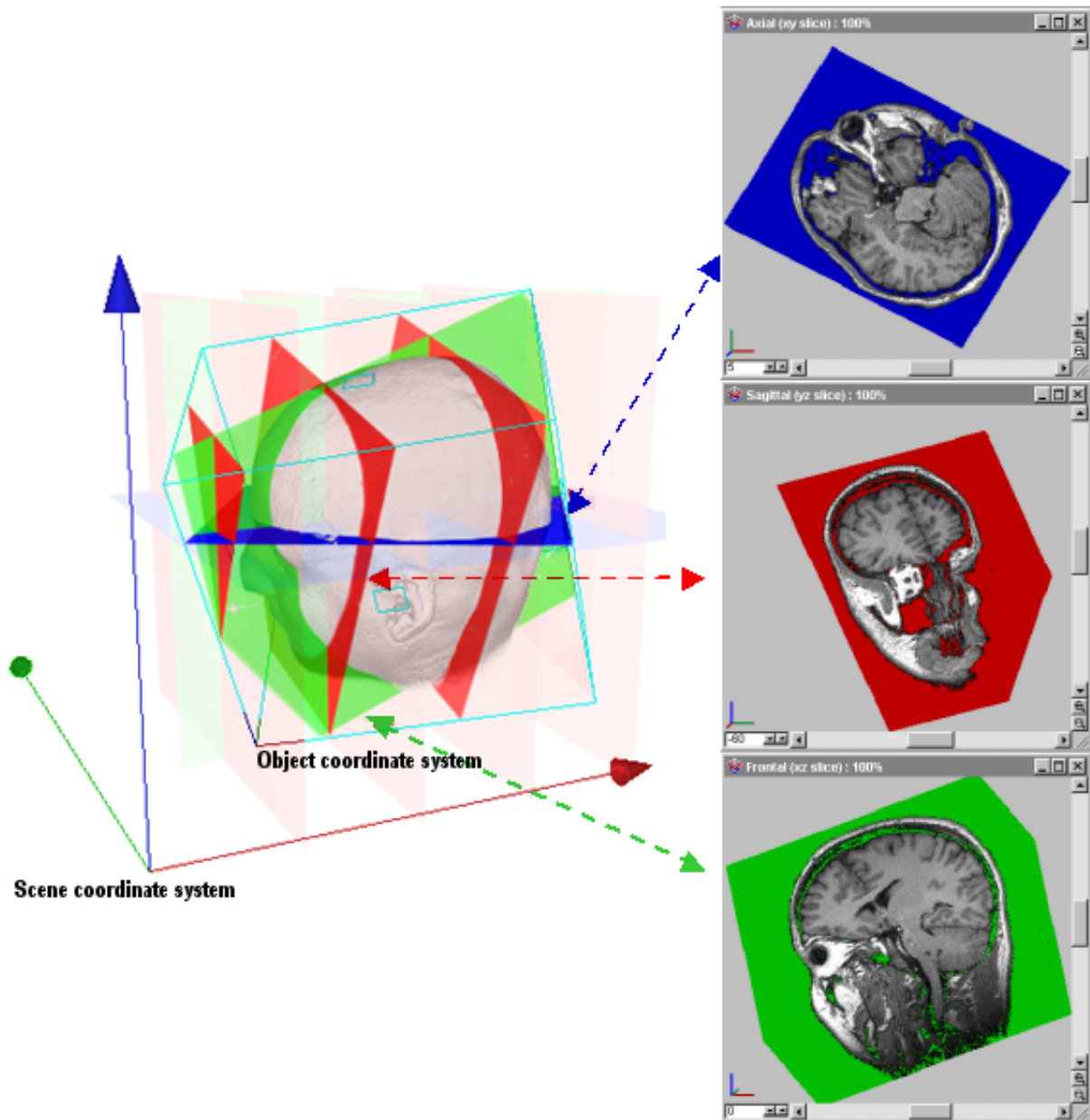


Fig. 78 MRI scan sliced in scene relative mode.

Cross Sections Displayed in the Slice Images

If several objects are loaded into the scene, only one of the objects will be displayed as slice images. All other objects or groups of objects will appear as a cross section through their bounding box if the box is crossed by the slice plane of the currently selected object. Only the bounding boxes will be displayed in the slice windows if several objects, a group of objects, or a polygon object are selected.

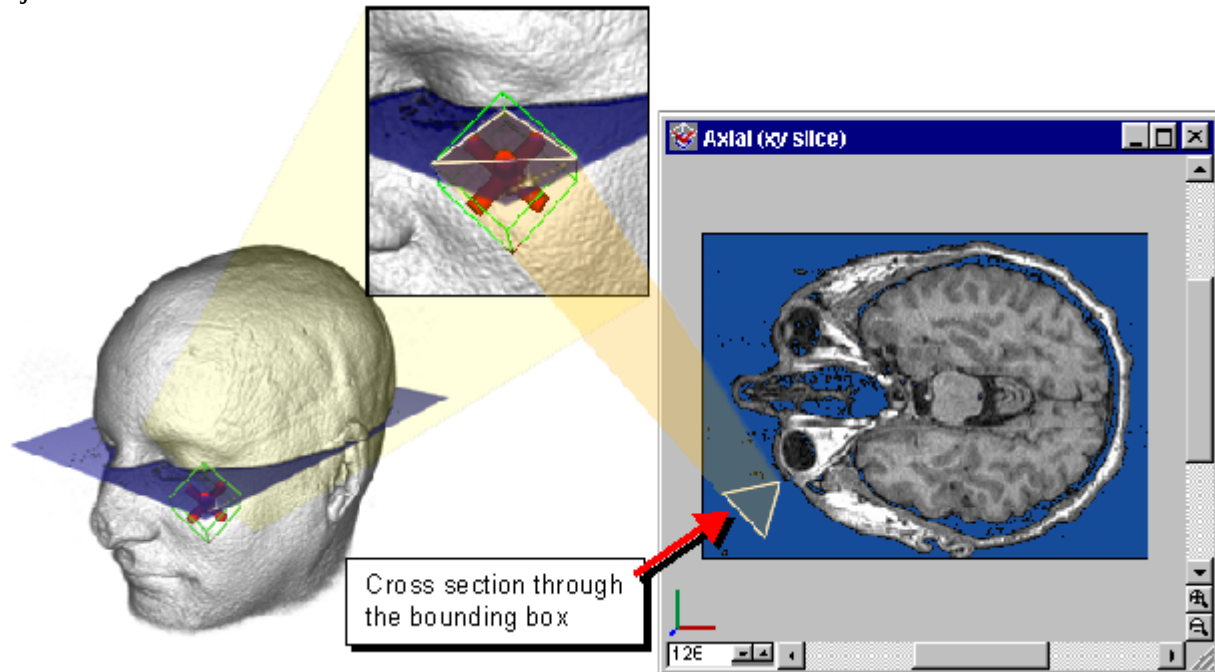


Fig. 79 If several objects are loaded into the scene, one of the objects will be displayed as a slice image; for the other objects, only the bounding boxes will be shown.

If a slice outside the active volume data set is chosen, only a red bounding box will be displayed in the slice windows to display the currently selected object.



Fig. 80 A red bounding box will be displayed if a slice outside the actual volume data set is chosen.

The object that was selected last will remain visible in the slice windows when it is deselected until a new object is selected. This feature helps the user to navigate in **Camera** mode with no bounding box visible (for more information on the **Camera** mode please refer to *Chapter 4.6.9 Camera View*).

4.5.2 3D Window

The **3D window** shows the result image of the rendering process. Two modes are supported in the 3D window: **Scene view** (i.e. **World View** mode) and **Camera view** (i.e. **Camera** mode).

In the title bar of the 3D window the currently selected mode (**World view** mode or **Camera view** mode) is displayed. In the left corner of the title bar you find the **Control** icon, which you use to access the **Control** menu. Double-clicking this icon will close the 3D window. You can use the **Control** menu to maximize or minimize the 3D window or to close it. The window buttons can be found in the right corner of the title bar. These buttons can also be used to maximize, minimize, or close the 3D window.

In the 3D window you will also find two scrollbars to pan large images as well as two **zoom** buttons.

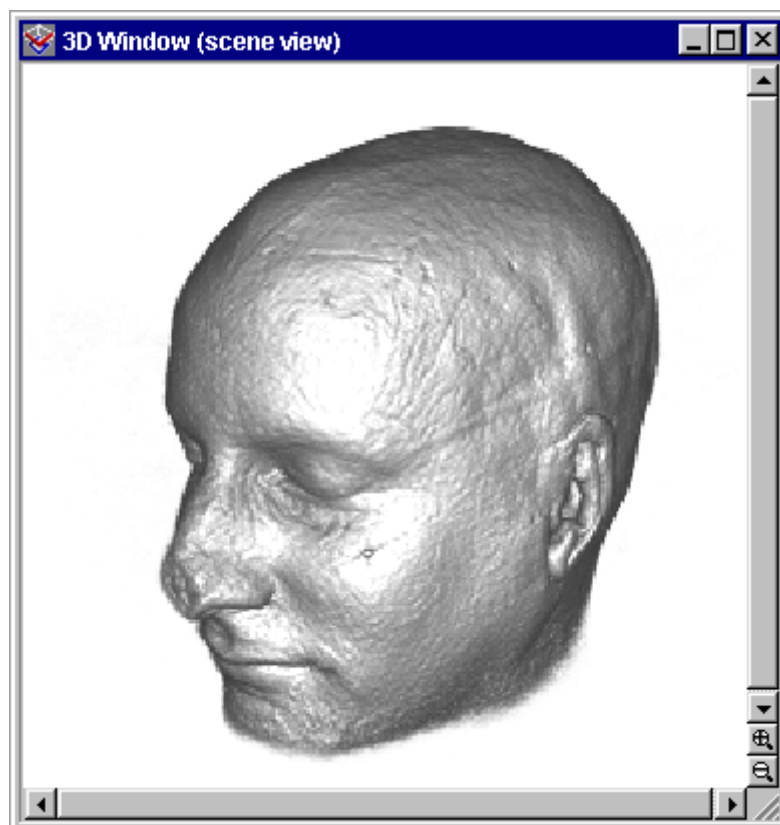


Fig. 81 The 3D window in scene view mode.

When clicking into the 3D window with the right mouse button, a context menu will be opened.

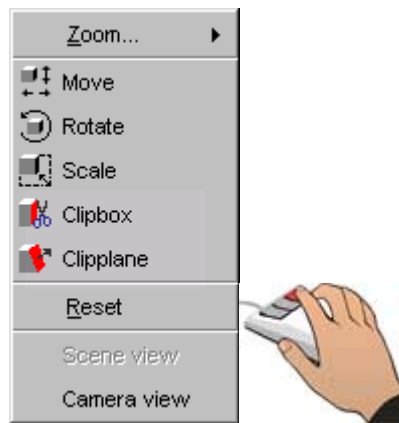


Fig. 82 The context menu in the 3D window.

Use the **Zoom** option to open the **Zoom** menu.



Fig. 83 The Zoom menu of the 3D window.

The 3D window may be zoomed in (i.e. enlarged) or zoomed out (i.e. reduced). These functions may also be applied by using the zoom buttons in the lower right corner of the 3D window. The image will then be enlarged or reduced by a preset zoom factor.



The **Fit to Window** option allows to zoom the active object so that it is displayed with maximum zoom factor. The **Actual Pixels** option applies a zoom factor so that one pixel in the 3D image of the 3D window will be one pixel on your screen.

In the following, the other options of the 3D view context menu will be explained.

- **Move**— Select this command to move the selected object or object group. The **Move** mode is characterized by the green bounding box around the selected object or group of objects. When moving the cursor into the bounding box, it will take the shape of one vertical and one horizontal arrow (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be moved in the image plane by clicking into the bounding box and dragging the mouse while the left mouse button is pressed. The object may be moved forwards or backwards (and thus will be enlarged or reduced) by clicking into the bounding box and dragging the mouse while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. The whole bounding box may be used as active area to apply the appropriate action. Using the Shift modifier in **Move** mode allows you to pan the object along either the vertical or horizontal direction of the 3D window image plane. For more information on the **Move** mode, please refer to *Chapter 4.6.7 Object Properties*.

- **Rotate**— Select this command to rotate the selected object or object group. The **Rotate** mode is characterized by the red bounding box around the selected object or group of objects. When moving the cursor into the bounding box, it will take the shape of one vertical and one horizontal circular arrow (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be rotated around the x- or y-axes of the image plane by clicking into the bounding box and dragging the mouse while the left mouse button is pressed. The object may be rotated around the viewing direction by clicking into the bounding box and dragging the mouse while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. The whole bounding box may be used as active area to apply the appropriate action. Using the Shift modifier in **Rotate** mode allows you to rotate the object in either around the vertical or horizontal axes of the 3D window image plane. For more information on the **Rotate** mode, please refer to *Chapter 4.6.7 Object Properties*.
- **Scale** — Select this command to scale the selected object or object group. The **Scale** mode is characterized by the dark blue bounding box with squared handles, i.e. active areas on each side of the selected object or group of objects. A rectangular shape will appear next to the cursor when moving it into the active area (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be scaled along the x-, y-, or z-axes by clicking the handle, i.e. the active area on one side of the bounding box and dragging the mouse while the left mouse button is pressed. Isotropic scaling may be performed by clicking into the bounding box and moving the mouse up or down while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. When several objects are selected, only isotropic scaling is supported. Group the objects first if you need to perform unisotropic scaling for several objects at a time. For more information on the **Scale** mode, please refer to *Chapter 4.6.7 Object Properties*.
- **Clipbox** — Select this command to box clip the selected object or object group along the axes of its bounding box. The **Clipbox** mode is characterized by the cyan bounding box with squared handles, i.e. active areas on each side of the selected object or group of objects. When moving the cursor into the active area, a scissors will appear next to the cursor (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be clipped by clicking one of the handles of the bounding box and dragging the mouse along the desired clip direction while the left mouse button is pressed. Group the objects first if you want to clip several objects at a time. For more information on the **Clipbox** mode, please refer to *Chapter 4.6.7 Object Properties*.
- **Clipplane** — Select this command to clip the selected object or object group by an arbitrary clipplane. The **Clipplane** mode is characterized by the cyan bounding box with a normal vector on one side of the active object. When moving the cursor into the bounding box, a scissors will appear next to the cursor (see the table in *Chapter 3.1.2 Mouse Usage*). The object may be clipped along an arbitrary clipplane by moving the mouse up and down while the middle mouse button (or the **Alt** key and the left mouse button) is pressed. To rotate the clipplane around the origin of the clipplane's normal vector click into the clipplane and drag the mouse while the left mouse button is pressed. The origin of the clipplane's normal vector may be moved to any arbitrary position on the clipplane by clicking the clipplane's normal vector origin with the left mouse button and dragging the mouse while the left mouse button is pressed. The clipplane will be disabled if several objects are selected. Group the objects first if you want to clip several objects with one clipplane at a time. For more information on the **Clipbox** mode, please refer to *Chapter 4.6.7 Object Properties*.

- **Reset** —Select this command to reset actions of all categories applied to the selected object such as translation, rotation, clipping, and scaling to their default values. Reset single categories of actions in the **Object properties** tool. For more information see also *Chapter 4.6.7 Object Properties*.
- **Camera mode / World view mode**—Select this command to switch between **Camera mode** and **World view mode**. These options are toggles, i.e. only visible one at a time depending on the mode you are currently working in. If you are working in **World view mode** (indicated in the 3D view window with the text **scene view**), you may switch to **Camera mode** and vice versa.

4.5.3 World and Camera View

VGStudio provides two different modes to view your data: **World view** mode and **Camera view** mode.

By default, VGStudio will start in world view mode. You may switch between **World view** mode and **Camera view** mode by clicking the icons in the icon bar or by using the **Camera view** or **World view** option in the **Scene** menu.

In **World view** mode you can view your data from “outside”. By using the **World view** tool you may rotate and move the whole scene or change the viewing angle without affecting the scene itself. For more information see *Chapter 4.6.8*.

In **Camera view** mode you can view your data from “inside”. This means that you can place a camera into the scene and adjust all camera parameters such as camera position, look-at point, up vector, and viewing angle. For more information see *Chapter 4.6.9*.

VGStudio users will be able to perform an arbitrary data walkthrough when activating the **Camera view** mode. A camera may be placed into any position within the scene or even within a data set. The viewing direction and viewing angle may also be chosen arbitrarily.

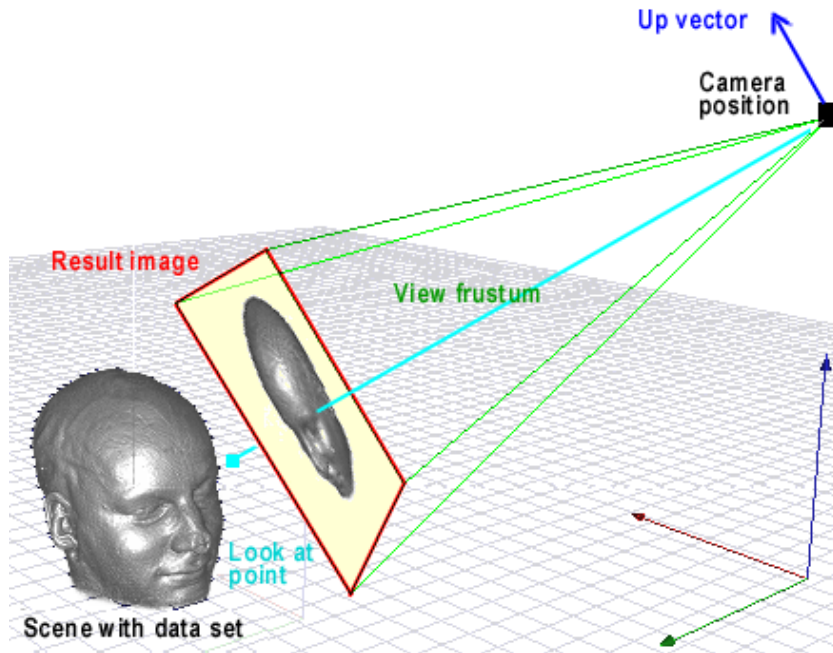


Fig. 84 The Camera view mode allows you to view your data from inside. You may adjust all camera parameters shown here according to your needs.

The camera symbol will appear in all slice images after having activated the **Camera view** mode. The camera symbol looks as follows:

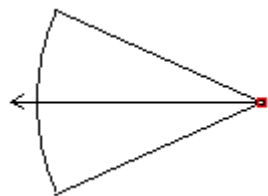


Fig. 85 The camera symbol as it is displayed in the slice images.

Several handles are included in the camera symbol. The **Camera position** handle is marked with a small circle. The **Look-at point** is marked by the tip of the viewing vector. The two front edges of the **View frustum** are the viewing angle handles.

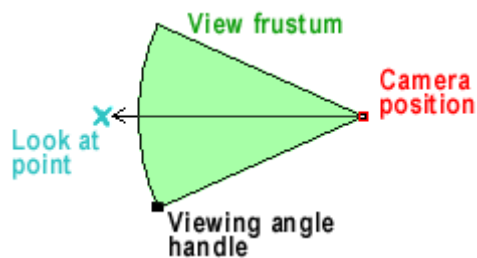


Fig. 86 All camera parameters may be changed by dragging the handles.

Each handle may be manipulated by using the mouse. To do so, click the camera handle in one of the slice images with the left mouse button and then drag the handle while the left mouse but-

ton is pressed to change the camera position. By using two slice images the user will gain full 3D control over the camera position. Grab one of the viewing angle handles and drag the **View frustum** so that it becomes wider or more narrow. This will change the viewing angle of your camera. The changes of the camera position will become visible in all images, i.e. all slice images and the 3D window simultaneously.

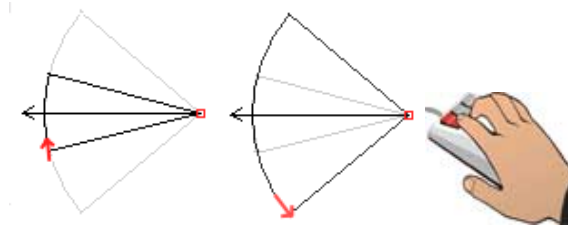


Fig. 87 Reduce or enlarge the view frustum by dragging the handles.

The up vector (the up direction defined in scene coordinates) of your camera may also be adjusted by clicking with the middle mouse button (or with the left mouse button while holding the **Alt** key pressed) into a slice window and dragging the mouse up or down while the middle mouse button is pressed. This will rotate the rendered image around the viewing vector.

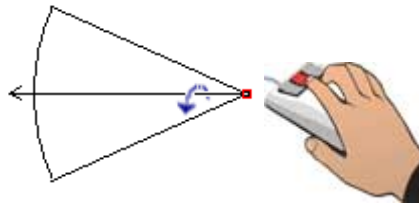


Fig. 88 Rotate the image around the viewing vector.

The length of the viewing vector is of no importance.

While moving the camera the slice images will show the three cross sections through the volume data with the appropriate handle either in camera position or the look-at handle as the center of the three sections. The active handle which marks the center of the slice sections will be displayed in red. The following image shows the slice images with the camera tool activated. The look-at handle is the active handle and the slices show the sections with the look-at handle as center.

All camera parameters described here may be adjusted exactly by typing in numerical values in the **Camera view** tool. For more information on this tool, please refer to *Chapter 4.6.9 Camera View*.

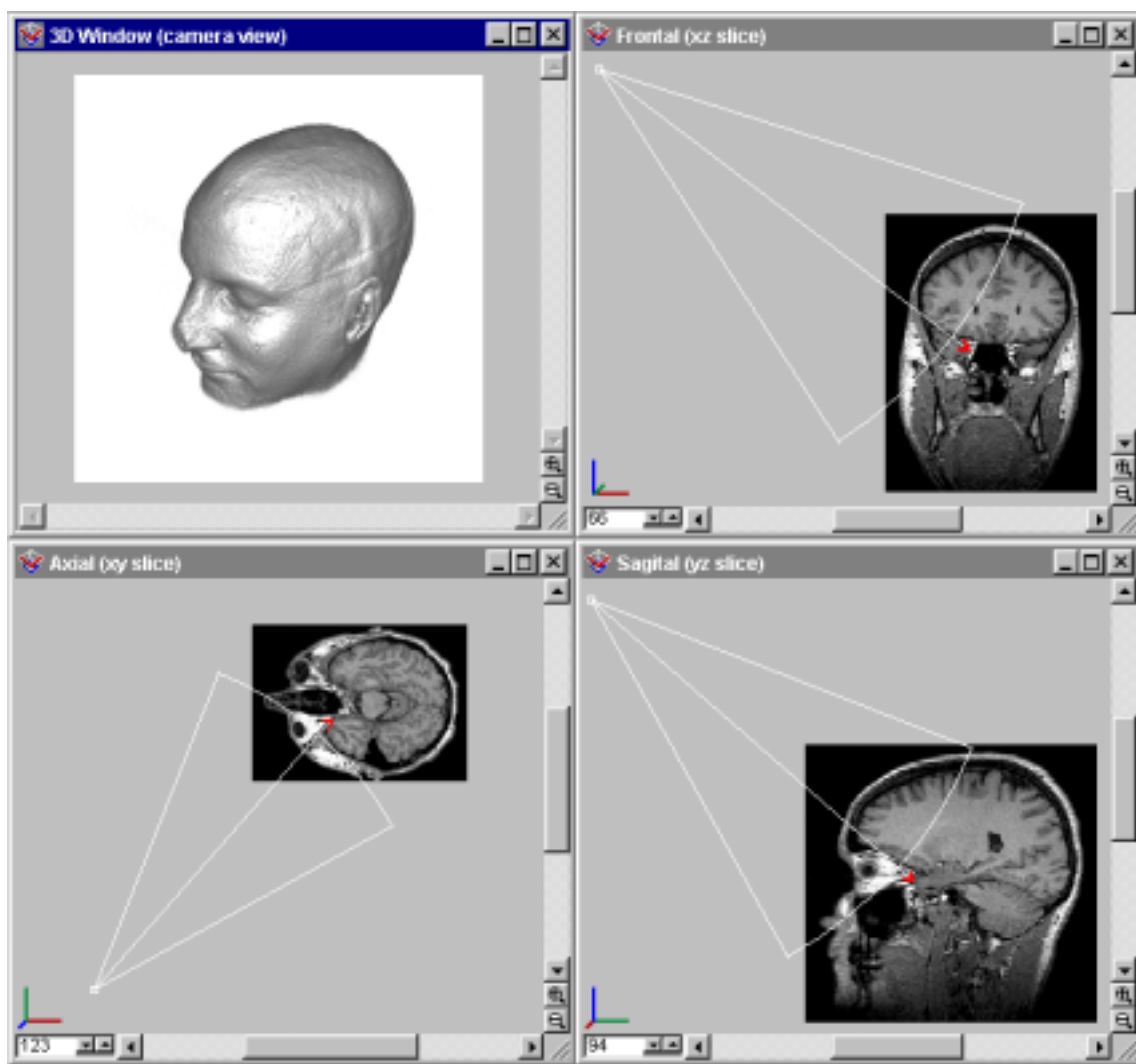


Fig. 89 The 3D window and the slice images while the Camera view mode is selected.



Reminder: The camera and look-at position are defined in scene coordinates while most of the other tools are displayed in object coordinates! Also, the color coding in the slice tools may not correspond to the color coding of the camera tool in case of a rotated object.

4.6 Tool Box

The tool box is located on the right-hand side of the VGStudio user interface. The activated tools will all be located in the tool box. You may scroll through the tool box by means of the scroll bar located on the right-hand side of the tool box.

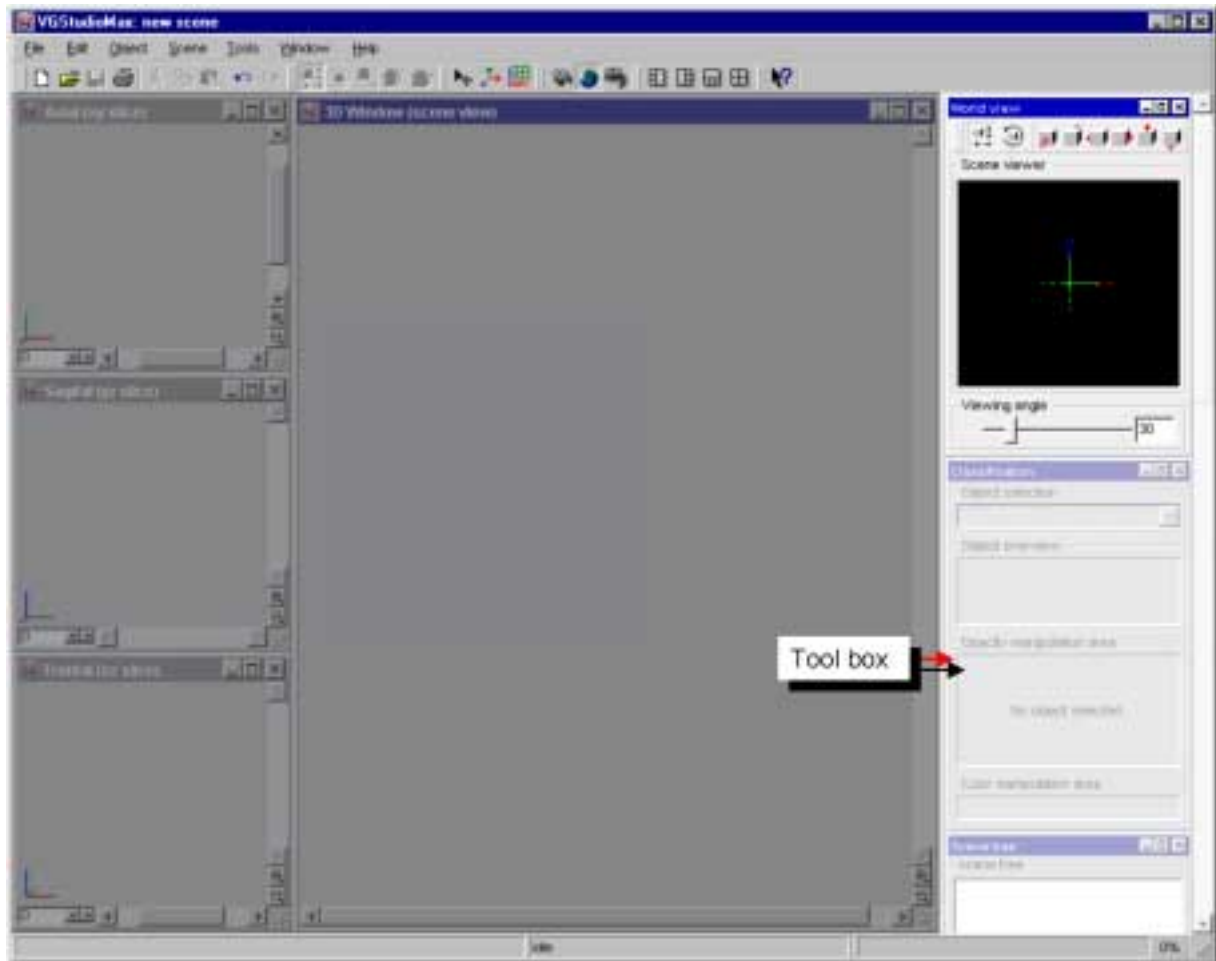


Fig. 90 The tool box of VGStudio.

Tools can be enabled or disabled. To do so click the corresponding menu item in the **Tools** menu. A check mark next to the entries will show that the tool is enabled. A tool which was just enabled will appear at the bottom end of the tool box.

You may also arrange the tools in an arbitrary vertical order within the tool box by clicking into their title bar with the left mouse button and then dragging them to the desired position within the tool box while the left mouse button is pressed.

Tools can also be dragged out of the toolbox by clicking into their title bar with the left mouse button and then dragging them to the desired position outside the tool box. The tools are then “floating” tools which are independent of the main application window. Tools dragged out of the

4. VGStudio Interface & Tools

tool box will stay on top all the time. Inside the tool box, the tools have a fixed size. If you need to enlarge or reduce the windows, e.g. for better handling, you first have to drag them out of the tool box. Most tools can be resized when they are located outside the tool box by clicking into the frame of the corresponding window and then dragging the mouse until the desired size is reached. When placing the tool back into the tool box, it will be reduced or enlarged to its default size. The tool will be resized to the size defined by the user once it is dragged out of the tool box again.

When you deactivate all tools, the tool box will shrink so that the whole window can be used as workspace. Activate a tool to expand the toolbox again.

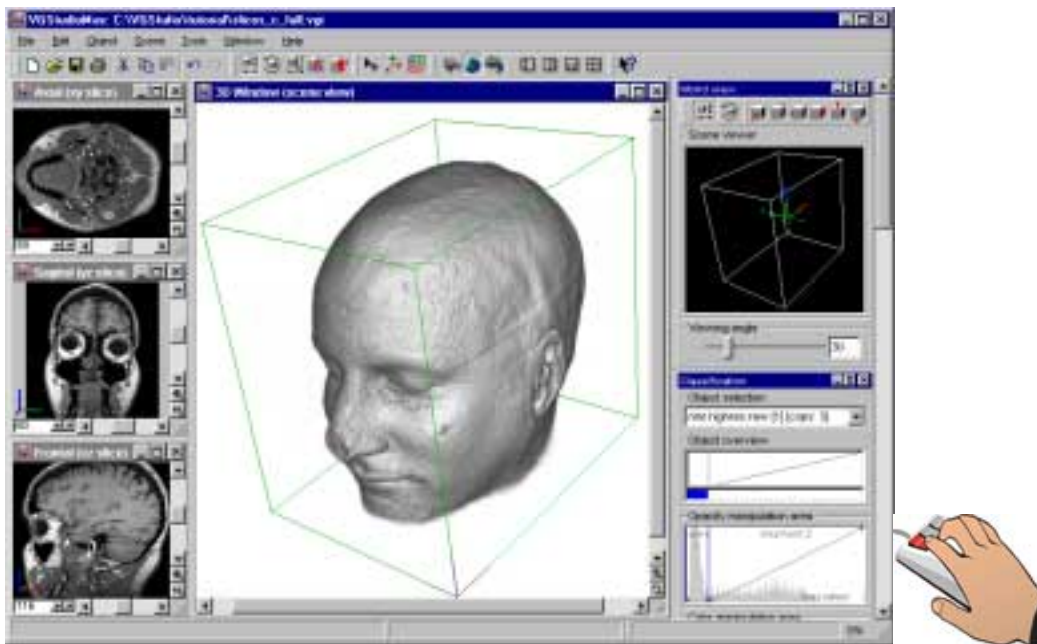


Fig. 91 The Classification tool is now inside the tool box. Click into the title bar of the tool and drag it out of the tool box while the left mouse button is pressed. You may then adjust the size of the tool.

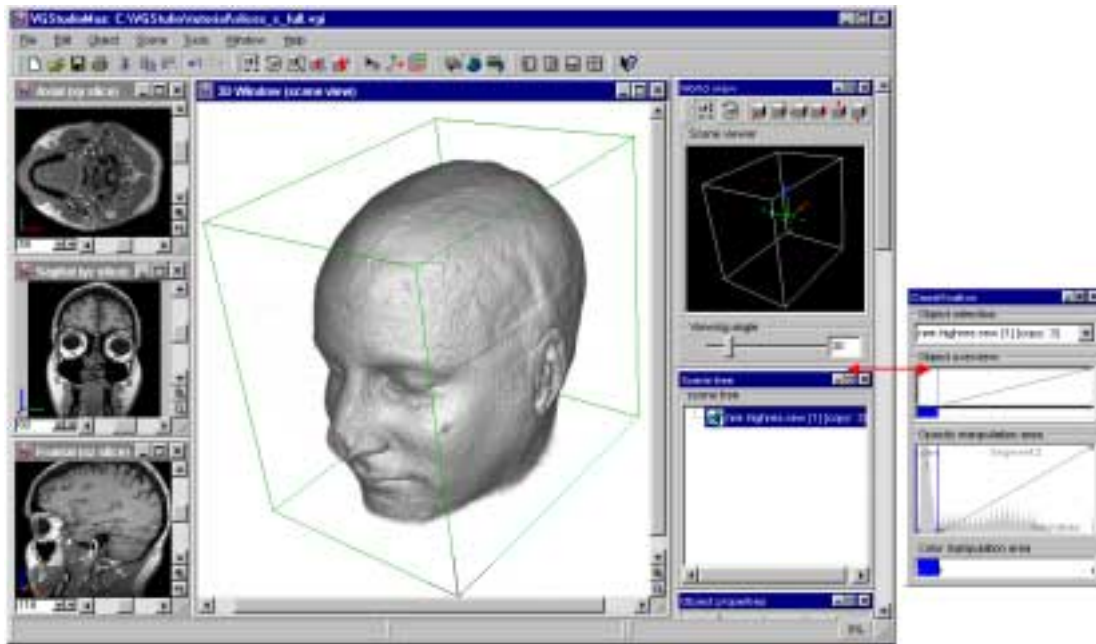


Fig. 92 The Classification tool is dragged out of the tool box where you may adjust its size to your needs.

You may use the **Close** button  to close a tool. Use the **Tools** menu to enable a tool again by clicking it. A check mark will then appear next to the menu item. For further information on the **Tools** menu, see also Chapter 4.3.6.

Use the **minimize** button  to minimize the tool. If you press the **minimize** button in a floating tool, the tool will be placed back into the tool box as a minimized tool and will appear at the end of the tool box.

When you click the **maximize** button  of a tool, it will be taken out of the tool box and will become a floating tool. If you press the **maximize** button  in a floating tool, the tool will be placed back into the tool box as the last tool in the box.

4.6.1 Classification Tool

The **Classification** tool is one of the most important and most powerful tools of VGStudio 1.1. The main purpose of the **Classification** tool is used to apply user-defined transfer functions to the data for both opacity and color. The opacity transfer function can be adjusted in the graph which is shown in the **Opacity manipulation area**.

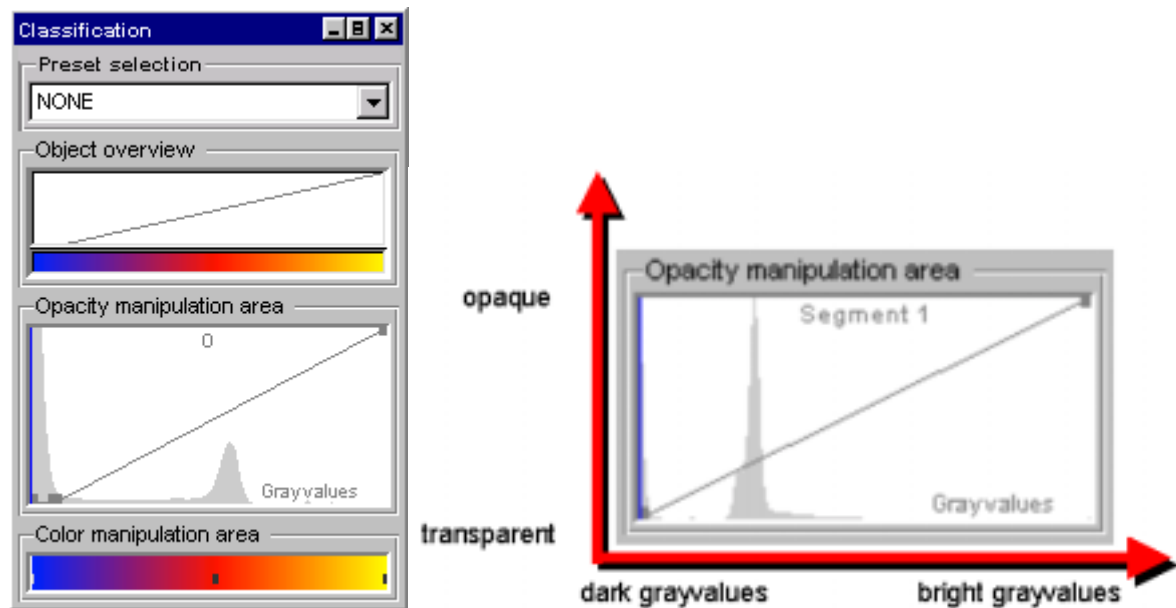


Fig. 93 The Opacity manipulation area of the Classification tool.

The default transfer function maps the darkest grayvalues to transparent and the brightest grayvalues to totally opaque. The default color mapping is set to white. The default mappings may be manipulated arbitrarily. Thus, the **Classification** tool allows the user to apply any transparency level or color to any grayvalue within the data set. The examples below show what the images will look like when you change the opacity values.

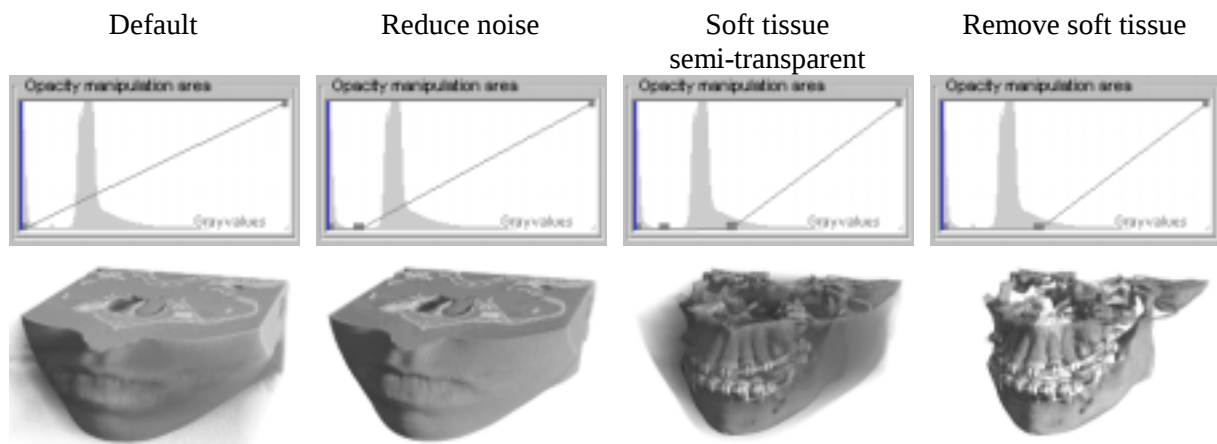


Fig. 94 When changing the opacity values, the images will look like shown here.



Reminder: Exceptions occur in case of RGBA color data, e.g. colored TIF, JPEG, BMP, or PPM images or RAW RGBA data. No color mapping will be possible for color data. The color intensity is used as “grayvalue” in the classification tool for color data.

The classification tool can be used in two different modes: Level/Window mode and Advance mode. Level/Window mode provides an easy to use interface which allows to apply a simple opacity ramp with a defined width and center. Window-leveling is mostly used and well known in the medical community. Advanced mode allows the user to apply arbitrary opacity functions which can not be generated by using a simple ramp. Both modes are described in this chapter.

The **Classification** tool consists of several elements:

- Preset selection

In Advanced mode:

- Object overview
- Opacity manipulation area
- Color manipulation area

In Level/Window mode:

- Level – Window area
- Opacity manipulation area

Preset selection

The **Preset selection** contains a set of predefined Window-Level/Opacity and color settings. Clicking the Preset selection will show several predefined settings. Clicking one of these presets changes the Window and Level settings or the opacity function in the classification tool to the preset values. You may apply the various presets to see which works best for displaying the volume.

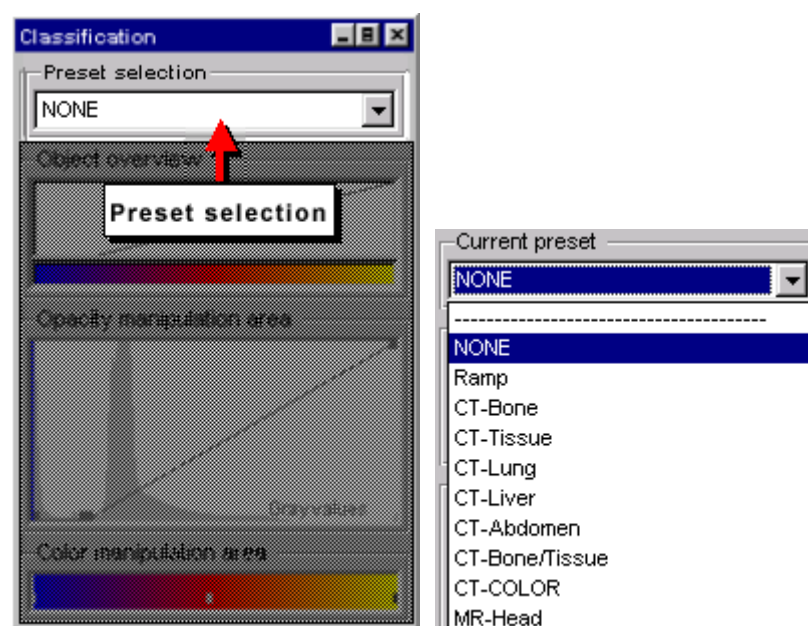


Fig. 95 Select a classification tool preset from the pull down list.

The following presets for medical users are included as default and therefore may not be removed from the preset list: Ramp, Inverse Ramp, CT-Bone, CT-Tissue, CT-Lung, CT-Liver, CT-Abdomen, CT-Bone/Tissue, CT-Color and MR-Head.

You may add your own or overwrite existing settings in the preset list by saving the actual settings defined in the classification tool. Press the right mouse key within the classification tool to bring up the context menu. Select the **Save preset** option to save the actual settings.



Fig. 96 The context menu with the Save/Delete preset options..

A dialog will come up to where you have to either select an existing preset to overwrite or to enter a name to create a new preset.



Fig. 97 The Save preset dialog..

A Preset will be applied relative to the existing data range of your data. This means that the color and opacity/window – level settings for a certain gray value may vary in case that the data range (minimum to maximum gray value in your data) changes. You may save absolute Presets to prevent this behavior. Activate the **Absolute Preset** check box in case that the Presets should be applied according to absolute gray values.

You may delete a preset from the preset list. To do so press the right mouse key within the classification tool to bring up the context menu. Select the **Delete preset** option to delete the selected preset. Keep in mind that default Presets can not be deleted.

Object overview (Advanced mode)

The **Object overview** section of the **Classification** tool is divided into two parts, i.e. the opacity area which shows the grayscale to opacity mapping function and the color area which shows the color mapping.

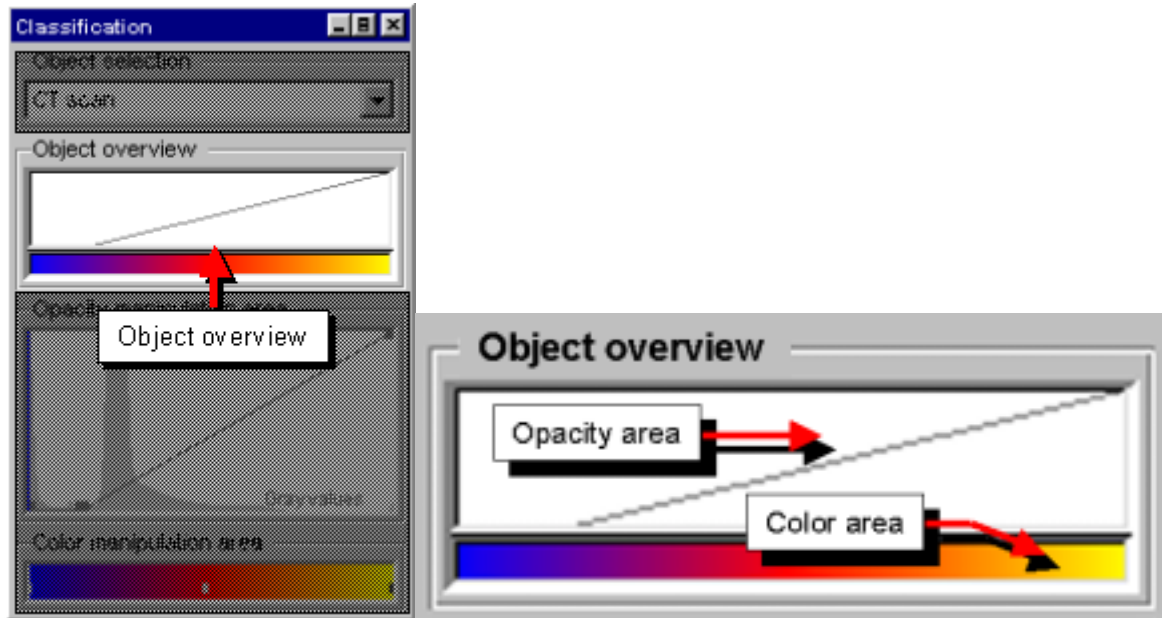


Fig. 98 The **Object overview** section is divided into two parts, i.e. the opacity area and the color area.

As the name says, the **Object overview** section provides the user with an overview of the entire grayscale and opacity range as well as the color settings of the selected object. To display the grayscale and opacity range of the active object, click with the left mouse button into the opacity area of the **Object overview** section. The values will disappear as soon as you release the mouse button.

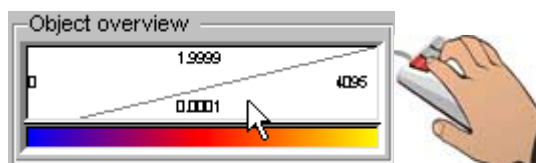


Fig. 99 When clicking into the opacity area of the **Object overview** section, the grayscale and opacity values of the active object will be displayed.

The **Object overview** section may also be used to define a Region of Interest (ROI) within the opacity area. The ROI will be displayed enlarged in the **Opacity manipulation area** of the classification tool.

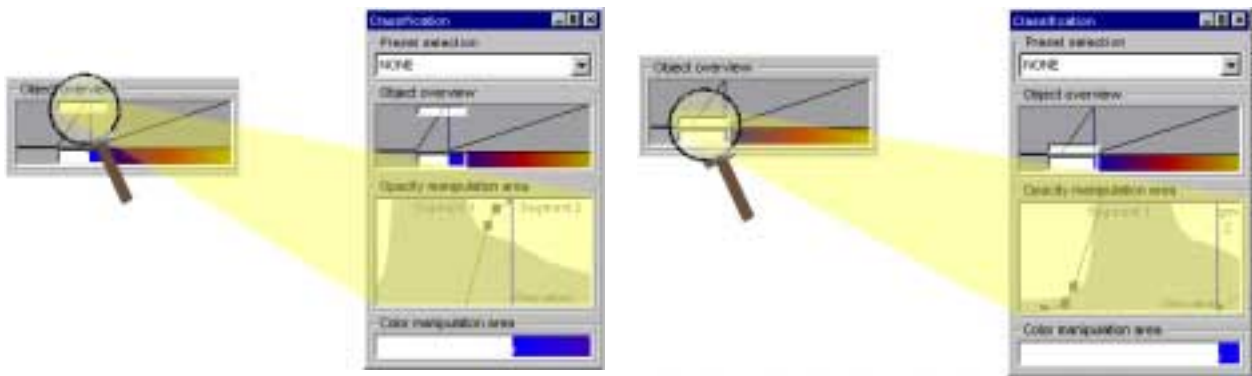


Fig. 100 Define regions of interest in the Object overview section of the Classification tool.

By default, the ROI covers the whole opacity area. The background of the opacity area will be white.

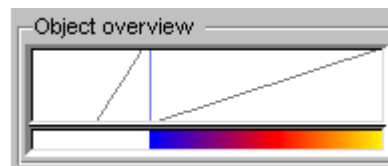


Fig. 101 The ROI covers the entire opacity area.

When defining a ROI the background of the opacity area will be gray while the ROI has a white background.

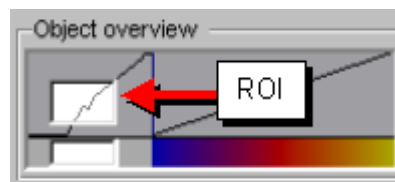


Fig. 102 Once you have defined a ROI, the opacity area will be displayed in gray and the ROI in white.

The ROI may also be set for a single segment by clicking with the left mouse button into the appropriate segment of the color area in the **Object overview** section.

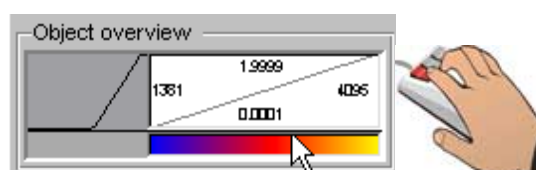


Fig. 103 Set a ROI for a single segment only.

Arbitrary ROIs may be defined by moving the mouse cursor to one of the four borders of the opacity area. The mouse cursor will change as shown in the images below which indicates that the manipulation of the ROI is possible. When the mouse cursor changes click the left mouse button and drag the ROI border in the desired direction. The appropriate border value will be displayed while changing the ROI.

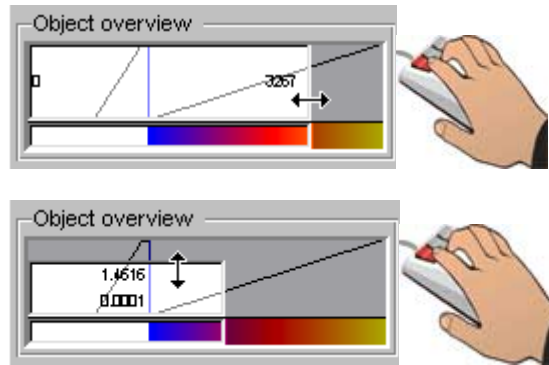


Fig. 104 Change a ROI by dragging the ROI's borders to the desired position.

A ROI may be moved in the opacity area like a magnifier. Click with the left mouse button into the ROI and drag the ROI around while keeping the left mouse button pressed. The appropriate border values will be displayed while moving the ROI.

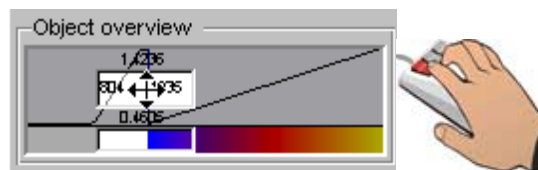


Fig. 105 Drag the ROI around in the opacity area.

Click with the right mouse button into the **Object overview** area to open a context menu containing the entries shown in the following figure.

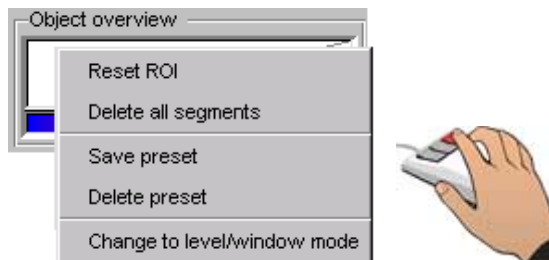


Fig. 106 The context menu which opens upon clicking into the opacity area with the right mouse button.

The menu option **Reset ROI** will reset all ROI settings.

The menu option **Delete all segments** allows you to reset all segment, opacity, and color settings to default values which means that all segments will be removed. The default opacity ramp is applied and the color is set to white. The **Save/Delete preset** options may be used to save or delete Window-Level/Opacity and color presets from the Preset selection list. See *Preset selection within this chapter*.

Opacity manipulation area (*Advanced mode*)

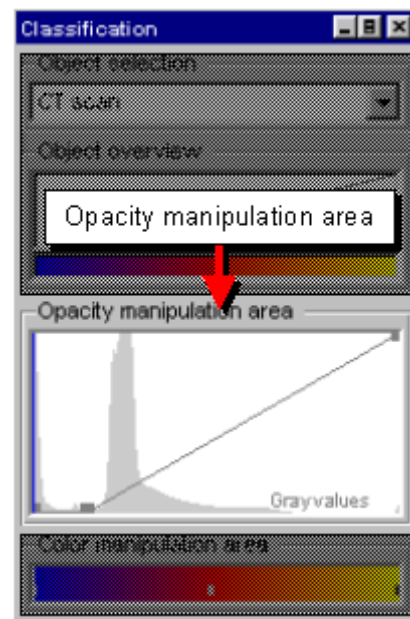


Fig. 107 The Opacity manipulation area.

The **Opacity manipulation area** contains the following elements:

- Histogram
- Opacity function
- Opacity handles
- Segment borders
- Segment names

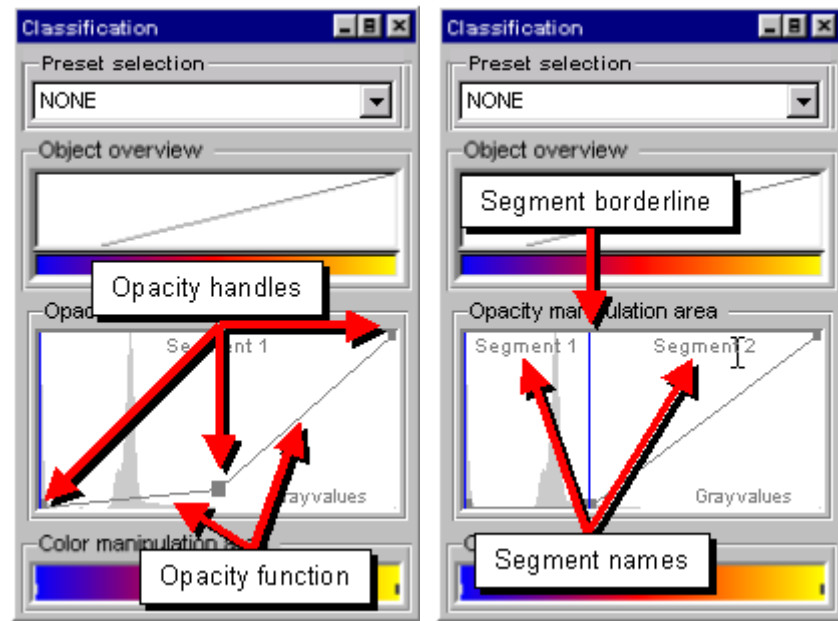


Fig. 108 The different elements of the Opacity manipulation area.

The grayvalue histogram of the active data set is displayed in the background of the opacity manipulation area. You may zoom in or zoom out on the histogram or disable the histogram by clicking with the right mouse button into the **Opacity manipulation area** and then clicking **Histogram** in the context menu. Another menu will then open where you may select the appropriate function (**Disable/Enable histogram**, **Zoom in**, **Zoom out**, or **Zoom reset**).

The default opacity mapping function will look like shown in the following figure. The opacity function looks like a linear ramp from the opacity handle at the lowest, darkest grayvalue with zero opacity to the opacity handle at the brightest grayvalue with maximum opacity.

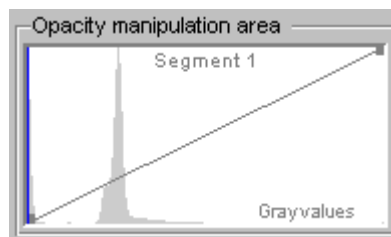


Fig. 109 The default opacity mapping function.

The opacity function may be adjusted to any arbitrary shape. New opacity handles may be inserted by clicking the desired position with the middle mouse button (or with the left mouse button while keeping the **Alt** key pressed). You may also insert a new handle by using the context menu which you open by clicking into the **Opacity manipulation area** with the right mouse button. Click the desired position with the right mouse button and then select **Insert handle** in the context menu.

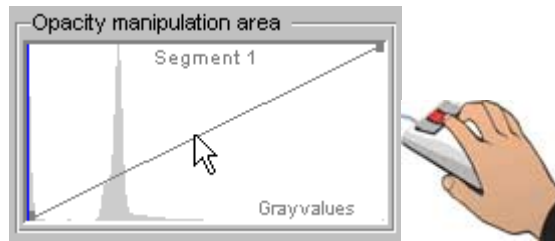


Fig. 110 Insert a new handle by clicking the desired position with the middle mouse button.

The handle may be moved by clicking it with the left mouse button and then dragging it to the desired position while keeping the left mouse button pressed. Opacity handles may be removed by clicking them with the middle mouse button (or with the left mouse button while keeping the **Alt** key pressed). You may also remove a handle by using the context menu which you open by clicking into the **Opacity manipulation area** with the right mouse button. Click the handle you wish to remove with the right mouse button and then select **Remove handle** in the context menu. Please note that the two outer handles can neither be moved nor removed.

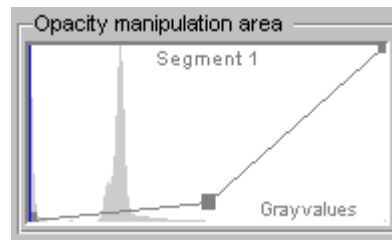


Fig. 111 The new handle is displayed.

Any element of the opacity function, i.e. opacity handles or line segments, may be moved within the opacity manipulation area by clicking the element and dragging it around while the left mouse button is pressed. The cursor's shape will change when moving it on a handle or the opacity function line to indicate that the appropriate element may be moved. The cursor's shape also indicates into which direction the element may be moved (generally in horizontal and vertical direction, which is indicated by one vertical and one horizontal arrow). Please note that the two outer handles may only be moved in vertical direction.

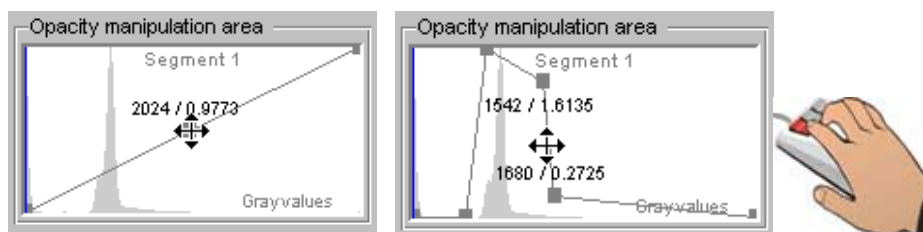


Fig. 112 You may drag the line and the handles to new positions with the left mouse button pressed.

VGStudio allows the user to generate the maximum number of one opacity handle per grayvalue. This provides a maximum degree of freedom when applying an arbitrary opacity mapping.

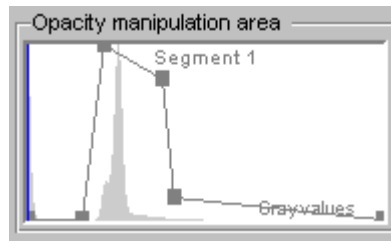


Fig. 113 The Opacity manipulation with four new handles.

VGStudio 1.1 provides the user with a powerful tool to separate structures within a volume data set by their grayvalue range. This process is called grayvalue segmentation. A segment is defined by a grayvalue range within a data set. A segment may include a range from one single grayvalue up to the full grayvalue range of the volume data set.

To define a grayvalue segment, place the cursor on the borders of the **Opacity manipulation area** so that the cursor's shape changes as shown in the following figure.

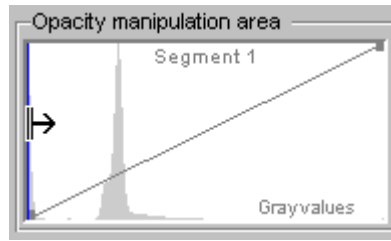


Fig. 114 To define a segment, drag the line to the desired position.

Keep the left mouse button pressed and drag the line to the desired position in the **Opacity manipulation area**. The segment ranges will be displayed while dragging the line.

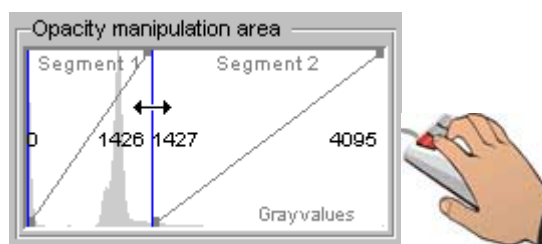


Fig. 115 While dragging the line, the segment ranges will be displayed.

A new segment may be generated by dragging either the left or the right border of the **Opacity manipulation area** or the blue segment border line. When placing the cursor on one of the segment border lines, it will assume different shapes. Each shape indicates the action that can be applied when clicking the line with the left mouse button and then dragging the line (see Fig. 116 for the different shapes the cursor may assume).

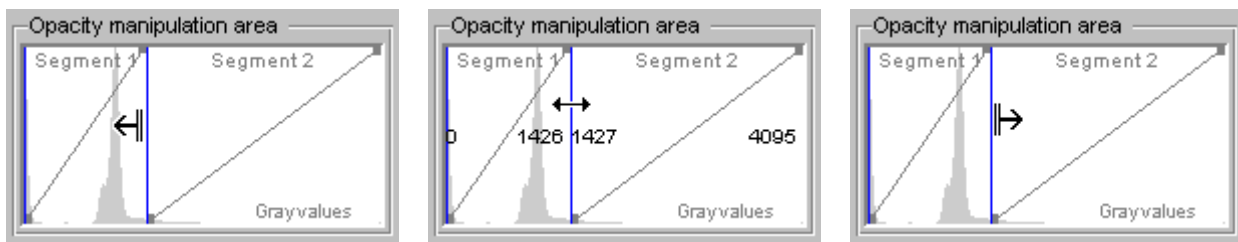


Fig. 116 The cursor shown in the left image indicates that you may generate a new segment to the left of the current segment's border. The middle image indicates that the segment border may be moved to the left or right. The right image indicates that you may generate a new segment to the right of the current segment's border.

VGStudio allows the user to generate the maximum number of one segment per grayvalue. This provides a maximum degree of freedom when applying arbitrary opacity and color values.

The segment names displayed in the **Opacity manipulation area** may be changed. To do so, simply click the name with the left mouse button and type in the new name.

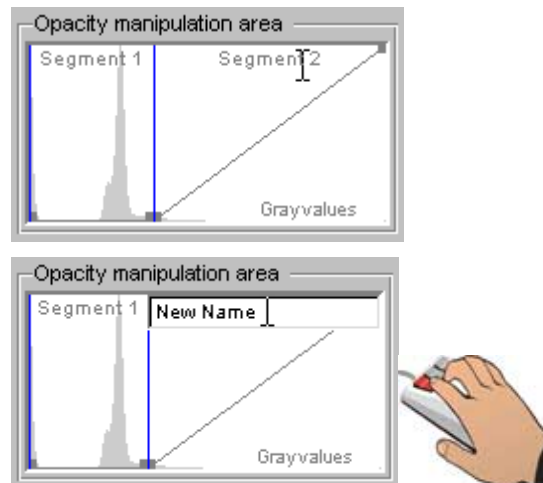


Fig. 117 Change the segment name in the Opacity manipulation area by clicking the name with the left mouse button and then typing in the new name.

Press the right mouse button within the **Opacity manipulation area** to the context menu. Features such as **Copy opacity curve**, **Paste opacity curve**, **Cut segment**, and **Delete segment** may be disabled; this depends on the position you click with the right mouse button within the **Opacity manipulation area**. In the context menu of the **Opacity manipulation area** you will find the following functions:

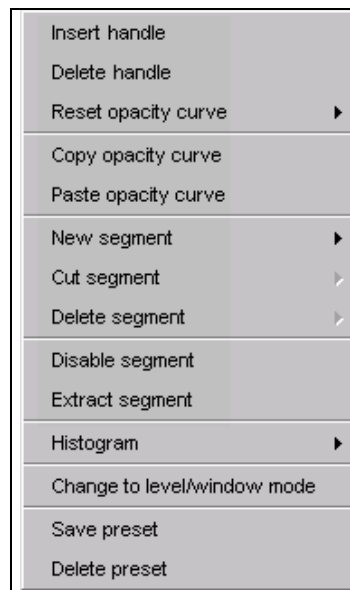
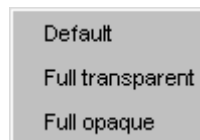


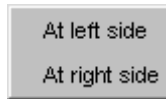
Fig. 118 The context menu of the Opacity manipulation area.

- **Insert handle**—Select this command to generate a new opacity handle in the **Opacity manipulation area**. The handle will be inserted at the position you click with the right mouse button.
- **Delete handle**—Select this command to remove an opacity handle from the **Opacity manipulation area**. Click the handle to be removed with the right mouse button and then select **Delete handle** in the menu.
- **Reset opacity curve**—Select this command to open the following menu:

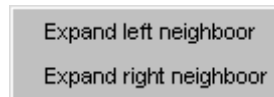


- **Default**—Select this command to apply the default opacity function to the appropriate segment.
- **Full transparent**—Select this command to set the opacity to totally transparent.
- **Full opaque**—Select this command to set the opacity to totally opaque.
- **Copy opacity curve**—Select this command to copy the current segment's opacity curve into the clipboard. Use **Paste opacity curve** to paste the copied opacity settings to another object or segment.
- **Paste opacity curve**—Select this command to paste a previously copied opacity curve to another object or segment.
- **New segment**—Select this command to generate a new segment. Use the following menu to decide on which side of the current segment the new segment is to be generated, i.e. either on

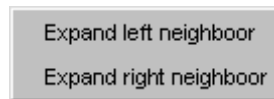
the left-hand side or the right-hand side.



- **Cut segment**—Select this command to cut the current segment. Use the following menu to decide which segment should be expanded when cutting the current segment.



- **Delete segment**—Select this command to delete the current segment. Use the following menu to decide which segment should be expanded when deleting the current segment.



- **Disable/Enable**—Select this command to disable a segment. In the **Opacity manipulation area**, a disabled segment will be shown with a gray background; the text *disabled* will be displayed in brackets beneath the segment name. In the 3D and the slice windows, the segment will no longer be visible. The same effect may be achieved by mapping the opacity curve to totally transparent. A disabled segment's opacity or color mapping may be manipulated, but the results of such a manipulation can only be observed in the 3D and the slice windows when the segment is enabled again.
- **Extract**—Select this command to extract a segment from the original volume object. VGStudio's **Extract** function allows the user to separate parts of a volume data set which are defined by a segment, i.e. by a grayvalue range. The extract process will generate a new independent object in the scene. The new object may be manipulated independently from the original object.

Extract Example

Since it is a very powerful and useful feature of VGStudio 1.1, the **Extract** function will be explained here by means of an example. We will use a CT scan of a human jaw.

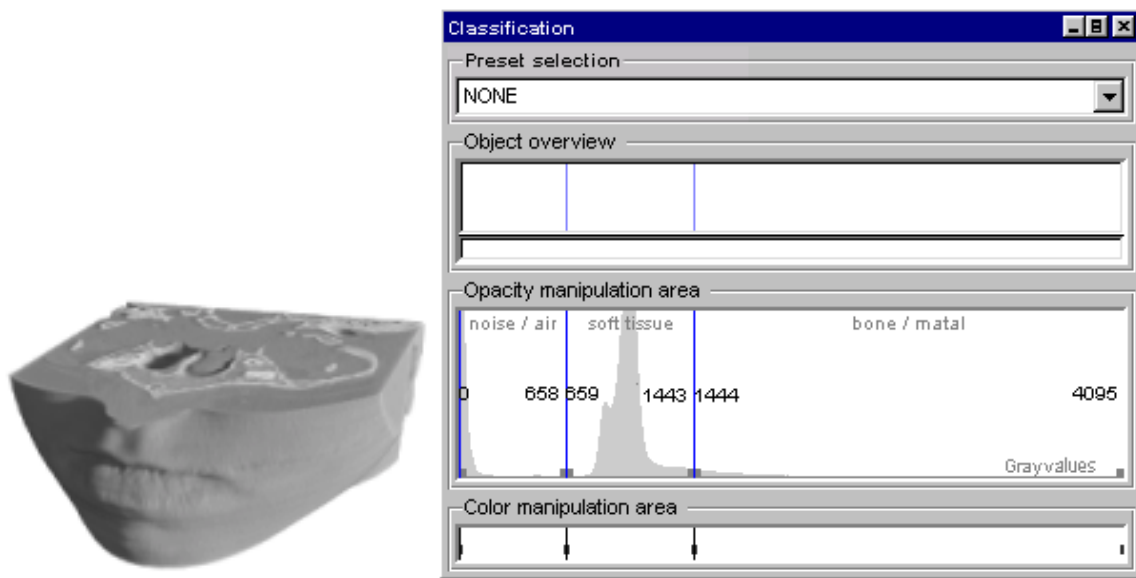
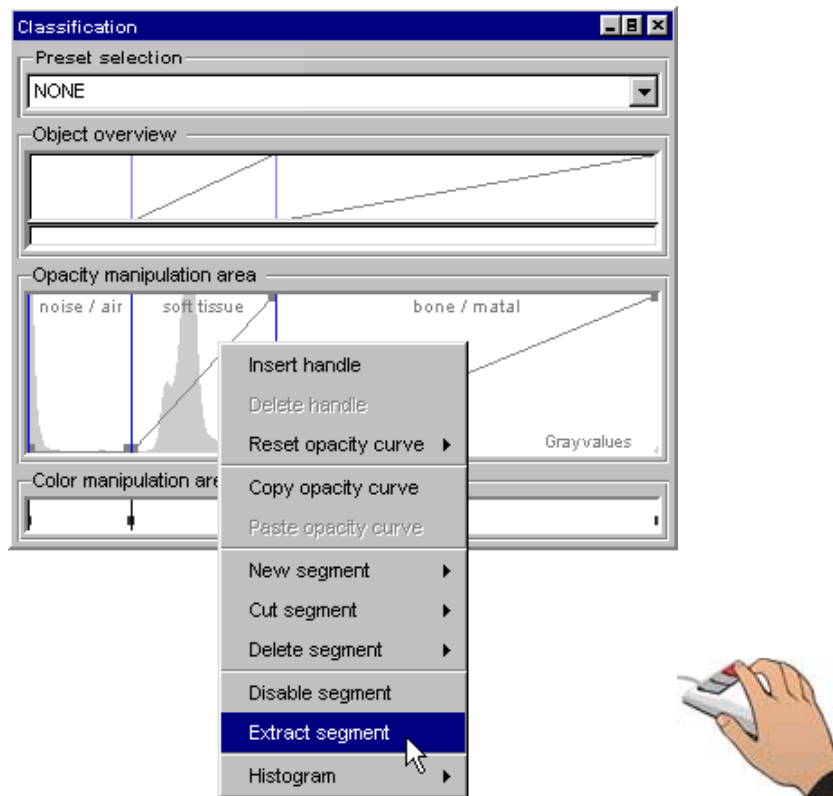


Fig. 119 The CT scan of a human jaw and the Classification tool with three grayvalue segments defined.

The classification tool above shows three grayvalue segments within the CT data set. Segment 1 includes the grayvalue range from 0 to 658. It represents the noise and air within the CT data set. Segment 2 ranges from 659 to 1443 and represents the soft tissue. Segment 3 includes the brightest grayvalues from 1444 to 4095. It represents the bone structures and the metal of the braces in the CT data set. As we can see in Chapter 4.6.1 *Classification Tool*, the opacity and color mapping of the three segments can be handled independently of each other. However, the geometric settings such as position, rotation, scaling, and clipping of one of the segments cannot be handled independently from the rest of the CT scan. The **Extract** function is an easy-to-use and powerful tool to generate images as shown below in Fig. 123 where the soft tissue is removed from half of the jaw.

In the example shown here we need to clip the soft tissue only. In order to clip only one segment the segment has to be extracted.



*Fig. 120 To extract a segment, click into the segment with the right mouse button and select **Extract segment** from the context menu.*

In the **Opacity manipulation area**, click into Segment 2 (named “soft tissue”) with the right mouse button. Select **Extract segment** in the context menu. After the extraction process, only the extracted soft tissue segment with a grayvalue range from 659 to 1443 will be shown in the **Classification** tool.

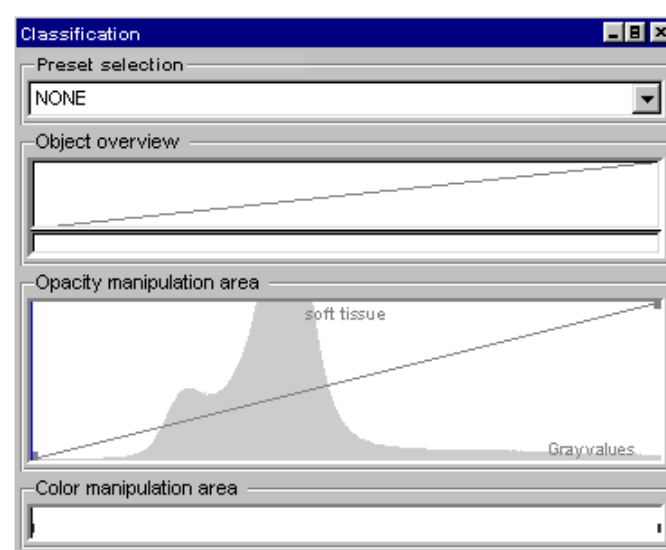


Fig. 121 After the extraction process, only the soft tissue segment will be shown.

In the **Scene tree** and in the **Object selection** box, the new object will be displayed with the following name: “soft tissue [extracted of CT scan of a human jaw: 1]”.

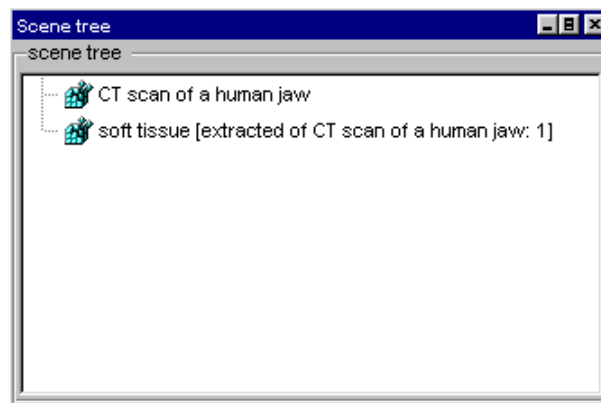


Fig. 122 In the Scene tree, the newly created object will be displayed.

The newly created object only includes the soft tissue and may now be manipulated independently from all other objects in the scene like any other object. It may be positioned, rotated, scaled, or clipped; the opacity and color mapping may also be changed. In our example, the soft tissue object was clipped half by means of the clipbox mode, so that half of the bone structure can be seen. Please note that you have to enable both the CT scan of the jaw and the extracted soft tissue; otherwise the bone structure will not be visible when clipping the object.

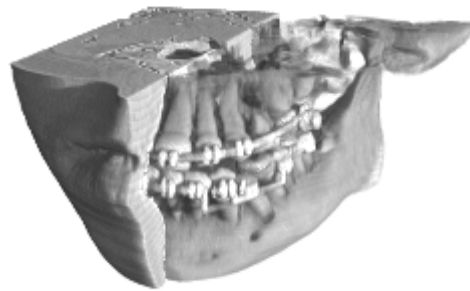


Fig. 123 The CT scan of a human jaw after the soft tissue has been removed from half of the jaw.

The extracted segment in the original volume data object will not be destroyed. The extracted segment will only be disabled in the original object.

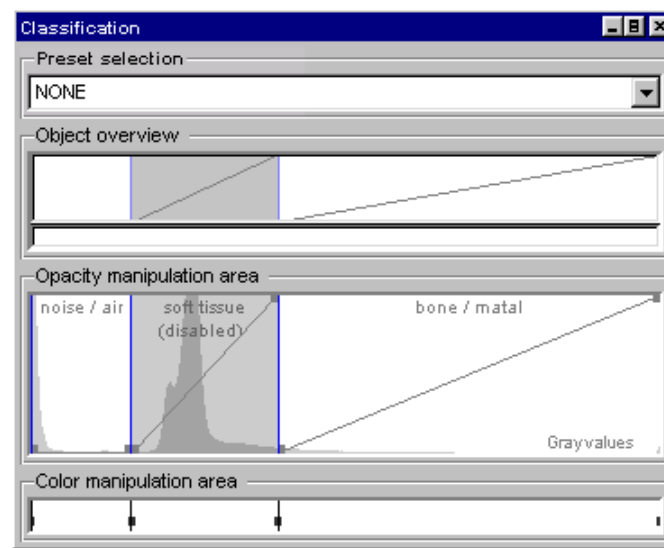


Fig. 124 The soft tissue segment will be disabled after the extraction process.

The extracted and disabled segment may be enabled again by using the **Enable segment** option in the context menu of the **Opacity manipulation area**. This allows the VGStudio user to extract a segment several times to apply different clippings or opacities as shown in the following example.

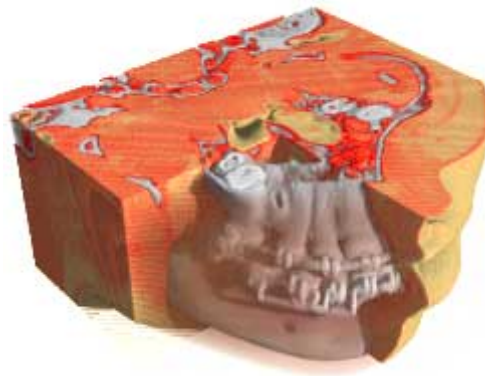


Fig. 125 Different clippings or opacities may be applied to an object.

Data extracted from an object may be saved to disk as a separate data file. If data from an extracted segment is saved with the **Export raw** option of the **File** menu, only the grayvalue range of the extracted segment will be saved. All other voxels with grayvalues below the data range of the extracted segment will be mapped to the minimum value of the appropriate data representation, all values above the data range will be mapped to the maximum value of the appropriate data representation.

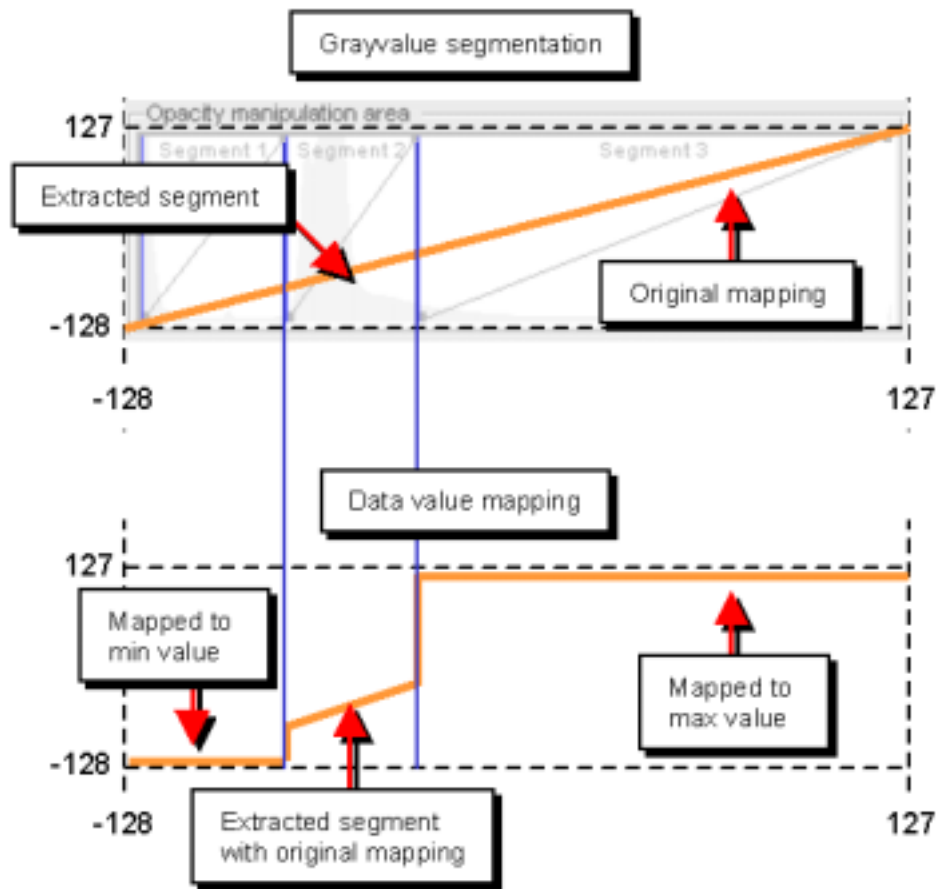


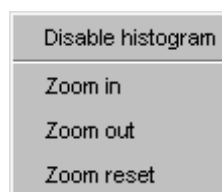
Fig. 126 After the extraction process, only the grayvalues within the extracted segments will remain.

In the example shown here a segment was extracted out of a signed 8 bit integer data set (data range -128 to 127). The voxels with grayvalues below the extracted segments data range will be mapped to -128 while the voxels with values above the extracted segments data range will be mapped to 127 . Only the grayvalues within the extracted segments data range will remain.

In most cases, the size of the bounding box of an extracted object will differ from the size of the original object. The new bounding box will be cropped so that the extracted object will fit exactly into the bounding box.

In the following you will find a description of the remaining context menu entries of the **Opacity manipulation area**.

- **Histogram**—Select this command to open the histogram menu.



- **Disable histogram**—Select this command to disable the histogram within the **Opacity manipulation area**.
- **Zoom in**—Select this command to zoom in the histogram within the **Opacity manipulation area**.
- **Zoom out**—Select this command to zoom out the histogram within the **Opacity manipulation area**.
- **Zoom reset**—Select this command to reset the zoom factor of the histogram within the **Opacity manipulation area** to its default value.
- **Change to Level/Window mode** —Select this command to switch the classification tool into Level/Window mode.
- **Save/Delete preset** —Select this command to save or delete Window-Level/Opacity and color presets from the Preset selection list. See *Preset selection within this chapter*.

Level-Window area (*Level/Window mode*)

The user may apply a value for Center (also known as Level value) and Width (also known as Window value) of a ramp in Level-Window mode. To adjust the values, simply type in the appropriate values or use the up and down arrows to either increase or reduce the Center or Width value. The resulting opacity ramp can be seen immediately in the Opacity manipulation area.

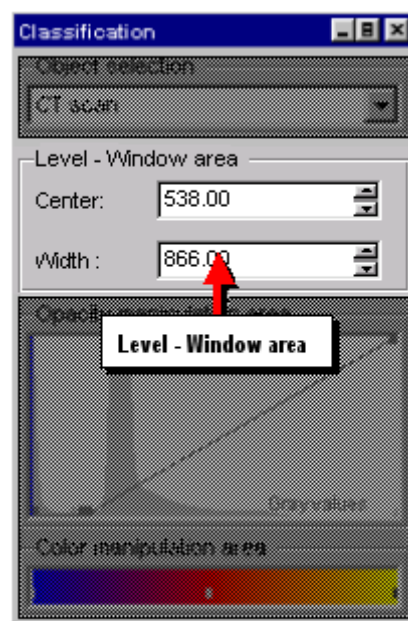


Fig. 127 The Opacity manipulation area.

Opacity manipulation area (Level/Window mode)

The opacity manipulation area can be used as a convenient tool to adjust the Level and Window values. Left-click into the opacity manipulation area and keep the left mouse button pressed

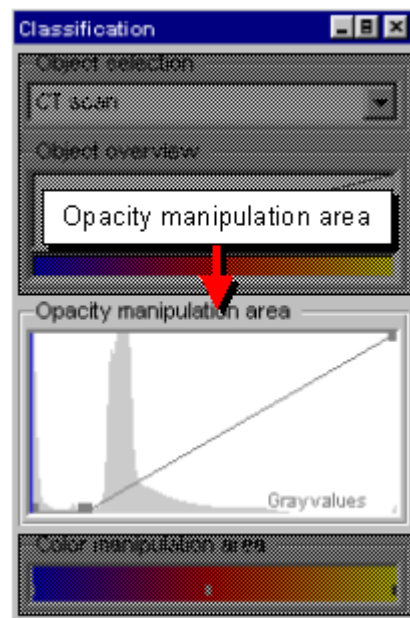


Fig. 128 The Opacity manipulation area.

while moving the cursor up and down will change the Center value while moving the cursor in the left and right direction will change the Width value.

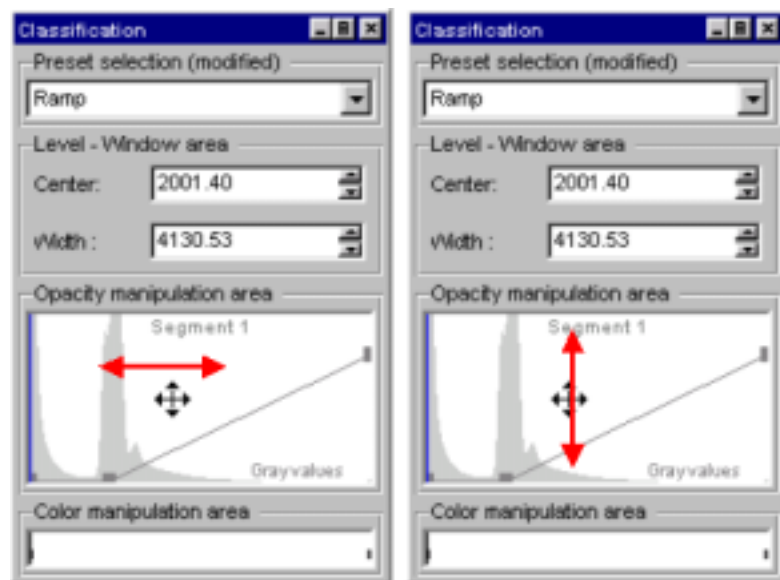


Fig. 129 Moving the cursor horizontal changes the Width value while moving the cursor vertical changes the Center value .

Color manipulation area

The **Color manipulation area** is used to apply and modify the color mapping of an object. The default color of a voxel object is white.

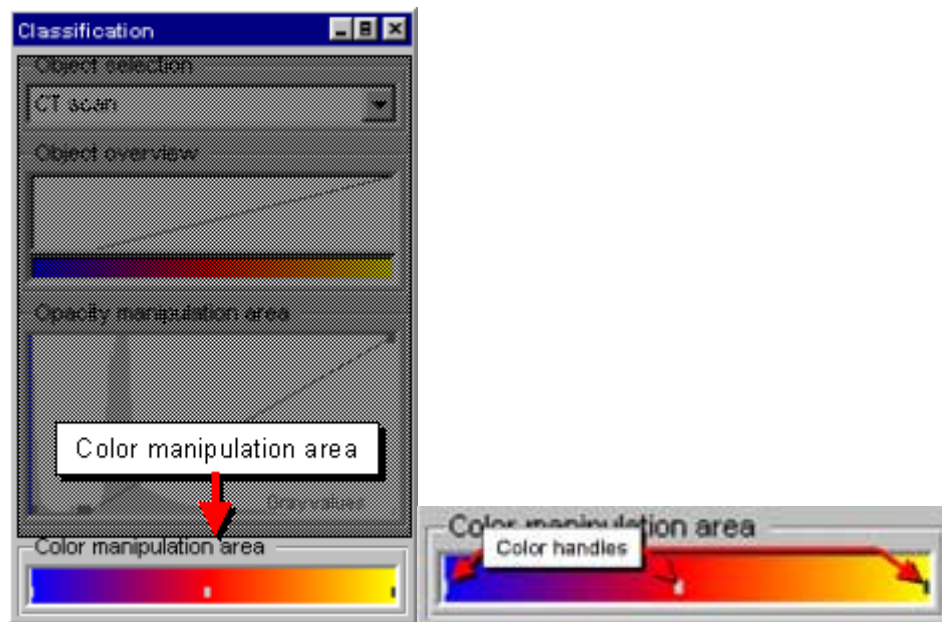


Fig. 130 The Color manipulation area of the Classification tool.



Reminder: No color mapping will be possible for RGBA color data.

A color may be applied to a color handle, an interval between two handles, or a whole segment. The appropriate element will be marked in the **Color manipulation area**.

To apply a color to a handle, interval, or segment double click the appropriate element with the left mouse button or open the context menu by clicking the element with the right mouse button.

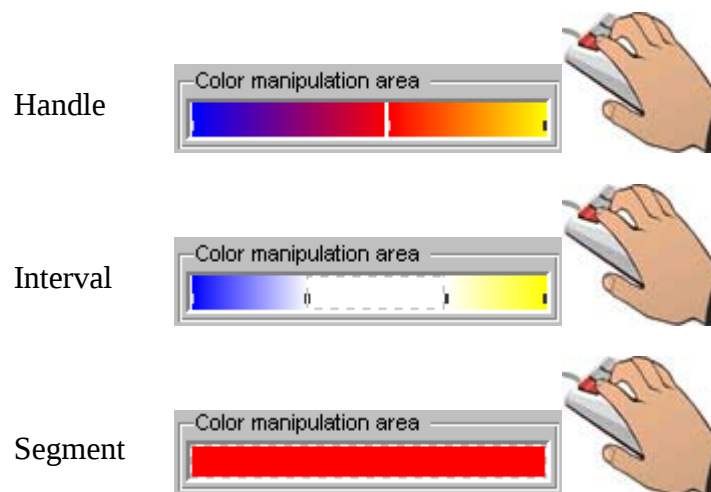


Fig. 131 Different colors may be applied to handles, intervals, and segments.

The two handles at an interval or segment border will receive the identical color when applying a color to an interval or a segment. Colors between two handles will be interpolated. This allows the VGStudio user to easily define color transitions. To create a sharp color transition either create grayvalue segments or insert two color handles with the appropriate color and place the handles directly side by side.

A single color handle or an interval not adjoined to a segment border may be moved. The mouse cursor will change to a two sided arrow as soon as your cursor is placed on a movable element of the color mapping area. Click a single color handle with the left mouse button or click into the appropriate interval and drag the mouse to the left or right to move the color mapping. The gray-values of the appropriate color handles will be displayed while moving the color handles or intervals.



Fig. 132 Color handles or intervals that are not adjoined to a segment border may be moved by clicking them and then dragging the mouse while the left mouse button is pressed.

The color mapping will be shifted during the creation process of new grayvalue segments. Color mapping will only be applied to a segment. Color mappings will not be interpolated across segment borders. You may apply a color to each color handle on both sides of a segment border.

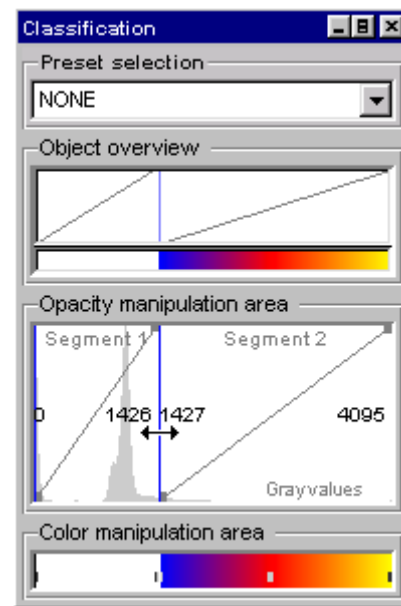


Fig. 133 A color is applied to segment 2.

VGStudio allows the user to insert the maximum number of one color handle per grayvalue. This provides a maximum degree of freedom by applying an arbitrary color mapping.

Press the right mouse button within the color manipulation area to open the context menu. Features such as **Copy**, **Paste segment color**, **Set segment color**, **Set interval color**, or **Set handle color** may be disabled; this depends on the position you click with the right mouse button within the **Color manipulation area**.



Fig. 134 The context menu of the Color manipulation area.

- **Insert handle**—Select this command to generate a new color handle in the **Color manipulation area**.
- **Delete handle**—Select this command to remove a color handle in the **Color manipulation area**.

- **Set handle color**—Select this command to apply a color to a single color handle in the **Color manipulation area**. Use the following menu to choose a color or to open the color selection tool to define a custom color.



Fig. 135 Select a color for handles, intervals, and segments.

- **Set interval color**—Select this command to apply a color to an interval between two color handles in the **Color manipulation area**.
- **Set segment color**—Select this command to apply a color to a whole segment in the **Color manipulation area**.
- **Copy segment color**—Select this command to copy the current segment's color mapping to the clipboard. Use **Paste segment color** to apply the copied color mapping to another object or segment.
- **Paste segment color**—Select this command to apply a previously copied segment color mapping to the currently selected object or segment.
- **Import segment color**—Select this command to import a previously saved segment color map file.
- **Export segment color**—Select this command to save the color mapping of the currently selected segment to a human readable colormap file on your disk.
- **Save/Delete preset** —Select this command to save or delete Window-Level/Opacity and color presets from the Preset selection list. See *Preset selection within this chapter*.
- **Change to Level/Window mode** —Select this command to switch the classification tool into Level/Window mode.

4.6.2 Scene Tree

The **Scene tree** shows all objects included in the scene. It also shows the object type and the hierarchical organization of objects in groups of objects. The **Scene tree** may be used to select one or several objects in the scene. Select a single object in the scene tree by clicking it with the left mouse button. Use the **Shift** or **Ctrl** modifier to select several objects. Keep the **Ctrl** key pressed

and select several objects in the **Scene tree** by clicking the objects with the left mouse button. Keep the **Shift** key pressed and click a second object in the scene tree, e.g. the last object in the row. All objects in between the two selected objects will then also be selected.

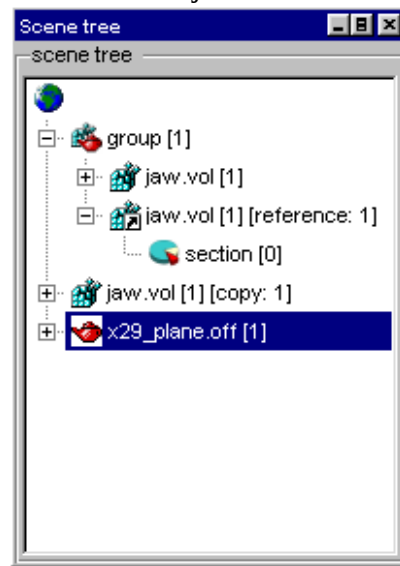


Fig. 136 The Scene tree shows all objects that are included in the scene.

The following symbols are used in the **Scene tree** tool:

Object type	Enabled	Disabled
Scene Object		
Voxel objects		
Polygon objects		
Reference of a voxel object		
Group of objects		
Section of an Object		

Sections: Each data set in VGStudio's Scene tree contains a single section as default. An object may contain several sections in case that the users loads a data set which was segmented with VGStudio MAX' segmentation capabilities. Each segment will result in an own section in the scene tree. VGStudio is not capable to generate sections however VGStudio is capable to handle data sets prepared by VGStudio MAX.

You may change the name of the object or object group. Simply double click the object with the left mouse button and then type in the new name.

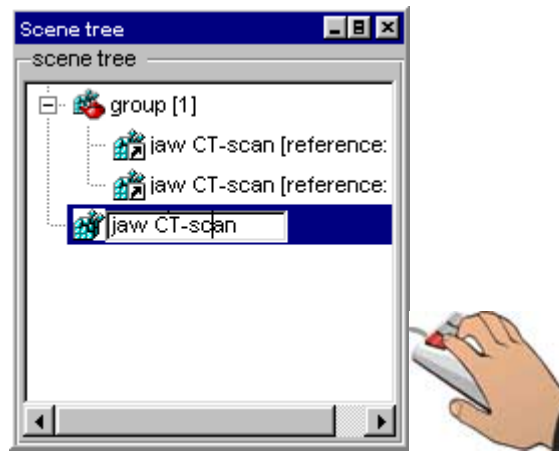


Fig. 137 The name of the object may be changed by double-clicking it and then typing in the new name.

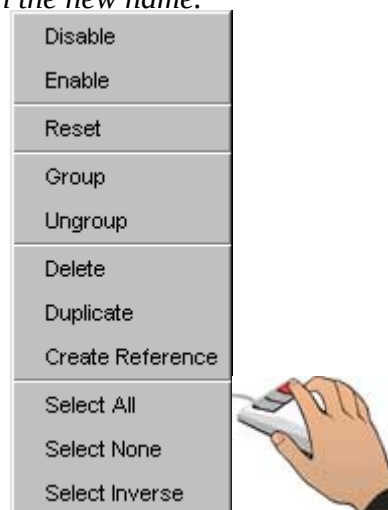


Fig. 138 The context menu of the Scene tree tool.

Click into the **Scene tree** tool with the right mouse button to open the following context menu:

- **Disable**—Select this command to disable an object or object group. A disabled object will no longer be displayed in the scene. No action can be applied to a disabled object. You first have to enable it again. To do so, click the object in the **Scene tree** window with the left mouse button, then click with the right mouse button into the **Scene tree** window to open the context menu and select the **Enable** option. The **Enable** and **Disable** options will toggle in the context menu, i.e. will only be visible one at a time.
- **Enable**—Select this command to enable a previously disabled object or object group. To do so, select a disabled object in the **Scene Tree** window by clicking it with the left mouse button, then click with the right mouse button into the **Scene tree** window to open the context menu and select the **Enable** option. The **Enable** and **Disable** options will toggle in the con-

text menu, i.e. will only be visible one at a time.

- **Reset** —Select this command to reset actions of all categories applied to the selected object such as translation, rotation, clipping, and scaling to the default values. Reset single categories of actions in the **Object properties** tool . See also *Chapter 4.6.7 Object Properties*.
- **Group** —Select this command to combine the current selection of objects or groups to a single group. A group of objects can be handled like a single object. The **Group** command remains disabled until more than one object is selected. Several objects can be selected by dragging a frame over the objects in the 3D view window, by clicking the objects with the left mouse button while the **Ctrl** key is pressed or by clicking the object's name with the left mouse button while the **Ctrl** key or **Shift** key is pressed in the scene tree tool. The bounding box of each selected object will be visible when several objects have been selected. After grouping the objects, a single bounding box around all the selected objects will be visible. You may also use the keyboard shortcut **Ctrl+G** to group objects. See also *Chapter 4.6.7 Object Properties*.
- **Ungroup** —Select this command to ungroup an object group previously created with the **Group** command. The **Ungroup** command remains disabled until an object group is selected. You may also use the keyboard shortcut **Ctrl+U** to ungroup objects. See also *Chapter 4.6.7 Object Properties*.



Reminder: The clipping of an object group will be reset as soon as you ungroup the object group.

- **Delete**—Select this command to delete any selected object in the scene. Note that you can undo a deletion process by selecting the **Undo** command defined earlier. Remember that you have to select the **Undo** command immediately after having deleted the object. You may also use the **Del** key to delete an object.
- **Duplicate**— The **Duplicate** option is the fastest possibility to generate and use a copy of an object. You may also use the keyboard shortcut **Ctrl+D** to duplicate objects. In contrast to the **Copy** and **Paste** command the **Duplicate** command does not use the clipboard. The copied object will be placed directly into the scene where it can be used immediately. When duplicating an object, VGStudio places the object directly above the original object. The relative position will be used as default offset. If the new object is moved, its offset to the original object is used as offset for every new duplication process. This procedure is called smart duplicate.



Reminder: The offset adjusted during a smart duplicate will be set to its default value (zero) as soon as the duplicated object is deselected or another object is selected.

- **Create Reference** — Select this command to create a reference of an object. A reference is a copy of an object which uses the same classification tool settings (color and opacity settings) as the original object. Due to this special property, a reference needs hardly any additional system memory. Therefore, a reference is a memory-saving possibility to copy objects. You may also use the keyboard shortcut **Ctrl+R** to create a reference. In the **Scene tree** tool, a small arrow will appear in the symbol displayed on the left-hand side of the scene name  and after the scene name, the text **[reference: #]** will appear. Applying the **Create Reference** command to a polygon object will result in a “normal” copy of the object. Creating a reference includes a smart placement functionality. An example: select an object and click **Create Reference** in the context menu or press **Ctrl+R**. The new referenced object will appear as the currently selected object. Move the reference to a new position in the scene. Select **Create Reference** in the context menu or press **Ctrl+R** once again. The second referenced object will appear in the same relative position as in the first reference.



Reminder: The new offsets of the smart create reference procedure will be reset to its default values as soon as you deselect the object.

- **Select All**—Select this command to select all objects in the scene. You may also use the keyboard shortcut **Ctrl+A** to select all objects.
- **Deselect**—Select this command to deselect all selected objects in the scene. You may also use the keyboard shortcut **Alt+D** to deselect all objects.
- **Select Inverse**—Select this command to invert the active objects in the scene. You may also use the keyboard shortcut **Alt+I** to generate an inverse selection.

4.6.3 Render Properties

The **Render properties** tools allows you to control the rendering-relevant settings of VGStudio 1.1. The rendering algorithm may be selected as well as the resolution of the resulting image and the image rendering quality.

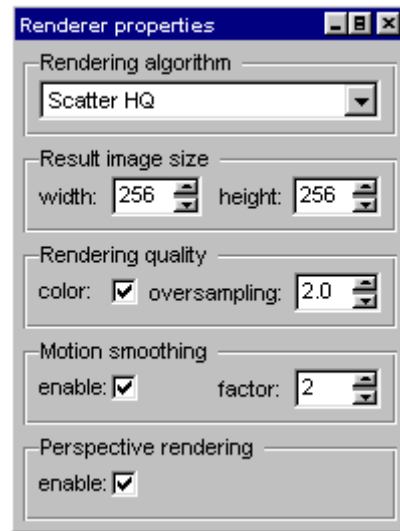


Fig. 139 The Render properties dialog.

Rendering algorithms

In VGStudio 1.1 you may choose between six different rendering algorithms. Use the **Rendering algorithm** section to select one of the following algorithms:

- Scatter
- Scatter HQ
- Scatter + gradients
- Maximum projection (MIP)
- Sum along ray
- X-ray

The following examples show one image in the six different rendering algorithms.

Examples:

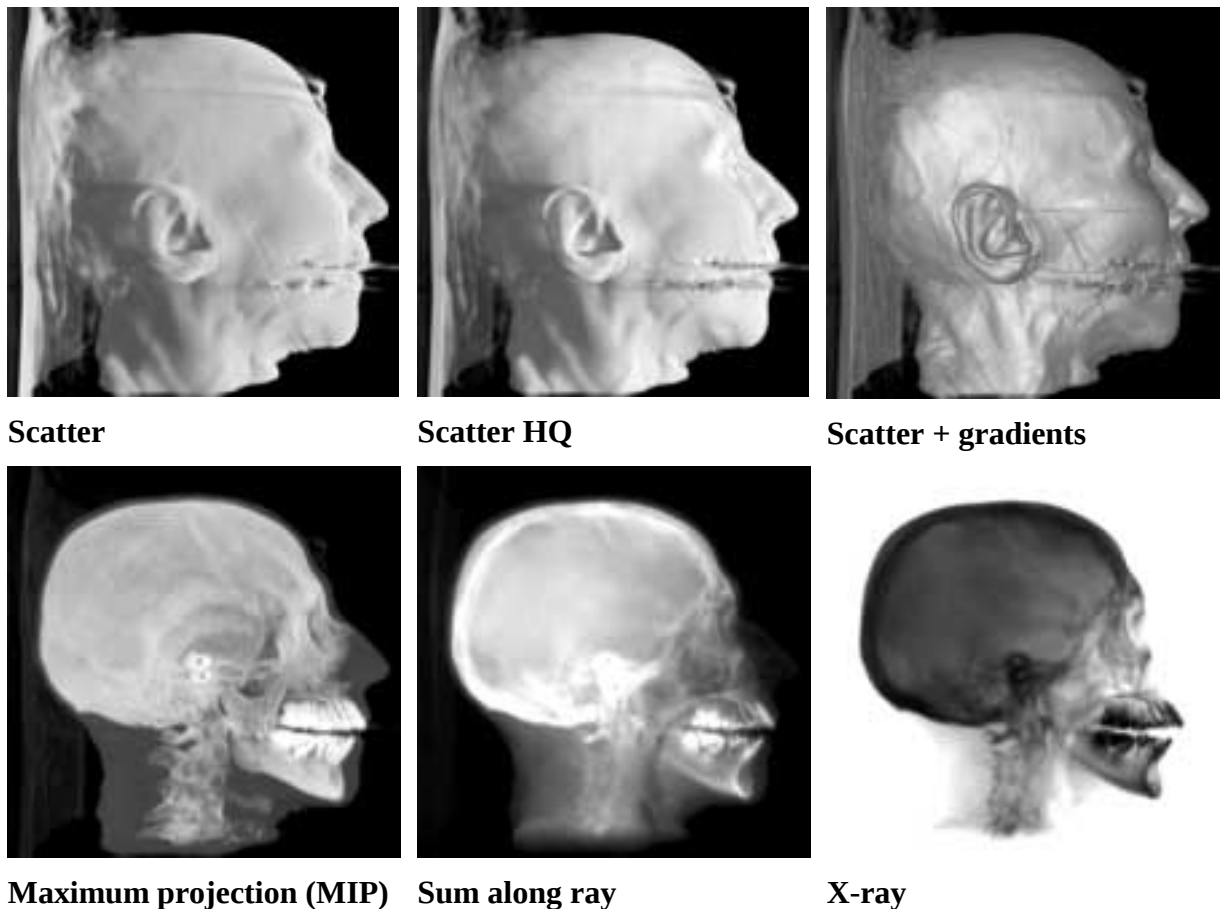


Fig. 140 One image is shown in the six rendering algorithms available in VGStudio.



Reminder: In most cases, the opacity settings have to be adjusted in the **Classification** tool to achieve optimal results with Maximum Projection (MIP), Sum along ray, or X-ray algorithms, e.g. reduce the opacity and at the same time increase the illumination intensity to achieve best results when working with the X-ray algorithm.

Result image size

Use the **Result image size** in the **Render properties** dialog to set the size in which the image should be rendered by VGStudio. In addition, the image on the screen may be enlarged or reduced by applying a zoom factor to the **3D View** window. Set the image size by simply typing in the desired values or by using the up and down arrows to either enlarge or reduce the width or height of the image.

Rendering quality

Images may be rendered in true color or in monochrome. Rendering in monochrome will increase the rendering speed by a factor of two.

Oversampling allows to adjust the resampling step width during the rendering process. Higher values normally lead to higher image quality. Images may appear darker with higher oversampling factors due to higher light absorption during the rendering process.

To adjust the values, simply type in the appropriate values or use the up and down arrows to either increase or reduce the oversampling value.

Motion smoothing

Motion smoothing allows to apply and adjust a reduction factor by which the image size is reduced in x- and y- direction while manipulating a scene. Higher reduction factors will lead to more smooth interaction. This is a helpful function especially on computers with a lower performance. Type in the appropriate value or use the arrows or the scroll function to enlarge or reduce the motion smoothing value.

Perspective rendering

This switch allows to disable/enable perspective rendering.

4.6.4 Light Properties

VGStudio supports the illumination of the scene by two light sources with parallel light. You may adjust the light settings in the **Light properties** dialog.

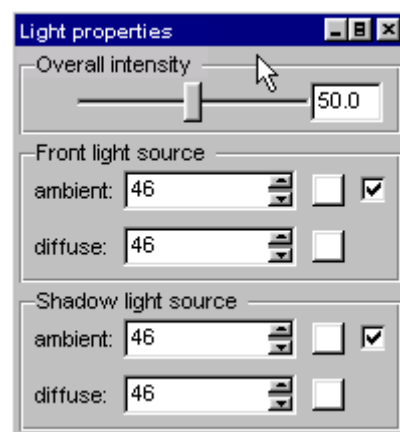


Fig. 141 The Light properties dialog.

The **Overall intensity** determines the total brightness of the scene's illumination. To adjust this value, simply drag the slider to the left or the right or type in the desired value and press **Enter**.

The **Front light source** is positioned in 0° , i.e. in the eye of the observer, the **Shadow light source** is positioned in 45° , to the right of the observer. The light sources are located at fixed positions relative to the observer.

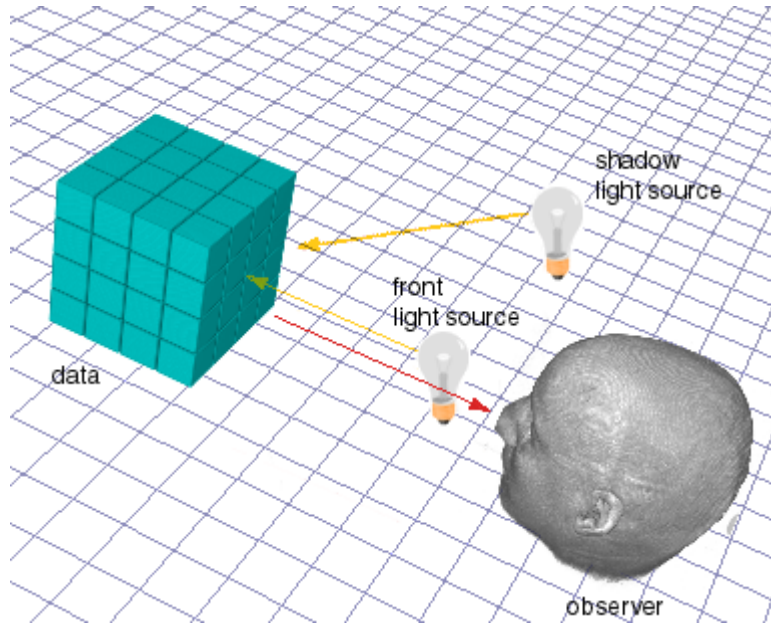


Fig. 142 The front light source and the shadow light source are located at fixed positions relative to the observer.

The two light sources **Front light** and **Shadow light** consist of two parts each, i.e. an **Ambient** part and a **Diffuse** part. Each part's intensity can be adjusted independently by typing in the desired values or using the up and down arrows.

Deactivating the shadow light source will result in an increased rendering speed (when working with the **Scatter** or **Scatter HQ** algorithms, the speed will be increased by a factor of two).

Click the white push buttons to apply a color to the appropriate light source.

Use the checkbox on the right-hand side to enable or disable the light sources.

4.6.5 Stereo Properties

VGStudio supports several stereo image rendering modes.

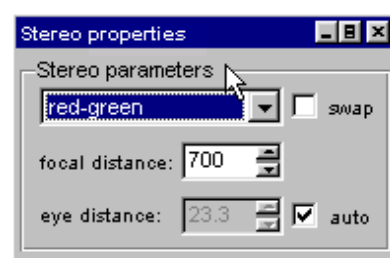


Fig. 143 The Stereo properties dialog.

Select one of the following rendering modes in the **Stereo parameters** listbox:

- **Red-green** (red on right eye)
- **Red-blue** (red on right eye)
- **Interlaced v**(ertical) (e.g. for autostereoscopic 3D displays)

VGStudio 1.1 supports the D4D display. The D4D is a flat autostereoscopic 3D display, the new type of computer output device for true 3D visual representation of data or other three-dimensional information. Information on the D4D can be found on <http://kastor.inf.tu-dresden.de/D4D/>

- **Interlaced h**(orizontal) (e.g. for HMD devices)

Select a stereo mode in the listbox to activate stereo rendering. Use the **Swap** checkbox to swap between left and right images. By changing the **Focal distance** and **Eye distance** values you may adjust the stereo projection parameters. Simply type in the appropriate value or use the up and down arrows to increase or reduce the values.

If the **Auto** checkbox is activated, a default relation of 30:1 between focal distance and eye distance will be applied.

While a stereo mode is activated images will be saved as stereo images when the **Save Image** option in the **File** menu is selected.

4.6.6 Polygon Properties

Select a polygon object in the scene and use the **Polygon properties** tool to adjust the polygon rendering mode for the selected object.

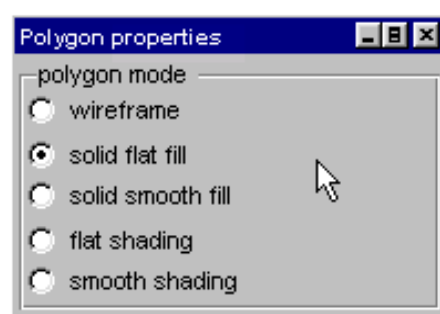


Fig. 144 The Polygon properties dialog.

Choose between a shading mode or wireframe mode. If no polygon object is selected, the **Polygon properties** tool will be disabled.

4.6.7 Object Properties

The **Object properties** tool provides four index cards for the different kinds of actions which may be applied to an object (i.e. translation, rotation, scaling, and clipping).

Each index card allows you to reset the properties to their default values by simply pressing the **Reset** button.

The entered values may be applied by pressing the **Apply** button. The appropriate action will also be applied when moving the mouse cursor away from the **Object properties** tool into the 3D window.

Position/Translation

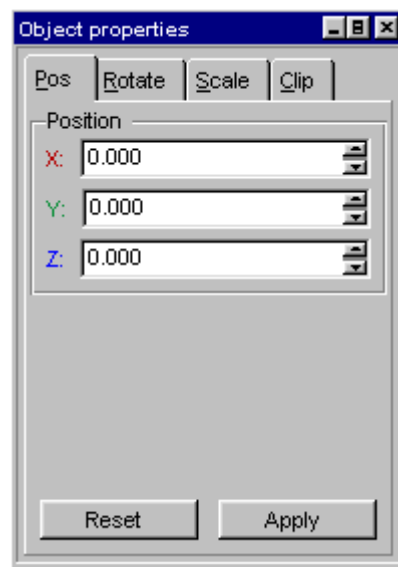


Fig. 145 The Object properties dialog with the index card Position selected.

When the **Pos** index card (i.e. the position/translation index card) is selected, the bounding box of the selected object will be displayed in green, the color of the **Position/Translation** mode.

All positions in the **Position** index card refer to scene coordinates. On the position/translation index card, the current position of an object is displayed in scene coordinates.

The position/translation dialog allows you to type in the exact position values in x, y and z coordinates. You may also use the up and down arrows to increase or reduce the values.

Press the **Reset** button to move the currently selected object back to the scene's origin.

Press the **Apply** button to accept the new values entered in the position dialog.

Rotation

When the **Rotate** index card is selected the bounding box of the selected object will be displayed in red, the color of the **Rotate** mode.

The index card **Rotate** provides the VGStudio user with two different interfaces to rotate the selected object in the scene, i.e. the **Standard** dialog and the **Advanced** dialog. Use the **Standard/Advanced** toggle button to switch between the two modes.

The **Standard** dialog looks like the following image.

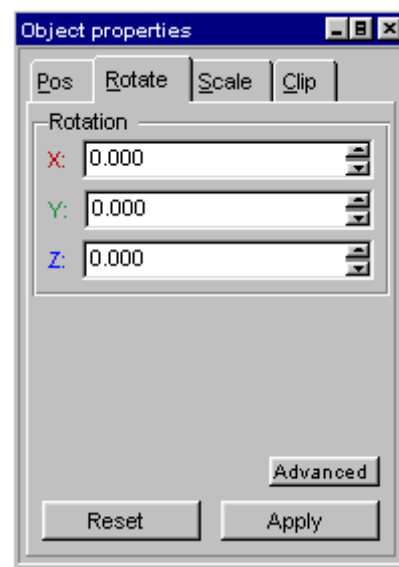


Fig. 146 The Standard dialog of the Rotate index card.

The **Standard** dialog provides you with an interface where you may enter **incremental** rotation values for each axis. Type in the incremental rotation around the x, y, or z axis or use the up and down arrows to increase or reduce the rotation values.

The **Advanced** dialog looks like the following image.

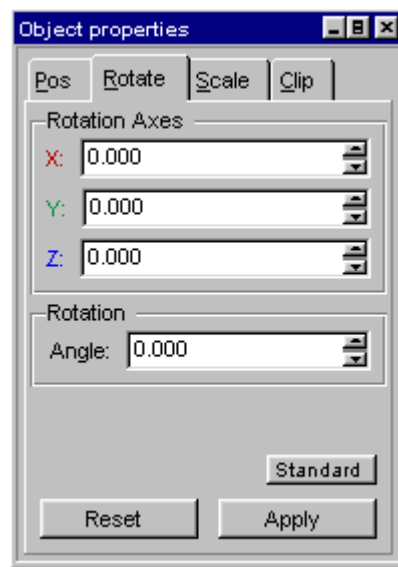


Fig. 147 The Advanced dialog of the Rotate index card.

The **Advanced** dialog provides you with an interface where you may enter **absolute** rotation values for the selected object. The absolute rotation is defined by a normalized vector in the 3D space and a rotation angle around this vector. Non-normalized vectors may also be entered. They will be normalized when the values are applied.

Type in the x, y, or z coordinates to define the vector around which you want to rotate the image or use the up and down arrows to increase or reduce the x, y, or z values.

Type in the absolute rotation angle around the axis defined by the x, y, or z value or use the up and down arrows to increase or reduce the rotation angle.

Press the **Reset** button to reset the orientation of the selected object to its original value.

Press the **Apply** button to activate the new values entered in the rotation dialog.

Scaling

When the **Scale** index card is selected the bounding box of the selected object will be displayed in dark blue, the color of the **Scale** mode.

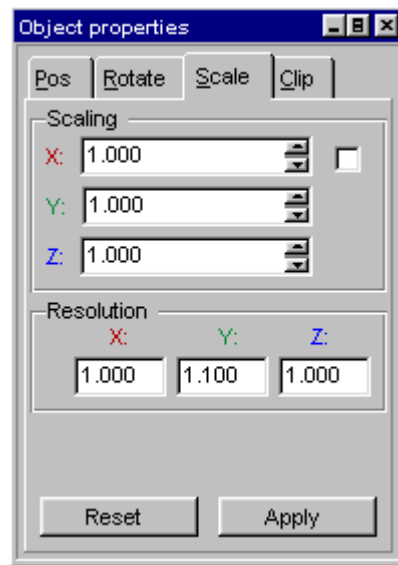


Fig. 148 The Scale index card of the Object properties dialog.

When several objects are selected, the index card **Scale** will be disabled. If you wish to manipulate several objects together, you have to group the objects first. For more information on the grouping and ungrouping of objects, please refer to *Chapter Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden..*

The index card **Scale** provides you with an interface which allows you to type in the scaling factors for the selected object. You may also use the up and down arrows to increase or reduce the values.

Use the checkbox on the right-hand side to lock the three values for isotropic scaling. The three values will then be changed simultaneously and cannot be changed independently of each other.

Use the **Reset** button to set the scaling values to the default values of 1.0.

On the index card **Scale** you may also enter the initial voxel resolution of the selected voxel object. The **Resolution** area will be disabled if an object group is selected.

Press the **Reset** button to reset the scaling of the selected object. The index card **Scale** Reset leaves the resolution settings untouched.

Press the **Apply** button to activate the new scaling values entered in the rotation dialog.



Reminder: You should not scale objects down to factors less than 0.1! Please take into account that scaling and resolution will end up in an effective object scaling. Very low object scaling values will result in reduced image quality. Higher over-sampling values may enhance the image quality again. In scenes that include objects with different scaling values you should scale up all objects so that the smallest ob-

ject will have an effective scaling value of at least 1.0.

Clipping

When the **Clip** index card is selected the bounding box of the selected object will be displayed in cyan, the color of the **Clip** mode.

The index card **Clip** provides the VGStudio user with two different interfaces to clip the selected object in the scene, i.e. the **Clipbox** dialog and the **Clipplane** dialog. Use the **Clipbox/Clipplane** toggle button to switch between the two modes.

All parameters in the **Clipbox** or **Clipplane** dialogs are in object voxel coordinates.

Clipbox — Select this command to box clip the selected object or object group along the axes of its bounding box. The **Clipbox** mode is characterized by the cyan bounding box with squared handles, i.e. active areas on each side of the selected object or group of objects (a small scissors will appear next to the cursor when you place it on one of the handles). The object may be clipped by typing in the position of each of the six clipplanes on the **Clip** index card. Use the two values for each coordinate axis to apply a clipplane to all sides of the selected object. Type in the values for the clipplane position or use the up and down arrows to increase or reduce the clipplane position values. Group the objects first if you want to clip several objects at a time.

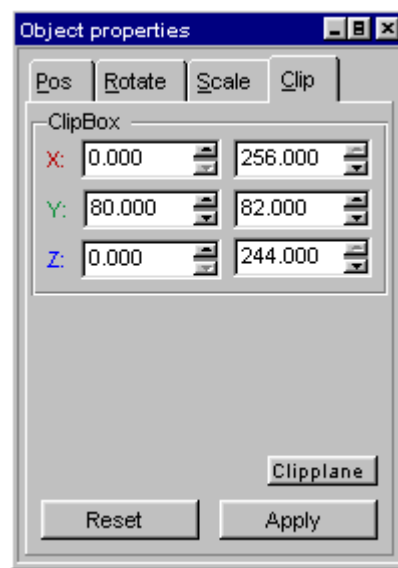


Fig. 149 The Clipbox index card of the Object properties dialog.

Press the **Reset** button to remove the clipping of the selected object. Press the **Apply** button to activate the appropriate parameters.

Clipplane — Select this command to clip the selected object or object group by an arbitrary clipplane. The **Clipplane** mode is characterized by the cyan bounding box with a normal vector on one side of the actual object. The object may be clipped along an arbitrary clipplane by typing

in the values for the arbitrary clipplanes in the **Clipplane** dialog of the **Clip** index card. The clipplane will be disabled if several objects are selected. Group the objects first if you want to clip several objects with one clipplane at a time.

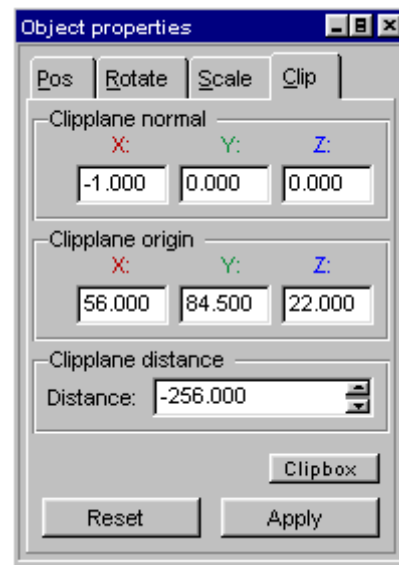


Fig. 150 The Clipplane index card of the Object properties dialog.

The arbitrary clipplane is defined by the **clipplane's normal** vector and the **distance** between the clipplane and the origin of the clipped object. The **clipplane's origin** may be placed to any arbitrary position in order to be able to rotate the clipplane around the specified point.

The clipping of an object group will be reset if the object group is ungrouped.

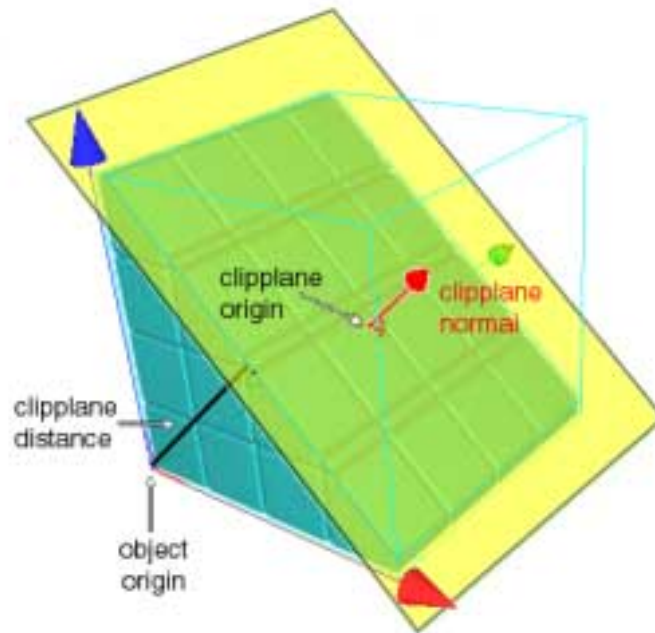


Fig. 151 The clipplane is defined by the clipplane's normal vector and the distance between the clipplane and the origin of the clipped object.

When several objects are selected, the **Clip** index card will be disabled. If you wish to manipulate several objects together, you have to group the objects first. For more information on the grouping and ungrouping of objects, please refer to *Chapter Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden..*

Press the **Reset** button to remove any clipplane from the selected object. Press the **Apply** button to activate the new values.

Center

When the **Center** index card is selected the center of an object or say the origin of the object coordinate system can be applied in voxel coordinates. By default the center of an object is at the position $(X_{max}/2, Y_{max}/2, Z_{max}/2)$ where X_{max} , Y_{max} and Z_{max} describe the objects dimension in voxels..

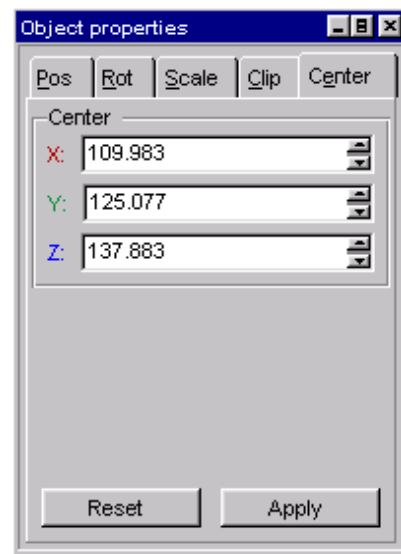


Fig. 152 The Clipplane index card of the Object properties dialog.

4.6.8 World View

The **World view** tool is used to steer your view on the scene. The position, rotation, and the viewing angle may be manipulated. In the **World view** tool an overview of the current scene is displayed in form of the bounding boxes of each object or group of objects.

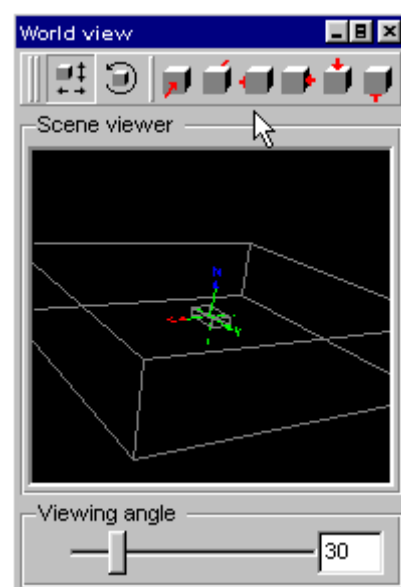


Fig. 153 The World view tool of VGStudio.

You activate the **World view** tool by pressing the **World view** mode button in the icon bar or by clicking **World view mode** in the **Scene** Menu. All changes can be observed in the **3D view** window. Changes in the **World view** tool will not affect the scene itself.

Click the **Move** button to activate the **World view** tool's **Move** mode.



The **Move** mode is characterized by the green color of the scene coordinate system axes in the **World view** tool. The scene may be moved in the image plane by clicking into the **Scene viewer** area with the left mouse button and dragging the mouse while the left mouse button is pressed. The scene may be moved forwards or backwards by clicking into the **Scene viewer** area and dragging the mouse while the middle mouse button (or the **Alt** key and the left mouse button) is pressed.

Using the **Shift** modifier in **Move** mode allows you to move the scene in vertical or horizontal direction.

Click the **Rotation** button to activate the **World view** tool's **Rotate** mode.



The **Rotate** mode is characterized by the red color of the scene coordinate system axes in the **World view** tool. The scene may be rotated around the x-, or y-axes of the image plane in the **Scene viewer** window by clicking into the **Scene viewer** area with the left mouse button and dragging the mouse while the left mouse button is pressed. The scene may be rotated around the viewing direction by clicking into the **Scene viewer** area and moving the mouse while the middle mouse button (or the **Alt** key and the left mouse button) is pressed.

Using the **Shift** modifier in **Rotate** mode allows you to rotate the scene around the vertical or horizontal axes of the image plane.

Click one of the six **Default view** buttons to view the scene either from the front, back, left, right, top, or bottom.



The distance between the observer and the scene's center, which can be adjusted in **Move** mode, will remain unchanged when one of the **Default view** buttons is pressed.

Drag the **Viewing angle** slider to the left or right or type in the desired value to adjust the viewing angle.

By clicking into the **Scene viewer** window with the right mouse button you open the following context menu.

When clicking **Zoom** the following menu will be opened.

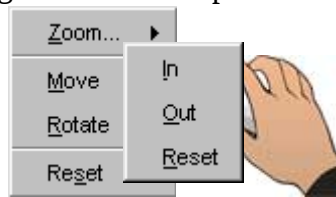


Fig. 154 The context menu of the Scene viewer area.

The **Scene viewer** window may be zoomed in or out. Click **Reset** to reset the zoom factor to its default value.

In the context menu, click **Move** or **Rotate** to access the **Move** or **Rotate** mode.

Select **Reset** to reset the **World view** settings to its default values.

For more detailed information on the **World view** mode, please refer to *Chapter 4.6.8*.

4.6.9 Camera View

While the **Camera mode** is activated you may use the **Camera View** tool to adjust camera-relevant settings. The **Camera View** tool is activated by pressing the **Camera mode** button in the icon bar or by clicking **Camera mode** in the **Scene Menu**.

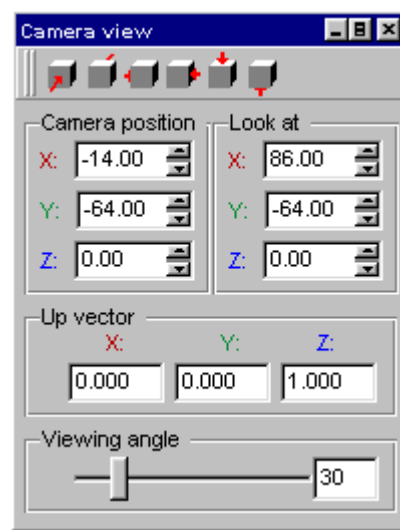


Fig. 155 The Camera view tool of VGStudio.

You may either type in the exact values for the **Camera position** and for the **Look-at** point or use the up and down arrows to increase or reduce the x, y, and z position values.

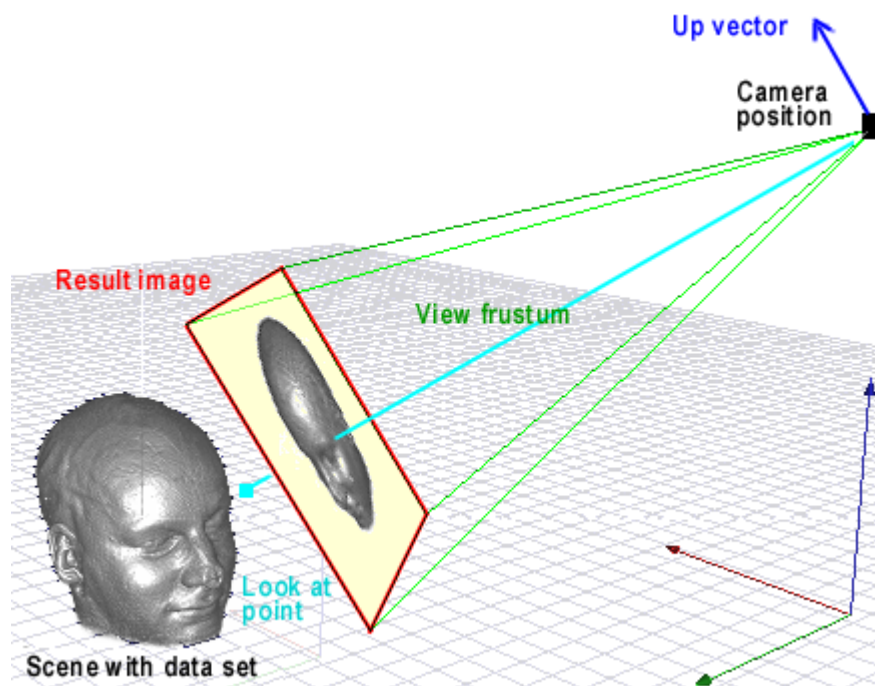


Fig. 156 The Camera view mode allows you to view your data from inside. You may adjust all camera parameters shown here according to your needs.

Use the **Up vector** section to type in the exact value for the up vector relative to scene coordinates.



Reminder: The camera and look-at position are defined in scene coordinates while most other tools work in object coordinates! The color coding in the slice tools may not fit to the color coding of the camera tool in case of an rotated object.

Click one of the six **Default view** buttons to view the scene either from the front, back, left, right, top, or bottom.

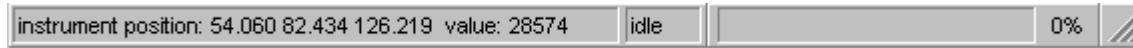


The distance between the observer and the scene's center, which can be adjusted in **Move** mode, will remain unchanged when one of the **Default view** buttons is pressed.

Drag the **Viewing angle** slider to the left or right or type in the desired value to adjust the viewing angle.

For more detailed information on the **Camera view** mode, please refer to *Chapter 4.5.3*.

4.7 Status Bar



The status bar is displayed at the bottom of the main window. In the status bar you will find information on the current process performed in VGStudio and the progress of the different processes as well as the instrument position and the appropriate gray or color values at the instrument's position when the instrument is activated.

5 Importing & Exporting Data

This chapter provides information on the data I/O capabilities of VGStudio. Detailed information on

- importing data and
- exporting data

will be given in this chapter.

5.1 Importing Data

5.1.1 The VGI - Volume Graphics Info - file

VGStudio allows its users to import a wide variety of different data files and data types. The voxel or volume data may be provided as a single data file or as a stack of several image data files.

Stack of Image Slices	
BMP	color and grayscale
TIFF	color and grayscale (8 bit only for grayscale)
JPEG	color and grayscale
PPM	color and grayscale
DICOM	See Appendix
HDF	See Appendix
RAW	signed/unsigned 8 bit integer
RAW	signed/unsigned 16 bit integer
RAW	signed/unsigned 32 bit integer (20 bit effective range)
RAW	32 bit float
RAW	32 bit RGBA
Volumes	
DICOM	
HDF	
Analyze™	
RAW	signed/unsigned 8 bit integer
RAW	signed/unsigned 16 bit integer
RAW	signed/unsigned 32 bit integer (20 bit effective range)
RAW	32 bit float
RAW	32 bit RGBA

Select the **Import** option in the **File** menu and choose the appropriate option to import the different data types and files.

5.1 Importing Data

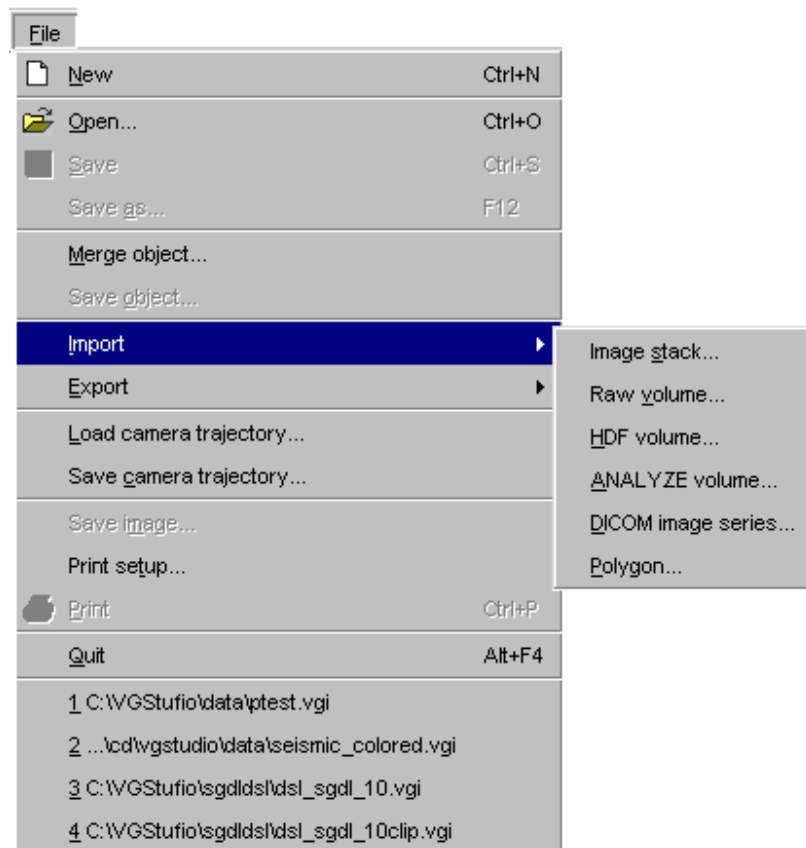


Fig. 157 Select Import in the File menu and choose the appropriate option to import the different data types.

After having imported the data, you may save your scene. Saving a scene with the **Save** or **Save as** option in the **File** menu will generate a Volume Graphics Info file (.vgi extension). The vgi file contains all information needed by VGStudio 1.1 to load data again by using the **Open** command in the **File** menu. You do not have to use the import procedure again. The vgi file contains data-relevant information such as data file names and the path to the data files, data type, file type, file size, and data mapping as well as scene-relevant information such as light settings, rendering algorithm, or background color.

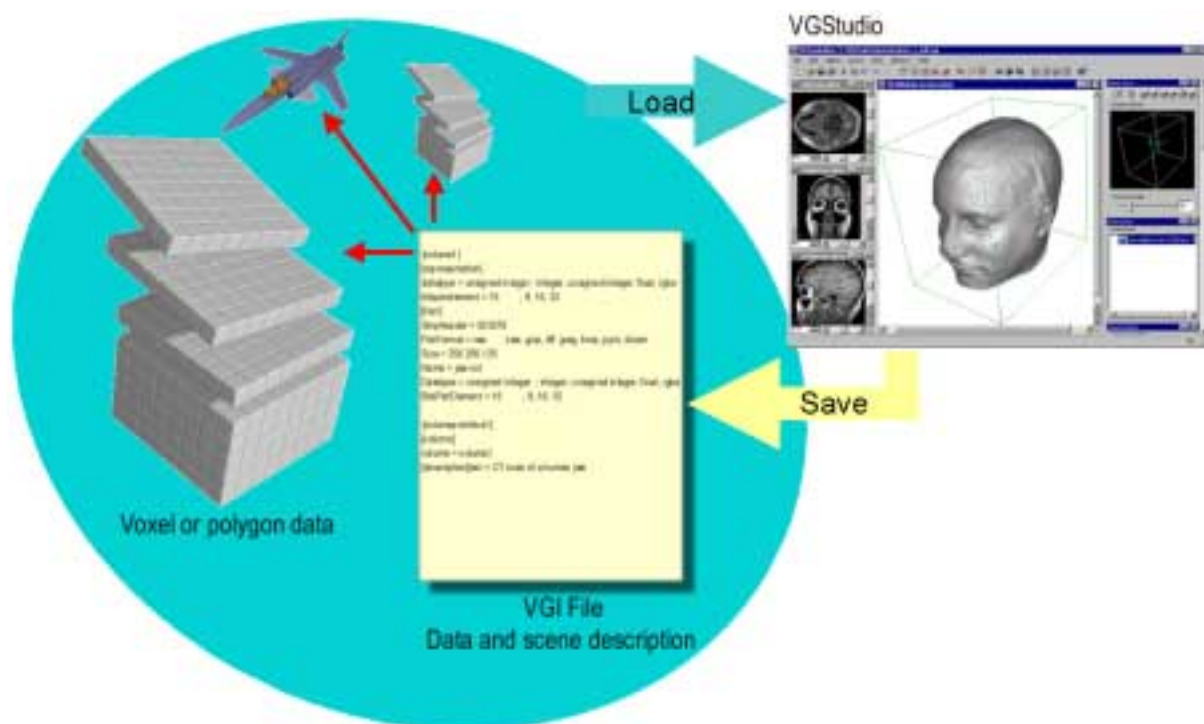


Fig. 158 Import data into VGStudio and then save the scene by using the save or save as command in the File menu to generate a vgi file.

Data saved in VGStudio always consists of two elements, i.e. the data file(s) and the Volume Graphics Info file. A vgi file contains references to all data included in the scene so that a complex scenario can be restored by loading a single vgi file. The concept of VGStudio's data handling is to leave the original data untouched. All information on how data has to be processed during the import will be saved in a vgi file.

Example:

A voxel data set includes 32 bit floating point data but the dynamics of the data is very low so that it will fit into a 8 bit integer (256 grayvalue) representation. During the import procedure, the user may specify that data should be converted into a 8 bit data representation. This will reduce the amount of RAM needed on your PC or workstation by a factor of 4! This conversion will be done automatically while loading the data into VGStudio. The original data set on your hard disk will remain untouched and no second 8 bit data set, which would increase your disk capacity requirements, has to be generated. However, VGStudio allows its users to export the data in the internal data representation chosen by the user (see *Chapter 5.2 Exporting Data*).

If you save your current work to a vgi file all the conversion information will be saved along with all the other scene-specific data. The next time the vgi file is loaded, the conversion will be carried out automatically.

5.1.2 Importing Stacks of Image Slices

To import a stack of images, click **File** in the menu bar and select **Import**. Then click **Image Slices** in the **Import** menu to open the **Image Slices Import Wizard**.

The **Image Slices Import Wizard** will guide you through the whole import process step by step. Click the **Next** or **Previous** buttons to go through the different steps of the import process. The different steps will be explained in the following:

Step 1: File type selection

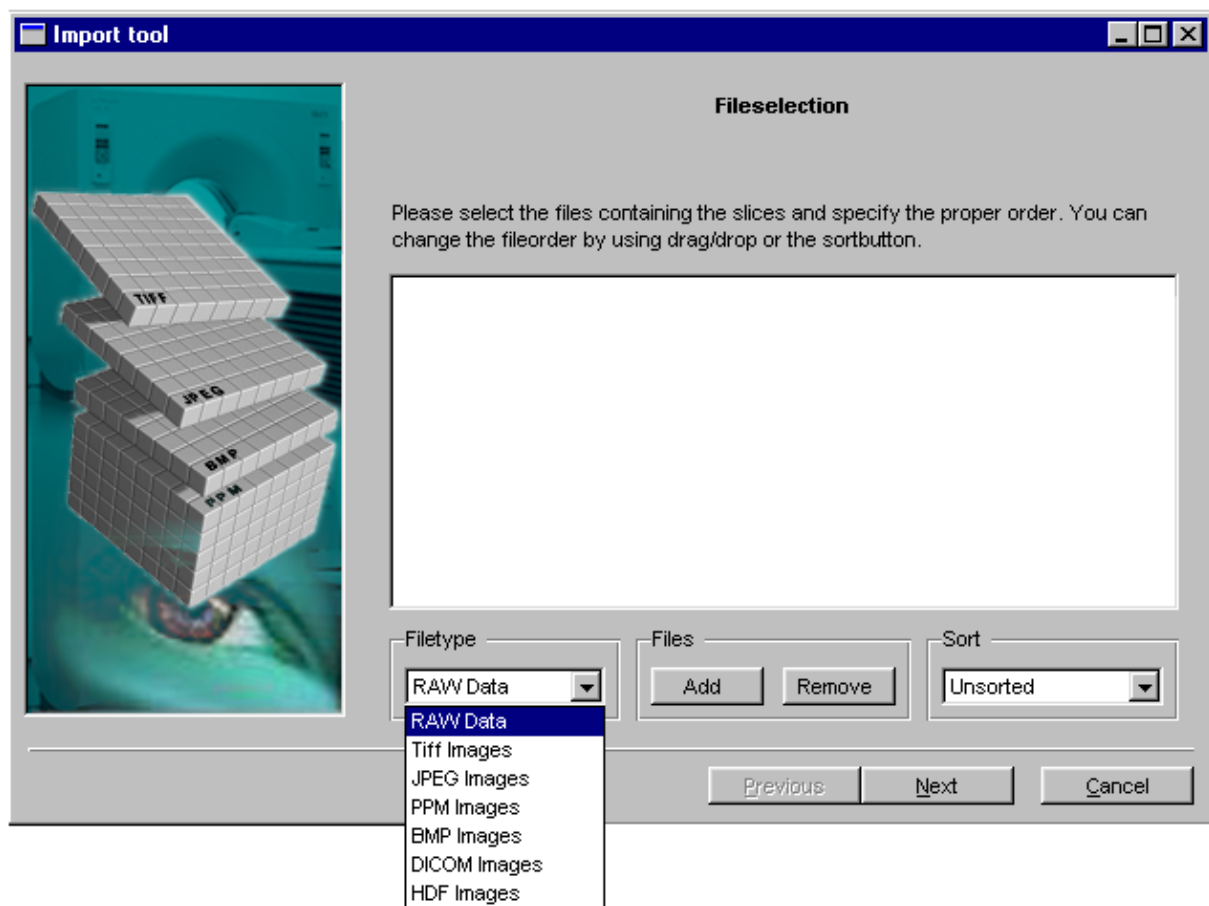


Fig. 159 Select the file type in the Import tool window.

Select the **File type** from the File type list. You may choose between RAW data, TIFF, JPEG, PPM, BMP, DICOM, and HDF images.

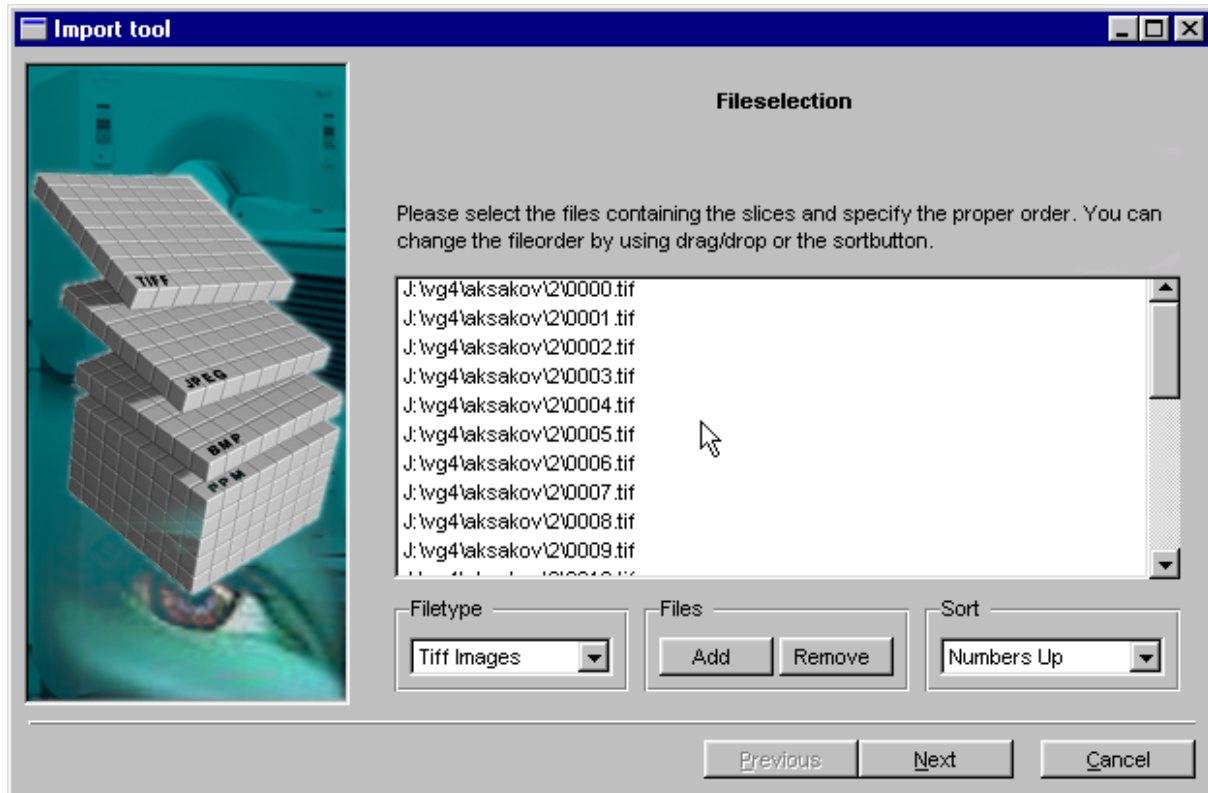
Step 2: File selection

Fig. 160 Select the files you want to import and add them to the list.

Click **Add** to open a file selection dialog. Select one or several files and click **Open**. The list with the selected files will then be displayed in the **Import tool** window. To add more files to the list click again **Add** and repeat the procedure.

To remove files from the list select one or several files and click **Remove**. You may also drag the selected files on the remove button to delete them from the list. The files will only be removed from the list and will not be deleted from the hard disk or other data source.

Step 3: File order

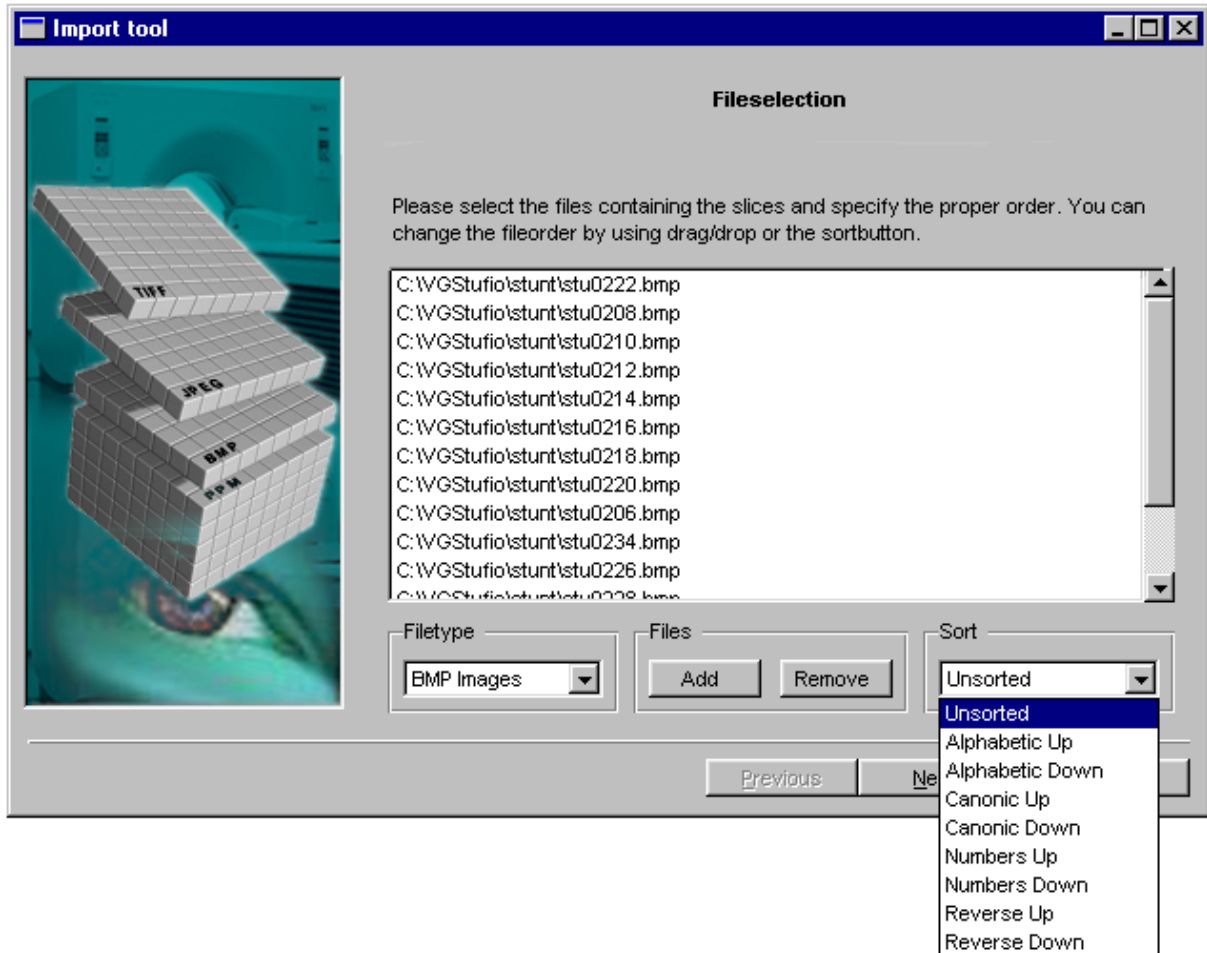


Fig. 161 Sort the files by using the Sort function of the Import tool window.

To sort the files, you may use the **Sort** function of the **Import tool** window; there, you may choose the order in which you wish to sort the files, e.g. alphabetical order. You may also use drag and drop to bring the files into the correct order.

Click **Next** to continue with the import process.

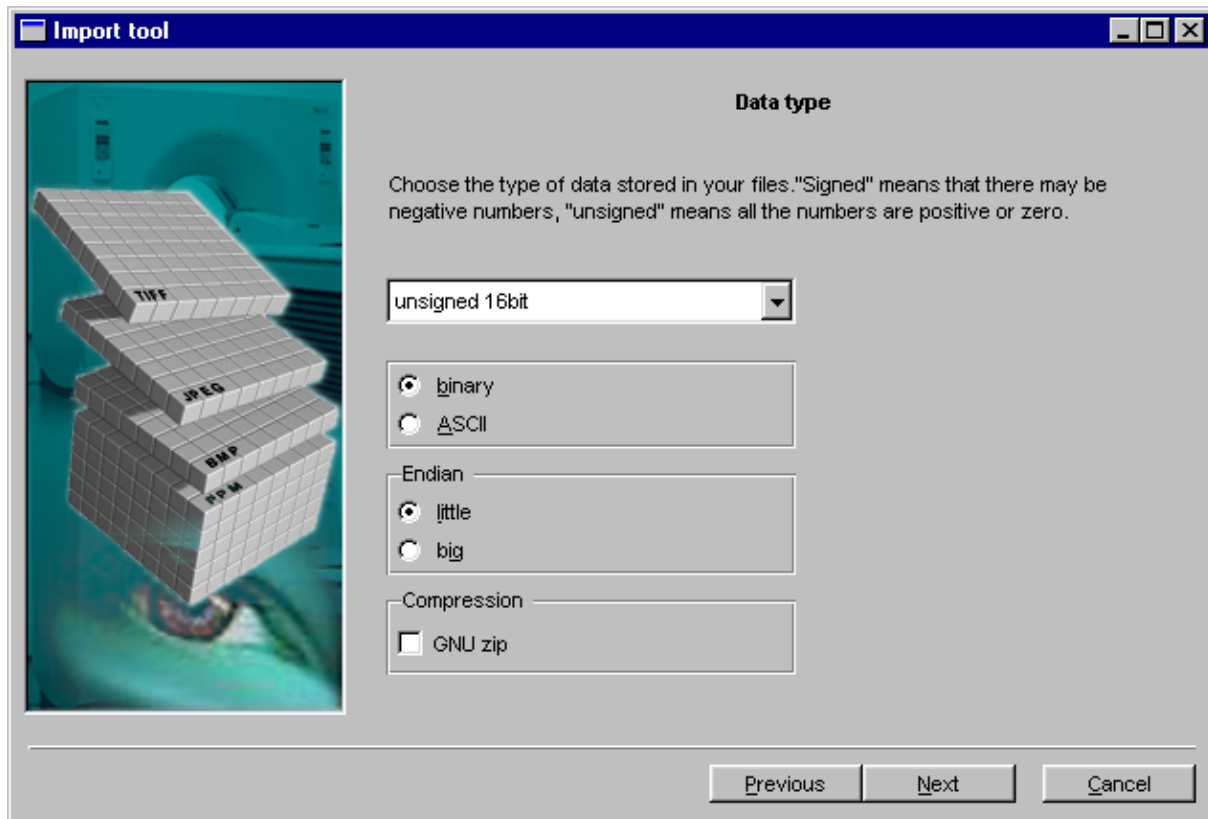
Step 4: Data type selection (for RAW data only)

Fig. 162 Specify the data type for RAW images.

The data type has to be specified if the file type RAW was selected. Select the data type of the chosen file from the pulldown menu. Possible data types are:

- signed or unsigned 8bit, 16bit, or 32bit
- 32bit float
- 32bit RGBA

Decide whether the data is to be stored in binary or in ASCII format and select the byte order.

VGStudio is capable to import GNU zip compressed data files. Mark the GNU zip checkbox to import compressed data.



Reminder: Compression will not work in conjunction with ASCII data.

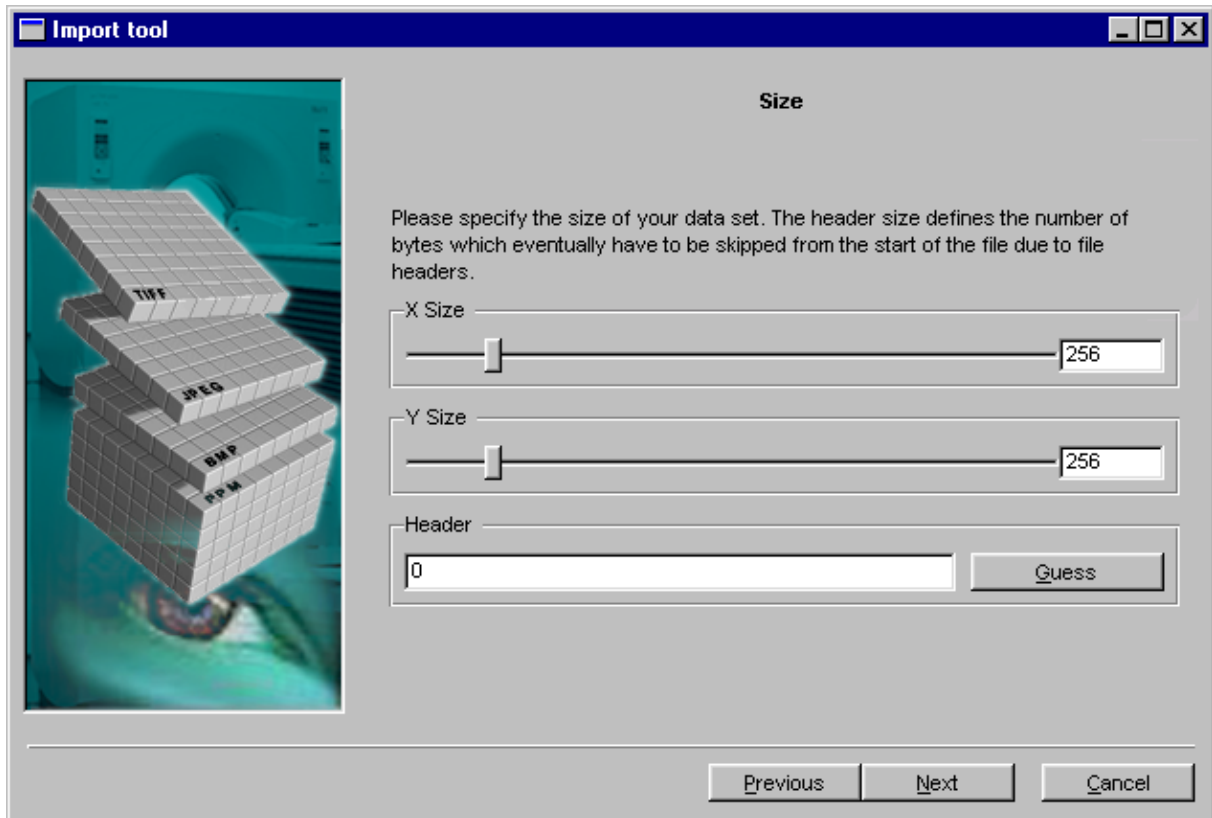
Step 5: Image size selection (for RAW data only)

Fig. 163 Select the image and header size for RAW data by dragging the sliders or typing in the desired values.

The image size and header size in bytes has to be specified if the file type RAW was selected.

Use the sliders or type in the x-, y-, and z-size of the volume data. If the volume data set includes a header enter the header size in bytes. The header has to be located at the beginning of the data file and will be skipped while loading. You can use the **Guess** button after having entered the size to compute the header size automatically.

Step 6: Data type selection (for TIFF, JPEG, BMP, and PPM images only)

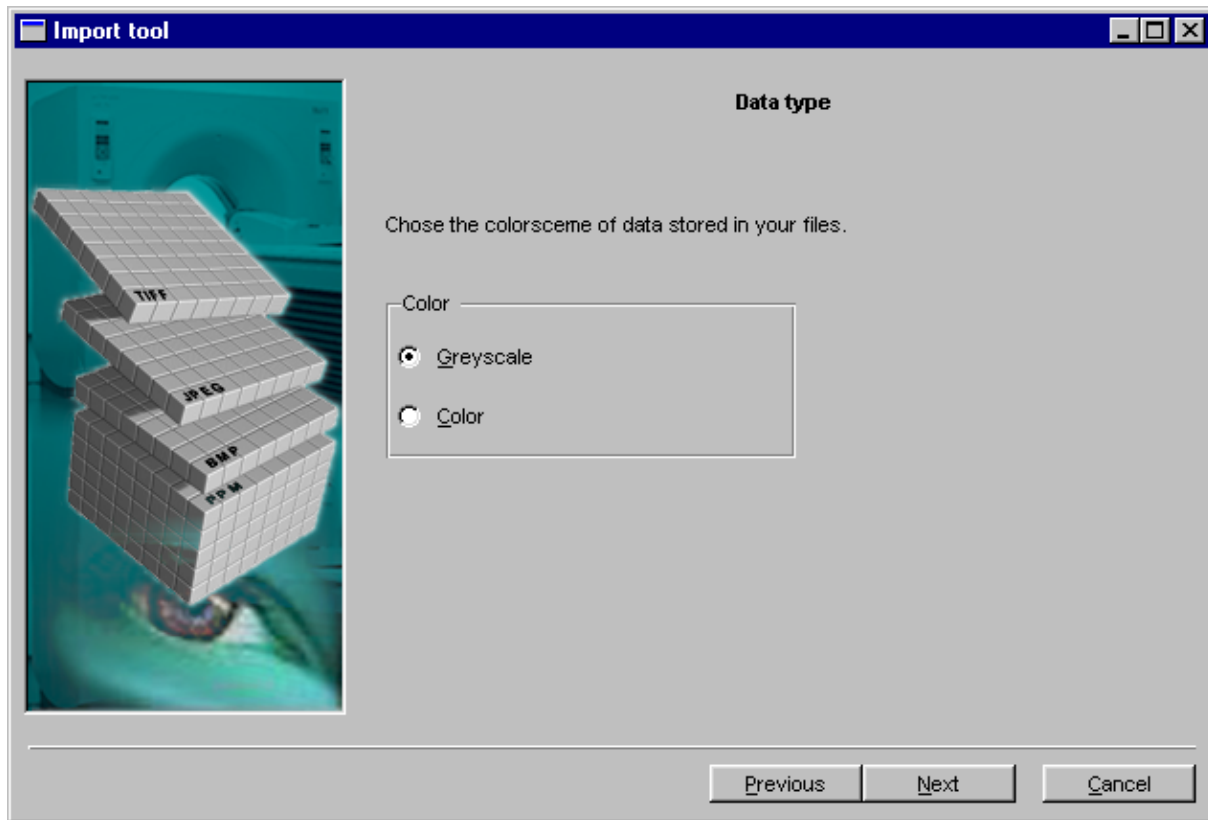


Fig. 164 Select the data type for TIFF, JPEG, BMP, and PPM images.

Image slices may be imported as grayscale or color data.

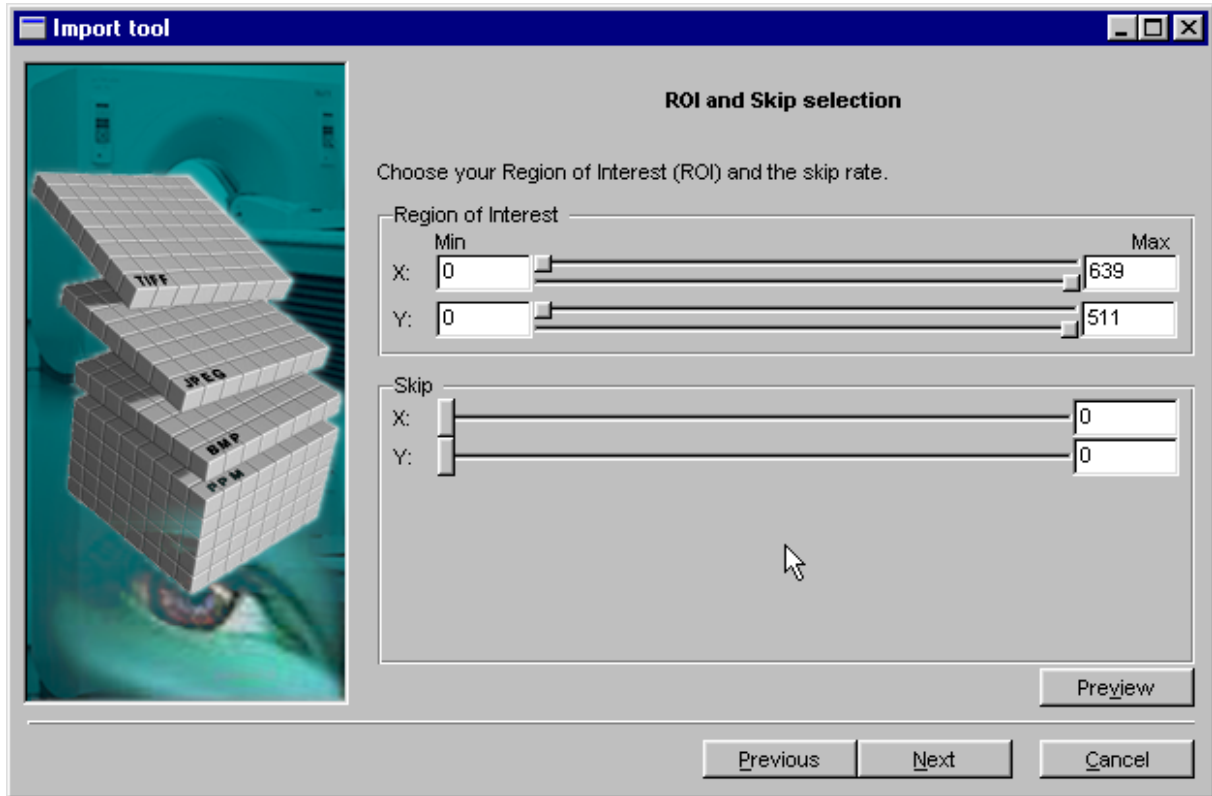
Step 7: ROI and Skip selection

Fig. 165 Define Regions of Interest and choose the skip rate.

Use this dialog of the import wizard to define a region of interest within the imported stack of images or to define the number of voxels to be skipped in each direction of the image planes by dragging the sliders or typing in the desired values. These functions may be of special interest for very large data volumes in order to reduce the amount of data loaded in VGStudio.

Use the four **Region of Interest** sliders to define a sub volume within the data set which should be loaded into VGStudio. Only the x- and y-direction can be manipulated here. To reduce the number of slices in z-direction deselect several of the images to be imported in the file selection dialog (see steps 1 and 2).

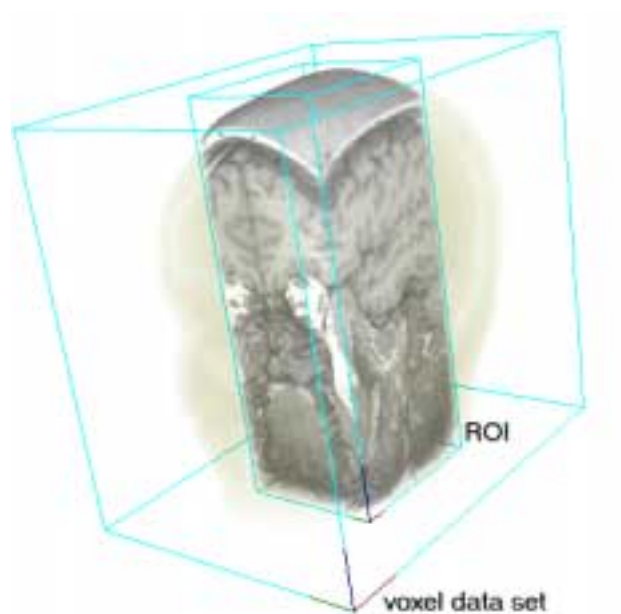


Fig. 166 Define a Region of Interest that is to be loaded into VGStudio.

Use the two **Skip** sliders to specify the number of voxels to be skipped in x- and y-direction. When choosing a value of 1, every second voxel will be skipped in the selected direction. To skip voxels in z-direction remove the appropriate files from the list of selected files (see step 1 and step 2).

The **Preview** function allows you to preview the new settings.

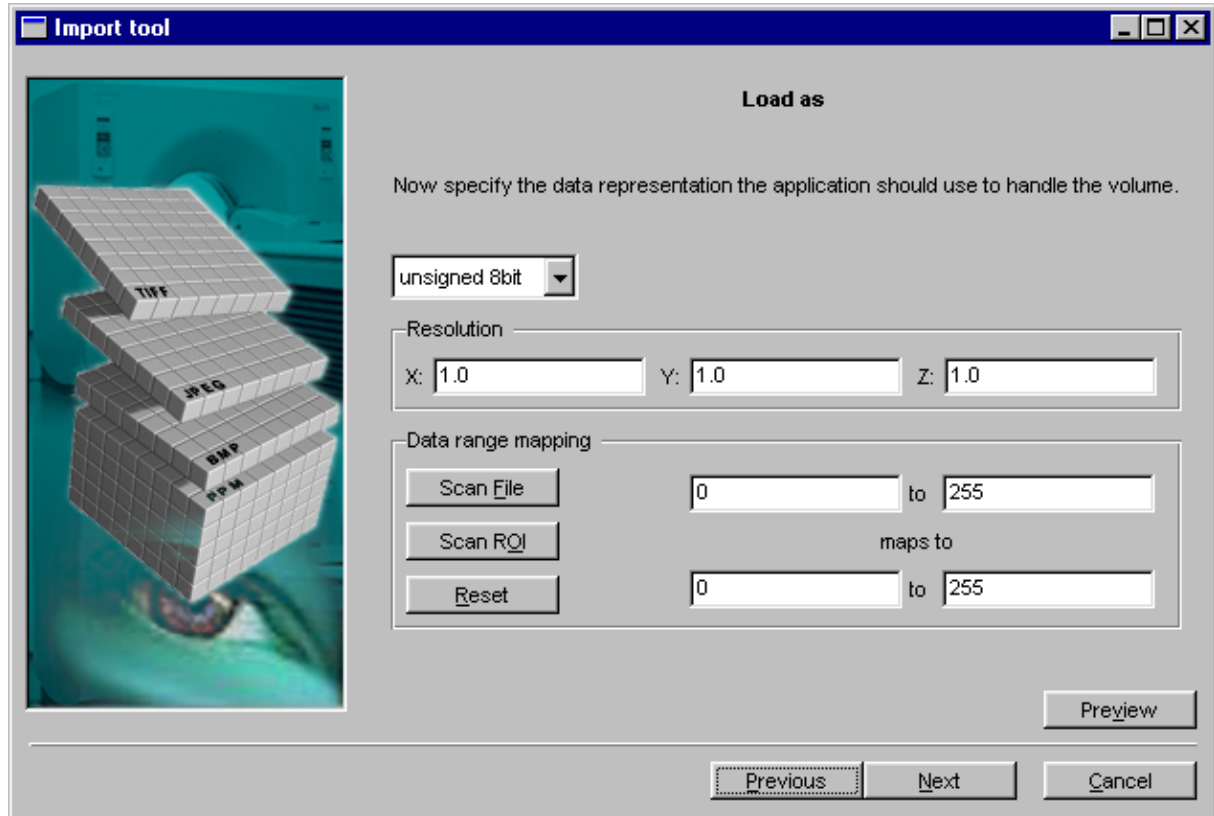
Step 8: Internal data representation

Fig. 167 Specify the data representation.

The data type may be changed while loading data into VGStudio, e.g. a 32 bit floating point data set on your hard disk may be mapped to a 16 bit integer data representation. In this case, this would reduce the amount of memory needed for visualization by a factor of two.

Any data type may be mapped to any other data type. The only exception are RGBA data sets.



Reminder: RGBA data cannot be mapped to any other data representation. Also, monochrome data types may not be mapped to RGBA data.

5. Importing & Exporting Data

unsigned 8bit	may be mapped to	unsigned 8bit
signed 8bit		signed 8bit
unsigned 16bit		unsigned 16bit
signed 16bit		signed 16bit
unsigned 32bit		unsigned 32bit
signed 32bit		signed 32bit
32bit float		32bit float
32bit RGBA	no mapping possible	32bit RGBA

The voxel **Resolution** may be adjusted for data sets with non-isotropic voxel dimensions.

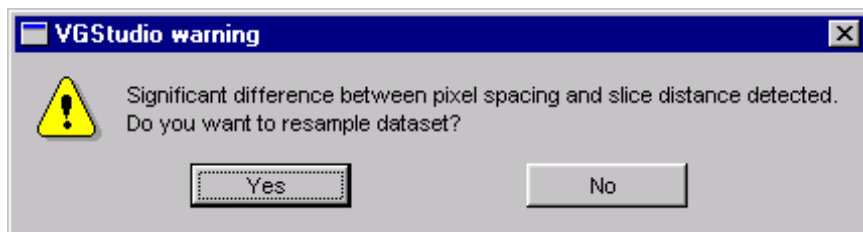


Fig. 168 Resampling warning Pop up.

A Warning dialog may come up in case that you import data series with Significant difference in voxel Resolution. Press **Yes** to resample the data. The software will calculate additional slices by trilinear resampling. This will result in a better 3D image quality. However keep in mind that slice images will be generated out of your original data which are not generated by the scanning device. The resampling will also result in an additional amount of memory needed by the VGStudio application. This process may exceed the available memory installed in your computer depending on your initial image data. Press **No** to skip the resampling process so that only the original image data is loaded. However this may result to low 3D image quality.

The **Data range** may be mapped arbitrarily within a maximum data range for the different data types. The maximum values will appear as default values when opening the dialog for the first time. Pressing the **Reset** button will restore these default values.

5.1 Importing Data

The maximum data ranges for the different data types that can be handled by VGStudio are listed in the following table:

Data type	Min value incl.	Max value incl.	Effective resolution
unsigned 8bit	0	255	8 bit
signed 8bit	-128	127	8 bit
unsigned 16bit	0	65535	16 bit
signed 16bit	-32768	32767	16 bit
unsigned 32bit	0	1048575	20 bit
signed 32bit	-524288	524287	20 bit
32bit float	---	---	16 bit



Reminder: For best results while working with scenes including several floating point data sets you should map the floating point data values of all data sets to the same data range.

Press the **Scan file** button to determine the data range included in the data set to be loaded.

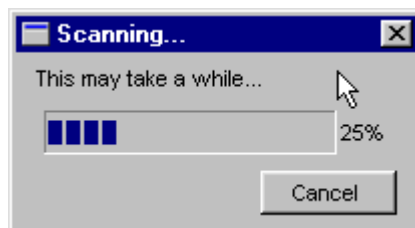


Fig. 169 Use the Scan function to determine the data range.

Clicking **Cancel** will stop the scan process, but the values determined during the partial scan will be displayed in the dialog.

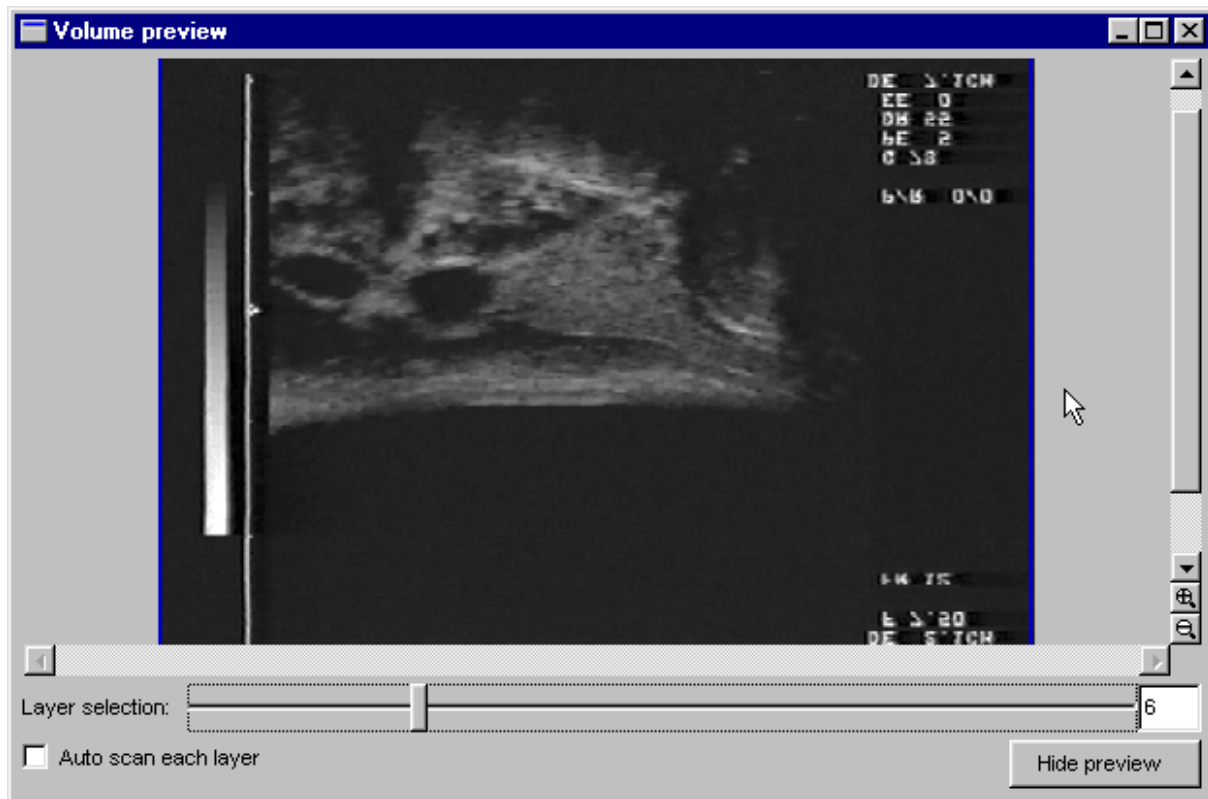
Step 9: Optional data preview

Fig. 170 Before starting the import procedure, you may preview your data as slice images.

The **Preview** window may be used to view your data as slices before starting the import process. This may help you to choose the right parameters. If you are not satisfied with the results, you may always go back to any previous step and change the settings and then check the results again in the **Preview** window. Use the slice selection slider to select the slice to be displayed.

A region of interest (ROI) may also be defined. To do so, grab one of the corners of the blue frame around the region of interest or grab the frame itself by clicking it with the left mouse button. You may now resize the region of interest by dragging the frame to the desired position while holding the left mouse button pressed.

Use the **Auto scan** checkbox to automatically scan the currently displayed slice for optimal grayvalue mapping. The **Auto scan** function will modify any previously adjusted data range mapping performed in step 8.



Reminder: The preview performance might be low when viewing ASCII or compressed data files.

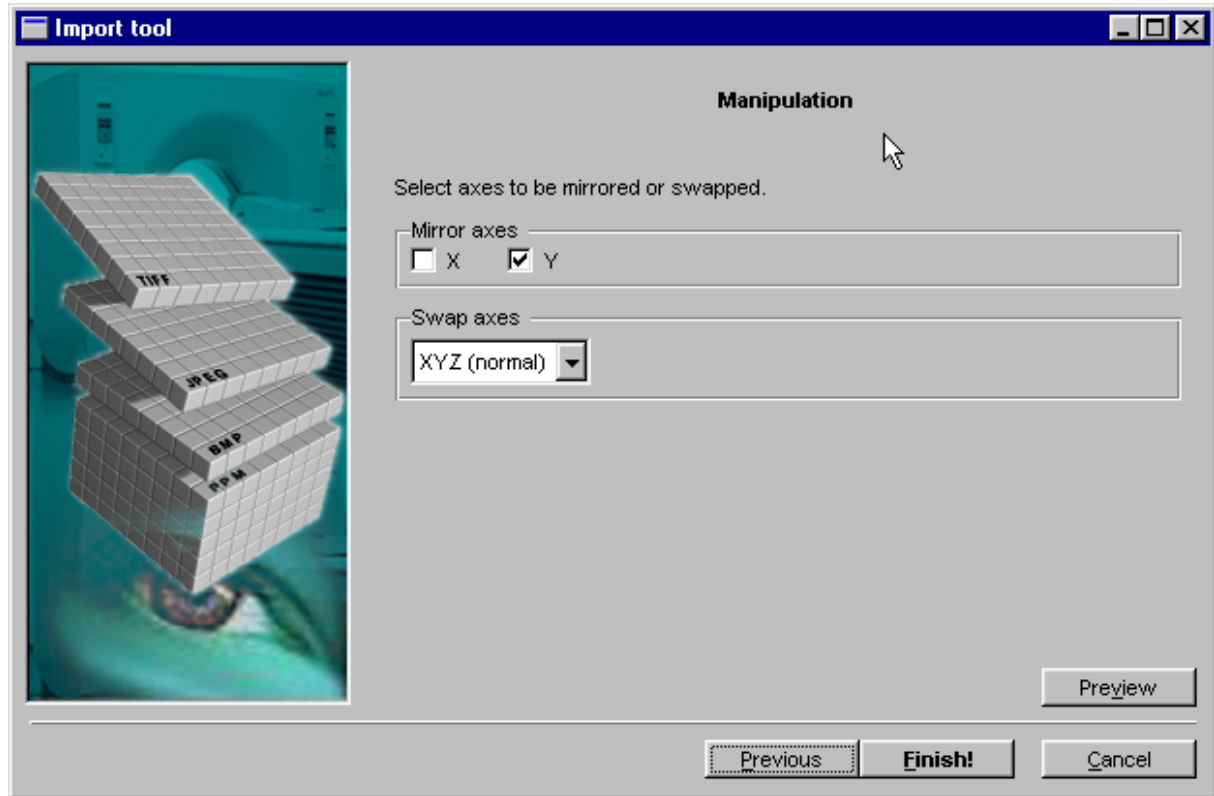
Step 10: Manipulation of the object coordinate system

Fig. 171 Mirror or swap the x- and y-axes of the data set.

The coordinate system of the imported data may be manipulated arbitrarily. The x- and y-axes of the data set may be mirrored. To mirror the z-axis change the sorting order in the file selection dialog (step 1). The order of the axes may be swapped.

You may now start the import procedure by clicking **Finish**.

5.1.3 Importing Raw Volume Data

To import Raw volume data, click **File** in the menu bar and select **Import**. Select **Raw Volume** from the **Import** menu to open the **Raw Volume Import Wizard**.

The **Raw Volume Import Wizard** guides you step by step through the whole import process. Click the **Next** or **Previous** buttons to go through the different steps of the import process. The different steps will be explained in the following:

Step 1: File selection

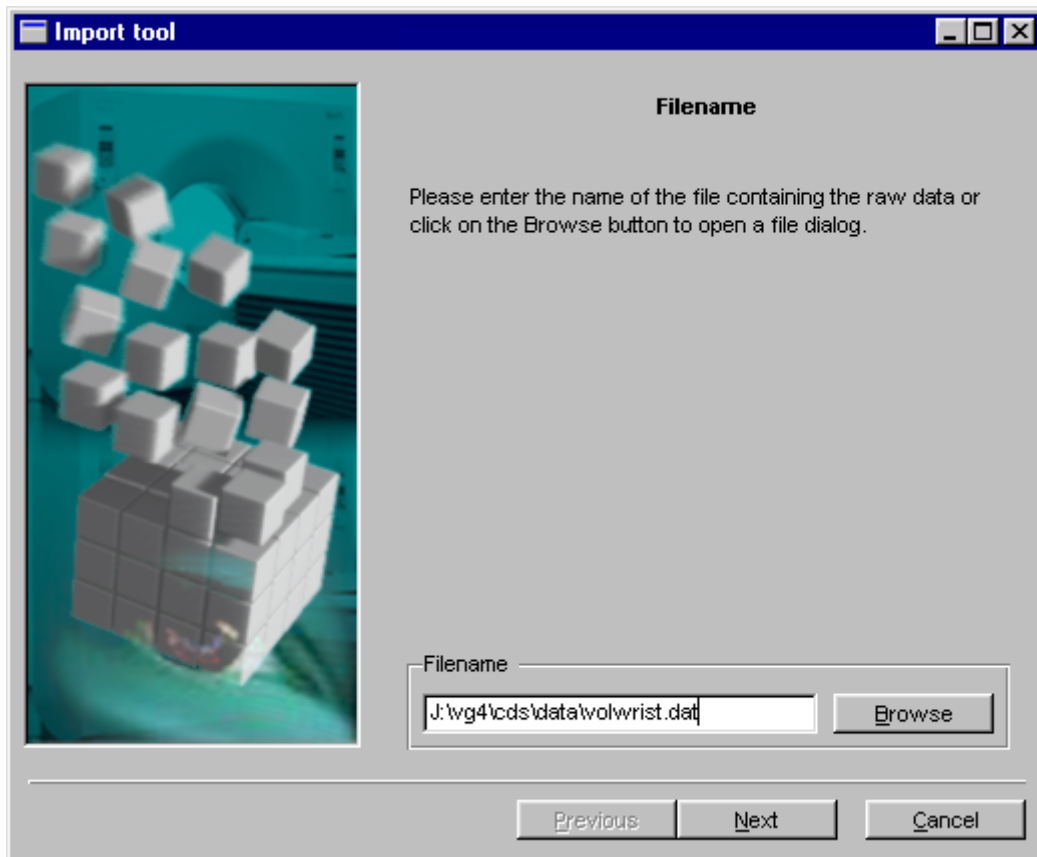


Fig. 172 Select the file you want to import.

Click **Browse** to open a file selection dialog. Select one file and click **Open**. The selected path and filename will appear in the **File name** section of the **Import Wizard**. Then click **Next** to continue.

Step 2: Data type selection

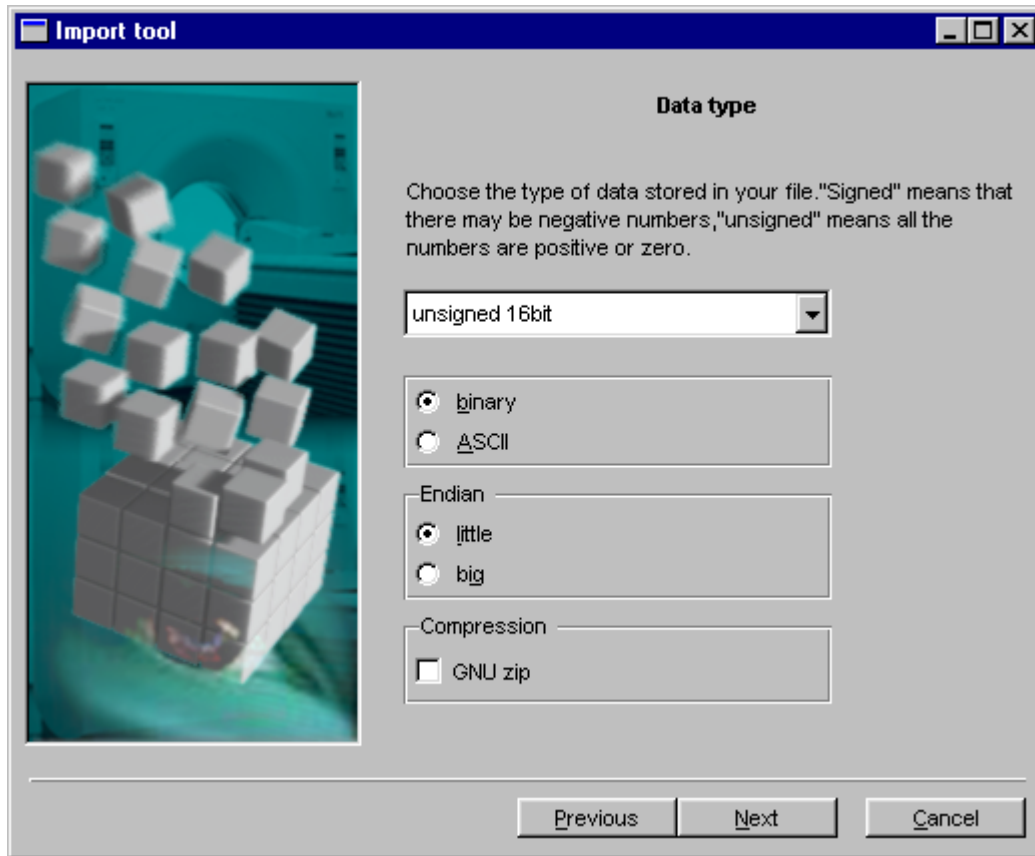


Fig. 173 Specify the data type for Raw images.

The data type has to be specified. Select the data type of the chosen file from the pulldown menu. Possible data types are:

- signed or unsigned 8bit, 16bit, or 32bit
- 32bit float
- 32bit RGBA

Decide whether the data is to be stored in binary or in ASCII format and select the byte order.

VGStudio is capable to import GNU zip compressed data files. Mark the GNU zip checkbox to import compressed data.



Reminder: Compression will not work in conjunction with ASCII data.

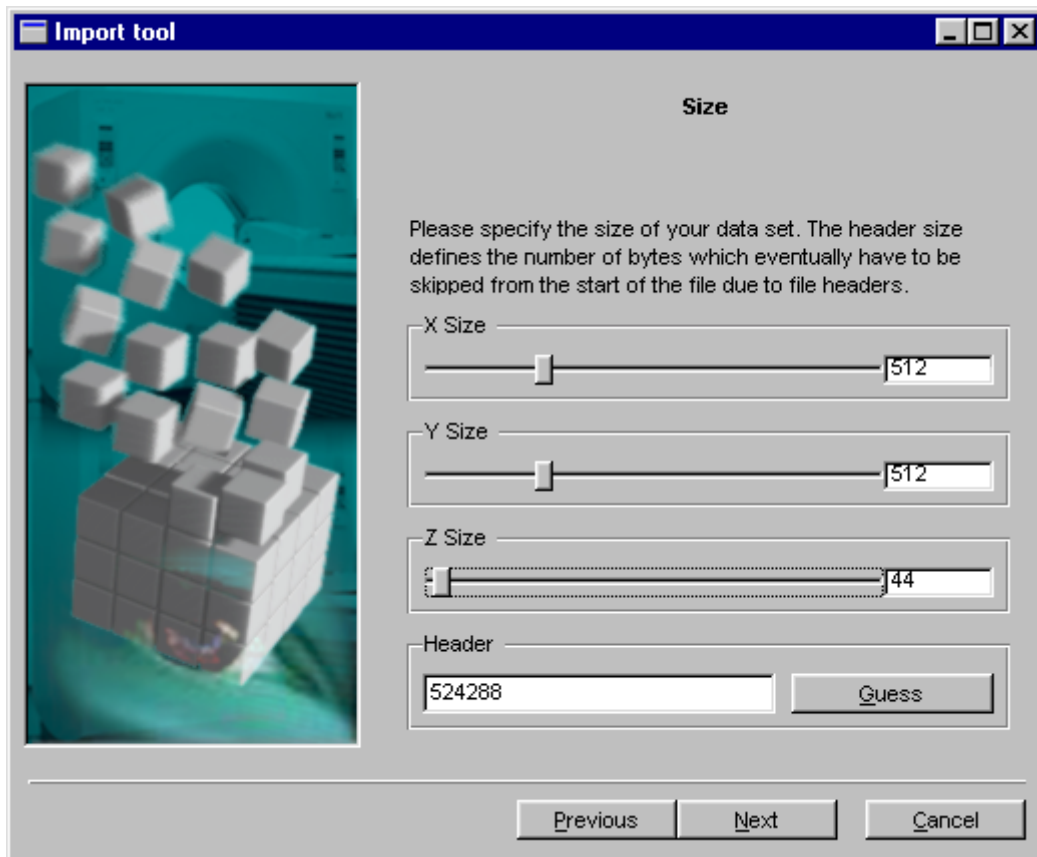
Step 3: Image size

Fig. 174 Select the image and header size by dragging the sliders or typing in the desired values.

Use the sliders or type in the x-, y-, and z-size of the volume data. If the volume data set includes a header enter the header size in bytes. The header has to be located at the beginning of the data file and will be skipped while loading. You can use the **Guess** button after having entered the size to compute the header size automatically.

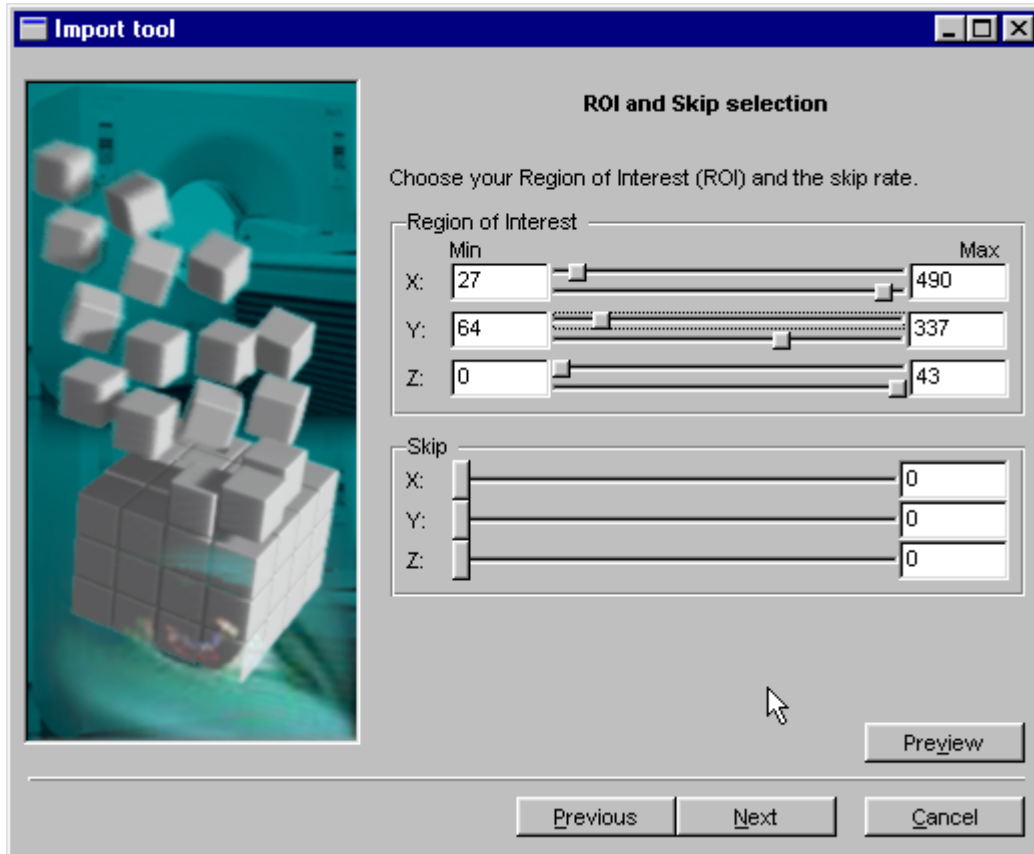
Step 4: ROI and Skip selection

Fig. 175 Define Regions of Interest and choose the skip rate.

Use this dialog of the import wizard to define a region of interest within the imported stack of images or to define the number of voxels to be skipped in each direction of the image planes by dragging the sliders or typing in the desired values. These functions may be of special interest for very large data volumes to reduce the amount of data loaded in VGStudio.

Use the six **Region of Interest** sliders to define a sub cube within the data set which should be loaded into VGStudio.

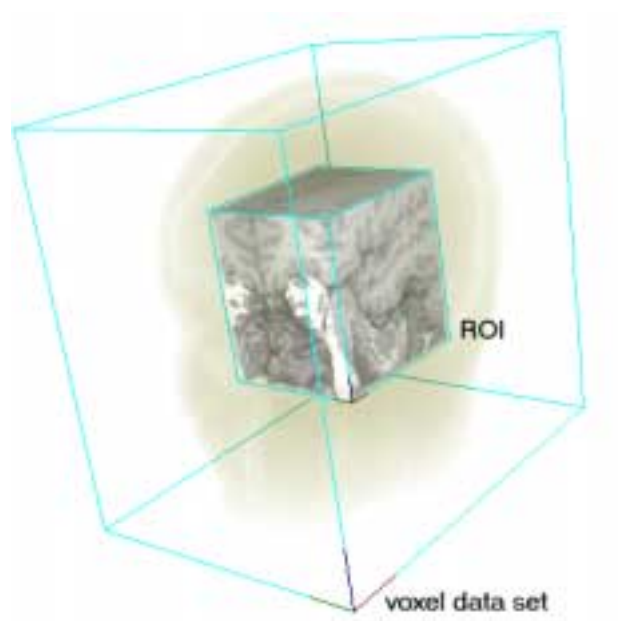


Fig. 176 Define a Region of Interest that is to be loaded into VGStudio.

Use the three **Skip** sliders to specify the number of voxels to be skipped in each direction. When choosing a value of 1, every second voxel will be skipped in the selected direction. The following image shows the example for skip values of 1 in each direction.

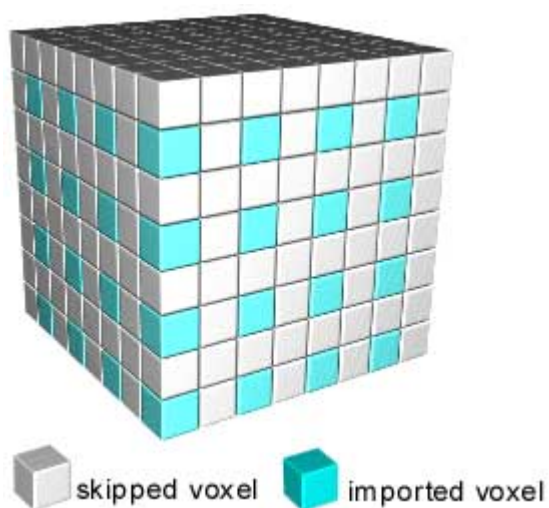


Fig. 177 For each direction, a skip value of 1 was chosen.

Step 5: Internal data representation

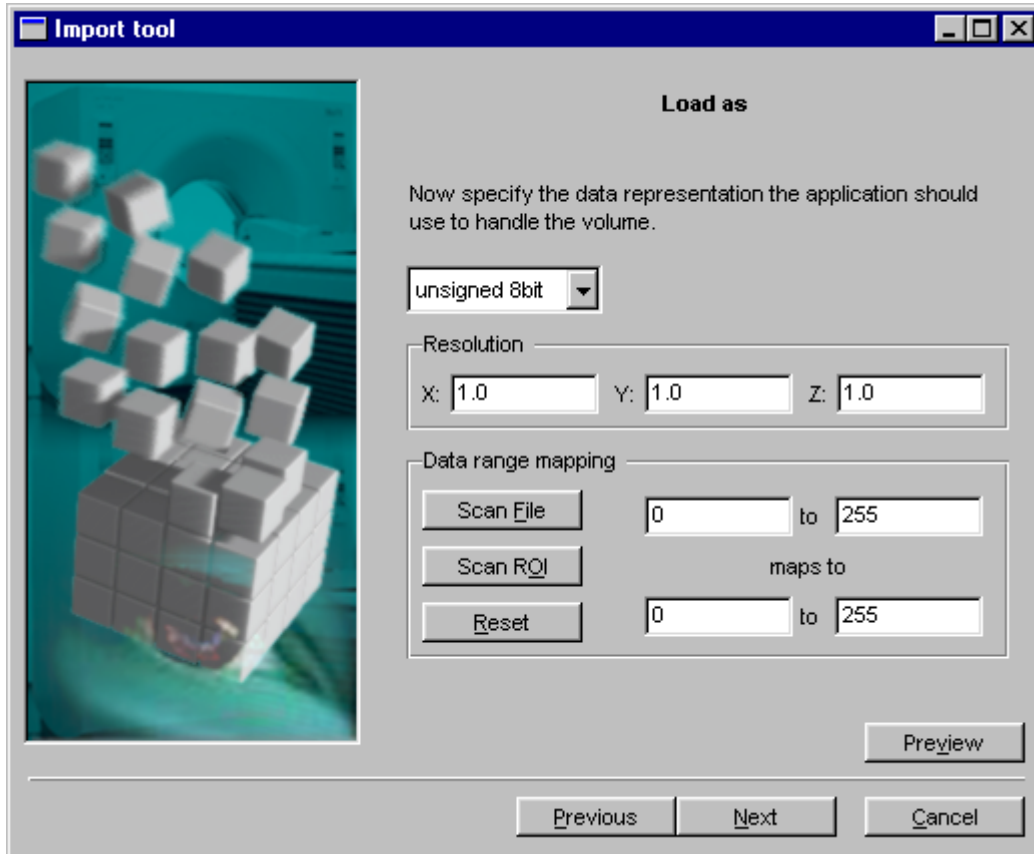


Fig. 178 Use this dialog to specify the internal data representation.

The data type may be changed while loading data into VGStudio, e.g. a 32 bit floating point data set on your hard disk may be mapped to a 16 bit integer data representation. In this case, this would reduce the amount of memory needed for visualization by a factor of two.

Any data type may be mapped to any other data type. The only exception are RGBA data sets.



Reminder: RGBA data can not be mapped to any other data representation. Also, monochrome data types may not be mapped to RGBA data.

5. Importing & Exporting Data

unsigned 8bit	may be mapped to	unsigned 8bit
signed 8bit		signed 8bit
unsigned 16bit		unsigned 16bit
signed 16bit		signed 16bit
unsigned 32bit		unsigned 32bit
signed 32bit		signed 32bit
32bit float		32bit float
32bit RGBA	no mapping possible	32bit RGBA

The voxel **Resolution** may be adjusted for data sets with non-isotropic voxel dimensions.

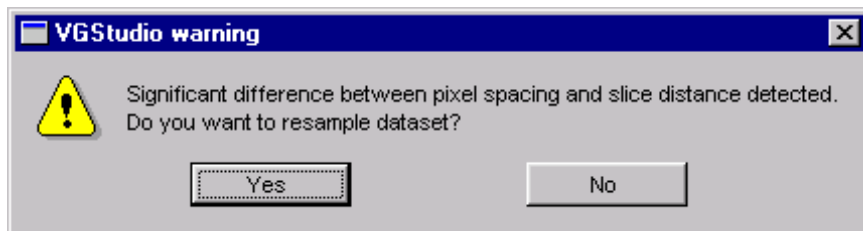


Fig. 179 Resampling warning Pop up.

A Warning dialog may come up in case that you import data series with Significant difference in voxel Resolution. Press **Yes** to resample the data. The software will calculate additional slices by trilinear resampling. This will result in a better 3D image quality. However keep in mind that slice images will be generated out of your original data which are not generated by the scanning device. The resampling will also result in an additional amount of memory needed by the VGStudio application. This process may exceed the available memory installed in your computer depending on your initial image data. Press **No** to skip the resampling process so that only the original image data is loaded. However this may result to low 3D image quality.

5.1 Importing Data

The **Data range** may be mapped arbitrarily within a maximum data range for the different data types. The maximum values will appear as default values when opening the dialog for the first time. Pressing the **Reset** button will restore these default values.

The maximum data ranges for the different data types that can be handled by VGStudio are listed in the following table:

Data type	Min value incl.	Max value incl.	Effective resolution
unsigned 8bit	0	255	8 bit
signed 8bit	-128	127	8 bit
unsigned 16bit	0	65535	16 bit
signed 16bit	-32768	32767	16 bit
unsigned 32bit	0	1048575	20 bit
signed 32bit	-524288	524287	20 bit
32bit float	---	---	16 bit



Reminder: For best results while working with scenes including several floating point data sets you should map the floating point data values of all data sets to the same data range.

Press the **Scan file** button to determine the data range included in the data set to be loaded.

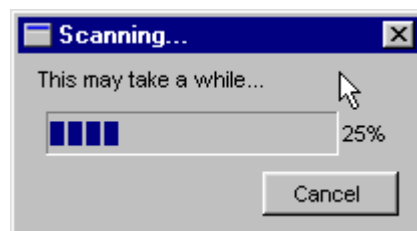


Fig. 180 Use the Scan function to determine the data range.

Clicking **Cancel** will stop the scan process, but the values determined during the partial scan will be displayed in the dialog.

Step 6: Optional preview

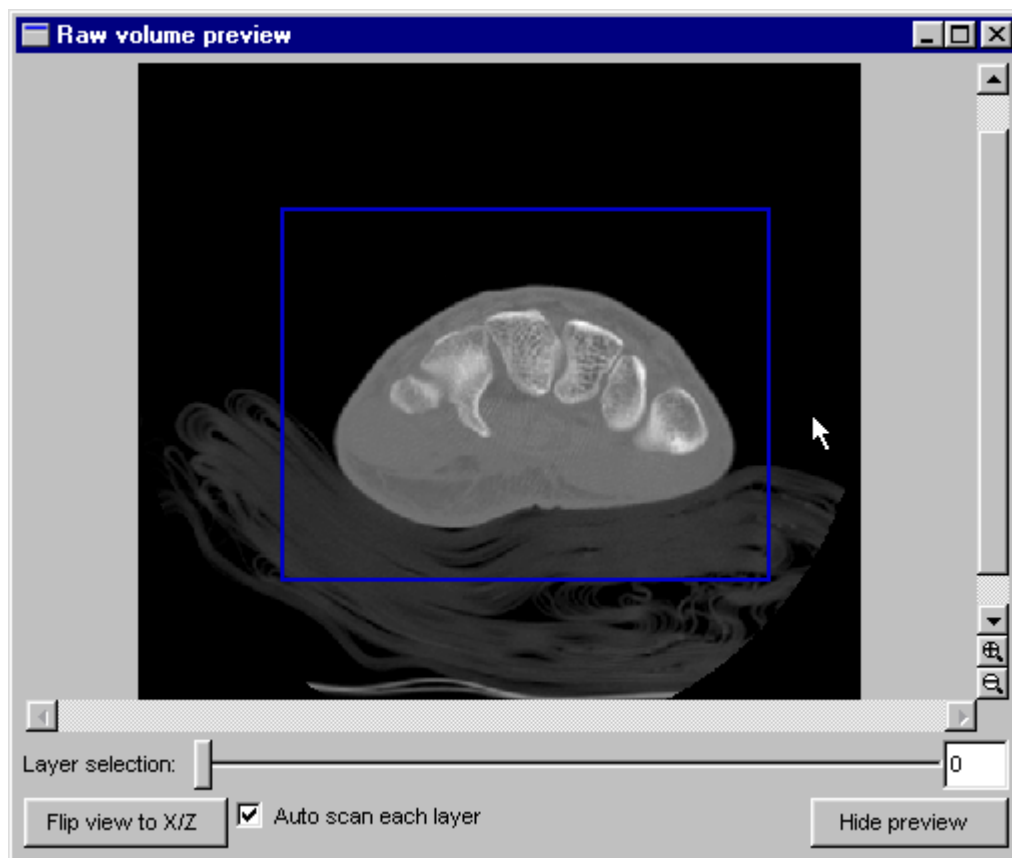


Fig. 181 Before starting the import procedure, the Raw volume data may be previewed as slice images.

The **Preview** window may be used to view your data as slices before starting the import process. This may help you to choose the right parameters. If you are not satisfied with the results, you may always go back to any previous step and change the settings and then check the results again in the **Preview** window. Use the slice selection slider to select the slice to be displayed.

A region of interest (ROI) may also be defined. To do so, grab one of the corners of the blue frame around the region of interest or grab the frame itself by clicking it with the left mouse button. You may now resize the region of interest by dragging the frame to the desired position while holding the left mouse button pressed.

Use the **Auto scan** checkbox to automatically scan the currently displayed slice for optimal grayvalue mapping. The **Auto scan** function will modify any previously adjusted data range mapping performed in step 5.



Reminder: The preview performance might be low when the viewed slice is flipped or when viewing ASCII or compressed data files.

Step 7: Manipulation of the object coordinate system

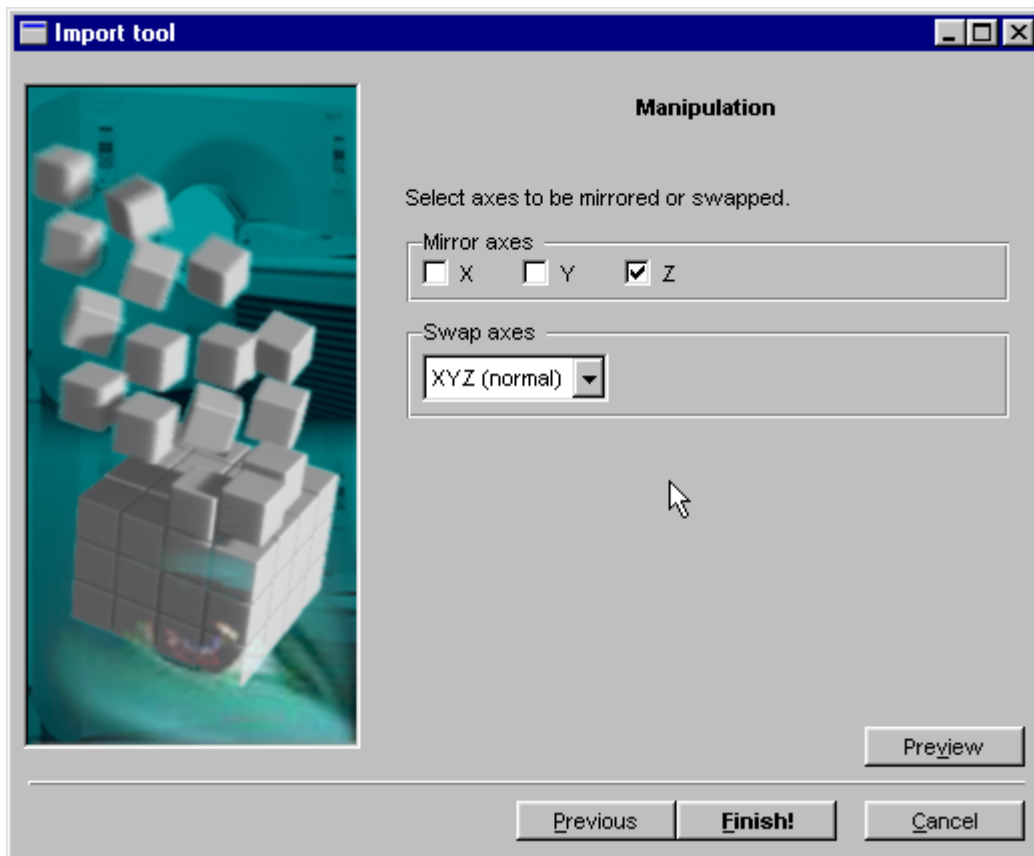


Fig. 182 Mirror or swap the x-, y-, and z-axes of the data set.

The coordinate system of the imported object may be manipulated arbitrarily. All three axes of the data set to be imported may be mirrored. The order of the axes may be swapped.

You may now start the import procedure by clicking **Finish**.

5.1.4 Importing HDF Data

VGStudio is capable to import image and volume data stored in the **H**ierarchical **D**ata **F**ormat (HDF 4.x). Select the **Import HDF volume** option in the **File** menu to load HDF volume data files into VGStudio. More information on HDF data can be found under the following internet address: <http://hdf.ncsa.uiuc.edu>.

5.1.5 Importing ANALYZE™ Data

VGStudio is capable to import data stored in the Analyze™ file format.

Select the **Import Analyze volume** option in the **File** menu to load Analyze volume data files into VGStudio. More information on the Analyze™ file format can be found under the following internet address: <http://www.mayo.edu/bir/analyze/AnalyzeFileInfo.html>.

5.1.6 Importing DICOM Data

Select the **Import DICOM image** option in the **File** menu to load DICOM volume data or image files into VGStudio. Use the file dialog to select one or several data files. The Dicom import dialog will pop up. Select a study and acquisition to be imported. Press **OK** to load the data or **Cancel** to abort the operation.

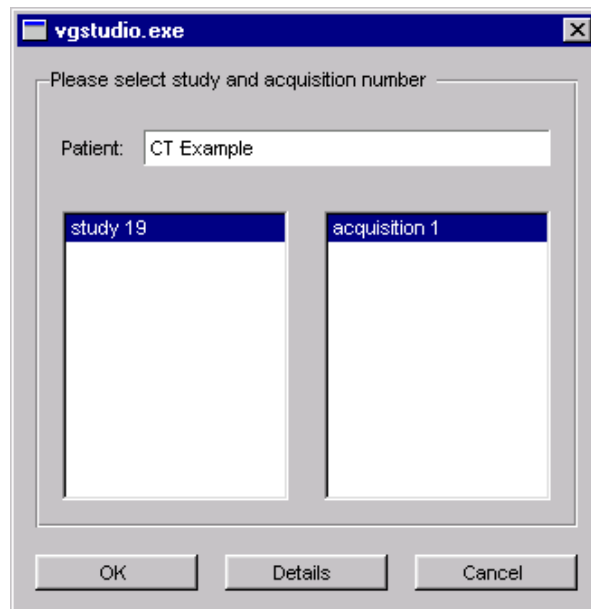


Fig. 183 The Import Dicom files window.

A Warning dialog may come up in case that you import DICOM image series with non equal slice distances or in case that the slice distance is more than three times the pixel resolution

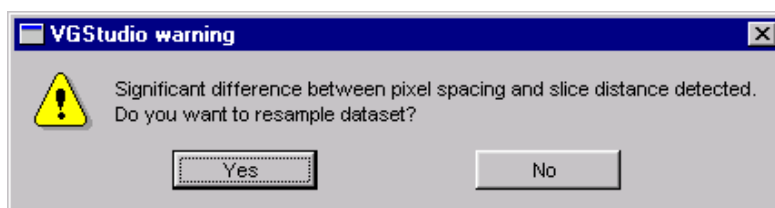


Fig. 184 Resampling warning Pop up.

within the slices. Press **Yes** to resample the data. The software will calculate additional slices by trilinear resampling. This will result in a better 3D image quality. However keep in mind that

5.1 Importing Data

slice images will be generated out of your original data which are not generated by the scanning device. The resampling will also result in an additional amount of memory needed by the VGStudio application. This process may exceed the available memory installed in your computer depending on your initial image data. Press **No** to skip the resampling process so that only the original image data is loaded. However this may result to low 3D image quality.

Press the **Details** button to get an detailed overview of the selected DICOM acquisitions which will be displayed in the **Import Dicom files** window along with other information included in the files such as patient name, date of birth etc.

You may again select or deselect one or several files to setup a correct lists of files to be imported into VGStudio. Only selected files which are highlighted by a blue background will be imported.

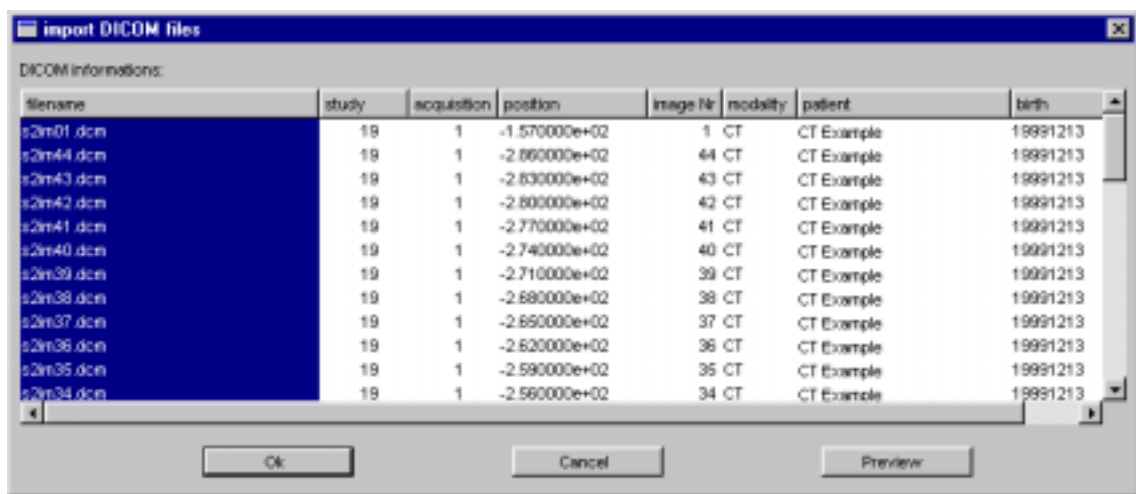


Fig. 185 The Import Dicom files window.

The **Preview** window may be used to view your data as slices before starting the import process. This may help you to choose the right parameters. If you are not satisfied with the results, you may always go back to any previous step and change the settings and then check the results again in the **Preview** window. Use the slice selection slider to select the slice to be displayed.

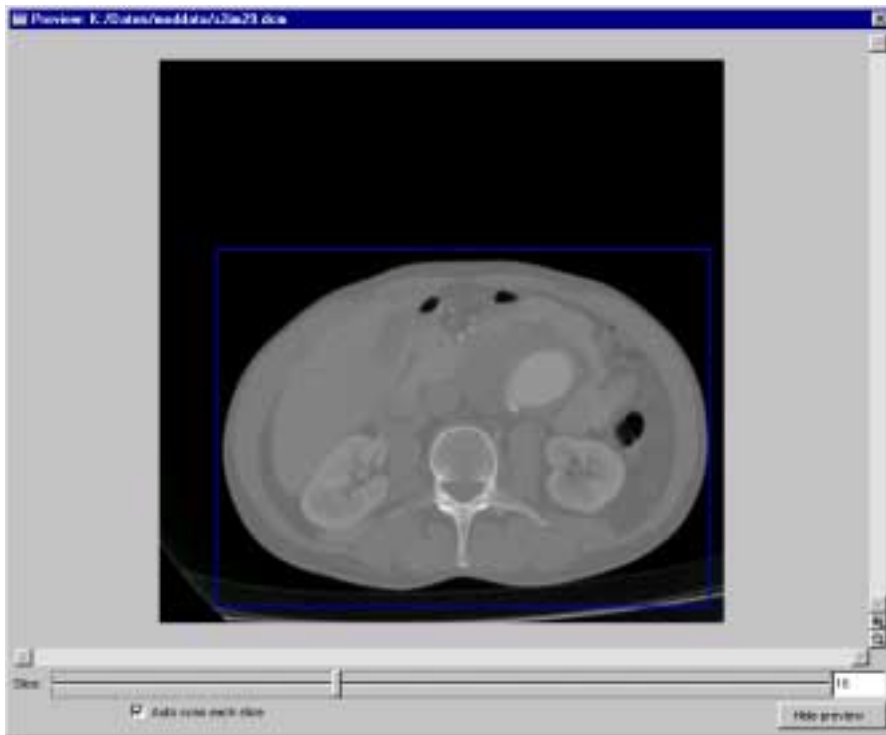


Fig. 186 The Import Dicom files window.

A region of interest (ROI) may also be defined. To do so, grab one of the corners of the blue frame around the region of interest or grab the frame itself by clicking it with the left mouse button. You may now resize the region of interest by dragging the frame to the desired position while holding the left mouse button pressed.

Use the **Auto scan** checkbox to automatically scan the currently displayed slice for optimal grayvalue mapping.

5.1.7 Importing Polygon Data

VGStudio is capable to import polygonal data stored in **Off file** format. More information on the off file format can be found in the Geomview Manual which can be accessed via the following internet address: http://www.geom.umn.edu/software/geomview/geomview_toc.html. The manual is provided by the Geometry Center of the University of Minnesota.

5.2 Exporting Data

5.2.1 Exporting Raw Volumes

A single volume object can be exported as a Raw volume data file. To do so, select **Export** and **Raw Volume** in the **File** menu.

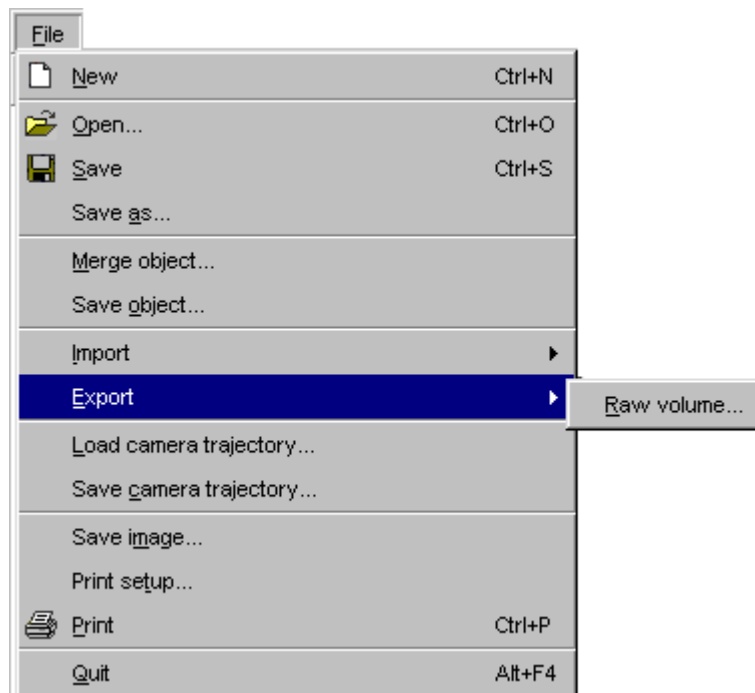


Fig. 187 Select Export / Raw volume to export a single volume object as a Raw volume data file.

The option remains disabled if no object is selected or if the active object is a polygon object or a group of objects. A single raw data file will be written to disk in the same data type (e.g. 8, 16, 32 bit unsigned/signed integer, 32 bit float, or 32 bit RGBA) the object was represented in VGStudio. For example, a data set which was loaded as 16 bit unsigned integer data into VGStudio will be written to disk as 16 bit unsigned integer data. The byte order will be the original byte order of your hardware. The voxel at position (0,0,0) will be written first, x is the inner loop variable, y the second loop variable, and z the outer loop variable.

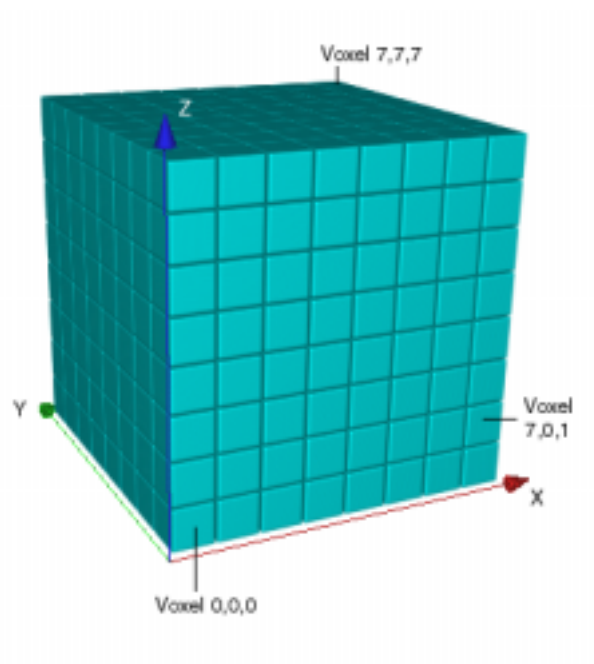


Fig. 188 The voxel at position (0,0,0) will be written first, x is the inner loop variable, y the second loop variable, and z the outer loop variable.

After the raw data file was written to disk the following dialog box will pop up.

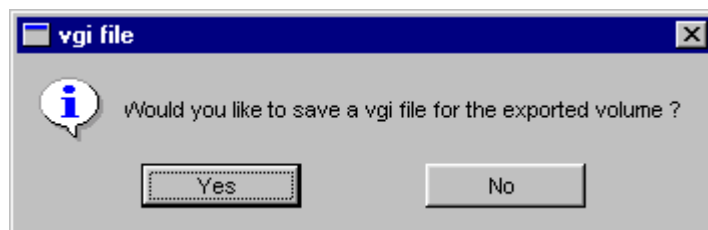


Fig. 189 VGStudio will ask you whether you want to save a vgi file for the exported volume.

Click **Yes** if you want to save a vgi file (Volume Graphics Info file) for the exported volume. Select **No** to skip this step.

6 Appendix

6.1 VGStudio 1.1 and memory consumption

6.1.1 Memory consumption of voxel data

A data set loaded into VGStudio is divided into sub-volumes of the size 16x16x16 voxels. The dimensions of a data set of the size 252x252x204 will be rounded up to a size of 256x256x208 in memory. This is called the **Data Size in Memory (DSM)**. Every data set in memory needs an additional amount of memory which is needed for performance optimization reasons. It is called the “**Spaceleaping Data**” (SD). The SD has the same dimensions as the original data in memory but it allocates only one byte per voxel, independent of the data type of the original data. In addition to the DSM and SD a few kByte additional memory are needed.

Memory consumption of data set of different data types: (size 252x252x204)

Data type	DSM in MB	SD in MB	Total Size in MB
8 Bit	13	13	26
16 Bit	26	13	39
32 Bit	52	13	65
RGBA	52	13	65

Memory consumption of objects in a VGStudio 1.1 scene

Original data	DSM + SD
Copy of an object	SD
References of an object	few kByte

6.1.2 Rendering large high quality images

The rendering of large images - VGStudio allows the user to render images up to 4096x4096 pixels which is 64 MB - requires large amounts of memory.

The amount of memory may be reduced by reducing the image size and the oversampling rate.

6.2 Limitations and Known Bugs

- The shadows appear to be bent.

The shadows rendered by VGStudio 1.1 are bent due to the lighting model used in VGStudio's renderer. This behavior will be corrected in one of the next VGStudio releases.

- Windows NT 4.0 crashes when visualizing very large amounts of data.

Under certain conditions, Windows NT 4.0 with Service Pack 5 or lower may crash when visualizing very large data amounts using up almost all available memory (RAM + Swap) on your system. To correct this fault, install the latest Windows NT 4.0 Service Pack.

- VGStudio 1.1 crashes during printing on a Linux system.

VGStudio 1.1 crashes when printing on a Linux system where no valid printer is configured. Please refer to your Linux distribution's manual and set up a printer.

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