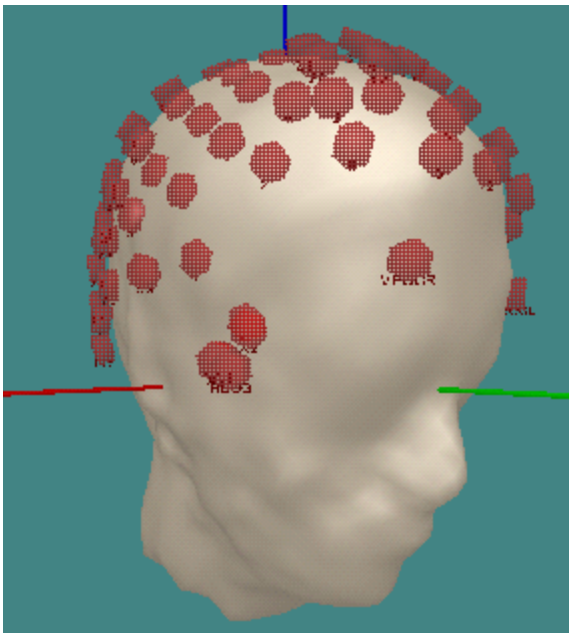
3DSpaceDx 4.5



Digitizing Electrode Positions
and Head Shapes

COMPUMEDICS
NeuroScan

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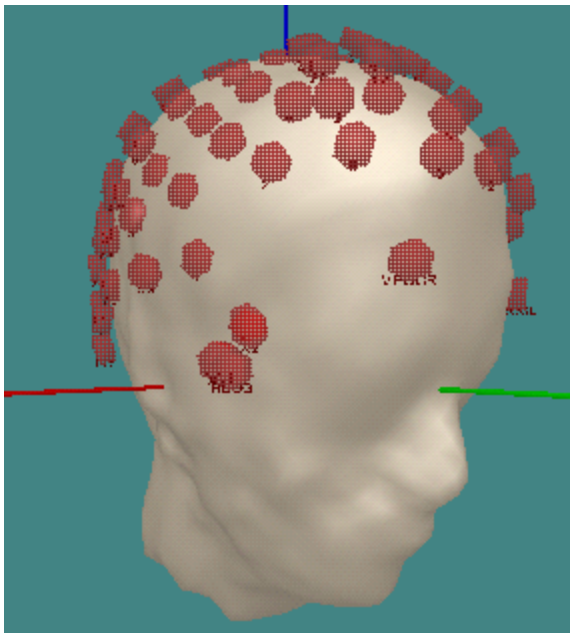

Digitizing Electrode Positions and Head Shapes

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1.1 Introduction

Welcome to the Compumedics/Neuroscan 3DSpaceDx program - a flexible 3 dimensional rendering package designed specifically for the neurophysiologist interested in source localization. 3DSpaceDx is designed to digitize precise electrode positions and head/body shapes, and generate and render realistic surfaces. 3D coordinates for electrodes and fiducial markers can be exported to most source analysis packages for precise localization of electrodes. 3D data can also be imported and displayed from other systems generating 3 dimensional data.

ABOUT THIS MANUAL

This manual is divided into three sections: an installation guide for the 3D Digitizer, a tutorials section designed to illustrate the use of the program, and a detailed description of the principles of operation. The rapid and accurate collection of 3D data from a real subject is a skill that requires both technique and practice. Therefore, we strongly recommend that you read and carefully follow the tutorials and principles of operation sections before you begin to collect any important data.

Please refer to the Installation section of the SCAN 4.5 manuals for SCAN system hardware and software installation directions. For the remainder of this manual, we will assume that all of the necessary hardware and software for Windows and SCAN 4.5 have been successfully installed, and that you have a basic understanding of the operations of Windows 2000 or XP.

Changes for SCAN 4.3 and newer versions

In SCAN 4.3, we have removed the mapping functionality in 3DSpace, and have transferred them to EDIT. This is an interim step toward the ultimate plan to transfer all of the functionality from 3DSpace to EDIT/ACQUIRE.

3DSpaceDx Video Requirements

The video requirements in 3DSpaceDx are increased in relation to the Scan 4.0 version of 3DSpace. While most new video boards should run 3DSpaceDx without any problems, you may find that your older video board is inadequate (in some cases, 3DSpaceDx may not run at all). To make maximum use of the capabilities in 3DSpaceDx, you should have a video board that meets the following specifications:

- **16MB VRAM** (32MB recommended)
- **Certified video drivers that are compatible with DirectX6.1**. (DirectX6.1 is installed from the Scan 4.5 CD). You should check with the manufacturer of your current video board if you see the message saying there are no Certified Drivers detected.
- **3D Acceleration**
- **PCI or APG bus**

When SCAN 4.5 is installed, you may see a message listing any video deficiencies, such as, No Certified Drivers, No 3D Acceleration, etc. If you are having video problems, you should also see the Advanced tab under **Edit** → **Options** in 3DSpaceDx (described below), or the **Help** → **About 3DSpaceDx** screen for information about what was detected from

your video board. In some cases you may be directed to run the DxDiagnose program. If you have continuing video problems, please contact Tech Support at techsup@neuroscan.com, or call (877-717-3975; International should use 704-749-3200).

1.2 3D Digitizer Installation

If you have purchased a 3D Digitizer for inputting three dimensional head shapes for the 3DSpaceDx program, please complete the following installation steps.

Note
If you received a USB cable to connect the digitizer to the computer, *do not connect it*. You must use the serial cable only. If you received the Polhemus software, there is generally no need to install it. The digitizer is controlled from the 3DSpaceDx program in Scan.

1.2.1 Hardware Installation

3DSpaceDx supports only the FASTRAK™ device. Described below are the specific interface concerns related to the 3DSpaceDx program. The user is referred to the accompanying Polhemus manual for all other hardware concerns. Familiarization with this manual and the operation of the device is required before proceeding with the steps listed below.

CAUTION - All Polhemus devices are sensitive to electrostatic discharge (ESD). Be sure to take precautions when following the instructions listed below. Power should not be applied to the device until so instructed.

1. Attach the serial communication cable. A 10 foot serial communication cable is provided. One end of the cable should be plugged into serial communications port COM1 or COM2. The other end should be plugged into the 9 pin connector labeled RS-232 on the digitization unit. *If you received a USB cable with the digitizer, do not connect it*.

2. Attach the transmitter. The transmitter is a plastic cube, roughly 2" on all sides, with a long cable and connector attached. With the power off, plug in and firmly screw the transmitter cable into the connector labeled **transmitter.** The transmitter should be attached to the head of an aluminum tripod, supplied with the system.

3. Attach the stylus. The digitizing stylus is a pen-like device with a long cable and connector attached. Plug in and firmly screw the stylus cable into the connector labeled **Receiver ONE.** The stylus must at all times occupy the first receiver position. Other positions will result in erroneous data.

4. Attach the power cable. An external transformer is provided with the FASTRAK. Make sure the power switch on the back panel is set to the off position. For both devices remove the power cable from the transformer and plug the circular DIN type connector into the connector labeled **POWER** on the back of the device. Now plug the power cable into the back of the transformer and the other end into the wall socket.

CAUTION - Never plug the DIN connector into the device with power applied to the transformer. Damage to the device may occur!

5. Attach the 3 additional receivers. Attach the three additional receivers. These receivers are used to form a reference plane on the head or object to be digitized. If the device was purchased directly from Compumedics/Neuroscan, the cables will be tied together to form a harness. Plug these connectors in **TWO**, **THREE,** and **FOUR**.

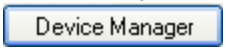
6. Check the serial communication parameters on the digitizer. The digitizer should be set for 57.6 Kilobaud, 8 bits, 1 stop bit, no parity. The appropriate switch settings can be found in the user manual of the device. If you purchased the digitizer from Compumedics/Neuroscan, the switches have likely been preset; however, it is a good idea to check them to make sure.

1.2.2 Software Installation

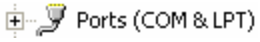
1. Check the serial communication parameters on the host computer. It may be necessary to configure the serial port to handle the 57.6 K baud rate required by the digitizer. To check and/or change the baud rate to these settings, click on the 

button and select 

. (These directions are for Windows XP; Windows 2000 will be similar).

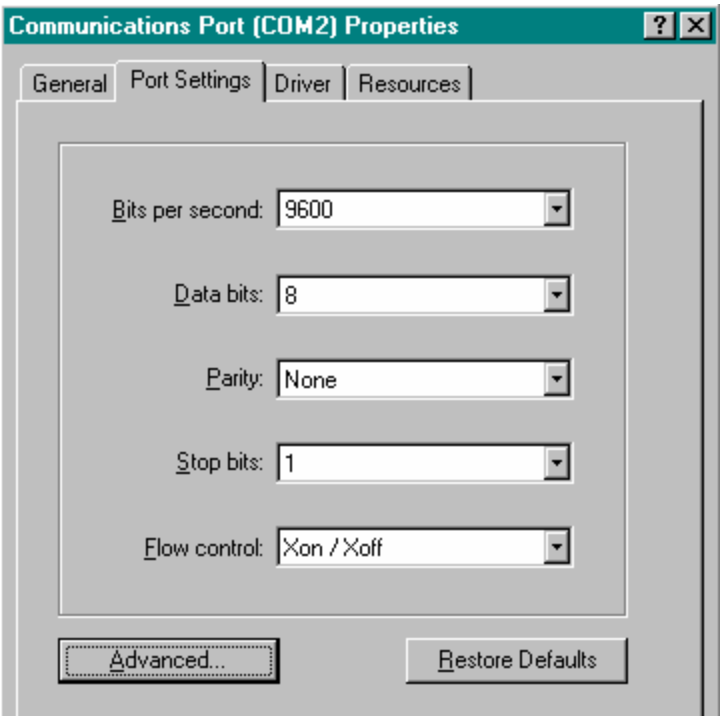
Click on the icon and the System Properties screen will appear. From the Hardware tab, click the 

button, and a list of the installed devices will appear.

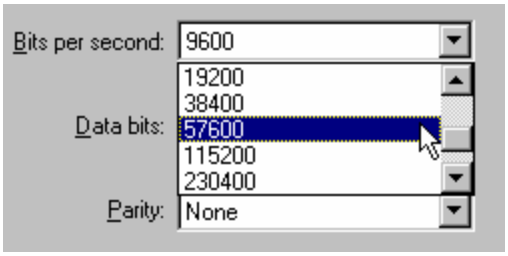
Double click on the Ports icon 

, and a device tree will expand to show the installed ports.

Double click on Communications Port (COM1 or COM2) and the Communications Port properties page will appear. In this example the baud rate of the system is set to 9600.



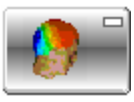
To change the settings, click on the 'pull-down' arrow located to the right of the number. A list box will appear. Select 57600 and click the OK button to modify the communications values.

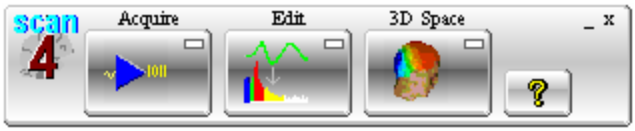


The Communication Properties dialog box will disappear and the System Properties dialog box will reappear. Click on the OK button to close this dialog box.

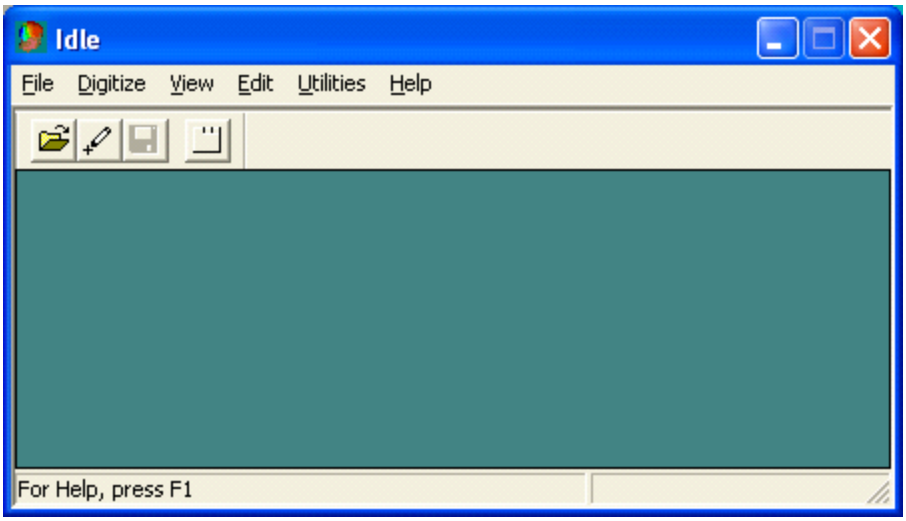
The host computer is now configured for 57K baud transmission rates.

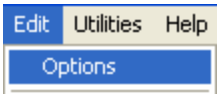
2. Check that the number of receivers for your digitization unit is set correctly. The number of receivers for the FASTRAK is four. The switches on the front of the unit should all be On. Three of the receivers (receivers 2-4) are used to form a reference plane and the position of the stylus (receiver 1) is computed relative to this plane. Consult the FASTRAK manual to set the number of receivers to four.

3. 3DSpaceDx installation. The last steps are to enter the necessary settings within 3DSpaceDx. Click on the 3DSpaceDx icon  from the SCAN 4.5 Program Launcher,

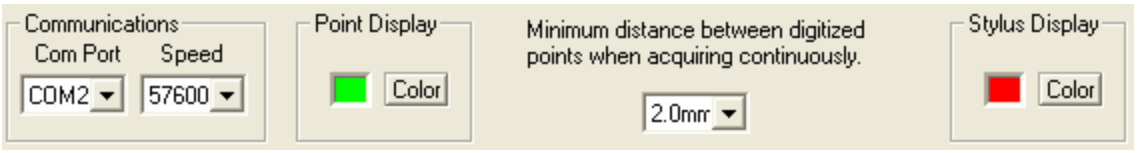


and the main screen will appear.



Click **Edit** → **Options** 

and select the **Digitizer Setup** tab. The Setup dialog box (shown below) will appear.



Under the Communications section, select the COM port that you are using, and the same BAUD rate that you set in the Device Manager and with the digitizer dip switches. Exit the program by clicking OK, and then **File** → **Exit** (or the X button). This will save your current configuration.

When you have everything set correctly, turn on the digitizer. *Remember, do NOT make any connections to the digitizer, or make any switch changes, while the system is ON.*

Troubleshooting tip: The program has been found to fail sometimes if the screen resolution exceeds 1024x768. If the program does not run, try lowering the screen resolution.

2 Tutorials

These tutorials are designed to illustrate the use of the 3DSpaceDx program. In these tutorials you will learn to do the following:

- Calibrate and verify operation of the system
- Digitize electrode and head shape information
- Export and import data to other systems

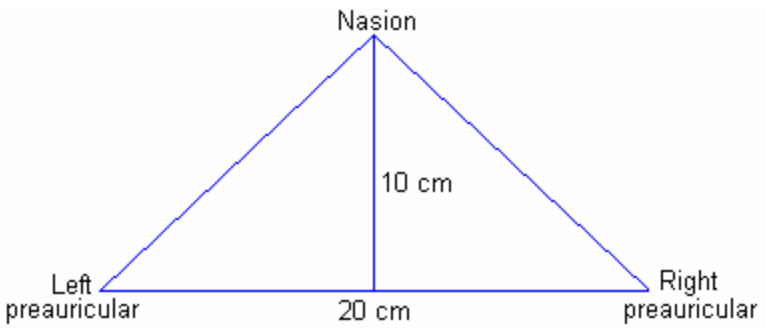
We recommend that you read the first two tutorials at a minimum before you begin to acquire important data. Most of the critical aspects of data acquisition are explained in these two tutorials.

2.1 Tutorial 1: Calibration

This tutorial will illustrate how to test your newly configured system. It should only be necessary to check the system occasionally. It is also recommended that you perform a system check if anything that might affect operation has changed, such as installing a new computer or recording in a new environment.

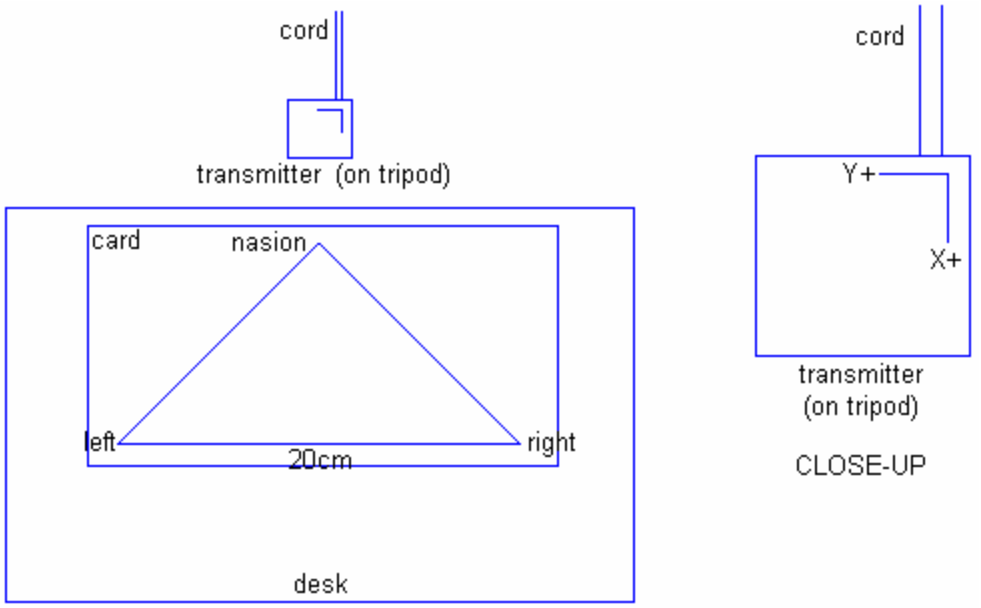
The simplest way to check the system is to digitize some object of known size and shape. Perhaps the easiest method is to draw a measured figure on a piece of paper. Follow these steps to perform a quick check of the system:

1. On a sheet of paper mark off a triangle measuring 20cm at its base and 10cm in height (see below).

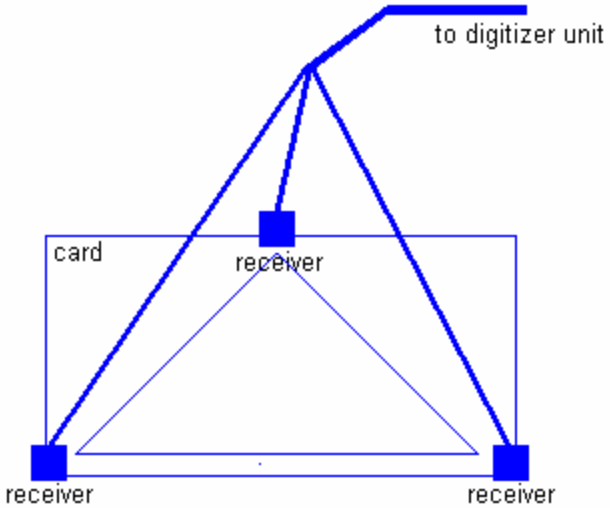


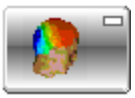
This triangle will represent the left and right preauricular and nasion points. These points serve as landmarks and a reference frame for the 3DSpaceDx program. Affix this figure onto the top of a wooden or nonmetallic surface with tape.

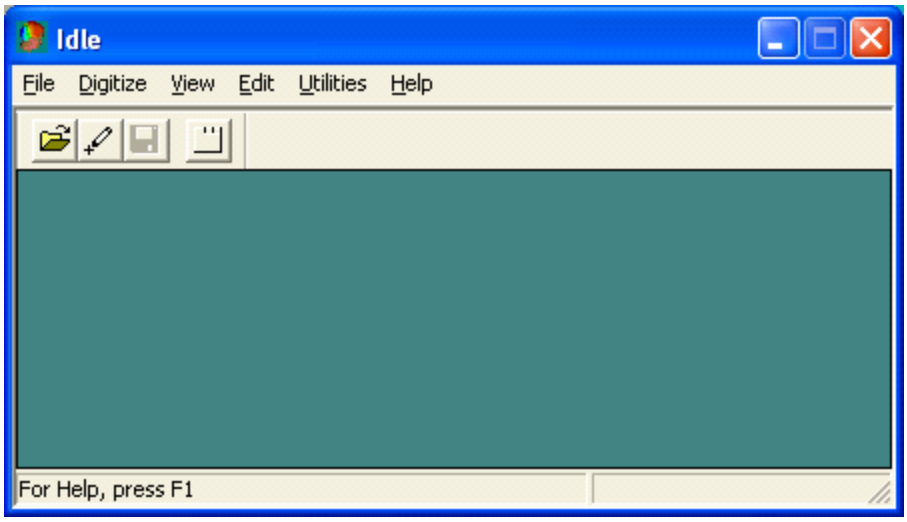
2. Move the transmitter mounted on the tripod so that +X axis of the transmitter is projecting toward the edge of the table (see below).



3. Position the three receivers (2-4) somewhere near the three points of the triangle (see below). It is not necessary to place the receivers precisely at the edge of each corner. They should be placed so that a triangular plane is formed. These three locations are digitized every time a sample location is obtained from the stylus receiver. A reference plane is computed and used to adjust the stylus position relative to this plane. The three receivers are normally placed on the head of the subject to compute the reference plane. With these three receivers attached the subject can move his or her head freely in space as long as the receivers are within range of the transmitter (approximately 50cm).



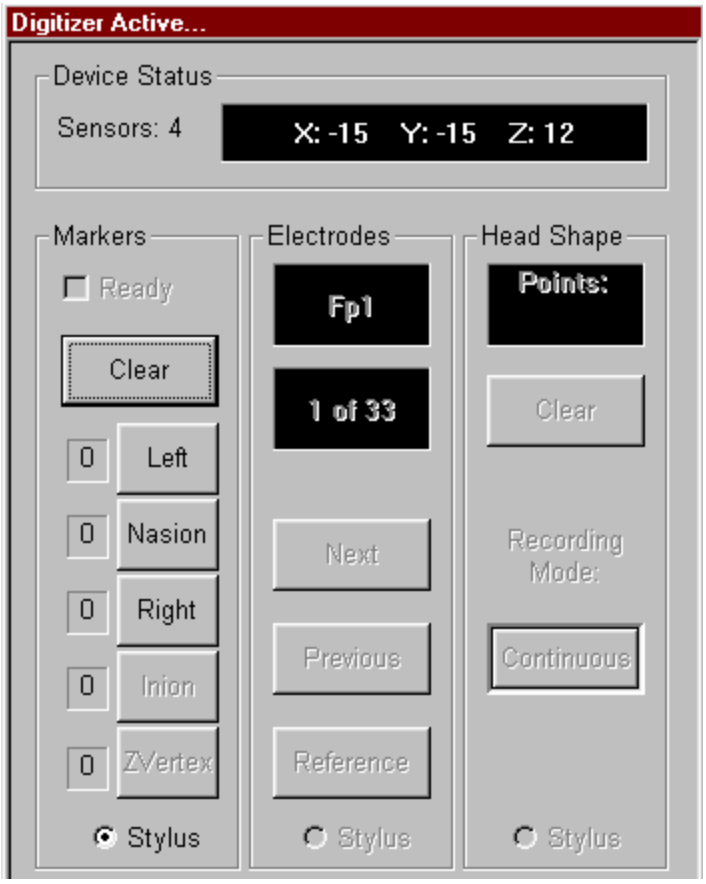
4. Start the 3DSpaceDx program by clicking on the 3DSpaceDx icon  from the SCAN 4.5 Program Launcher, and the main screen shown below will appear.



5. If you were going to digitize electrode positions, you would need to specify the Setup File under **Edit** → **Options** → **Electrode Setup**. For this calibration tutorial, we will not be using any electrode positions. If your digitizer is not ON already, turn it on now. (If you have difficulty establishing communication between the digitizer and 3DSpaceDx, try turning the digitizer on *before* starting 3DSpaceDx). When you turn it on, you should see the light on the front blink a few times. Wait for it to stop blinking before you proceed. Click **Digitize** → **Record**,

or the **Digitize** icon  . A dialog box will appear (shown below) indicating that the 3DSpaceDx device is initializing. Depending on the type of device this process should require between 5 to 10 seconds. An LED indicator on the FASTRAK will blink periodically until the device is ready.

6. 3DSpaceDx uses a preauricular-nasion (PAN) reference plane for the collection of all points. The location of these points on the head is described in greater detail in the electrode and head shape tutorial. In this example, we will use the measured points (see diagram above) marked Left, Right and Nasion to model these points. Shown below is the Digitizer control dialog box. The dialog box contains four groups of information: Device status, Markers, Electrodes and Head Shape.



In the Markers group are buttons corresponding to the three points of the PAN reference plane (plus the Inion and ZVertex). The Stylus button under the Markers section should be selected by default; the Clear button is also highlighted by default. Position the stylus on the "Left" position on your calibration drawing, and click the Stylus button once. If the sound system on your PC is functioning, you should hear a beep. The Left position is digitized, and the "Nasion" button is highlighted. After digitizing the Nasion, digitize the "Right" position. You should see "1"s in the fields beside the three buttons.

Although the digitization device is highly accurate we have found that in practice users vary in their ability to reliably place the stylus at the same location to locate the markers. It is advisable in normal digitizing circumstances, therefore, to make repeated measurements of the PAN coordinates. The group median is computed each time a point is collected. Computation of the median has the effect of removing the erroneous points. When digitizing a real subject, we recommend digitizing each marker at least three times. Accurate and repeatable localization of the PAN coordinates is critical because these points are used as a reference plane for all subsequently digitized points. Therefore, after digitizing the Right point, the program will automatically highlight the Left button again in case you wish to repeat the measurements. For this tutorial, you may repeat them if you wish.

After marking the Right point, you will see "R", "N" and "L" appear in a line on the display part 

of the digitization screen, and a check will appear by the Ready field directly under Markers. This means you can move to the Electrodes or Head Shape fields and begin their digitization.

You might also notice that the 3D coordinates (X, Y, and Z) of the PAN coordinates will appear (in centimeters) in the 'Device status' group (see below). The distances will be expressed as a relative distance of the stylus from the centroid of the reference plane formed by the three additional sensors.

Position the stylus button on the Left position on the paper where you drew the triangle, and look at the values in the Device Status field. If the digitizer is calibrated correctly, you should see the following.

The X coordinate shows -10cm while Y and Z show zero. Then move the stylus to the Right position. You should see the following values in the Device Status field, with 10cm for the X coordinate.

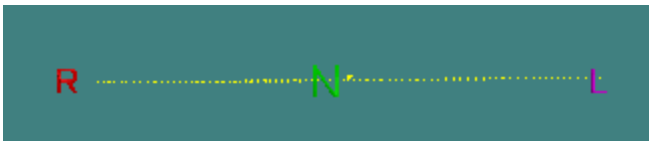
Then move the stylus to the Nasion position, and you should see the following values.

Since you have not moved the stylus upward in the 3rd dimension, the Z value is always 0.

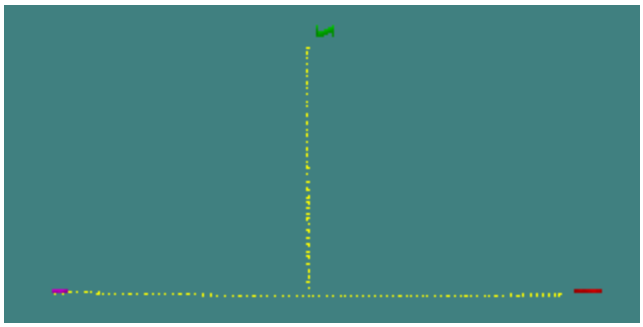
7. With the PAN markers in place you can now begin to explore the use of the digitizer. First, we'll digitize along the X and Y axes. Click the Stylus field under Head Shape. In Continuous digitization mode, we'll "draw" axes. Position the stylus at the Left position, and, using a nonmetallic straight edge, hold down the stylus button and "draw" a line to the Right position. Don't move the stylus too fast, just a steady smooth movement. If you have your PC sound system on, you will hear the points as they are digitized. You will also see Point counter in the Head Shape field increment, and you will see the dotted line appear on the display area.

> *Note: You can change the color of the digitized points, the color of the stylus tip position, and the minimum "closeness" of the digitized points from the* ***Edit*** → ***Options*** → ***Digitizer Setup*** *display (described in more detail below).*

Then digitize the vertical line going to the Nasion from the midpoint of the Left-Right line you just digitized. The result lines in the display area of 3DSpaceDx should look something like the following.



Where is the vertical line, and why are Left and Right reversed? The view you are seeing is as if you are looking from the vantage point of the transmitter. You are looking edge-on to the lines, which are lying flat in 2 dimensions, and Left and Right are in fact reversed - if you drew the triangle diagram as indicated above. To see the vertical line you need to rotate the head. Click the Top View icon  , and you should see the following.



This is now as if you are looking directly down on the triangle you drew. Since the R, N, and L are 2 dimensional objects, they appear as lines when viewed from above or from the sides. Experiment with the various viewing icons on the Toolbar. Try Spinning, rotating horizontally and vertically, resizing, front\back and left\right views, and so forth.

You may have noticed that additional Toolbar icons appeared when you went into digitizer mode, including these  . The first one is an editing tool, and will be discussed in the Electrode and Head Shape tutorial. The other three are toggles for displaying the X, Y, and Z axes, the electrode shapes, and the electrode labels. Toggle the XYZ axes on and spin the lines.

8. The last step is to save the results. Exit digitizer mode, and click **File** → **Save As...**. A standard Save As... utility will appear. Click the down arrow by the "Save as type" field, and you'll see a list of file types that may be saved. These will be discussed in more detail in the Importing and Exporting files tutorial. For now, select the 3DD Files (*.3DD) file type, and click Save. The file has now been stored in a binary *.3dd* format and can be recalled at any later time.

This last step completes the first tutorial in the use of the 3DSpaceDx program. In this tutorial you learned to:

- Start the 3DSpaceDx program
- Setup the PAN reference plane
- Digitize continuous points
- Verify accuracy
- Rotate and change the viewer perspective
- Save the results to a *.*3dd* file

In the next tutorial you will begin to collect electrode and head shape information from a real subject.

2.2 Tutorial 2: Electrode Positions and Head Shape

In this tutorial you will learn how to digitize the electrode positions and the head shape. Skull landmarks and precise electrode position data are very useful for the co-registration of the electrodes with other imaging methods such as CT, PET, SPECT, fMRI and MRI. Although it is quite common to construct group averages from individual subjects with electrophysiological data, the average head shape and size is rarely considered even though there is increasing evidence that individual anatomy may play a substantial role in source localization.

The procedures to digitize the electrode positions and collection of head shape information are very similar to those described in the previous tutorial. If you have not practiced this tutorial, please go back and familiarize yourself with the methods described in that section.

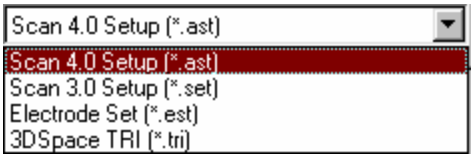
1. Move the subject into a comfortable chair sitting in the upright position. The chair should have good back support, but should not have any head support to obstruct access to the back of the head. A secretary style chair is a good choice. You should be able to move easily around the subject so that all electrodes are easily accessible with the digitizing stylus.

2. Position the magnetic transmitter less than 30cm from the subject's face. Be sure that the orientation of the transmitter is such that the positive X axis is in line of site with the subject's face.

3. Position the three receivers on the subject's head, forming a triangle. One receiver should be placed at each temple and the third should be placed near the inion. If an electrode cap is used the receivers can be attached with a Velcro strip sewn into the cap. If it is not possible to use the electrode cap, a head band with Velcro strips can be used.

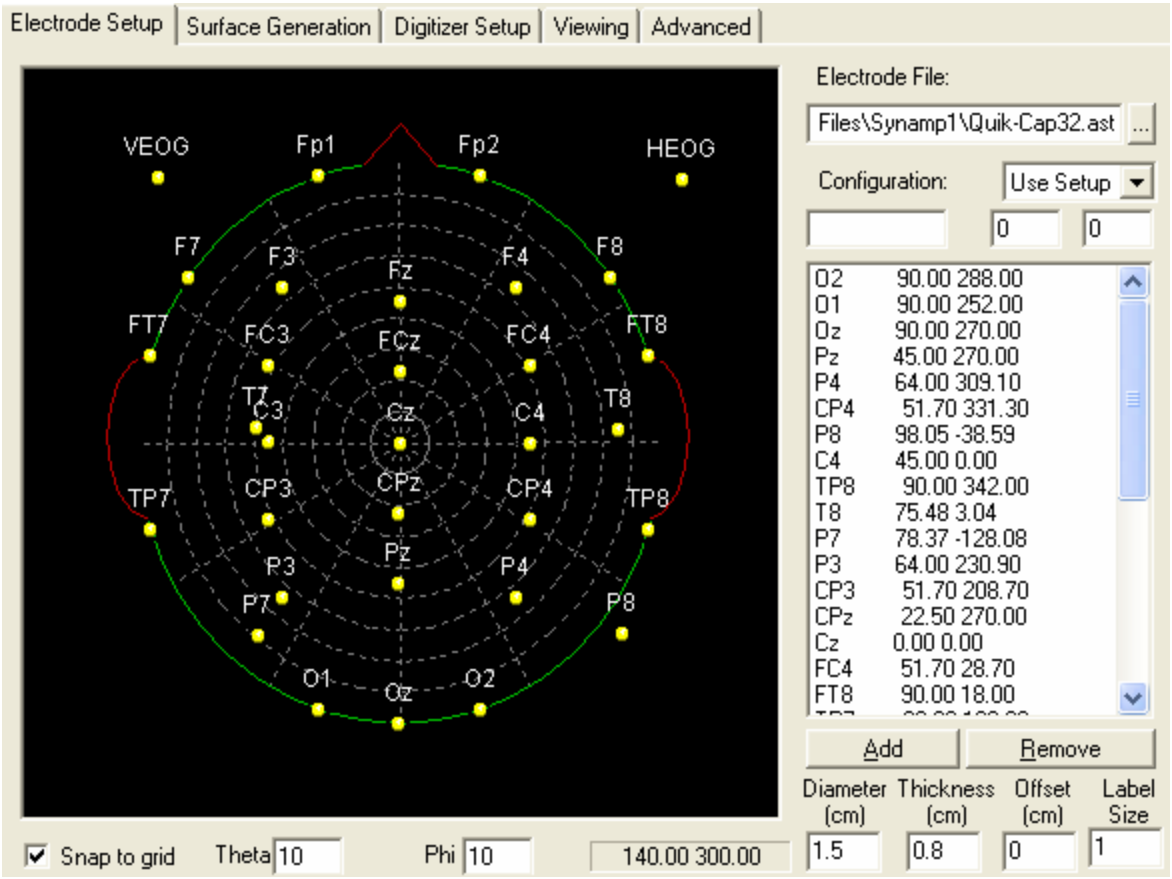
4. The first thing you need to do is to select a setup file, or other file containing the electrode label information. In 3DSpaceDx, click **Edit** → **Options**, or click the **Program Options** icon  .

5. You will see the Options display. There are 5 tabs: Electrode Setup, Surface Generation, Digitizer Setup, Viewing and Advanced. On the **Electrode Setup** display, you can select what file and type of file to use as a setup file for digitization. On the right side of the Electrode File line, you will see a Browse button  . Click it and you will see the standard Open File utility. In the Files of Type pull-down list, select Scan 4.0 Setup (*.ast), if needed, and select, for example, the *Quik-Cap32.ast* file from the ...*Scan4.5**Setup Files**SynAmps1* folder.



In normal use, you would likely start with an AST file. If you have a data file, but do not have the setup file used to create it, you can recreate the setup file simply by using the Create AST File option under Edit, in the EDIT program.

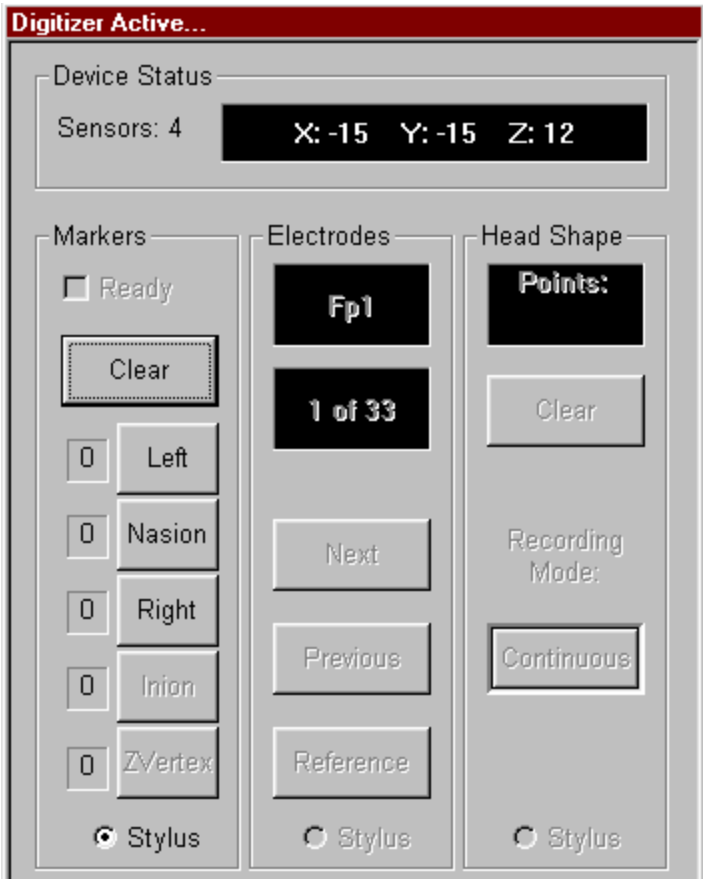
The electrode setup information for that file is then displayed.



Leave all the settings at their default values for this demonstration. Click OK.

6. Turn on the digitizer, if it is not already on. (If you have difficulty establishing communication between the digitizer and 3DSpaceDX, try turning the digitizer on *before* you enter 3DSpaceDx). It is assumed at this point that you have already made the necessary connections and entered the correct settings for communication between the digitizer and the PC. If not, please review these sections above. Now, select **Digitize** → **Record**, or click the **Digitize** icon  . You will see a message saying that the digitizer is being configured.

If you see any other messages, then there is a problem either with the communication between the devices, or with the digitizer itself. After the digitizer is configured, you will see a display on the right side of the screen.



The Device Status area will show how many sensors are detected (4), and the XYZ coordinates of the stylus. The rest of the display contains 3 columns: Markers, Electrodes, and Head Shape. In this tutorial, we will be using a model head with the measured electrode positions marked on the head. This will allow us to digitize the PAN coordinate markers, the electrodes, and the head shape in that order. In reality, you will likely perform the measurements in a different order. For example, you might digitize the PAN coordinates, then digitize the head shape. After that you would typically then put on an electrode cap, replace the sensors in their precise, original locations, and digitize the electrode positions (described in more detail below). This sequence allows you to digitize the head shape without having to go around the electrodes. To make the PAN measurements as accurate as possible, you should mark the Nasion, Left and Right measurement points with a wax pencil so you can identify the precise locations when you replace the sensors. If you plan on acquiring data from the same subject at separate points in time (across days), it would be beneficial to take pictures showing the precise marker measurements. It is very important to obtain as identical as possible marker measurements.

It is necessary to digitize the PAN coordinates first. These are the left and right preauricular points and the nasion. These are the 3 required points to form the reference plane. Place the stylus tip at the left preauricular point (detailed below) and click the button on the stylus one time. You should see a "1" by the Left button when the point has been digitized. Repeat the same operations for the Nasion and Right preauricular points. If you make a mistake, you can click the Clear

button to start over.

You can obtain repeated measurements of the 3 points for more precise calculations (it is a good idea to digitize the points 3 times each). Note that the program will cycle from Left to Nasion to Right repeatedly. You also have the option to digitize the Inion and ZVertex, if so desired. These points may be used by other source localization software, such as Curry. They are not required for 3DSpaceDx.

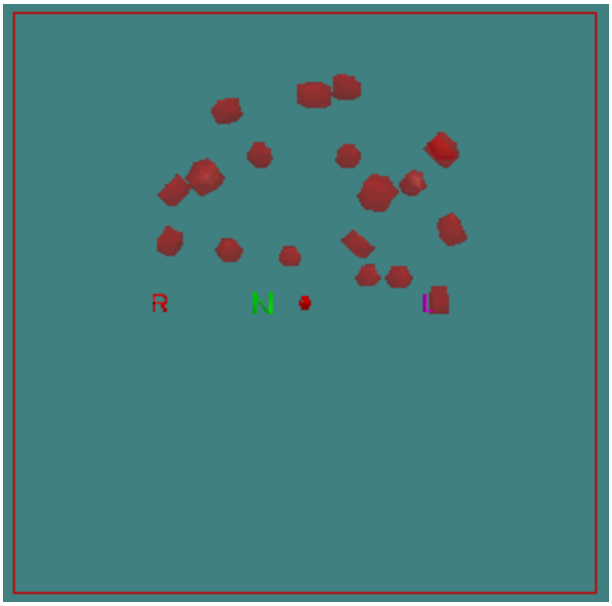
As you digitize the PAN coordinates, you will see the points appear on the screen (L, R, and N). You can enlarge the display by clicking the Enlarge icon  . Your display now may appear similar to the following.

7. Next, we will digitize the electrode positions. Click the Stylus button at the bottom of the Electrodes column.

The first electrode in your setup file will appear in the top window. Digitize each

electrode position, in the same way that you obtained the PAN coordinate positions. If you make a mistake, you can use the Next and Previous buttons to step through the electrode sequence and redigitize the electrodes, as needed. After the electrodes are digitized you will be asked for the Reference electrode, which we will ignore for this demonstration. Locating the reference electrode position is useful for source analysis programs.

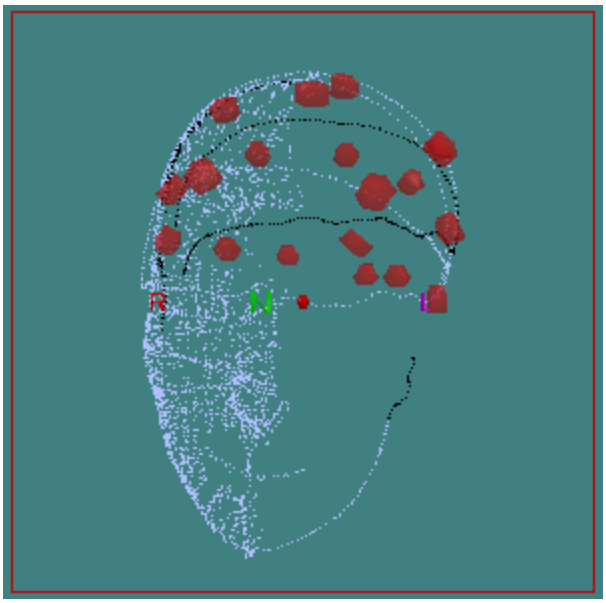
You will see each electrode appear on the screen as it is digitized. The final display may look similar to the following (the red square and center dot seen in this and in subsequent figures are part the Cut Plane editing tool, explained below).



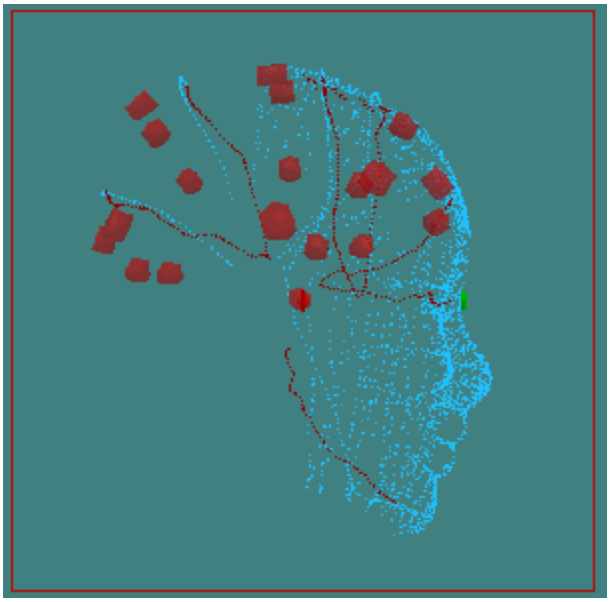
8. The next step is to digitize the head shape. Click the Stylus button at the bottom of the Head Shape column.

The Points counter at the top will keep a running count of the number of digitized points. You may toggle the Continuous button to "Single", if you wish to do single point digitization (Continuous digitization is typical). If you make any serious mistakes during digitization and wish to start over, click the Clear button.

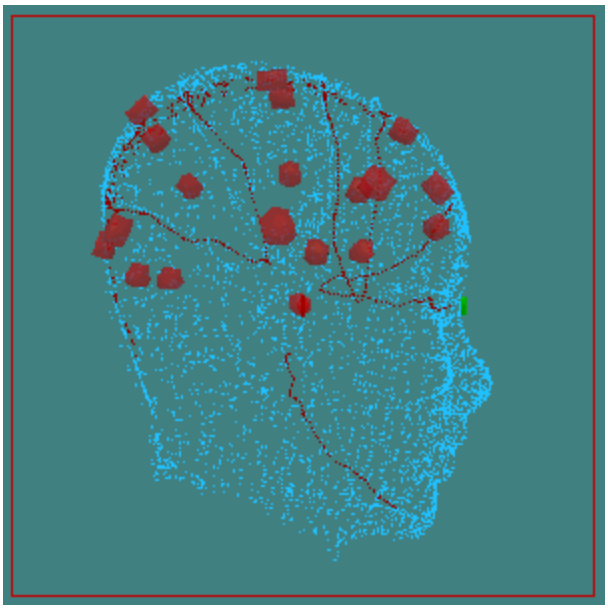
When you are ready to begin digitizing the head shape, place the tip of the stylus at a point on the head. The idea is to digitize all surfaces from the neck up. If you divide the head into regions, it is easier to keep track of what you have and have not sampled. Keep the stylus tip in contact with the surface being sampled. Digitization will occur as long as you hold the stylus button down. If you have your sound system activated on your PC, you will hear the points as they are being acquired. Release the button BEFORE you remove the stylus from the head, and press the button AFTER you make new contact with the head, in order to avoid spurious points being digitized. Don't move the stylus too fast. You should see the points appearing on the display in 3DSpaceDx along with your actual movements about the head. If you move the stylus faster than the data transfer can manage, you will lose points and have to make more passes over the same area. Below is an example of the right facial area.



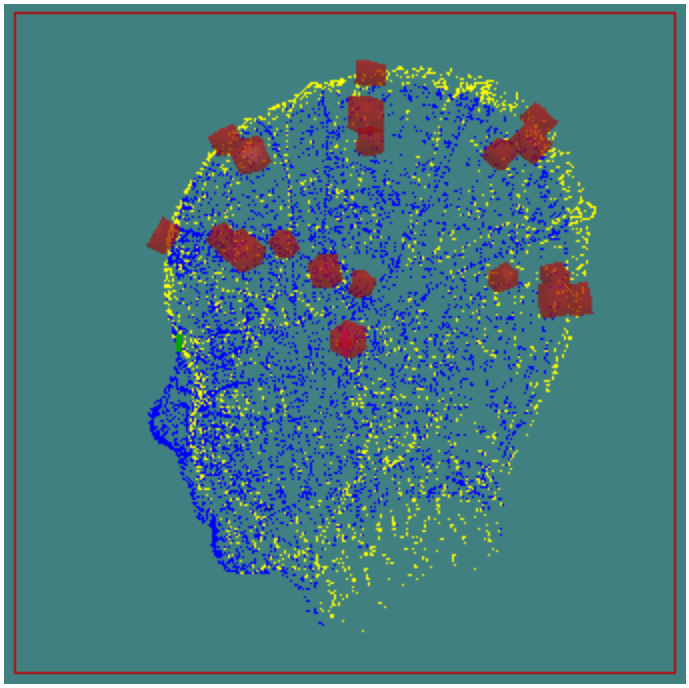
Note that you can change the orientation of the head using the Toolbar icons to get different perspectives.



Below is a view of the right side of the head following digitization.

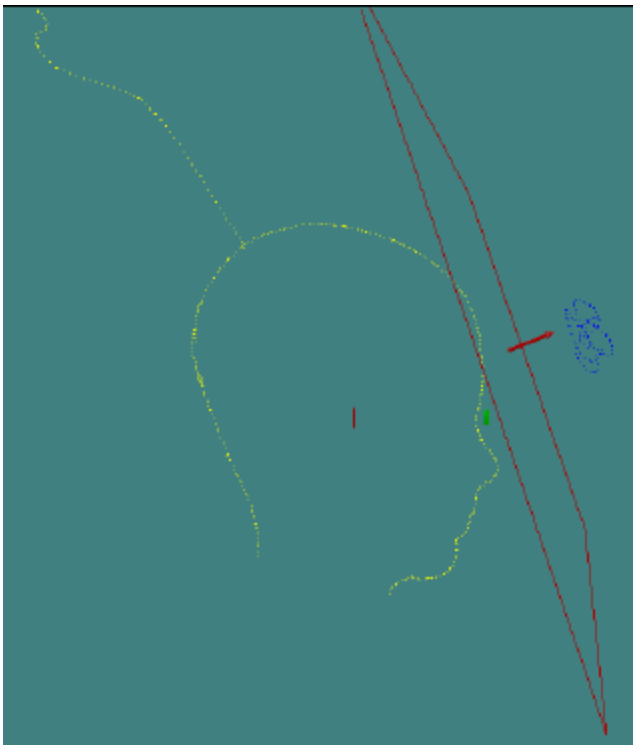


The final head shape may appear similar to the following. The different colors, in this example, are the result of the Cut Plane position. Points behind and in front of the Cut Plane have different colors (described in more detail below).



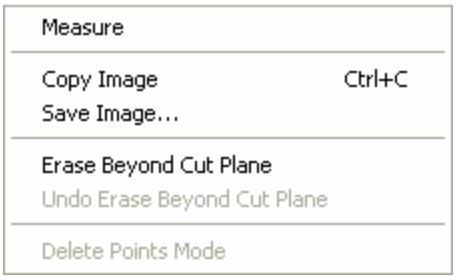
9. Editing spurious points. If you are new to digitizing, you will likely digitize errant points by mistake. This can easily happen if you pull the stylus away from the head while the button is still being pressed. There are two ways to remove unwanted points - the Cut Plane and the Delete Points Mode. The Cut Plane is useful when there is a whole section of bad points that can easily be sectioned off from the good points. The Delete Points Mode is used to remove individual points, one at a time, and is good for getting into tight places. We'll use the Cut Plane tool first.

Click on the Cut plane icon  . Below is a partially digitized head shape, with a cluster of errant points in the front and a mistaken string going off from the back of the head.

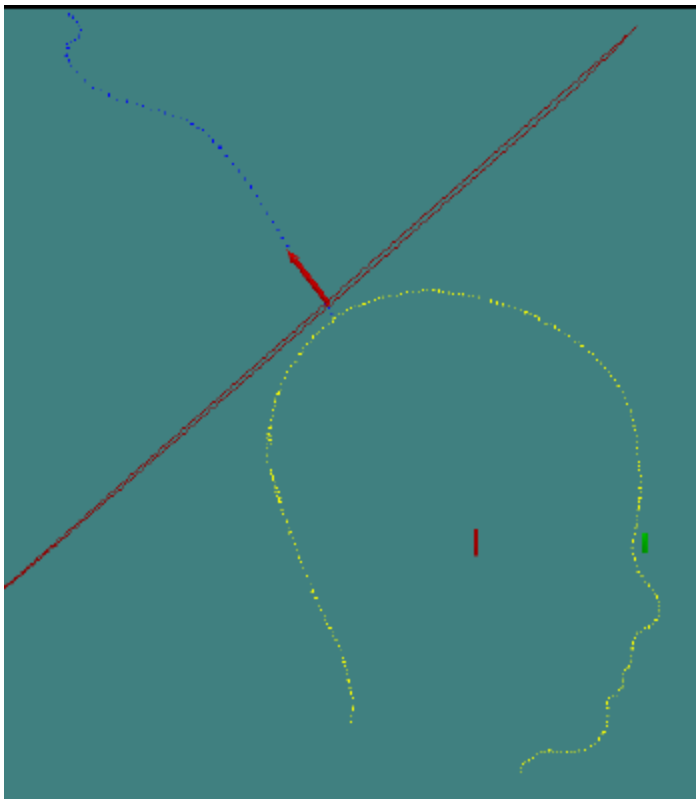


When the Cut Plane icon is first clicked, you will see a square encompassing the center of the screen. In the center of the square, there is a spot. Grab the spot with the mouse, using the left mouse button. By moving the mouse around, you will see that the spot is, in fact, a pointer, and that the square plane can be rotated. If you grab the pointer with the right mouse button, you can move the entire tool. The idea is to first position the pointer between the region of digitized points you want to remove, then rotate the square in such a way so that the pointer is directed away from the digitized points you want to retain (see the figure below).

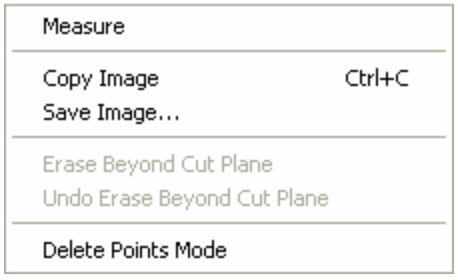
Notice that the color of the digitized points will change, depending on the position of the Cut Plane. When you have successfully segregated the bad points from the good ones, click the right button. You probably have already seen the list of options accessed from the right mouse button.



Select the Erase Beyond Cut Plane line, and the unwanted points will be removed. If you made a mistake, click the right button again, and select the Undo Erase Beyond Cut Plane line. The other unwanted string of points in the figure above may be removed in the same way.



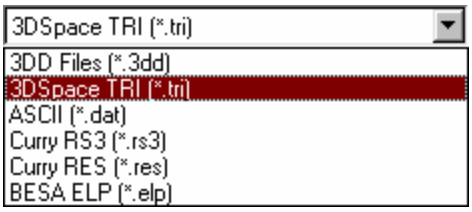
Alternatively, you can delete the bad points one at a time. Click the right mouse button in the digitization screen, and see the following list of options. Select the Delete Points Mode.



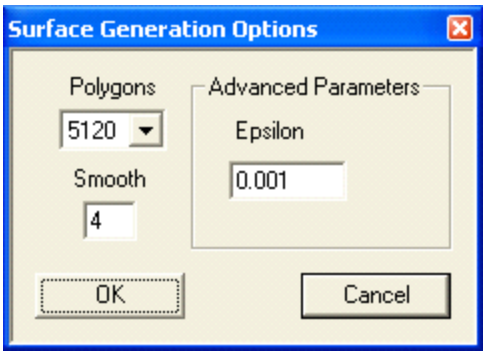
The appearance of digitized points will change slightly. Position the mouse cursor over a bad point, and click the left mouse button to remove it. Remove all unwanted points this way. When you are finished, click the right mouse button again, and disable the Delete Points Mode.

10. Now that you have the head shape digitized and corrected, the next step is to create a triangulated rendering. This is also an opportunity to save the file in

whatever forms may be needed. The file types are discussed more thoroughly in the Import and Export tutorial below. Exit digitizer mode. Click **File** → **Save As...**, and you will see a standard Save File utility. *(Note: the same results may be obtained using the **Convert 3DD** option under **Utilities**).* Click the down arrow for Files Types to see the options for saving files.



For now, select the 3DSpaceDx Files (*.tri) option, enter a file name and path, and click Save. When you convert a 3DD file to a TRI file, you will see the following screen.

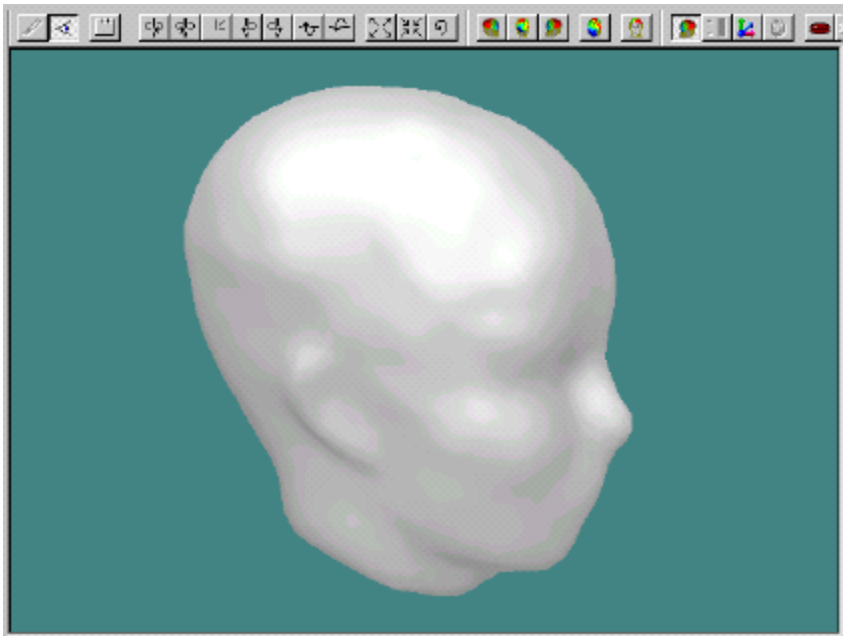


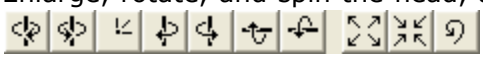
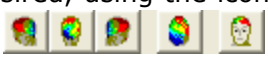
The *Polygons* and *Smooth* fields allow you to set the number of polygon surfaces and degree of smoothing for use in TRI file calculations. The number of polygons determines the number of facets on the head shape. The Smooth field is an iterative setting, and determines the number of smoothing passes that are made. The greater the number of smoothings, the smoother the surface of the head shape will be. The default settings, 5120 and 4, typically result in a smooth rendering of the head shape. You can increase or decrease these as desired.

> *Epsilon* sets the convergence criterion used in creating the TRI file. The smaller the number, the better the convergence, or "fit". Below a certain point, the smaller epsilon number will have no additional effect. The default "0.001" works well in most instances.

You will see a series of operations be calculated on the Status Bar at the bottom of the 3DSpaceDx screen (Surface transforms, Equilibrating surface, etc.). When it stops, the .tri file has been calculated and saved.

11. To view the .tri file, close the 3DD file, then click **File** → **Open**, or click the  icon. A standard Open Files utility will appear. Select the file you just saved, and click Open. You will see the results of the triangulation rendering.



Enlarge, rotate, and spin the head, as desired, using the icons on the Toolbar  and  . You may also display the color scale, electrodes, labels, axes, etc., using other icons  . The functions of all of the icons are described in the *Operating 3DSpaceDx* section of the manual. However, holding the mouse over any of the icons will give a brief description of what the button does, and the functions are fairly self-evident when you try them.

When acquiring a complete head shape, a 2 dimensional projection of 3 dimensional points often can present problems with the viewing of points at different planes or depths. There are two ways to help visualize these points.

One method is to use the Spin and different View icons. By spinning the head around, or by looking at it from different angles, you can get an idea of which sections need more sampling.

A second method is to use the **Cut Plane** editing tool. To use the Cut Plane tool, click on its icon from the Toolbar  . You will see a square appear around the head shape you are creating. The directions for controlling the Cut Plane tool are presented in detail earlier in this tutorial. It is mentioned there that the color of the digitized points will change depending on which side of the Cut Plane they fall. By angling the Cut Plane in different orientations, and by moving the Cut Plane and watching the points change color, you can get an idea of regions that may be undersampled.

This last step completes the electrode and head shape tutorial. In this tutorial you learned to:

- Position the subject, receivers, and transmitter

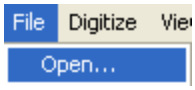
- Load a setup file
- Digitize the PAN markers
- Digitize the electrode positions
- Digitize the head shape
- Use the Cut Plane

2.3 Tutorial 3: Exporting and Importing Data

Getting data in and out of the program is an important component of any software package. In the case of 3DSpaceDx the electrode locations are of particular importance for source analysis software. In this tutorial we will illustrate first how to export the data to the Curry source analysis program. Next we will perform a basic import of a data file in ASCII format.

Exporting data to Curry

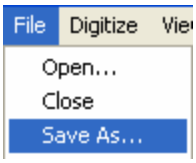
1. The Curry source analysis software provides a method to load information about the electrode locations in the form of a *.res, .rs3*, or *.3dd* file (*.rs3* files are used with Curry 4; 3dd files are used with Curry 5 and 6). The *.res* and *.rs3* files are expected to contain specific information regarding marker and electrode positions, as is contained in *.3dd* files. To export a file, first load a *.3dd* file. *Note: if you have Curry 5, you can use the .3dd as it is. Source and PCA/ICA also use the .3dd file as it is*. This file must contain information about electrode positions and the PAN marker coordinates.

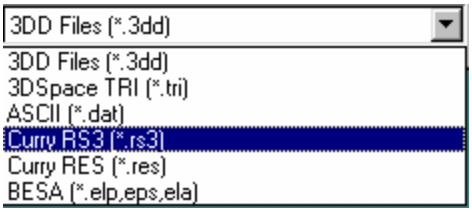
   Click **File** → **Open** 

. A standard Open File utility will appear. Click on the down arrow by the Files of type line to see the types of files that can be imported.

   Set the file type to 3DD files (.3DD), and select the demo file *Quik-Cap32.3dd*, (\ *Scan Data**Demo Files**3DD Files*) and click Open.

2. Now, we want to export that file for use with Curry 3 or 4 (you do not need to do this if you have Curry 5 or 6). Click **File** → **Save As...**, or click the **Save As** icon  from the Toolbar, and a Save As... window will appear.





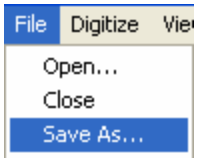
Click the pull-down arrow for the Save as Type, and select the Curry (.rs3) option. Designate a path, enter a file name, and click Save.

Shown below is a section of the output of the Curry *.res* file; *.rs3* files are more complex, but may also be viewed with, for example, Wordpad. The first three lines of the *.res* file correspond to the right, left and nasion PAN coordinates. The negative numbers in the first column are used by Curry to indicate that marker coordinates follow. The next three columns correspond to X, Y and Z coordinates in millimeters. The last column is not used.

```
-1    73.0234    -0.0000     0.0000    0
-2   -73.0234     0.0000     0.0000    0
-3     5.1842    95.0867    -0.0000    0
 1   -30.4051   112.1919    79.0192    0
 2    -4.4969   116.2886    84.4968    0
 3    21.8114   112.7396    85.5357    0
 4   -24.0390   107.3898    98.1682    0
 5    10.5042   107.9228   102.3886    0
 6   -58.7389    88.7976    73.2008    0
 7   -45.1840    88.8573   103.8730    0
 8    28.6168    90.7654   109.9878    0
 9    48.2141    95.2426    87.5745    0
10   -57.5731    77.6315    96.2994    0
11 .....
```

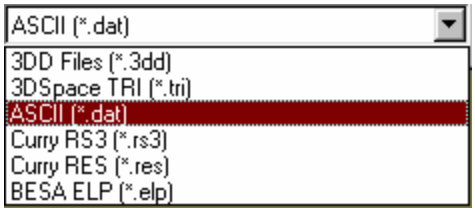
To use this file in Curry copy the file to the desired directory and follow the instructions in the Curry manual.

Exporting data in ASCII format



1. The first step is to import a data file that you want to export. Let's use the same *mac.3dd* file from the previous example for exporting to Curry. Assuming that you have retrieved the file, as in the previous example, the next step to obtain an ASCII file of the data is to click **File** → **Save As...**.

2. A standard Save As utility will appear. Select the ASCII (*.dat) file type, then designate



a path, enter a file name, and click Save. Shown below is a section of the output

of the ASCII file. The first column is used as a text label field. The first three lines correspond to the PAN markers. Lines 4-124 correspond to electrode positions. The line labeled centroid corresponds to the computed center. The remaining lines starting with the number 32 correspond to surface points. The values are used to identify each line and the following table can be used to decode each number:

Number	Meaning
78	Nasion marker
76	Left marker
82	Right marker
69	Electrode
32	surface point

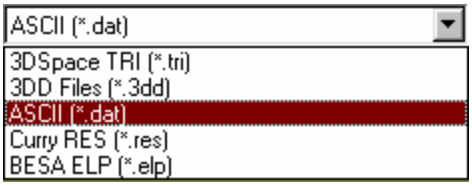
The last three columns correspond to the X, Y, and Z values for each point in centimeters. *Note - all values are relative to the computed centroid.*

Nasion	78	2.796448	9.102936	-0.002365
Left	76	6.802643	-2.505890	-0.87681
Right	82	-6.802643	2.505890	0.876816
1	69	-3.040512	11.219193	7.901917
2	69	-0.449692	11.628860	8.449677
3	69	2.181137	11.273956	8.553574
4	69	-2.403900	10.738983	9.816818
5	69	1.050415	10.792282	10.238861
6	69	-5.873886	8.879761	7.320084
7	69	-4.518402	8.885727	10.387299
8	69	2.861679	9.076538	10.998779
9	69	4.821411	9.524261	8.757446
10	69	-5.757309	7.763153	9.629944.....
Centroid	67	0.000000	0.000000	0.000000
	32	2.285919	3.800034	13.978745
	32	2.240265	3.822693	14.042313
	32	2.295517	3.940018	14.164398

Importing data in ASCII format

1. To obtain an ASCII import of the data, select **File** → **Open**.

2. A standard Open File utility will appear. Click on the down arrow by the "Files of type" line, and select the ASCII (*.dat) file type. Select the file and click Open to import the file.



The file format for an ASCII import is identical to the export format.

*Hint - One way to modify a 3DD file is to export it to a *.dat and then edit it with an ASCII text editor. This procedure can be used to remove unwanted electrodes or other data points from the file. After the file has been edited use the Import ASCII File option to load the modified data.*

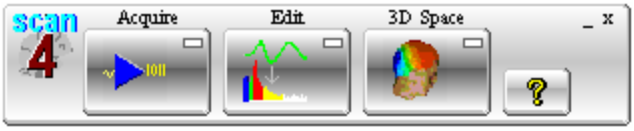
This last step completes the Exporting and Importing data tutorial. In this tutorial you learned to:

- Export a file to CURRY
- Export an ASCII file
- Import an ASCII file

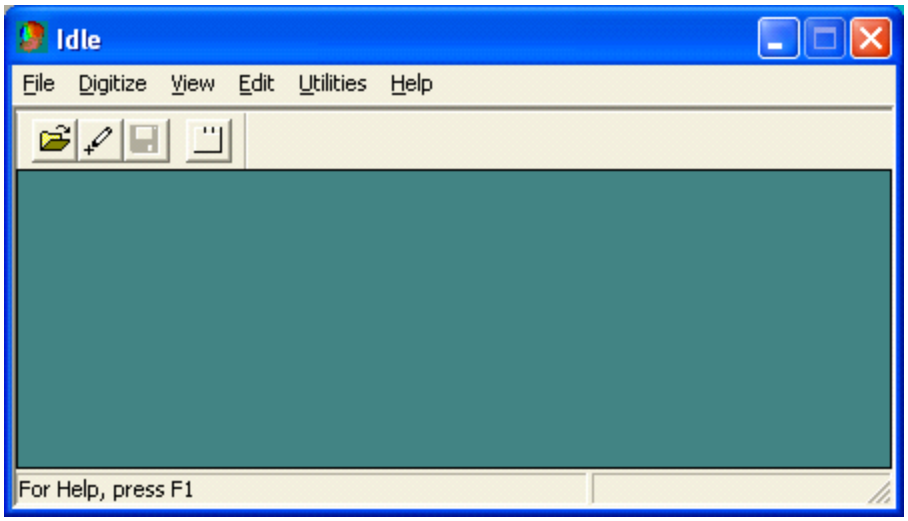
3 Operating 3DSpaceDx

To start 3DSpaceDx, double click on the SCAN 4.5 icon 

, and the SCAN 4.5 Program Launcher will appear.



Click on the 3DSpaceDx icon, and the Main Screen of 3DSpaceDx will appear.

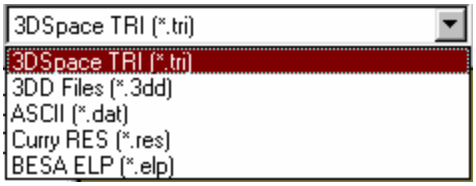


A description of the 3DSpaceDx Main Menu bar selections and their associated fields are listed below:

3.1 File

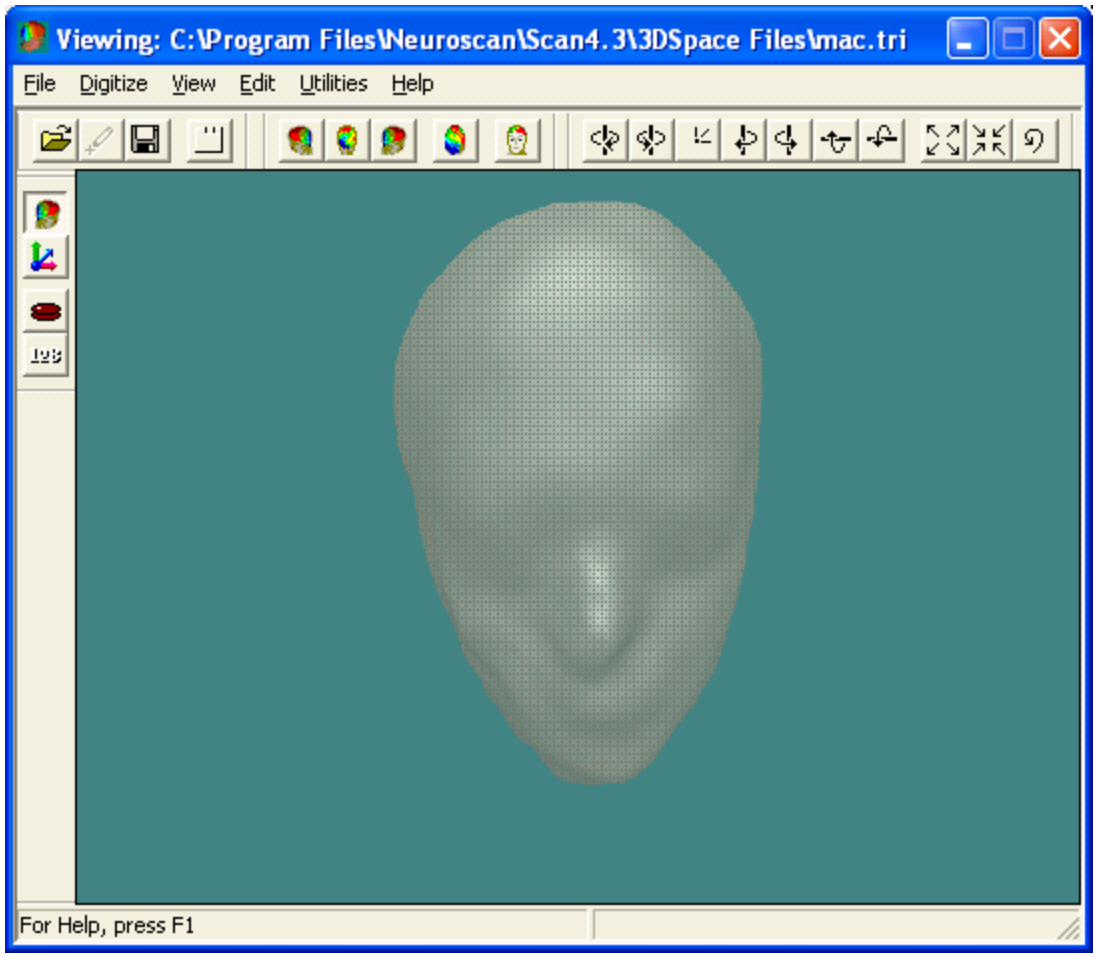
When you select the **File** option, you will see a menu with the following options.

Open... - The **Open** option calls a standard open file utility. Click the pull down arrow at the end of the Files of Type field to see the types of files that may be opened.

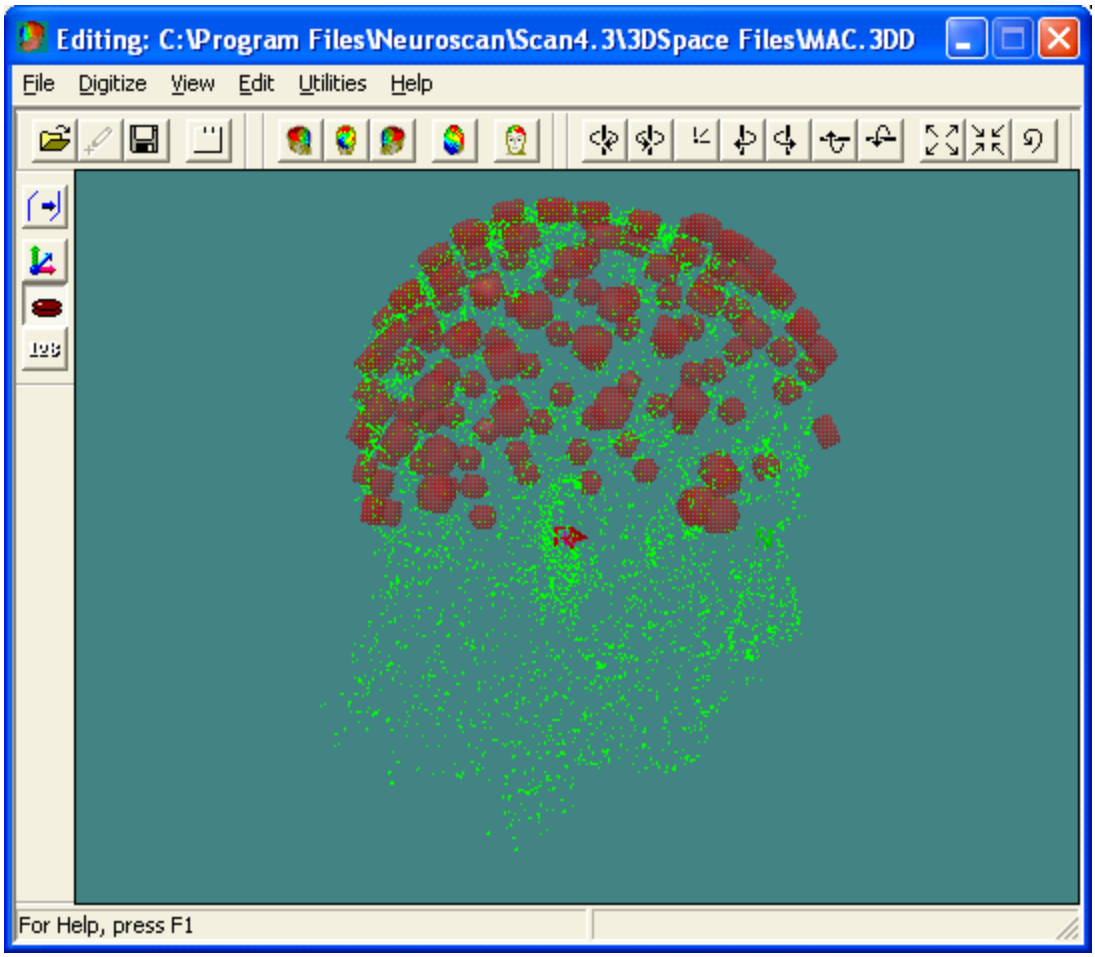


The 3DSpaceDx program opens 5 file types - .tri, .3dd, .dat, .res, and .elp.

***.tri** files. TRI, or triangulated, files are created from 3DD files. 3DD files contain the PAN coordinate position data, the electrode position data, and the raw digitized head shape points. The 3DD files are converted to TRI files, which are displayed as a realistic head shape rendering. An example of a TRI file is shown below (this is the *mac.tri* demo file). Notice that many more Toolbar icons appear when you open a data file. These are used to control the position, size, and other display features, and are described below.



***.3dd** files. 3DD files contain the raw digitized PAN, electrode position and head shape point locations. 3DD files may be converted to TRI files by using the Convert 3dd... option under Utilities, or the Save As option, as described below. An example of a 3DD file is shown below (this is the *mac.3DD* demo file).



***.dat** files. DAT files are text files that contain PAN coordinate, electrode position and label, centroid, and head shape information. An example is given in the Import\Export tutorial above.

***.res** files. RES files are text files used by Curry, and contain PAN coordinate and electrode position information. An example is given in the Import\Export tutorial above. (RS3 files are used by Curry 4 and 5 - see the RS3 file section below under Save As).

***.elp** files. ELP files are text files used by BESA, and contain theta, phi and "w" electrode position information.

Mouse and Keyboard Display Controls. Once you have retrieved a TRI file, you can spin, rotate, resize it and so forth using the Toolbar icons, as described in the Toolbar section below (these controls function with TRI files, but not 3DD files). There are additional ways you can control the display using the left and right mouse buttons and the arrow keys on the keyboard. *Note: These operations have the same effect on objects in the digitizer display. You can spin, rotate, resize, etc. the points when you digitize them.*

Left mouse button positioning. With the TRI file retrieved, position the mouse on the display, and click and hold the left mouse button. Then move the

mouse in the left or right direction. In this way, you can manually spin the head in either direction. You can also grab the head with the left mouse button and spin it up or down, or in any direction. To return the head to its original position, click the Reset orientation and/or Reset view icons on the Toolbar  or  .

Right mouse button positioning. In a similar fashion, you can grab the head with the right mouse button, and move the head around the display screen. Note that when you do this, you are actually changing your viewing perspective to the head. By moving the head to the right side of the screen, for example, you are actually seeing it from your original fixed position, so the perspective will change somewhat.

When you release the right mouse button, you will see a menu option screen (left click outside the menu to close it). These options will be explained below.

Arrow keys. The arrow keys on the keyboard can also be used to position the head. Be sure you have clicked the mouse inside the display area once (to give that window the focus). The Up and Down arrow keys can be used to enlarge or reduce the size of the TRI file (or graphics in the digitizer display screen). The left and right arrow keys perform the same operation as grabbing the head with the Right mouse button and moving it left and right.

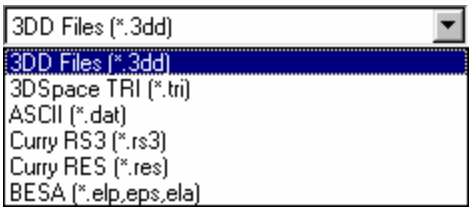
CTRL + arrow keys. You can also change perspectives by using the combination of the CTRL key and the arrow keys. Using *CTRL + left or right arrow* keys gives changing perspectives from a camera lens view (with some peripheral distortion). Note that the direction of the head movement with respect to the keys pressed is opposite. That is because it is the orientation of you, the camera lens viewer, that is changing, rather than the object viewed. The *CTRL + up or down arrow* keys shift position of the camera lens view down or up, respectively.

Shift + arrow keys. The combination of the *Shift + up or down arrow* keys has the same effect as dragging the head up and down with the right mouse button.

Note: The mouse and arrow keys have similar functions with objects on the digitizer display screen. When Editing, it may be useful to use a combination of zoom and position operations to isolate bad points, then use the Cut Plane Editing tool to remove them. All of the keyboard options may be used with a 3DD file; however, some are not operational with other types of files.

Close... - The **Close** option closes the file currently being displayed.

Save As... - The **Save As...** option opens a standard Save As utility screen. Depending on the type of file you have open, you will see the option to save the file as one of the following types.



These are described above under Open. The Open and Save As options can be used to convert files from one type to another. For example, you may retrieve a .3DD, and save it as a .TRI file. This performs the same conversion as the Convert 3DD option under Utilities.

***.rs3 / *res** - rs3 and res files are used by Curry. These options appear only when you are saving a 3DD file.

BESA (*.elp, eps, ela) - These files are used by BESA. These options appear only when you are saving a 3DD file.

Exit - Exits the 3DSpaceDx program.

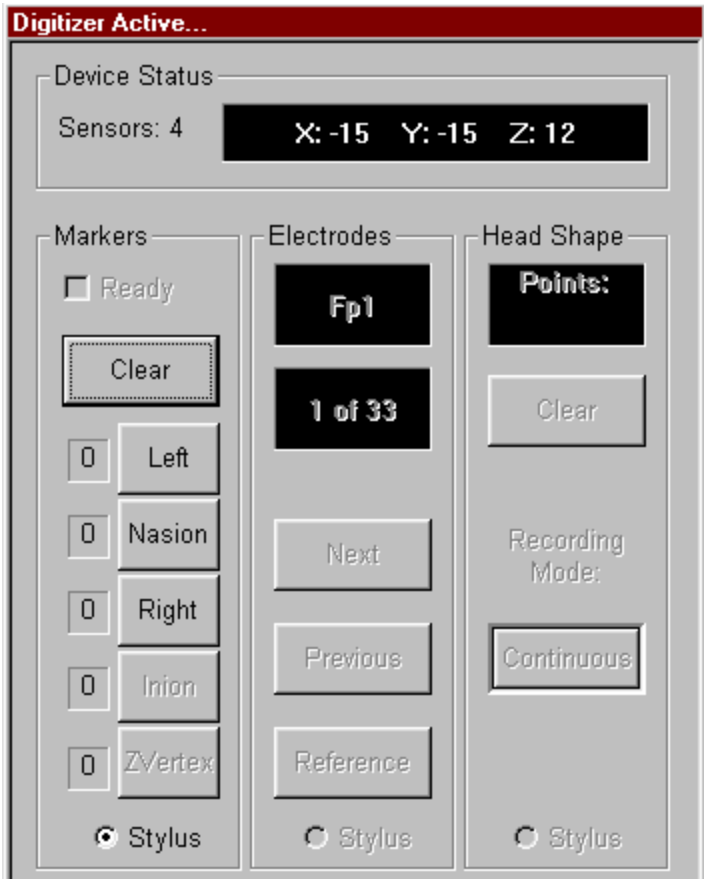
3.2 Digitize

The Digitize menu consists of two options 

.

Record. The option is used when you are ready to digitize the various points from the subject's head. Make sure your digitizer is already connected and on (before going into 3DSpaceDx). After you click the Record option, you should see the following screen. You should also see the light on the front of the FASTRAK blink about 5 times as it is being configured.

If you see any other messages, then there is a problem either with the communication between the devices, or with the digitizer itself. After the digitizer is configured, you will see the following screen.

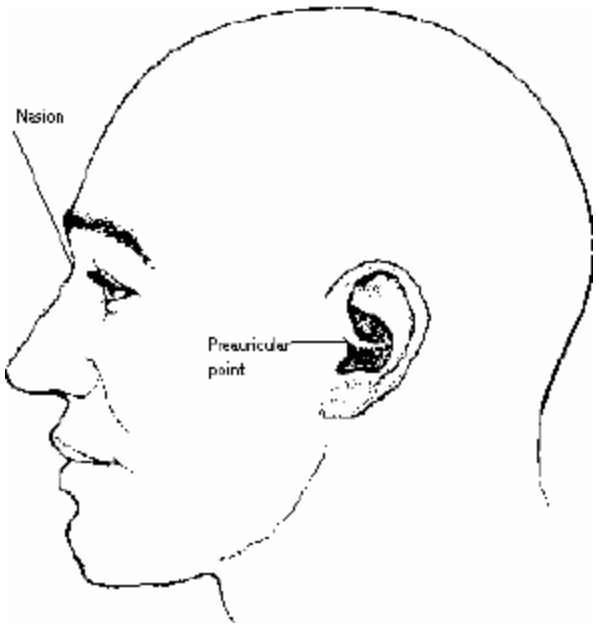


Beginning with SCAN 4.2, you can access this screen even if you have no digitizer connected. In that case, the Device Status field will read NO DIGITIZER HARDWARE .

The screen is divided into 4 sections: Device Status, Markers, Electrodes and Head Shape.

Device Status. This region gives information about the status of your digitizer. You should see 4 sensors and the X, Y and Z coordinates of the stylus tip.

Markers. The initial step in the digitization process is to digitize the structural landmarks. These points are used when combining these data with other data for source localization analyses (as with Curry). Five landmarks are possible: Left preauricular, Nasion, Right preauricular, Inion, and ZVertex (or Cz). 3DSpaceDx requires only the first three - the others are there if you wish to obtain them. The location of the Nasion and Preauricular points are shown in the diagram below.



The program is set for repeated measurements of the Left and Right preauricular points and the Nasion. Together, these are referred to as the PAN markers. Position the stylus at the left preauricular point, and click the stylus button. If you have the sound system activated on your PC, you should hear a tone when you press the stylus button. You should see the "0" change to a "1" beside the Left field. Repeat the process to obtain the Nasion and Right positions. A check mark will appear in the "Ready" field above. At this point, you may digitize the electrode positions or head shape, however, the accurate measurement of the PAN coordinates is very important. We recommend that you repeat the sequence of measurement of the points at least 3 times. The program will automatically go back to the Left point after your obtain the Right one, for this reason. The average of the points will be calculated and stored. If you wish to obtain the Inion or ZVertex, click either button with the mouse, then digitize the point as usual.

CZ Finder. The ZVertex button can also be used in the automatic CZ Finder routine. For this option, the audio part of your PC should be enabled. Find the PAN coordinates as described above. Then click the ZVertex button. Move the cursor in the vicinity of CZ on the subject's head. When you are close to CZ (within about 1 cm), you will hear a continuous hum/buzz from your computer. This is a useful landmark for placing the CZ electrode, or for insuring that the cap is positioned correctly.

Electrodes. It is necessary to have selected a setup file, or other file containing electrode information, prior to digitizing the electrode positions (described below). The first in the sequence of electrodes will be displayed in the top field. The field below it shows the number of the electrode from the electrode list. Position the stylus tip on the indicated electrode, and click the stylus button one time. If you have the sound system activated on your PC, you should hear a tone when you press the stylus button. The next electrode in the sequence will then be displayed. Proceed through the sequence, digitizing all electrodes. If you make a mistake, you can use the Next and Previous buttons to step through the sequence to get to the electrode to be redigitized. At the end of the sequence you will be asked for the Reference electrode. This is not needed for digitizing in 3DSpaceDx, but it may be

necessary for source localization. If you are using a linked ears reference, you should skip digitization of the ears. For a single reference, position and click the stylus. You can digitize the reference at any time by clicking the Reference button, then digitize as normal.

Head Shape. The Points counter will keep a running total of the number of points digitized. *Note: When you are not sure if the points are being registered, because there may be so many in the area you are digitizing, you can always check the counter to see if it is incrementing.*

The Recording Mode may be toggled between Continuous and Single point digitization. Typically, you would use Continuous mode for head shape measurement. As long as you hold the stylus button down, digitization will continue. If you have the sound system activated on your PC, you should hear a tone when you press the stylus button. In Single Point mode, digitization will occur one point at a time. In other words, you need to press the stylus button for each single point.

Note
You do not need to digitize the head shape if all you want to do is use the electrode and landmark positions in Source, PCA/ICA, or Curry. The head shape is used in 3D mapping in EDIT.

Fit Surface. Fit Surface will calculate the head shape using only the points that have been digitized up to a given point. It will place the points in a regular array, removing the redundant ones. It will help you determine when you have collected enough points to generate a realistic head shape.

3.3 View

The View option is used for sizing and positioning the 3DD or TRI displays. Click the View option from the Main Menu line, and you will see the following options.

Most of the options can be accessed more easily from icons on the Toolbar, described below. Note that the left and right mouse buttons, and arrow keys on the keyboard, perform the same or similar functions of the icons. *Note: You need to have a 3DD or TRI file displayed to activate some of these options*.

Image Size

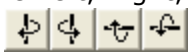
Enlarge. Enlarges the head size. This has the same function as the  icon, and

the up arrow from the keyboard.

Reduce. Reduces the head size. This has the same function as the  icon, and the down arrow from the keyboard.

Orientation

Head. Allows you to select the Left, Right, Front, Back or Top views of the head. You may also use the  icons from the Toolbar to select the different views.

Rotate. Allows you to rotate the head in the Left, Right, Up or Down directions in 45 degree intervals. You may also use the  icons from the Toolbar to perform the rotations.

Reset orientation. Resets the head to its initial orientation. You may also use the  icon from the Toolbar to perform the same function.

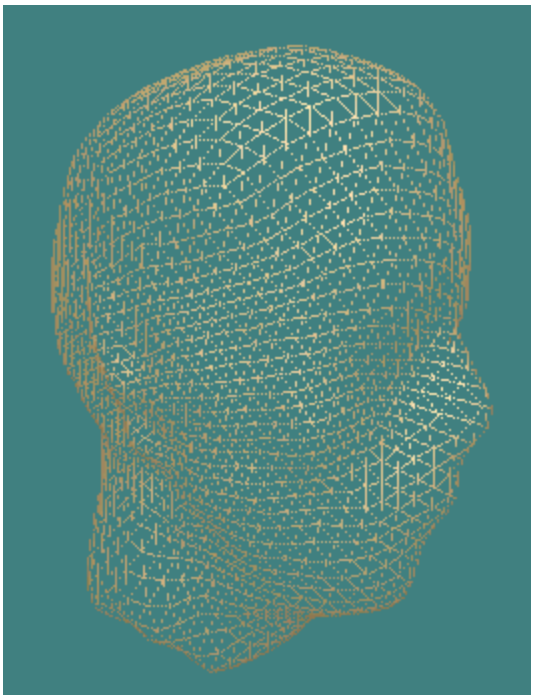
Spin. Starts the head spinning in either Left (clockwise) or Right (counterclockwise) direction. You may also use the  icons from the Toolbar to spin the head in either the left or right direction. The rate of the spin is set under **Edit** → **Options** (or the Options icon  from the Toolbar), then the Viewing tab, and Spin Rate field.

Objects

Axes. Displays the x, y, and z axes. The  icon from the Toolbar may also be used to toggle the axes on and off.

Head Surface. Displays the head shape. The  icon will also toggle the display of the head shape on and off.

Wireframe Head. This option will display the head as a wire frame rendering, as shown below.



Electrodes. This option is used to display the electrode shapes on the head surface. The  icon may also be used to toggle the electrodes display.

Electrode Labels. This option is used to display the electrode labels on the electrodes. It may be accessed also with the  icon. You can change the color of the labels by going to **Edit\ Options** (or by clicking the  icon), then clicking the Viewing tab. In the Window Colors area, select Foreground, and choose a different color from the palette.

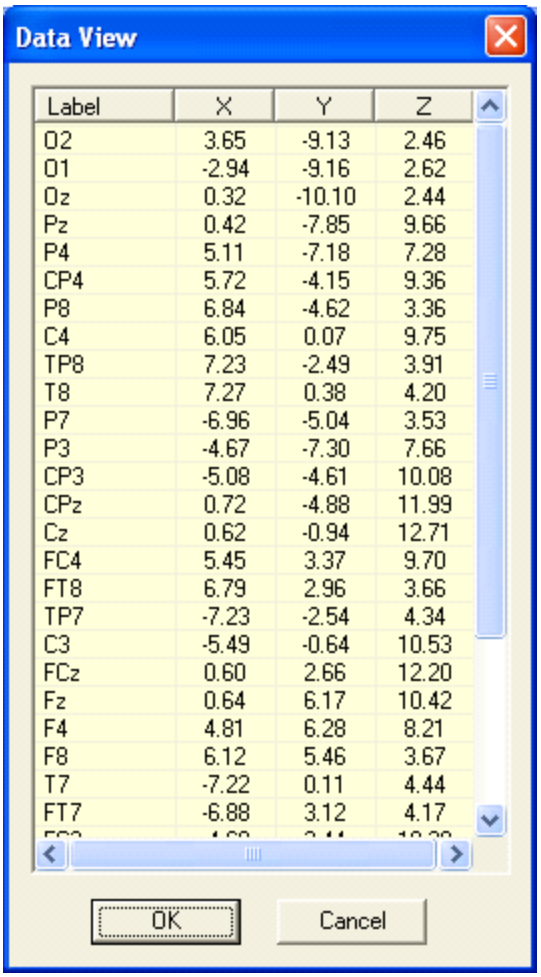
Use Cut Plane. The Cut Plane is an editing tool for use when you wish to remove areas of unwanted points that have been digitized (described in more detail below). You may also use the  icon to toggle the Cut Plane on and off.

Reset Camera. This option returns the camera perspective of the head to its original position. It may be access also from the  icon.

Toolbars. The Toolbars line, when checked, will display the Toolbar icons, described below.

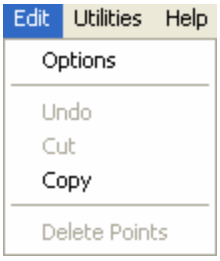
Status bar. The Status bar line, when checked, displayed the Status bar at the bottom of the main display (contents described below).

XYZ Values. Retrieve a 3DD file and select this option to see the XYZ coordinates for the electrodes.

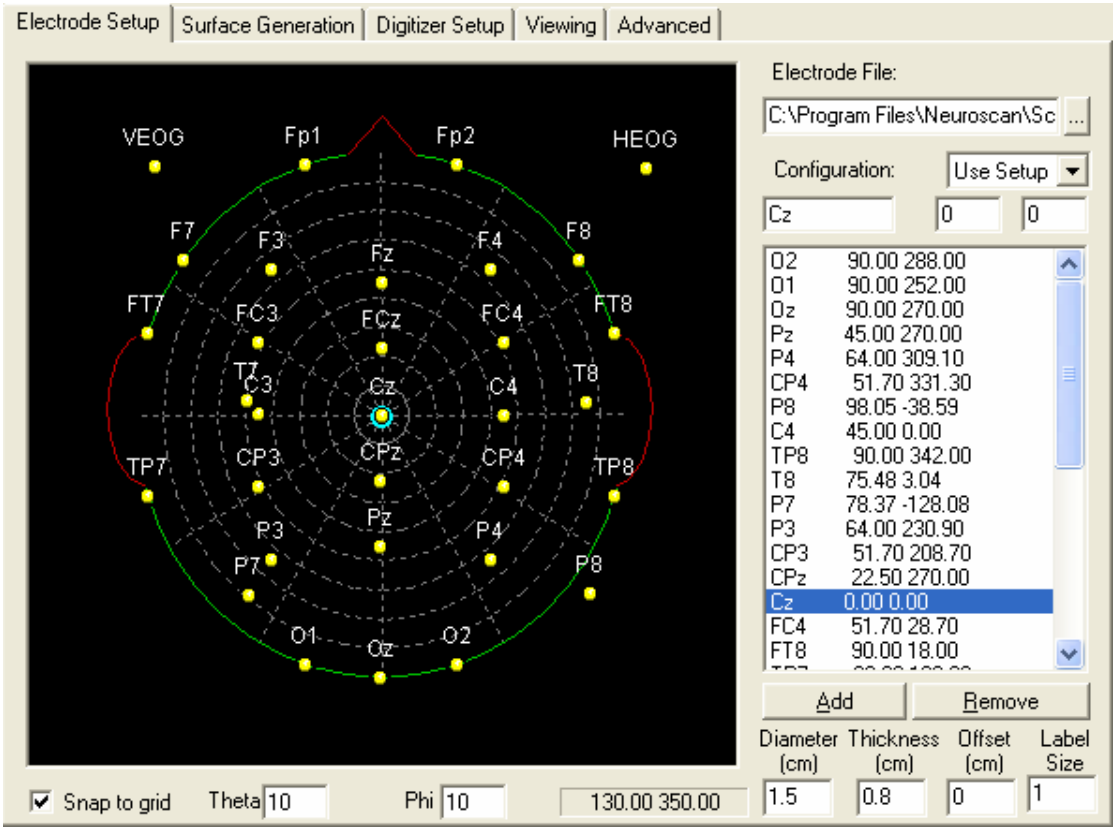


3.4 Edit

The Edit section allows you to select and modify setup files, enter a wide variety of parameter settings, delete spurious points that have been digitized, and other options. Click the Edit option to see the following menu list.



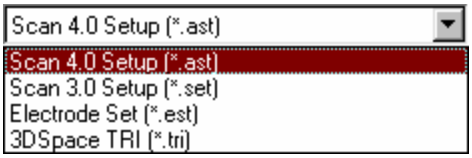
Options. Clicking the options feature displays a multi-tab display with the Electrode Setup "card" on top.



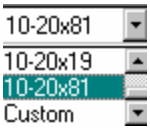
Electrode Setup. When digitizing the electrode positions, the program needs some way to determine the number of electrodes and their labels. That information is contained in any of several files. Select a file in the **Electrode Setup** display. There are several types of files, including *.ast (setup files from Scan 4), *.est, *.set (setup files from Scan 3), or *.tri (from 3DSpaceDx) files. EST files are files created by 3DSpaceDx to save electrode configuration changes made in the other files. If, for example, you retrieve an AST file, and move/add/delete an electrode, you see the Save As utility when you attempt to exit the Electrodes Setup display, asking for a file name with an EST extension. The EST files can be retrieved at a later time, with the changes saved.

After selecting a file, the electrodes and their 2D coordinates are displayed on the screen in graphic and text formats. These are the electrodes that will be used when you digitize the electrode positions.

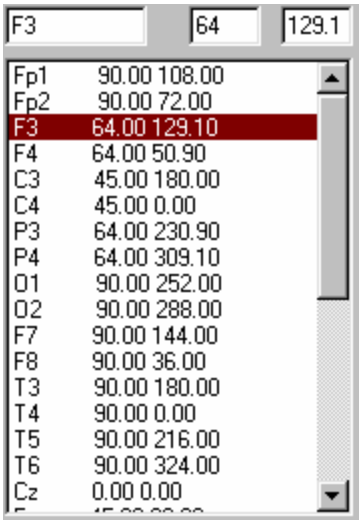
Click the button to the right of the Electrode File display field, and a standard Open File utility will appear. Then click the down arrow by the Files of Type field to get a list of possible file types to use. Select the file you want and click Open.



Alternatively, you can click on the down arrow by the Configuration field. This will open a pull down menu that has all of the same options, with some additional ones.

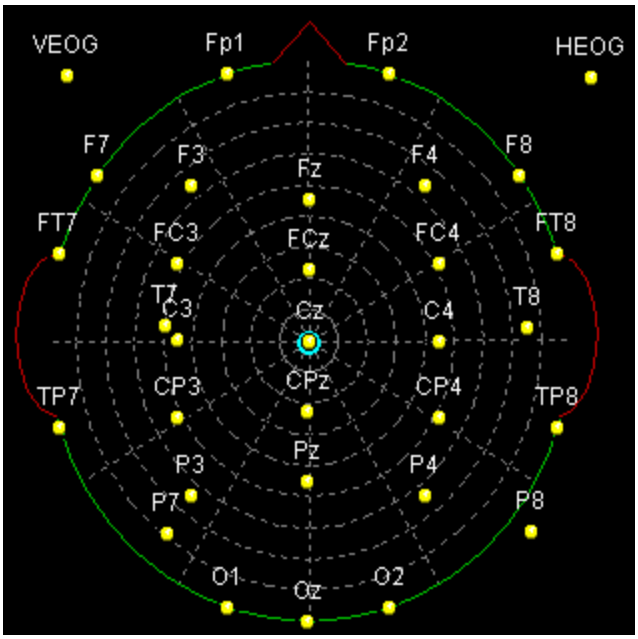


If you select one of the first 3 options (Use Setup, Use EST, or Use TRI), you will get the same Open File utility described above. The 10-20x19 and 10-20x81 are preset files using the traditional and revised 10-20 system labels and placements. If you choose Custom, you can create your own custom setup. In the figure below, the *CAP32.ast* file was selected. A list of the electrodes and their theta\phi coordinates (described below) is displayed in the window under the Configuration field.



When you highlight an electrode, either by clicking it from the list or by clicking the electrode in the electrode position display, you will see the label and its theta\phi coordinates just above the electrode list.

On the electrode position display, you can adjust the placements, as desired, by clicking an electrode and moving it.



A light blue circle will appear around an electrode when you select it, and the corresponding electrode will be highlighted on the electrode list. Notice also that its theta\phi coordinates will change on the electrode list.

As you just move the mouse around in the display area, you will see the pointer location field change according to its current theta, phi position 130.00 350.00. You may notice that 0 0 is the center of the grid. Theta (the "X" value) increases in positive value as you move away from the center in any direction. Phi (the "Y" values) values increase from zero to 360 degrees as you go around the circle in a counterclockwise direction. The starting point - where phi is zero - is on the line that projects to the right ear from the center (or approximately from Cz to T4 positions).

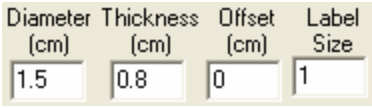
Notice there is a circular grid system for placing the electrodes. If you have the "Snap to grid" field checked ☑ Snap to grid, the electrode will "snap" to specified positions on the display. You can control the extent or sensitivity of the "snapping" by the values that you enter in the theta and phi fields Theta 10 Phi 10. Valid entries for these fields are from .01 to 10 degrees. When theta is set to 10, for example, the moving electrode will snap from one position to the next, latitudinally, in 10 degree steps. Similarly, when phi is set for 10, the moving electrode will snap from one position to the next, longitudinally, in 10 degree steps.

If the "Snap to grid" field is not checked, you can place the electrode at any position. It will not snap to the nearest specified position in discrete steps.

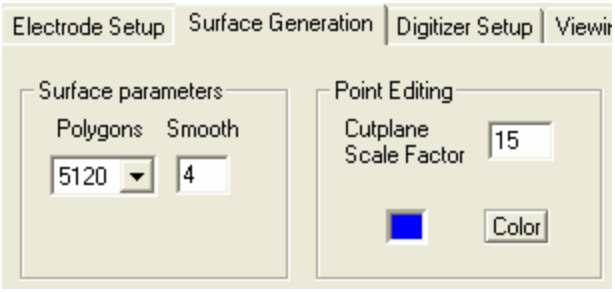
In the lower left hand corner of the screen are some additional electrode setting boxes.

The Diameter setting determines how large the electrode display will be (in cm) when the positions are digitized or displayed with, for example, the TRI file. The

Thickness setting determines the thickness of the displayed electrodes. The offset value allows you to move the electrodes out from the head. The Label Size setting allows you to adjust the size of the electrode labels.



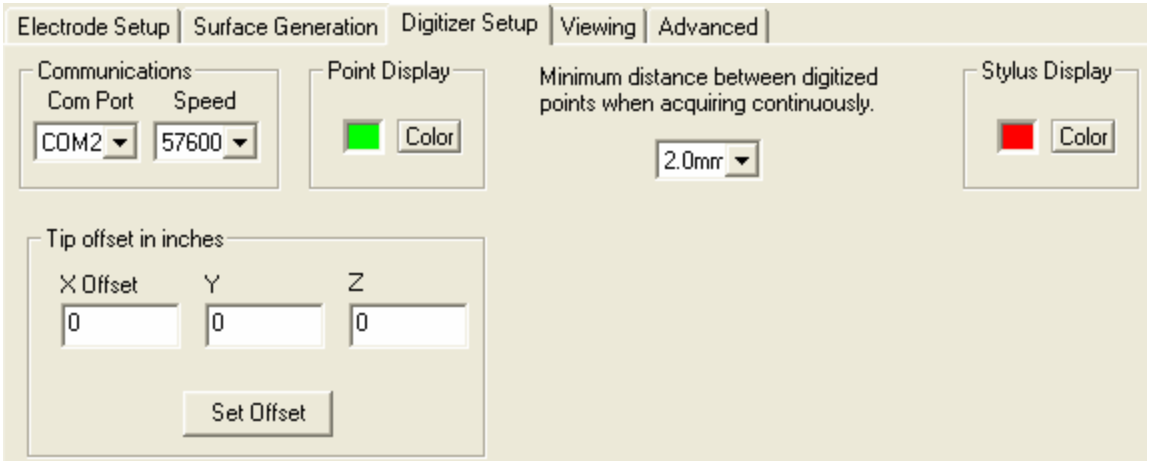
Surface Generation. The **Surface Generation** screen is displayed below, and consists of the following fields:



Polygons / Smooth: These fields allow you to set the number of polygon surfaces and degree of smoothing for use in TRI file calculations. The number of polygons determines the number of facets on the head shape. The Smooth field is an iterative setting, and determines the number of smoothing passes that are made. The greater the number of smoothings, the smoother the surface of the head shape will be. The default settings, 5120 and 4, typically result in a smooth rendering of the head shape. You can increase or decrease these as desired. If the Spinning of the TRI file is particularly slow, for example, you can improve the performance by decreasing the number of polygons.

Point Editing. The Point Editing field lets you vary the Cut Plane Scale Factor, and is used in conjunction with the Cut Plane editing tool. The Scale Factor sets the size of the Cut Plane rectangle that appears when you use the Cut Plane  . Valid entries are 10 to 100. You can also select the color to be used for the Cut Plane rectangle. The rectangle appears when you select the Cut Plane option. *Note: The Scale Factor and color choice must be set prior to digitizing, and cannot be changed "on the fly"*.

Digitizer Setup. The **Digitizer Setup** screen allows you to enter necessary settings for the communication and display options for the digitizer.



Communications. Select the desired COM port and BAUD rate. The COM port is the one that has the serial cable to the digitizer connected to it. If you have more than one COM port, be sure you have the correct one entered (see also the installation section at the beginning of the manual). The BAUD rate is the speed at which transmission will occur between the digitizer and the PC. The recommended rate is 57,600BPS. There must be agreement between this setting, the actual COM port setting (as may be seen in the Windows Device Manager, and the dip switch settings on the back of the digitizer). Refer also to the Installation section earlier in this manual.

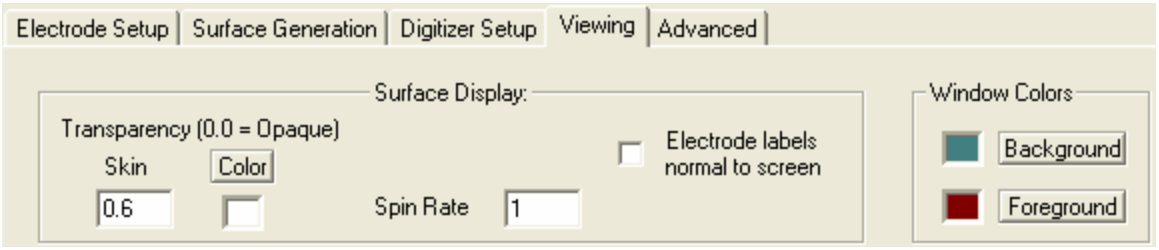
Point Display. The Point Display determines the color of the points that are digitized. If you change the color during digitization, all of the point colors will change (those digitized already, and those to be digitized). The "Color" button for the Point and Stylus Displays accesses a standard color selection grid. If you don't see a color you want, click on the Define Custom Colors bar, and select the color of your choice.

Minimum distance between digitized points when acquiring continuously. Select the desired minimum distance between digitized points - the program will not accept points closer than the value entered. The possibilities are 2, 5, 10 and 20mm.

Stylus Display. Select a color for the Stylus Display. This is the point that represents the position of the stylus in 3D space. The "Color" button for the Point and Stylus Displays accesses a standard color selection grid. If you don't see a color you want, click on the Define Custom Colors bar, and select the color of your choice.

Tip offset in inches. These fields display any offsets in the stylus tip. If you find, for example, that there is a consistent offset when you run the calibration tutorial, you can see it in these fields and correct for it using the commands listed in the Polhemus manual.

Viewing. The **Viewing** screen allows you to specify a number of parameters pertaining to realistic head depictions. The display is divided into 4 areas.



Surface Display. The Surface Display settings allow you to set several display parameters.

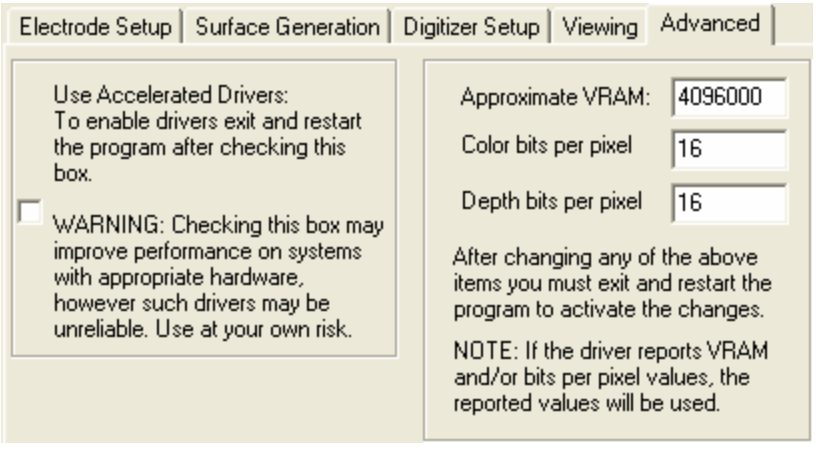
Transparency. These settings refer to the transparency of the skin. The greater the number (up to 1.0), the more transparent the skin will be. A setting of 0.0 means the skin will be completely opaque. The Color button allows you to select a color for the skin. If you don't see a color you like on the color grid, click on the Define Custom Colors bar, and select the color you wish.

Spin Rate. The Spin Rate determines the rate of the spinning when you select Spin left or Spin right (by setting the number of degrees rotated with each screen refresh). The greater the Spin Rate number, the faster the 3D object will spin.

Electrode labels normal to screen. When this field is checked, the orientation of the electrode labels will be normal [vertical] in relation to your perspective. Unchecked, the orientation of the labels will move with the head, and may appear upside down, rotated by any number of degrees, etc. They will be correct only from a top view looking down on the head.

Window Colors. The Window Colors buttons allow you to set independently the Background color of the 3DSpaceDx display, and the Foreground color. The foreground color is used, for example, for the Electrode Labels. When you click on the Background or Foreground buttons, you will see a standard color display menu. If you don't see a color you like, you can select one from the Define Custom Color option.

Advanced. The remaining tab under Options is the **Advanced** section. This section is divided into 2 parts, as shown below.



The Use Accelerated Drivers option may be enabled to improve performance. As stated on the display, the drivers may be unreliable, and are enabled at your own risk.

The Approximate VRAM field displays the amount of memory (video RAM) detected on the graphics card. Memory is proportional to the amount of screen resolution. Color bits per pixel corresponds to the number of colors available. It should always be 16. Depth bits corresponds to the number of bits available for shading. It should also be set to 16. The only time you should enter a different value is if the video card is not registered on DirectX.

Copy. The Copy command copies the 3DSpaceDx display to the clipboard, where you may Paste it into other software applications.

Delete Points. The Delete Points Mode is used to remove unwanted digitized points, one at a time, from 3DD files. After retrieving the 3DD file, select the Delete Points option, or, click the right mouse button to access additional options. Select the Delete Points Mode. The appearance of the digitized head shape points will change slightly in color. With the left mouse button, click on the unwanted points to remove them. If you have your PC's audio system on, you will hear it beep as you delete the points. See also the Cut Plane feature. The Cut Plane is used to delete whole sections of unwanted points.

3.5 Utilities

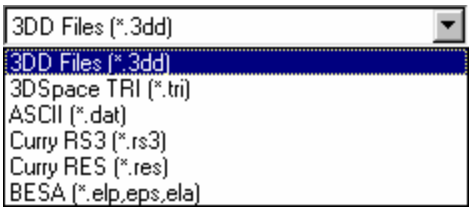
The Utilities section allows you to merge electrode files with head shape files, convert 3DD files to TRI or other types of files, and to average multiple TRI files into a single one.

Merge Electrodes. The **Merge Electrodes** option allows you to merge, or add, a file with electrode position information (typically a 3DD file), to a working file. With a working 3DD file displayed, select the Merge Electrodes option. An Open File utility will appear. Select the 3DD file with the desired electrode position information, and click Open to merge the information.

This is useful during digitization when, for example, you digitize the PAN coordinates and the head shape information *with the cap off*, and then save that file. Let's say you then place the cap back on (with the same receiver locations), and digitize the PAN coordinates again (precisely) along with the electrode position data, and save that file. You may then retrieve the first 3DD file with head shape information, and merge the electrode position 3DD file with it.

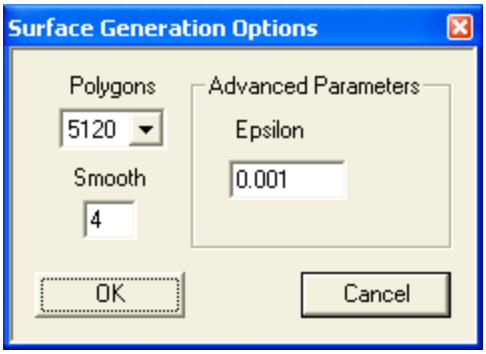
Convert 3DD.... The **Convert 3DD** option is used to convert 3DD files into different forms. It operates as a stand-alone utility - you do not need to retrieve a file to convert it. The same conversion may be accomplished by retrieving a file, clicking Save As, and designating the file type. Click **Files** → **Convert 3DD...**, and the Open Files utility screen will appear.

Go to the desired directory and select the *.3DD file that you wish to convert, then click Open. A Save As utility will appear.



Click the pull down menu at the end of the Save as type line, and select the type of file you want the 3DD file converted to. The file type options are *.3dd, *.tri, *.dat, *.rs3, *.res and *.elp files. These are described in detail above, and in the Import/Export tutorial above. Briefly, TRI files display the digitized points in a realistic head shape, ASCII files are text files that may be edited or imported into other programs, and RS3 and RES files are used by Curry (Curry 4 and 5 use RS3 files - these may be created from 3DD files, but not from TRI files. Curry 5 also uses 3DD files). After clicking the Save button, you can monitor the progress of the conversion in the Status Bar at the bottom of the 3DSpaceDx main screen.

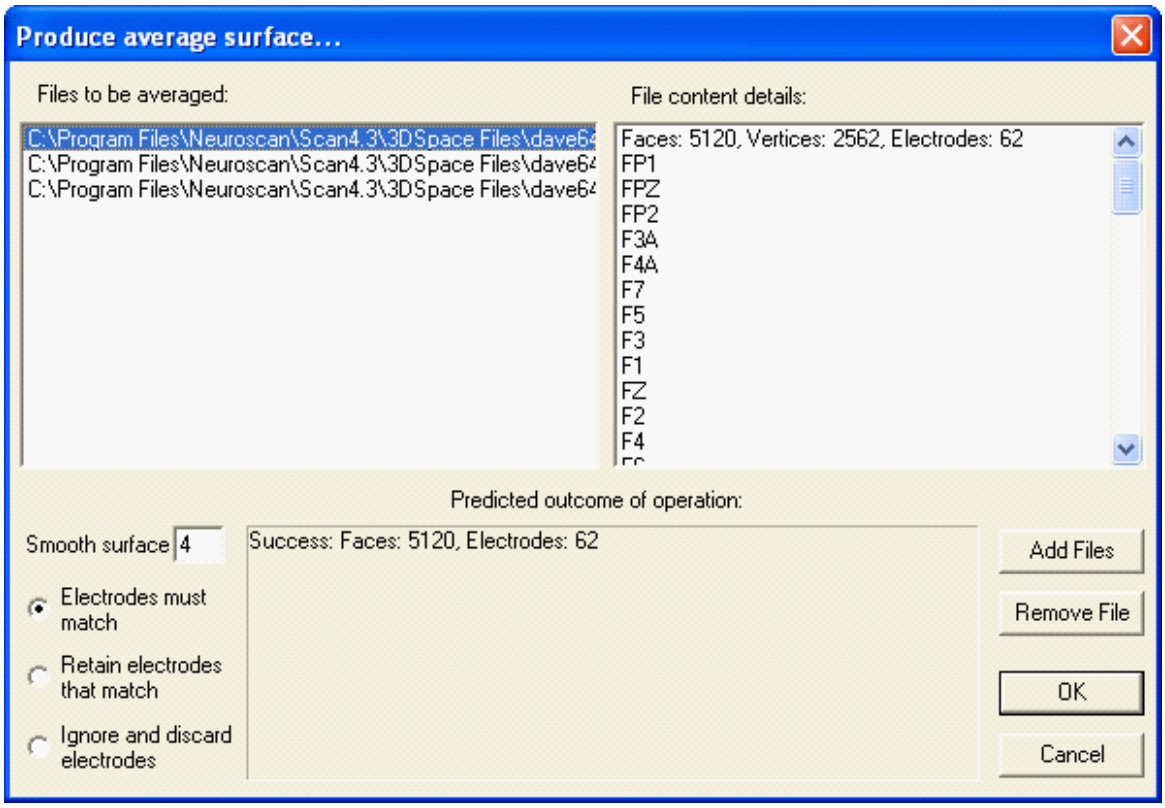
When you convert a 3DD file to a TRI file, you will see the following screen appear.

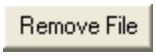


Polygons/Smooth - These fields allow you to set the number of polygon surfaces and degree of smoothing for use in TRI file calculations. The number of polygons determines the number of facets on the head shape. The Smooth field is an iterative setting, and determines the number of smoothing passes that are made. The greater the number of smoothings, the smoother the surface of the head shape will be. The default settings, 5120 and 4, typically result in a smooth rendering of the head shape. You can increase or decrease these as desired. If the Spinning of the TRI file is particularly slow, for example, you can improve the performance by decreasing the number of polygons.

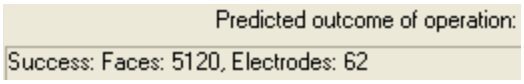
Advanced Parameters - Epsilon sets the convergence criterion used in creating the TRI file. The smaller the number, the better the convergence, or "fit". Below a certain point, the smaller epsilon number will have no additional effect. The default "0.001" works well in most instances.

Average TRI Surfaces.... The **Average TRI Surfaces** option allows you to average 2 or more TRI files together to make a composite average. Clicking on the option displays first an Open File utility. Use this to select the first TRI file that you wish to include the average surface... window. You will then see the Produce average surface... display.

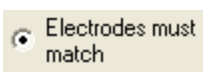


The screen will come up with the single file displayed, as shown. Click the Add Files button  to access a standard Open Files utility. You may then select the next TRI file that you want to average. Repeat the Add Files sequence to retrieve all the files that you want to include in the average. (Note: you can select multiple files using the Ctrl button on the keyboard as you select the files with the mouse). The selected files will appear in the "Files to be averaged" list. Highlight one to see the "File content details". This information includes the number of Faces, Vertices and Electrodes, and a list of the electrode labels. To remove a file you have selected, highlight the file and click the Remove Files button  .

The program will estimate the success of combining the files you have selected. See the Predicted Outcome of Operation area for the prediction.

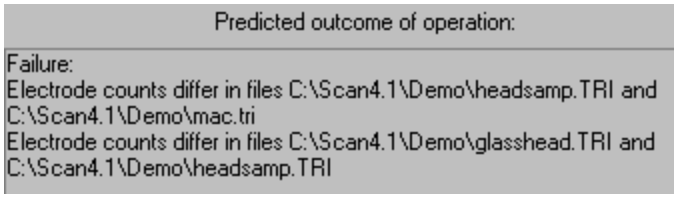


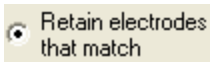
If the files all have the same number of electrodes, you can average them with no loss of information. If, however, the files have differing numbers of electrodes, you can still do the average, with certain constraints. On the lower left section of the screen you will see 3 radial button fields. Selecting one of these will impose restraints on how the electrode information will be treated.



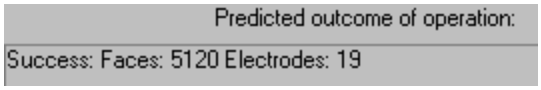
. If you select this option, you are saying that the electrodes must match exactly across all TRI files. If you have differing numbers of electrodes you will

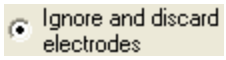
get a "Failure" message in the "Predicted outcome of operation" window, and you cannot average the files.





. If you select this option you are saying to include only the same number of electrodes from each file. If one file has 62 electrodes and another has 64 electrodes, the result of the average will contain 62 electrodes. The "Predicted outcome of operation" window will predict "Success" and display how many electrodes (and faces) there are in common across files.



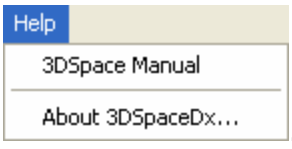


. Selecting this option will ignore the electrodes altogether in the averaging of the TRI files. The "Predicted outcome of operation" window will predict "Success", and display the number of faces. The number of faces should be the same as the number of polygons entered under **Edit** → **Options** → **Surface Generation**. Where there are differing numbers of faces across TRI files, the program converts to the least number of faces present in any file.

. After selecting one of the 3 options above, enter a value in the Smooth surface field. This determines the number of passes a smoothing operation is made across points (or facets). Higher numbers will result in more smoothing. Then click the OK button, and a standard Save As utility will appear. Enter a name and path for the new average TRI file, and click Save. Use **File** → **Open TRI** to see the result of the average.

3.6 Help

The Help menu consists of the following two choices:



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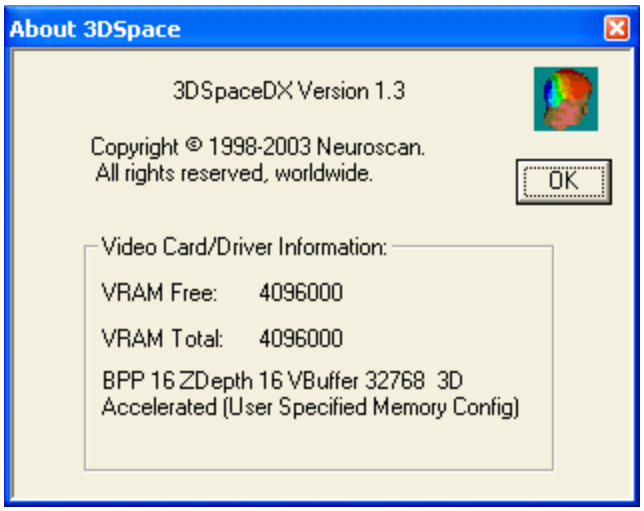
3DSpaceDx Manual. Selecting this option connects automatically to the 3DSpaceDx manual (PDF file). All of the PDF files may be found in the Pdf folder under Scan4.5. We recommend that you keep these files current by periodically downloading the latest versions from our web site (www.neuroscan.com).

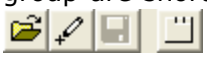
About 3DSpaceDx.... This display not only shows the version of the *3DSpaceDx.exe*

file that you have, but also information about your computer.



The lower part of the screen shows Video Card/Driver information that has been detected by the program. If you are having difficulties with video performance in 3DSpaceDx, you may be directed to this screen by Technical Support.

4 Toolbar Icons

The Toolbar contains several groupings of icons, and additional icons will appear depending on the operation selected. The first group are shortcut buttons for some basic commands: Digitize, View and Program options  .

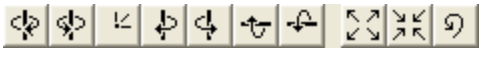
Open File. The Open File icon displays the standard utility display for retrieving the various files types that may be opened with 3DSpaceDx. Click the pull-down arrow at the end of the Files of type field to see the types of files that may be opened.

Digitize. The Digitize button opens the Digitize screen and places the program in Digitizer mode, as described under **Digitize** → **Record** above. Click it again to exit the Digitizer mode.

Save. The Save icon access the standard Save As display that is used to save a current file (with modifications, as desired), and to convert a file to a different file type (including exportation in a different format). Click the pull-down arrow at the end of the Save as Type field to see the types of files that may be saved.

Program options. The Program options button opens the Options screen, and is the same as selecting **Edit** → **Options**, described above.

The second group of icons is related to position and size of the 3DD or TRI file. The icons appear (or become active) after you retrieve a file. The buttons have the same function as the **View** → **Image Size** and **Orientation** options, described above.



Spin left. The Spin left button causes the TRI to rotate or spin to the left, or in a clockwise direction. Click the button once to start the slow spinning, and click it again to stop it at a perspective of interest.

Spin right. Same as Spin left, except that the spinning is in the counterclockwise direction.

Reset orientation. Returns the TRI file to the initial face forward position.

Rotate left. Clicking the Rotate left button rotates the head 45 degrees to the left, in a clockwise direction.

Rotate right. Same as Rotate left, except the direction of rotation is counterclockwise.

Rotate up. Clicking the Rotate up button rotates the TRI file head upward by 45 degrees.

Rotate down. Same as Rotate up, except the head is rotated down by 45 degrees.

Larger. Increases the head size display.

Smaller. Decreases the head size display.

Reset view. Returns the head to its original size.

The next set of Toolbar icons can be used to select quickly any of several views of the 3DD or TRI file head  . The buttons correspond to Left, Back, Right, Top and Front views. The buttons have the same functions as described under **View** → **Orientation** → **Head**, described above.

The next set of buttons appear (or become active) after a TRI or 3DD file has been retrieved, and are used as toggles for displaying different types of information  .

Surface. Toggles on and off the head shape surface.

Axes. Toggles the display of the x, y and z axes on and off.

Electrodes. Toggles the electrode shapes on and off.

Electrode labels. Toggles the electrode labels on and off.

The remaining icon turns on and off the Cut Plane editing tool  , which is used for deleting unwanted digitized points.

Cut plane. This option turns on and off the Cut plane edit tool (refer to the Electrode Position and Head Shape tutorial for examples of its use). When you display the Cut plane  , it will appear as a square with a cluster of dots in the center. It is

controlled with both the left and right mouse buttons. "Grab" the center cluster of points with the left mouse button (click the pointer and hold the button down), and move the mouse away from the cluster and around the screen. You'll see that the square is a rotatable plane, and the cluster of points is a pointer. The left button is used to rotate the cut plane. The right mouse button is used to reposition the cut plane and pointer on the screen. Grab the pointer with the right button (click the pointer and hold the button down) and drag it around the screen. As you drag or rotate the cut plane across some digitized points, you will see them change color. The points that are on the pointer side of the cut plane, whose colors are changed, will be deleted; the ones on the back side of the plane, with their original color, will be retained.

You may find that controlling the cut plane requires some practice. The easiest way to use it is to use the right button to drag the pointer between the good points and the bad points. Then use the left button to orient the plane so that the bad ones fall on the "pointer" side of the plane.

To delete the unwanted points, click the right button elsewhere one the screen. You will see a list of options. Click the Erase Beyond Cut Plane option to remove the unwanted points.

If you find you accidentally deleted some points that were good, click the right button and then select Undo Erase Beyond Cut Plane to restore them.

The other options on this list are described below.

5 Right Mouse Button Menus

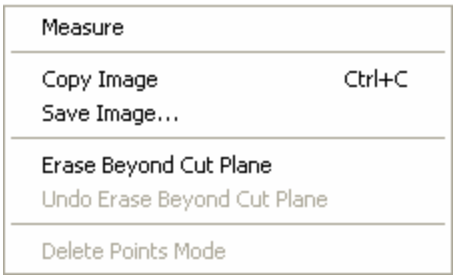
Some options in 3DSpaceDx are accessed by clicking the right mouse button. These options will vary depending on the type of file that has been retrieved, or the operation that is being conducted. When clicking the right mouse button for the menu options, click at a point other than on the head (as that may grab the head and move it).

Menu Options with TRI files. When you have a TRI file displayed, the right mouse menu options include the following.

Copy Image. Copy Image copies the display section to the clipboard, where it may be Pasted into other applications (such as Paint).

Save Image. Selecting this option displays the standard Save As display where you may save the display part of the screen as a BitMap (BMP) file.

Menu Options with a 3DD File Displayed or During Digitization. Under either of those conditions, you will see the following option list when you click the right mouse button. Only those not described immediately above are listed below.



Measure. Measure is a tool for measuring the distance on the actual 3D surface. Enable it by clicking the right mouse button on the digitizer screen, to access the menu options, then click the Measure line.

With the digitizer on, and in Digitize mode, you may then move the stylus from the starting to the ending points of the 3D surface you want to measure. Hold the stylus button down while performing the measurement. There will be no sounds during the measurement. Then look in the lower right hand corner of the 3DSpaceDx screen. On the Status Bar line, at the far right, you will see two fields with numbers in them 

. The first is the straight line distance (in cm) between the two points, and the second in the actual distance traveled (in cm) across the 3D surface. This can be useful if you are applying individual electrodes and want to measure the actual distances needed for 10-20 system placements, or for locating electrode positions for placement of the caps.

Erase Beyond Cut Plane. Selecting this option will delete unwanted points that lie beyond the boundary of the Cut Plane (refer to the Cut Plane section above for more details).

Undo Erase Beyond Cut Plane. Selecting this option will restore points that have been deleted using the Erase Beyond Cut Plane option above (only those points from the most immediate use of the Erase Beyond Cut Plane operation may be restored).

Delete Points Mode. The Delete Points Mode is used to remove unwanted digitized points, one at a time, from 3DD files. After retrieving the 3DD file, select the Delete Points option, or, click the right mouse button to access additional options. Select the Delete Points Mode. The appearance of the digitized head shape points will change slightly in color. With the left mouse button, click on the unwanted points to remove them. If you have your PC's audio system on, you will hear it beep as you delete the points. See also the Cut Plane feature. The Cut Plane is used to delete whole sections of unwanted points.