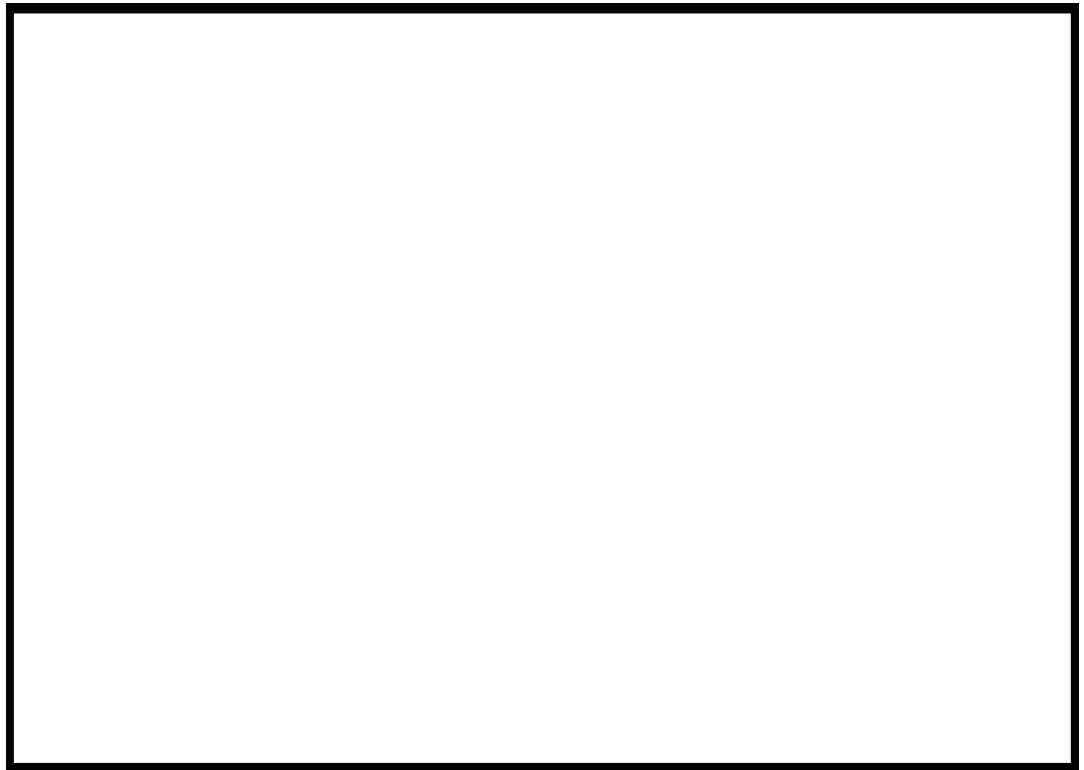

Ariel Dynamics, Inc.

DIGI4 Module

Revision 1.0



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ARIEL DIGITIZE PROGRAM

INTRODUCTION

Digitizing is the first step for analysis after the recorded images have been captured and stored on the hard disk of the computer. The APAS 4 SCREEN DIGITIZING APPLICATION (**DIGI4**) software is a Windows based program for digitizing images to be analyzed using the **Ariel Performance Analysis System (APAS)**.

Initially, the video image is captured and stored in memory. This eliminates any further need for video apparatus. The image sequence is then retrieved from computer memory and displayed, one image at a time, on the digitizing monitor. The captured image can be enhanced or altered in several ways. These included Zooming the whole frame or a defined, isolated portion of the view. Changing the size may help the person digitizing to more accurately determine a particular joint which in the standard view could not be identified.

Using the video cursor, the location of each of the subject's body joints is selected and entered into the computer. As each point is selected, it is displayed within the video image on the monitor. This assists the user to evaluate his current joint selection with the perspective of the previously identified joint center. Another useful feature is the "rubber-band" effect. This situation occurs when the previously selected joint in the current frame is "fixed" while the next joint center is being located. The computer connects the preceding joint center with the cursor. As the cursor is moved to establish the joint center location, a line is created which moves according to the cursor motion. This assist in digitizing since the connection between the two points represents the segment between the two joints.

Digitizing can be performed in one of two modes, either **Manual** or **Automatic**. **Manual** digitizing is performed under computer control and the digitizing of video images is computer assisted. Under manual control, user participation in the digitizing process provides an opportunity for error checking and visual feedback which rarely slows the digitizing process

adversely. A trained operator with a reasonable knowledge of anatomy and a consistent pattern of digitizing can rapidly produce high-quality digitized images. **Automatic** digitizing requires some sort of highly visible markers. These may be reflective markers, LED's or simply markers with a high contrast to the immediate background such as black markers against a white background. User input is minimal as the computer automatically tracks the markers based on color, contrast, position, velocity and acceleration.

Full 3-Dimensional integration has also been incorporated. During the digitizing process, 3D stick figures and graphical information can be displayed simultaneously. Graphs and stick figure images are updated immediately as the sequence is digitized.

The file structure of the APAS also opens the possibility of sharing data with other users. Since data records are stored as a file on the hard disk, these files can be transmitted worldwide by modem or through File Transfer Protocols (FTP) on the Internet for collaborative purposes.

The DIGI4 program presents many options and features to the user, however, they are relatively easy to master once you understand the concepts behind them. This manual is arranged to teach you these concepts in a logical order by showing you, in step-by-step fashion, how to use DIGI4.

WHAT'S NEW IN DIGI4 1.0

A few of the new features you will see in DIGI4 version 1.0

1. **Multiple Screen Digitizing.** Up to four images can be displayed and digitized simultaneously.
2. **Multimedia Compatible** Image files can be displayed in *.AVI format utilizing Intel Indeo technology.
3. **Real-Time Video Capture.** Video can be captured directly from the video source at rates up to 30 frames per second.
4. **Real-Time 3D Transformation.** 3D data files can be generated and displayed simultaneously with the digitizing process.
5. **Software Support For Panning Camera.** Software developed by Ariel Dynamics allows for "Panning" cameras without additional hardware.
6. **Image Enhancement.** Several image processing options have been added to filter and/or adjust the AVI images.
7. **Improved AutoDigitizing.** User adjustable spot locator parameters have been added.
8. **Zoom Windows.** Static and Dynamics Zoom Windows have been added for improved digitizing capabilities.

9. **APAS Tool Bar.** A toolbar has been added to allow the user to activate individual APAS modules from within the main programs.
10. **Software Support For 120 Hz Camcorders.** Software developed by Ariel Dynamics has been added for the JVC 120 Hz camcorders.

SYSTEM REQUIREMENTS

The following table provides the basic guidelines for required hardware to provide the best possible performance. Required software includes Microsoft Windows 95/98 or later and APAS2000 Revision 1.0 or later.

Image Format	Required Hardware/Software
.PCL(.PCX)	No Additional Hardware Required
*.AVI	Video For Windows Compliant Video Board Appropriate Software Compressor/Decompressor (CoDec) for reading AVI file

TO START THE DIGI4 PROGRAM

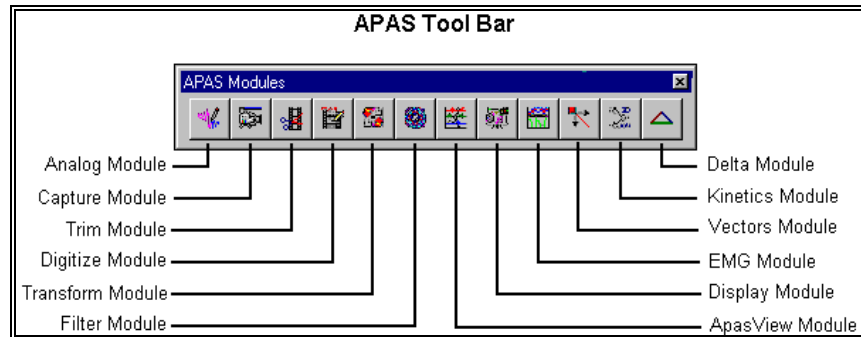
1. Double-click the **DIGI4** icon located in the **APAS System** window group. The main DIGITIZE menu will appear. You are now ready to create a new digitizing Sequence or restore a previously created Sequence.

SCREEN LAYOUT

Prior to beginning the Digitizing process, you should familiarize yourself with the screen layouts of the various digitizing menus. Many functions can be selected using the **DIGI4 Tool Bar** or by selecting the appropriate command from the **Pull-Down Menus**.

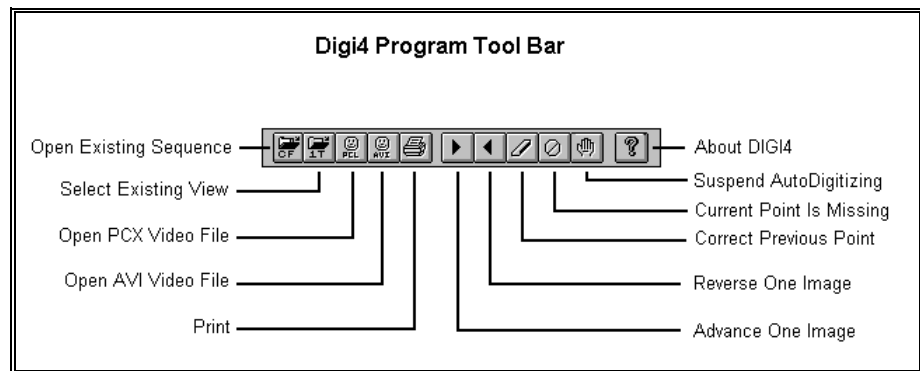
THE APAS TOOL BAR

You can activate any of the APAS software modules from within the current program by selecting the icons located on the APAS tool bar. The tool bar is toggled on/off using the APAS Toolbar command in the VIEW menu. A check mark in the left column of the menu indicates that the toolbar is currently active. The toolbar can be re-located anywhere in the main program window by dragging it with the mouse. Clicking the appropriate icon can activate the following program modules. Icons are pictorial representations of programs, commands or functions.



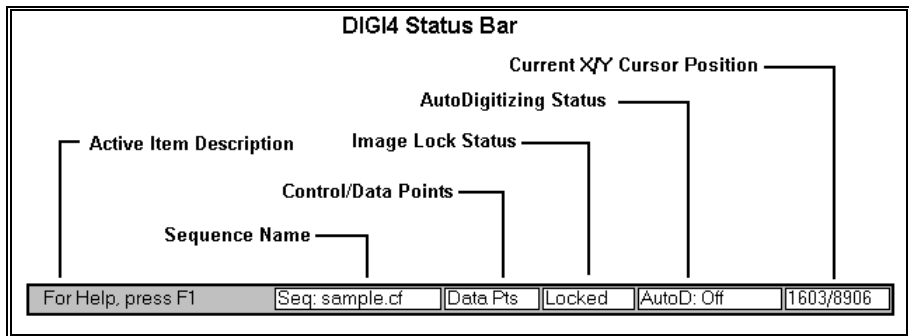
THE DIGI4 TOOL BAR

You can activate many functions by selecting the icons located on the DIGI4 program tool bar. The tool bar is located near the top of the window. Icons are pictorial representations of commands or functions. You can access the following commands by clicking the appropriate icon.



THE STATUS BAR

The status bar provides useful information about the current status of the image file. The status bar is located at the bottom of the DIGI4 window. The far left side of the status bar is divided into five separate fields; **Sequence Name Field**, **Control/Data Point Field**, **Frame Lock Status Field**, **AutoDigitizing Status Field** and the **Current X/Y Position Field**.



Sequence Name indicates the name of the current sequence. A missing sequence name indicates that the sequence has not been selected.

Control/Data Points indicates whether the current display shows sequence data points or the control frame.

Image Lock Status indicates the current state of the Image Lock as specified in the Lock command of the Images menu. When images are locked, the advance/reverse command acts on all open view windows. If the images are unlocked, the advance/reverse command affects only the active window.

AutoDigitizing Status indicates the current status of the AutoDigitizing option. When AutoDigitizing is active, the first frames will display **AutoD : LEARN**. Afterwards, the **AutoD : ON** indicator will be visible. When AutoDigitizing is not active the **AutoD : OFF** will be displayed.

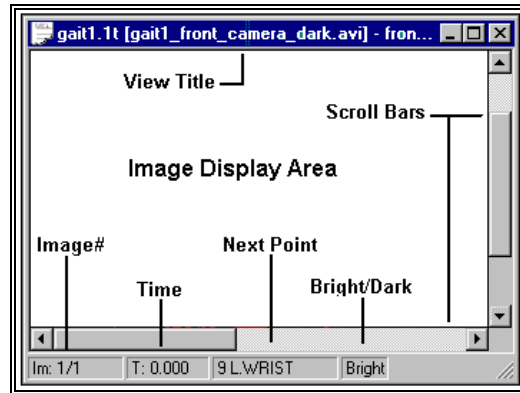
X/Y Cursor Position indicates the current X and Y cursor position on the color display.

VIEW WINDOW LAYOUT

When a View Window is opened, additional windows will be displayed inside the DIGI4 main window. Up to four windows can be opened simultaneously. The **View Title** will be displayed at the top of each View Window. The View Window title incorporates the *.1t filename along with the IMAGE file being used and the View information string. The View Window Status bar is divided into four fields and is located at the bottom of each View Window. The first field displays the digitized **Image number** and the current **Image number** of the file. For example, the Image # designated as 100/150 would mean that there are 150 images up to the currently displayed image while only 100 of the 150 images have been digitized. The second field displays the current sequence **Time**. This number is calculated based on the FRAME RATE value specified in the View Information menu. If a frame rate of 60 is used, each time the image is advanced the Time field will be incremented by a value of $1/60 = 0.01667$ seconds. The **Next Point** field specifies which point should be digitized next for this window. The order of the points is determined by the Point Identification Table. When all points have been digitized for the current image this field will display the label COMPLETE. The **Bright/Dark** field is active only when AutoDigitizing. This field indicates

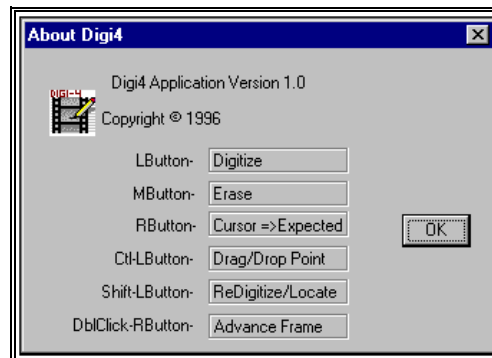
whether the markers used for AutoDigitizing are **Bright** (against a dark background) or **Dark** (against a light background). Each individual view can be independently set for **Bright** or **Dark** markers.

Scroll Bars located immediately above the View Status bar and also at the right side of the View Window allow the image to be scrolled left/right and up/down. The small arrow in the upper right corner of the View Window can be used to expand the window to the full screen.



MOUSE BUTTON FUNCTIONS

The Digitizing phase of the analysis makes extensive use of the mouse. The arrow keys can be utilized for "fine-tuning" the digitized point, however, most users rely solely on the mouse. The APAS computer is supplied with either a two or three button mouse. There is a **Left** (L), **Middle** (M) and **Right** (R) button. Several functions have been incorporated into the mouse buttons to simplify the Digitizing process. These functions are listed when you select the ? icon from the DIGI4 Toolbar.



Left - Selects the current position of the cursor as the digitized point location

Middle - Corrects the last digitized point. When a joint is Digitized incorrectly, the Middle mouse button can be used to correct the point. The cursor will reverse one joint for each time the Middle button is pressed.

Right - Moves cursor to the “estimated” location of the next point to be digitized. Since this requires previous information to “estimate” the point location, this function has no affect in the first frame

Ctrl-Left [Drag & Drop] - Press the Control key and Left mouse button simultaneously to Drag the point nearest to cursor to desired screen location then release the mouse button. If you desire to Abort the Drag/Drop feature, simply drag off the client area and release the mouse button.

Shift-Left [Redigitize] - Pressing the Shift key and Left mouse button simultaneously will cause a Dialog Box to appear selecting a joint. After a joint is selected, if AutoDigitizing is active, the program will perform an Initial Locate for the spot associated with the specified joint starting at the cursor location of the mouse click. If AutoDigitizing is inactive, then the specified joint is re-digitized at the cursor location of the click.

Double-Click Right - . When all the points for the current frame have been digitized and the Status Bar indicates that the image is Complete, the Right mouse button can be “double-clicked” to advance to the next image.

ACTIVE HOT-KEYS FOR DIGITIZING

Even though the Digitizing phase of the analysis makes extensive use of the mouse, some users may prefer to use the keyboard for several of the more common commands. The arrow keys can be utilized for “fine-tuning” the digitized point. Pressing the ENTER key is identical to the Left mouse button and will enter the cursor location as the digitized point. Several other common commands are listed below:

ALT-Right Arrow - When all the points for the current frame have been digitized and the Status Bar indicates that the image is Complete, pressing the ALT key and the Right Arrow key will advance to the next image.

ALT-Left Arrow - When all the points for the current frame have been digitized and the Status Bar indicates that the image is Complete, pressing the ALT key and the Left Arrow key will reverse to the previous image.

DEL - Pressing the DEL key will erase the digitized location for the current point.

CTRL-DEL - Pressing the CTRL key in combination with the DEL key will erase all points in the current frame.

CTRL-SHIFT-Left - Press the Control and Shift keys in combination with the Left mouse button to Auto Locate the centroid of the current point. This function can be used in both manual and automatic digitizing modes or when digitizing control points.

ESC - Pressing the ESC key will set the current point to “Missing” status.

ALT-0 - Pressing the ALT key in combination with the number 0 key will apply a zooming factor of 0.5X.

ALT-1 - Pressing the ALT key in combination with the number 1 key will apply a zooming factor of 1X.

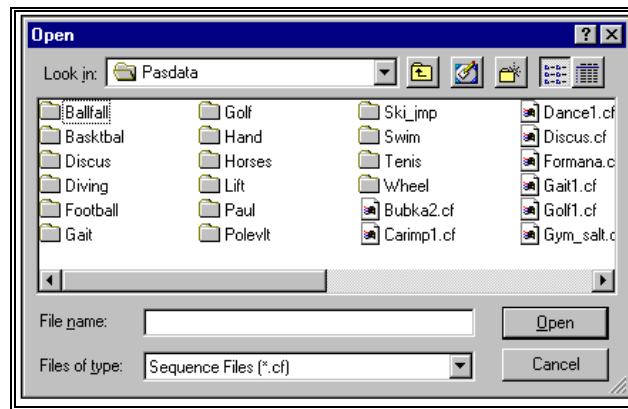
ALT-2 - Pressing the ALT key in combination with the number 2 key will apply a zooming factor of 2X.

ALT-3 - Pressing the ALT key in combination with the number 3 key will apply a zooming factor of 3X.

ALT-4 - Pressing the ALT key in combination with the number 4 key will apply a zooming factor of 4X.

CREATING A NEW SEQUENCE FILE

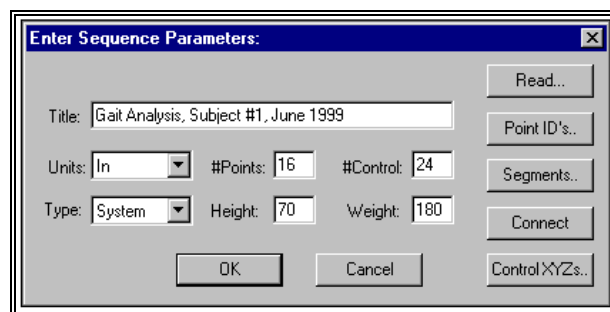
1. Choose the **SEQUENCE, NEW** command from the **FILE** menu. The NEW File Dialog box will appear.



2. Specify the Name and location of the New Sequence file.

The NEW File Dialog box looks for APAS sequence file types (files that have the extension of .CF). The current file type is listed in the lower left corner of the dialog box. The New File Dialog box can be used to specify the Drive, Directory, Type and Name of the image file to be saved. Type the Name of the New image file in the File Name box and select OK to proceed. You must have the .CF extension on the new sequence file.

3. Enter the Sequence Parameters



Title - The Sequence Title can be up to 40 characters long and should specify information pertaining to the activity being analyzed. Titles should be used that will enable the activity to be identified many months from now.

Units - The Units field is used to specify the units for the analysis. Available choices include millimeters (mm), centimeters (cm), meters (m), kilometers (km), inches (in), feet (ft) and miles (mi). The Unit value can be changed by selecting the arrow button to the right of the entry field.

#Points - The #Points indicates how many points will be used to analyze the activity. This value does not include the fixed point. When this option is selected, the Enter Point Selections menu will be displayed.

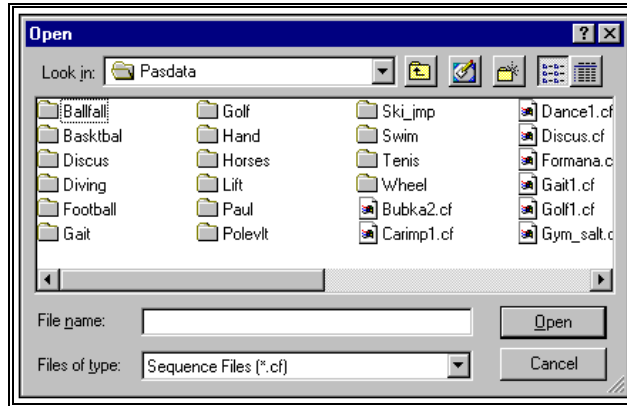
#Control - The #Control indicates how many Control points will be used for calibrating the image space. Two dimensional analysis requires a minimum of 2 points, however, 4 or more coplanar points are recommended. Three dimensional analysis requires a minimum of 6 non-coplanar points. When this option is selected, the Enter Control Point Coordinates menu will be displayed.

Type - Type is selected when you wish to set or change the type of point (body joint) or segment identifiers used for this sequence. The currently selected type is displayed in the Type field. This can be changed by selecting the arrow button to the right of the entry field. "System" is selected when you wish to use the system default point and segment identifiers for this sequence. By selecting default identifiers all names, connections and segment masses are defined and you merely select the points to be used. System identifiers are adequate for the majority of human body motion analysis that you are likely to perform. "User-Defined" is selected when you wish to define your own point and segment names, segment connections, and segment mass information. This is typically required when analyzing performance sequences that do not involve the human body (e.g. animal studies or formation analysis).

Height - The Height is the subject's height entered in the indicated units. It is an optional field and is only used by the analysis system during kinetic analysis for the determination of "standard" body segment lengths and radii of gyration.

Weight - The Weight is the subject's weight entered in the indicated units. It is an optional field and is only used by the analysis system during kinetic analysis for the determination of "standard" body segment masses and moments of inertia.

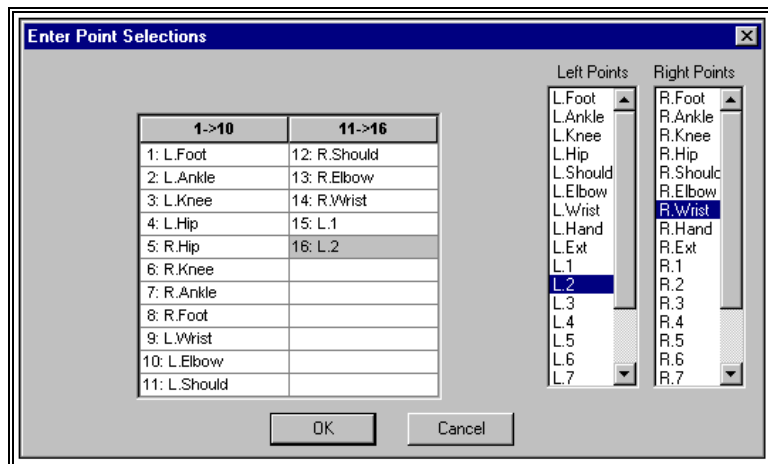
Read - The Read option can be used to Read the Sequence Information from a previously digitized sequence. When multiple trials are being analyzed using the same Sequence Information this option can save a significant amount of time. When the Read option is selected, the Select Sequence to Copy menu will be presented. Select the name of the sequence to be copied in the File Name field. The .CF extension is required on all file names. This option will copy the entire sequence information (title, units, #points, #control, type, height and weight in addition to segment names, connections and control point locations). The necessary fields should be modified to reflect the current sequence.



Connect - The connect option should be used to re-connect System-Defined points anytime that the point information is changed. When the System-Defined Point ID's are first entered, the APAS will automatically connect the points to form the body segments. For example, the software knows that the Left Foot connects to the Left Ankle and the Left Ankle connects to the Left Knee etc. This information is saved in the Sequence file. If these points or connections are changed at anytime, the saved information is updated by selecting the Connect option. **NOTE:** If the CONNECT button is selected, segments that do not use System-Defined points will be erased. This button does not affect User-Defined points.

4. Specify the Point Identifications

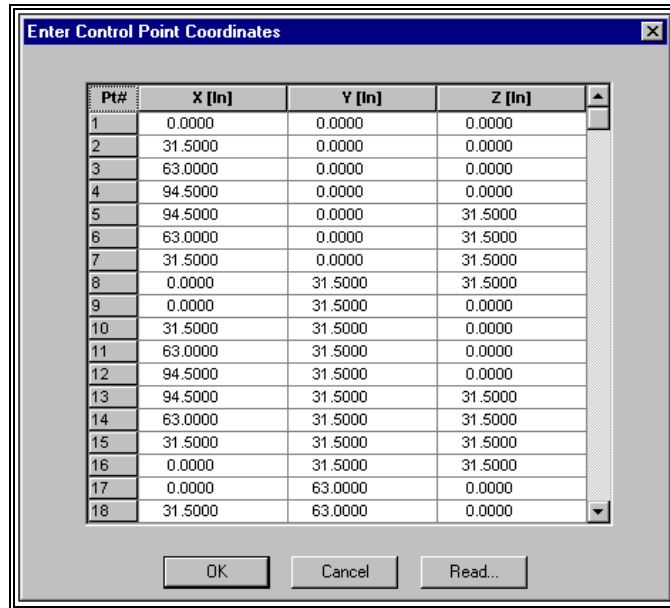
The left side of the menu displays the previously specified number of points. The point ID's are selected by clicking the left mouse button on the appropriate left/right label listed on the right side of the menu box. Select OK when all points have been selected to return to the Sequence Parameter menu.



5. Specify Control Point Coordinate Locations.

Type the X, Y, Z coordinate values for each control point, pressing ENTER after each value. Values must be entered in the units of measure selected for this sequence or incorrect results will be computed. To display additional points that could not be

displayed on the current page, select the MORE button. The READ button allows the ability to read the control point locations from a previously digitized sequence. When all values have been entered, check them a second time for accuracy. Corrections may be made by pressing the ENTER key until the cursor is positioned over the desired value. When all values have been entered correctly, select OK to accept the values and return to the Sequence Parameter menu.



6. Select Connect (Only If Point ID's Have Been Changed)

The connect option should be used to re-connect the points anytime that the point information is changed. When the Point ID's are first entered, the APAS will automatically connect the points to form the body segments. For example, the software knows that the Left Foot connects to the Left Ankle and the Left Ankle connects to the Left Knee etc. This information is saved in the Sequence file. If these points or connections are changed at anytime, the saved information is updated by selecting the Connect option.

7. Select **OK**. You are now ready to Open a New View within the Sequence. Up to nine views can be used to analyze a single sequence, however, only four views can be opened simultaneously.

OPENING A PREVIOUSLY CREATED SEQUENCE

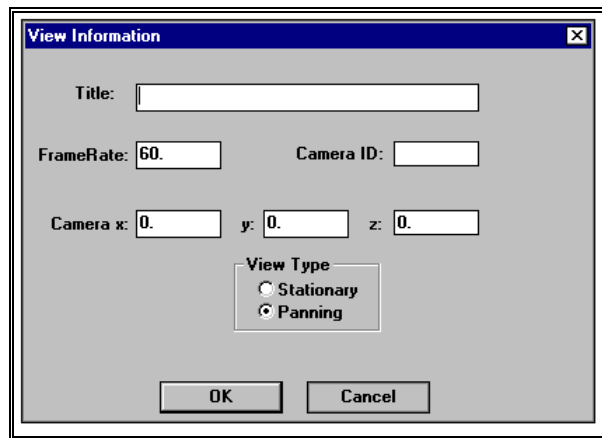
1. Choose the **SEQUENCE, OLD** command from the **FILE** menu. This can also be performed in a single step by selecting the

OPEN EXISTING SEQUENCE icon from the Tool Bar. The Open Existing Sequence menu box will appear.

2. Select the desired sequence.

CREATING A NEW DIGITIZING VIEW FILE

1. Select the **New View** command from the **File** menu. The View Information menu will appear.
2. Enter the View Information.



Title - The view title should be used to help identify this view when subsequently referenced. It is suggested to enter a label that is descriptive of this particular view. For example, "Subject 1 Gait, Left View."

Frame Rate - The Frame Rate is the number of images per second that are captured in the image file. This item is always required and should be as accurate as possible in order to yield accurate velocity and acceleration computations. For most APAS applications, the Frame Rate can be calculated by dividing the video speed by the sum of the skip factor plus one. For example, if 300 images were captured from a 60 Hz video system with a skip factor of 1, the Frame Rate will equal 30 since $((60 / (1 + 1)) = 30$ Hz. Refer to the chart below for additional examples.

# Images	#Skip	#Images	Frame Rate
300	0	$300 / (0+1) = 300$	$60 / (0+1) = 60$ Hz
300	1	$300 / (1+1) = 150$	$60 / (1+1) = 30$ Hz
300	2	$300 / (2+1) = 100$	$60 / (2+1) = 20$ Hz
300	3	$300 / (3+1) = 75$	$60 / (3+1) = 15$ Hz

Camera ID - Camera ID is an optional field provided to identify the type of camera used to record this view.

Camera X, Y, Z - Camera X, Y, and Z defines the coordinate values for the location of the camera in the frame of reference of your control points. The camera location is not required information to perform an analysis, however, if the location is known you may request a validity check of the transformation from digitizing space to image space. This may be of value when publishing studies and demonstrating the validity of the method used.

View Type - View Type is used to specify each individual camera view as either STATIONARY or PANNING. Stationary views are cameras that record the activity of interest from a "fixed" camera. Fixed cameras can not be altered in any manner (zoomed, focused, moved etc) when recording the calibration points and activity data. Panning views are cameras that record the calibration points and activity by Panning the camera from left-to-right or vice-versa. As with the Stationary views, the zoom and focus should remain constant while recording the calibration points and activity. Please refer to the PANNING CAMERAS section for additional information on digitizing panning views.

3. Open the Image File

Select the **Open PCX/AVI Images** command from the **File** menu. When this option is selected the Open file menu box will be presented. Select the desired image file by entering the file name and pressing the ENTER key. The Video File Information menu will be displayed.

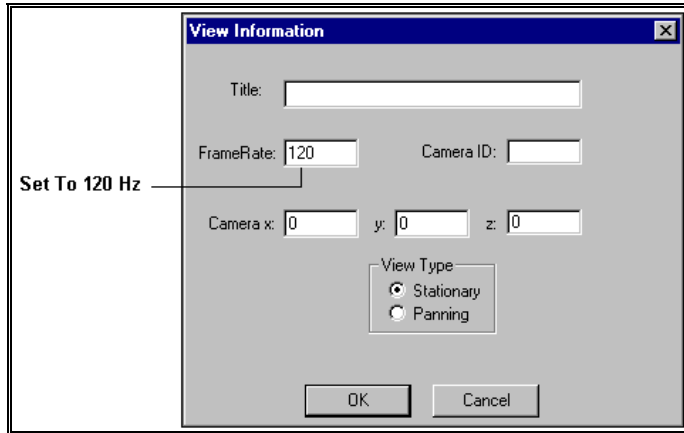
Select **OK** to proceed and display the first image in the AVI/PCX file in the active window.

4. You are now ready to begin the Digitizing Process. Please refer to the DIGITIZING PROCESS section for additional assistance.

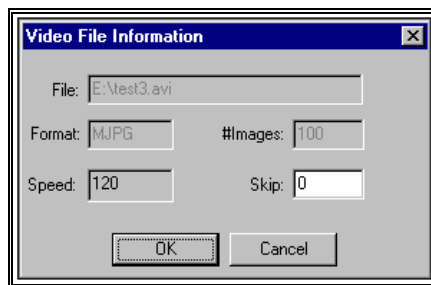
JVC HIGH_SPEED CAMCORDER

When digitizing AVI files captured from the JVC 120 Hz Camcorders, there are a few extra points that must be emphasized. The exact same steps are followed as described in the section "Creating A New Digitizing View File" with the following exceptions.

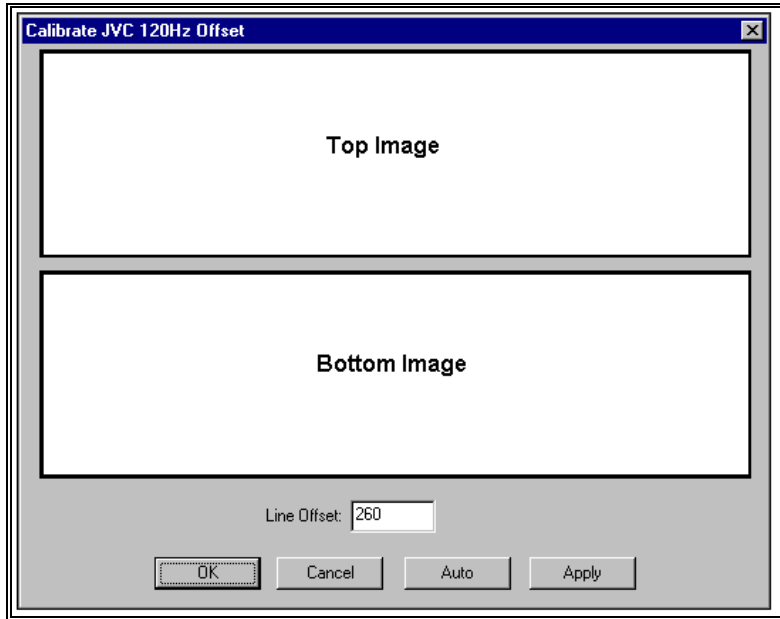
1. The Frame Rate must be set to 120 or 240 (depending on the high-speed mode used for recording) in the View Information menu.



2. Make certain that the SPEED field is labeled as 120 or 240. If not, the file should be opened in TRIM module and specified as either 120 Hz or 240 Hz. Then select the Save Trimming option without actually trimming the file.



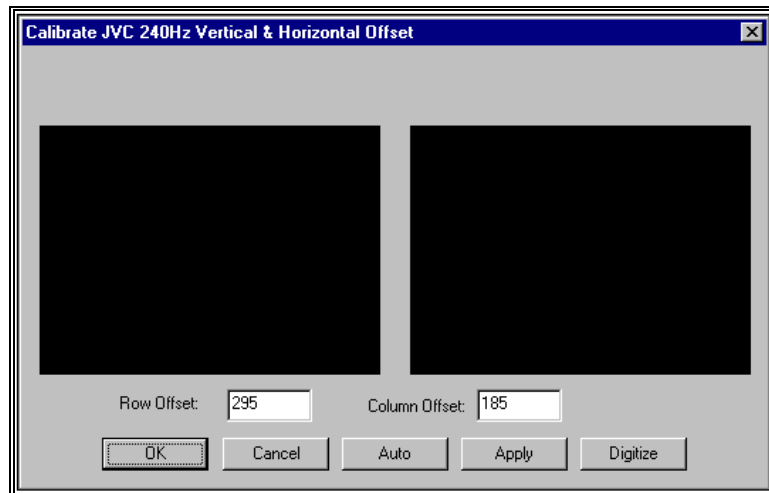
3. Select the **CALIBRATE** command from the **IMAGES** menu to display the Calibrate JVC 120Hz Offset menu. It is recommended to select the **AUTO** button to automatically determine the image offset. Select the **OK** button to return to the digitizing screen.



The JVC high-speed camcorder is capable of recording at a rate of either 120 or 240 images per second by splitting the image to approximately one-half or one-quarter normal screen size. When the recording is played back on any standard video player, 2 images will be simultaneously displayed in the 120 Hz mode (2X High Density Mode) while 4 images will be simultaneously displayed in the 240 Hz mode (4X High Density Mode). These images are $1/120^{\text{th}}$ second apart and $1/240^{\text{th}}$ second apart respectively.

In theory, the expected split would occur at the horizontal and vertical middle of the screen. This equates to horizontal line 360 and vertical line 240 since there are 720 lines of horizontal resolution and 480 lines of vertical resolution. However, reality has indicated that this is not always the situation. For this reason, the Calibrate function is used to determine the image offsets for the high-speed video.

The steps for calibration are almost identical for both the 120 and 240 Hz modes. Any of three options can be used to perform the calibration process, however, the "Automatic" method is recommended. These options are selected using the buttons in the lower portion of the Calibrate menu.



Manual Calibration Option

In the “Calibrate” menu, the user specifies the row or column number (or both in the case of 240 Hz) where the last high speed image appears in the normal speed video. In the case of 120 Hz, the normal video consists of 2 high speed images either horizontal scenes or vertical scenes. In the case of 240 Hz, there are 2 rows and 2 columns of high-speed images per normal image. The dialog displays 2 images, the 1st and last high-speed images for the current normal image. Edit boxes display the current values for the row/column offsets for the "Last" image. The idea is to have the top or the left or both edges of the two displayed images appear identically. One can enter a value for the offset[s] and click on the “**Apply**” button to re-display the images with this new value.

Digitize Calibration Option

The “**Digitize**” option is another method for calibration. When this option is selected, the user will be prompted to digitize the same image feature in the two images. From this information the program calculates the row and/or column offsets.

Automatic Calibration Option

Or one can select “**Auto**” and the program will automatically compare the two images pixel by pixel and determine the row and/or column offsets. The calculated offset is then entered in the Line Offset field. **This last option is the most reliable and is the recommended method.** Typically the calibration needs to be performed only once on a system. The indicator that the 120/240 Hz is NOT calibrated is the presence of jitter when advancing images.

Save Calibration Settings

This information can only be saved to a file once. This usually happens in TRIM when the trimmed file is saved. Therefore this information should be setup properly before the trimmed file is saved. It can be changed temporarily but will revert to the original values the next time the AVI is opened. To save permanently, open the video file in the TRIMMER module, specify new values, and then save the trimmed file without actually trimming any images.

OPENING A PREVIOUSLY CREATED VIEW

1. Select the **Old View** command from the **File** menu. . This can also be performed in a single step by selecting the OPEN EXISTING VIEW icon from the Tool Bar. The Open Existing View File menu will appear.
2. Select the desired view file. When a view file is opened, the program will prompt the user with this filename and whether to Open it. Cancel can be selected to open another AVI/PCL file.

DIGITIZING PROCESS

Once the Sequence information has been provided and one or more Views have been created for each camera recording in the sequence, the digitizing process can proceed. Beginning with the Fixed Point, each point should be digitized using the mouse. The next point to be digitized will be labeled in the View Window Status Bar. When the current image is finished and the Status Bar indicates COMPLETE, the image can be advanced by pressing the Right mouse button. Continue this process until all the images in the image file have been digitized.

Each View represents a digitized image from a particular camera view and as such consists of two-dimensional coordinates. When all views have been digitized, the Transform module combines them to form a true three-dimensional image sequence. If only one view is digitized and transformed, the resulting image sequence will be two-dimensional.

The digitizing process can be broken down into two general steps: Control (or Calibration) and Body Joints. Each step requires digitizing the Fixed Point. There is no specific order to accomplish these two steps, however, it is recommended that the user digitize the Control Points first.

FIXED/PANNING POINT

With every digitized image, there is one additional point that must be digitized first; the Fixed Point (or Panning Point for Panning Camera views). This is a point selected somewhere in the background of the film or video image. The point must be stationary (thus the name fixed point) and should be clearly visible in every frame. Do not select a point that will be obscured by the subject during the activity. The purpose of this point is to provide a

fixed reference against which all the other points in the image are measured. This same point must also be visible in the image with the control points.

Position the cursor to the selected fixed point and click the left mouse button. A small box appears on the graphic display to mark the location of the Fixed Point. The digitizing module expects the Fixed Points from subsequent images to fall within this box which represents the normal variation due to field interlace or vibration.

Digitizing a Fixed Point outside of this box will be considered an error by the computer. In this manner, the system prevents inadvertent digitizing of incorrect fixed point information.

IMPORTANT INFORMATION ABOUT THE FIXED POINT

1. The Fixed Point must be the exact same point for the calibration and body joint images "within" a single camera view.
2. The Fixed Point must be the exact same point "within" a view but can be different "between" views. In other words, Camera #1 must have the same fixed point in the calibration and data images while Camera #2 can use a different fixed point.

PANNING CAMERAS

When digitizing Panning Camera views, the Fixed Point will be replaced by the Panning Point. Only one panning point needs to be digitized in each image. As the camera view is panned, the panning point will most likely need to be adjusted as initial panning points move out of the image. Panning points are specified using the **PAN POINT** command in the **CONTROL** menu.

BODY JOINTS

The term "Body Joint" is used in this discussion, however, it should be noted that the digitized points do not have to be on the human body. These can represent any digitized points of interest as defined in the Sequence Information menu.

Digitizing the actual body joints for the first image may now proceed. . The next point to be digitized will be labeled in the View Window Status Bar. Position the video cursor to that joint and click the left mouse button. The digitized point will appear on the graphic display. Continue to position the video cursor to each point and click the mouse. As this is done, not only will the point locations appear on the graphic display, but a stick figure image of the subject will be constructed as additional points are added. After the last point in the image has been digitized, the word **COMPLETE** will appear in place of the current joint name on the View Window Status Bar. Attempts to digitize additional points will elicit a beep to signal that an error has been made.

If a mistake is made while digitizing, either by digitizing the wrong joint or positioning the cursor improperly, corrections of one or more digitized points may be made by pressing the middle button on the mouse or selecting the Erase icon from the toolbar. Each time this function is selected, the last point will be removed or un-digitized from the current image. Thus, to remove the last three points, this function would be selected three times. After removing the incorrect points, the correct points are then digitized to

complete the frame. Once all desired images are completed, press the advance icon in the toolbar to proceed to the next image.

The system is now ready for the second image to be digitized, with an additional feature of the digitizing module immediately apparent. The video cursor is now pre-positioned for each point to be digitized. This is because the digitizing module learns to identify the body joints as they are digitized. The more frames digitized, the better the learning process will be. However, the human eye is still superior to the computer in locating body joints, so use the initial cursor location as an approximation and make fine adjustments manually to achieve the best level of accuracy for digitizing. As digitizing proceeds, only small adjustments should be needed, thus repositioning greatly speeds the digitizing process. Digitize the fixed point and all the body joints for the second image just as with the first image, then select Advance.

CONTROL (CALIBRATION) POINTS

There is one additional operation that must be performed for each view that is digitized. In addition to digitizing the subject, the control points used to calibrate the image space must also be digitized once for each camera view. Although this discussion is being presented at the end of the digitizing process, it is usually a good idea to digitize the control points **FIRST**, so that they are not forgotten. This is also required for Real-Time 3D Integration. It is possible, however, to digitize control points at any time, from the first digitized image to the last.

STATIONARY CAMERAS

Control Points for stationary cameras are digitized using the following steps:

1. Follow the steps listed in the "Creating A New Digitizing View File" section above.
2. If multiple views are open simultaneously, click the left mouse button on the name located in the top section of the desired View Window to make this window active. Be careful not to click the mouse in the image portion of the window. If this is done, the computer will think you are attempting to digitize this view. Select the **ERASE** icon to remove any accidental digitizing.
3. Select the **DIGITIZE** command from the **CONTROL** menu. The current video image will be removed from the active view window.
4. Select the **OPEN VIDEO** command from the **CONTROL** menu a second time. Then select **AVI FILE**. A menu will be displayed to allow the user to select the AVI File for Control Points. Click once on the desired file and a small preview window will display the image. Select the **OPEN** button to accept the file. **NOTE:** Be sure to select a view file from the **SAME** camera or the wrong control point information will be read
5. A panel of numbered images will be presented to allow the selection of the desired image for digitizing. If you do not see the desired image, select the **NEXT** or **+** button to advance the images in sets or one at a time. Double-clicking on an image will toggle between an expanded and compressed image size.

Select the desired image with a left click of the mouse. Then select **OK** to proceed.

The Digitizing module now allows the digitizing of Control points in a manner similar to digitizing an image of the subject's activity. First digitize the Fixed Point. It is important to select the same fixed point as used for the activity itself. Next digitize each of the control points in the exact order that they were defined (the order that coordinate locations were entered) when this sequence was created. It is highly recommended to make a sketch or drawing of the control points from each camera view and to number them so that they are not entered incorrectly during digitizing. Save these drawings if there will be additional sequences using the same control points. As the control points are digitized, they will appear on the graphic display as numbered points. When all the points have been digitized, compare the display with the drawing to ensure that the points have been digitized correctly. Repeat the steps listed above to digitize the control points for all desired views in the sequence.

WARNING

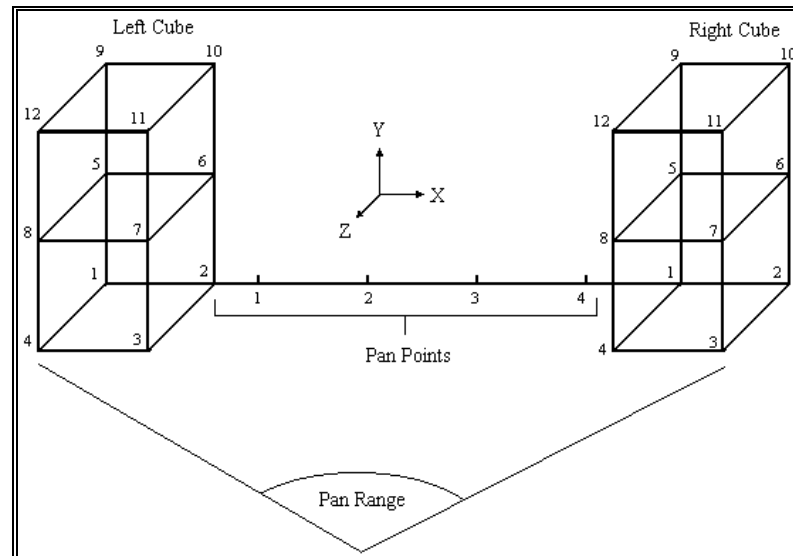
If the control points are wrong, the resulting image sequence will be wrong!

When all the control points have been digitized correctly, follow the steps listed below to return to digitizing body joints.

1. Select the **FINISH** command from the **CONTROL** menu.
2. At this point, it is possible to continue digitizing images in the sequence or, if digitizing is complete for each camera view, to leave the digitizing module.

PANNING CAMERAS

Digitizing the Control Points for Panning cameras is similar to stationary cameras except that Panning cameras require two sets of control points, with Panning points in between. Refer to the figure below.



The Left and Right Control fixtures require a minimum of 8 points each (though 14 or more are highly recommended). All points should have Cartesian coordinates measured relative to a single origin, though each set of control points will be digitized separately. As with stationary cameras, the coordinate axes are based on the right-hand-rule.

It does not matter if one digitizes the Left or Right set of control points first, though it is recommended to establish a “standard” order for digitizing so that essential items will not be forgotten. This discussion will present the Left set of control points first.

Control Points for Panning cameras are digitized using the following steps:

1. Creating A New Digitizing View File and be certain to set the View Type to **Panning** in the View Information menu. This will identify the view as a panning camera view
2. If multiple views are open simultaneously, click the left mouse button on the name located in the top section of the desired Panning View Window to make this window active. Be careful not to click the mouse in the image portion of the window. If this is done, the computer will think you are attempting to digitize this view. Select the ERASE icon to remove any accidental digitizing.
3. Select the **DIGITIZE** command from the **CONTROL** menu. The current video image will be removed from the active view window.
4. Select the **PAN LEFT** command from the **CONTROL** menu. This designates that the Left Control Points will be digitized. The current selection is designated by the checkmark next to the command. If this is already checked, proceed to the following step.
5. Select the **OPEN VIDEO** command from the **CONTROL** menu and select **AVI FILE**. A menu will be displayed to allow the user to select the AVI File for the panning Control Points. Click once on the desired file and a small preview window will display the image. Select the **OPEN** button to accept the file. NOTE: Be sure to select a view file from the SAME camera or the wrong control point information will be read
6. A panel of numbered images will be presented to allow the selection of the desired image for digitizing. If you do not see the desired image, select the **NEXT** or **+** button to advance the images in sets or one at a time. Double-clicking on an image will toggle between an expanded and compressed image size. Select the desired image with a left click of the mouse. Then select **OK** to proceed.
7. The Digitizing module now allows the digitizing of Control points in a manner similar to digitizing an image of the subject’s activity. Digitize each of the control points in the exact order that they were defined (the order that coordinate locations were entered) when this sequence was created. It is highly recommended to make a sketch or drawing of the control points from each camera view and to number them so that they are not entered incorrectly during digitizing. Save these drawings if there will be additional sequences using the same control points. As the

control points are digitized, they will appear on the graphic display as numbered points. When all the Left Control points have been digitized, compare the display with the drawing to ensure that the points have been digitized correctly.

8. Select the **FINISH** command from the **CONTROL** menu to save the Left Control Data. (NOTE: The steps listed above are now repeated for the Right control points).
9. Select the **DIGITIZE** command from the **CONTROL** menu.
10. Select the **PAN RIGHT** command from the **CONTROL** menu. This designates that the Right Control Points will be digitized.
11. Select the **OPEN VIDEO** command from the **CONTROL** menu and select **AVI FILE**. A menu will be displayed to allow the user to select the AVI File for the panning Control Points. Click once on the desired file and a small preview window will display the image. Select the **OPEN** button to accept the file. NOTE: Be sure to select a view file from the SAME camera or the wrong control point information will be read
12. A panel of numbered images will be presented to allow the selection of the desired image for digitizing. If you do not see the desired image, select the **NEXT** or **+** button to advance the images in sets or one at a time. Double-clicking on an image will toggle between an expanded and compressed image size. Select the desired image with a left click of the mouse. Then select **OK** to proceed.
13. The Digitizing module now allows the digitizing of Control points in a manner similar to digitizing an image of the subject's activity. Digitize each of the Right control points in the exact order that they were defined (the order that coordinate locations were entered) when this sequence was created. When all the Right Control points have been digitized, compare the display with the drawing to ensure that the points have been digitized correctly.
14. Select the **FINISH** command from the **CONTROL** menu to save the Right Control Data.

WARNING

If the control points are wrong, the resulting image sequence will be wrong!

At this point, it is possible to continue digitizing images in the sequence or, if digitizing is complete for each camera view, to leave the digitizing module.

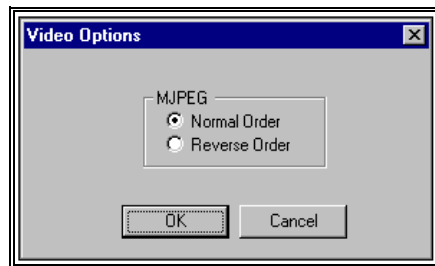
DIGITIZING OPTIONS

There are a number of optional features available in the Digitizing Module that have been designed to augment or enhance the digitizing process. Several other options require a more detailed discussion and have been listed under individual headings (Automatic Digitizing, Panning Cameras etc.).

IMAGE ORDER

The **VIDEO** command is used to specify the display order for the odd and even video fields. Depending on the hardware and software combinations used for recording and displaying the AVI files, it is possible for the order of the displayed fields to be reversed. For this reason, the Ariel DIGITIZE program provides the option to specify the order for displaying the AVI files. If it appears that the images are “jerky” or are being displayed in a “zigzag” manner, the field order probably needs to be reversed. The order can be changed using the following steps.

1. Select the **VIDEO** command from the **IMAGES** menu.
2. Specify Normal or Reverse Order by clicking next to the desired option. The current setting is designated by the mark to the left.



OPENING MULTIPLE VIEW FILES

1. Select **New View** from the **File** menu.
2. Enter the View Information
3. Open the corresponding image file.
4. Begin the Digitizing process.

In the Digitizing phase of the analysis, certain joints may often be obscured from a particular view. This situation often meant that the joint had to be “estimated” with limited information. The DIGI4 program allows up to four views to be opened and digitized either simultaneously or individually. This is a useful feature in cases of obscured joints. While one view may have a joint that is not visible, other views will show the same joint from a different perspective. This allows a more educated estimate to be made for digitizing the joint in the view where the joint is obscured.

LOCKING MULTIPLE IMAGES

1. Select the **LOCK** command from the **IMAGES** menu.

When two or more images are opened simultaneously it is often helpful to have the images advance and/or reverse at the same rate. The Advance, Reverse, First, Last and Select commands in the Images menu affect all View Windows when the LOCK function is turned on. When the LOCK function is turned off these commands only affect the active window. The current status of the LOCK function is shown in the Status bar.

CORRECTING DIGITIZED POINTS

Points that are digitized incorrectly can be corrected by one of three methods:

1. Selecting the **Correct** command in the **Images** menu. Each time the Correct command is selected, the cursor will reverse one point.
2. The middle button on the three button mouse can also be utilized for correcting points. Each time the middle button is pressed, the cursor will reverse one point.
3. Selecting the **Erase All** command in the **Images** menu. When the Erase All command is selected, all digitized points in the current image will be erased.

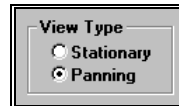
ENTERING MISSING POINTS

Points that are unable to be digitized should be entered as Missing by selecting the **Missing** command from the **Images** menu. An example of this function would be the case of a baseball batter hitting a ball. If the ball is digitized as one of the points it may move beyond the boundary of the image. In this case the ball would be entered as Missing when it is no longer visible. This command is useful for points that are missing in only a few images. For points not visible for extended periods, please refer to the help section on INVISIBLE POINTS.

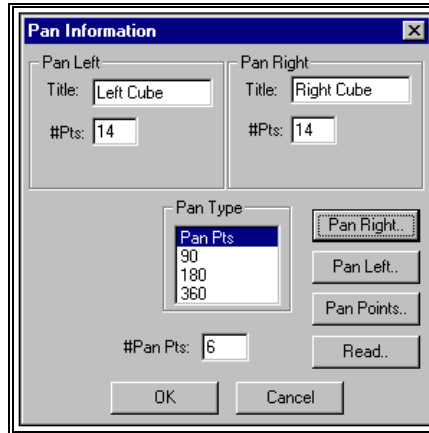
PANNING CAMERAS

The ARIEL DIGI4 software supports panning camera video data from either of two sources: Utilizing the ARIEL Panorama “Panning” head (hardware based) or simply panning the camera while on a tripod (software based). The procedure for digitizing the panning camera view is identical to the stationary camera with the exception of the calibration process. Panning camera views require a “left” and “right” calibration device instead of a single fixture.

1. Enter the View Information and set the View Type to **Panning** in the View Information menu. This will identify the view as a panning camera view. Press **OK** to proceed.



2. Enter the Panning Information.



Pan Left/Right - When digitizing a panning camera view, it is necessary to digitize a set of pan/control points with the camera panned Left and a set with the camera panned Right. The X,Y,Z coordinates must be known for all control points. Additionally, all coordinates must be relative to a single XYZ origin (0,0,0).

Title - Allows the user to specify an identification label for the Left and Right set of panning control points.

#Pts - Used to enter the number of panning control points for each of the Left/Right sets.

Pan Type - Two types of panning views are supported by the **DIGI4** program. The PAN TYPE is used to specify which method is being used.

Pan Pts - The Pan Points method requires a Left and Right calibration fixture with points of known coordinates lying between the two fixtures. No external hardware is required to be attached to the camera. When this option is used, the user must specify the number of points between the two fixtures (**#Pan Pts**).

90/180/360 - These numbers refer to the "Panning Range" when using the ARIEL Panorama hardware. The Panning Range is set by switches on the back panel of the Panning Unit. This option only requires a Left and Right calibration fixture. Points between the two fixtures are not used, thus **#Pan Pts** is not available.

Pan Right/Left/Points - These buttons are selected to enter the X, Y and Z coordinates for the corresponding fixtures. All coordinates must be relative to a single origin designated as (0, 0, 0) and entered in the units specified in the Sequence Information menu. Coordinates can also be **READ** from previously created files.

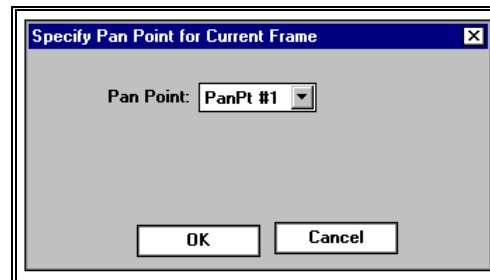
3. Open the Image File

Select the **Open PCX/AVI Images** command from the **File** menu.

When this option is selected the Open file menu box will be presented. Select the desired image file by entering the file name and pressing the ENTER key.

4. Begin the Digitizing Process.

Beginning with the Pan Point#/Bar, each point should be digitized using the mouse. The next point to be digitized will be labeled in the View Window Status Bar. When the current image is finished and the Status Bar indicates COMPLETE, the image can be advanced by double-clicking the Right mouse button. As the camera view is panned, the Pan Points will have to be changed as it moves out of view and the next Pan Point becomes visible. The Pan Point is changed by selecting **Pan Point** from the **Control Menu**. Continue the digitizing process until all the images in the image file have been digitized.



REAL-TIME 3D INTEGRATION

The 3D feature can be activated to simultaneously generate “*.3D” files while digitizing multiple views of a sequence. As each point is digitized for each of the active views, a graphical display is created with position data for up to 6 curves, a 3D stick figure, or both. Regardless of which type of 3D displays are selected, a *.3D file is generated with a complete set of information for all joints plus the computed Center-Of Gravity. These displays are extremely helpful in verifying that accurate digitizing is being performed. Generating the *.3D file in the DIGI4 module also eliminates the need for executing the ARIEL Transformation module, thus decreasing the time required for a complete analysis.

REQUIREMENTS FOR 3D INTEGRATION

REQUIREMENTS FOR CORRECT 3D OPERATION

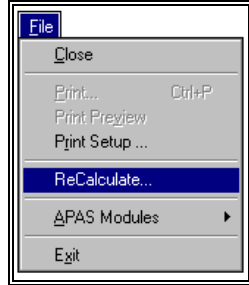
For correct operation of the 3D algorithm, the following conditions must be adhered to **PRIOR** to activating the 3D option. Specific notification messages will appear if these requirements have not been met.

1. The CONTROL points must be digitized from each of the active views
2. The SYNCH points must be properly designated for each of the active views. It is recommended to CAPTURE each view from the same starting image to synchronize the images by default. The only limitation imposed is that the program will not handle SYNCH points between images.

UPDATING THE 3D FILE INFORMATION

When the 3D option is active, a *.3D file is generated for each joint plus the CG using the digitized information during the digitizing process. If any changes are performed on points that have already been digitized, the 3D calculations must be re-calculated to reflect the new changes. This is accomplished by the following steps:

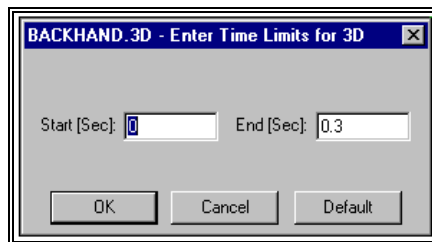
1. Select the **ReCalculate** command from the **FILE** menu. When this option is selected, you will be presented with the Time Limits menu.



2. Enter the desired Start and End Time Limits for the 3D calculation. The default values indicate the entire sequence where time matched values exist. If you wish to use the entire sequence for the 3D calculation, select the OK button.

There may be times when you wish to only consider a portion of the digitized data, eliminating images at the beginning and/or end of the sequence. In this case, manually enter the desired time range by typing in the Start and End times. Then select the OK button.

The DEFAULT button will restore the Start and End times to the original values to encompass the entire "time-matched" sequence.

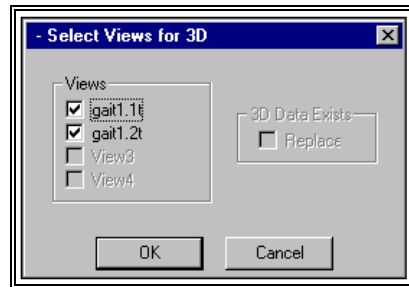


ACTIVATING THE 3D FIGURE OPTION

STARTING THE 3D FIGURE OPTION

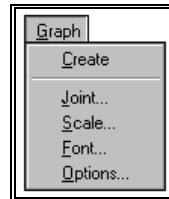
1. Select the **FIGURE** command from the **3D** menu.

2. Select the views to be used for generating the 3D information. Views are selected/deselected using the left button of the mouse and clicking the button to the left of each view name. If a *.3D file already exists for this Sequence (by previously selecting the 3D option or executing the Transform module), you will be prompted to either Keep or Replace the data. Placing a check in the button to the left of the REPLACE will replace the existing file with the newly generated data.

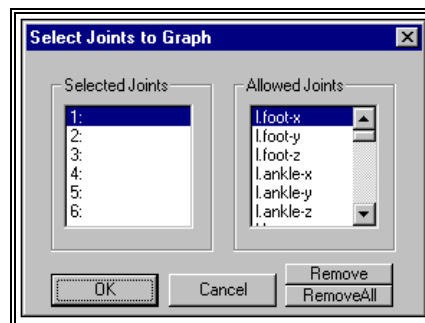


ADDING 3D GRAPH TO THE 3D FIGURE OPTION

In addition to the 3D stick figure, up to 6 graphs can be displayed simultaneously during the digitizing process.



1. Select the **CREATE** command from the **GRAPH** menu. A window will appear for Selecting the Joints To Graph.



The Allowed Joints are displayed in the right side table. Up to 6 joints can be selected using the left mouse button. When a joint is selected, the Joint Name will be placed in the Selected Joints table. Joints can be removed one at a time by highlighting the joint in the Selected Joints table and selecting the REMOVE button in the lower right corner of the menu box. Selecting the REMOVE ALL button will clear the entire Selected Joints table.

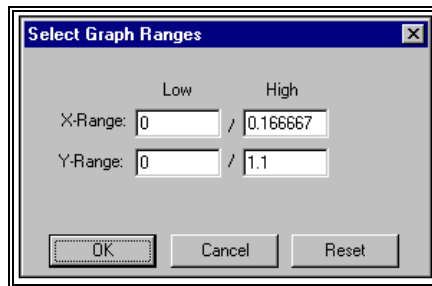
Once the joints have been specified, select the OK button to display the graph(s) or the CANCEL button to abort.

If the digitizing status of the current images are COMPLETE, the graph(s) will appear in the display window. If the current images are not digitized (or currently in progress), the graph(s) will be displayed only up to the current point. The current digitizing status is displayed in the lower portion of each View Window.

2. After the display of the graph(s) appear, several options exist for enhancing the display. They are all selected from the **GRAPH** menu.

The **JOINT** command is selected to change any of the currently displayed joints. This option allows the user to add, delete and/or change the currently displayed joints. A maximum of 6 joints are allowed at a single time for the graphing option.

The **SCALE** command is selected to change the SCALE of the displayed graphs. When this option is selected, a menu will appear to allow the user to set the Low and High range for both the X and Y axes. The RESET button will restore the X and Y range to the original settings.



The **FONT** command is selected to change the FONT of the labels displayed on the graph. When this option is selected, a menu will appear to allow the user select the Font, Font Style, Size and Effects of the text information on the graph.

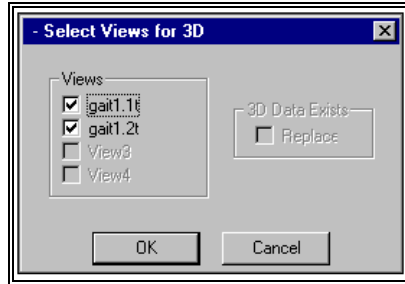
The **OPTIONS** command has been reserved for future enhancements to the graphical data.

ACTIVATING THE 3D GRAPH OPTION

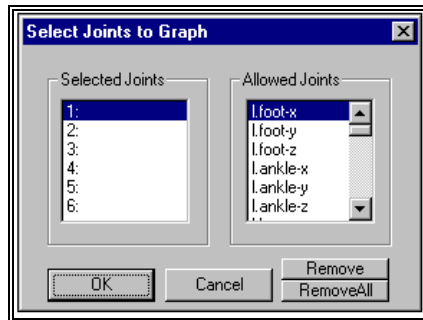
STARTING THE 3D GRAPH OPTION

1. Select the **GRAPH** command from the **3D** menu.
2. Select the views to be used for generating the 3D-GRAPH information. Views are selected/de-selected using the left button of the mouse and clicking the button to the left of each view name. If a *.3D file already exists for this Sequence (by previously selecting the 3D option or executing the Transform

module), you will be prompted to either Keep or Replace the data. Placing a check in the button to the left of the REPLACE will replace the existing file with the newly generated data.

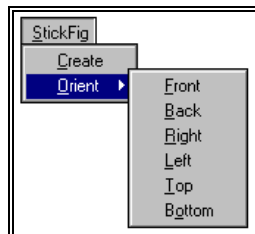


3. Select the JOINTS TO GRAPH from the displayed points. The Allowed Joints are displayed in the right side table. Up to 6 joints can be selected using the left mouse button. When a joint is selected, the Joint Name will be placed in the Selected Joints table. Joints can be removed one at a time by highlighting the joint in the Selected Joints table and selecting the REMOVE button in the lower right corner of the menu box. Selecting the REMOVE ALL button will clear the entire Selected Joints table. Once the joints have been specified, select the OK button to proceed or the CANCEL button to abort.



ADDING 3D FIGURE TO THE 3D GRAPH OPTION

In addition to the graphical display, a 3D stick figure can be displayed simultaneously during the digitizing process.



1. Select the **CREATE** command from the **STICK FIGURE** menu. A window will appear for displaying the 3D stick figure. If the

digitizing status of the current images are COMPLETE, the figure will appear in the display window. If the current images are not digitized (or currently in progress), the image will be displayed only up to the current point. The current digitizing status is displayed in the lower portion of each View Window.

2. After the "stick figure" image is created, the displayed image can be viewed from any orthogonal axis (Front, Back, Right, Left, Top, Bottom) by selecting the **ORIENT** command from the **STICK FIGURE** menu.

AUTODIGITIZING

The AutoDigitizing feature can be utilized with either the *.AVI or *.PCX video formats, though AVI is the recommended format. For best results, it is recommended that high contrast markers be used.

STARTING / STOPPING AUTODIGITIZING

STARTING THE AUTODIGITIZING FEATURE

1. Select the **START** command from the **AUTOMATIC** menu. You will be presented with the Select Views for AutoDigitizing menu showing all active views.
2. Select the views for automatic digitizing by clicking in the box next to each desired view. The checkmark indicates that automatic digitizing will be applied. Blank boxes must be manually digitized.
3. Proceed with the Digitizing process. The Auto-Locate Properties menu will be displayed the first time each point is digitized. One image for each view must be completely digitized manually to initiate the automatic tracking algorithm.

NOTE: If a point is digitized incorrectly, select the CANCEL button and Re-Digitize the point.

SUSPENDING THE AUTODIGITIZING FEATURE

Automatic Digitizing can be suspended using one of two methods:

1. Select the **SUSPEND** command from the **AUTOMATIC** menu. Digitizing can be suspended to examine or adjust any points during the AutoDigitizing process.

OR

2. Select the **SUSPEND** icon from the **DIGI4 Toolbar**.

Automatic Digitizing can be resumed by:

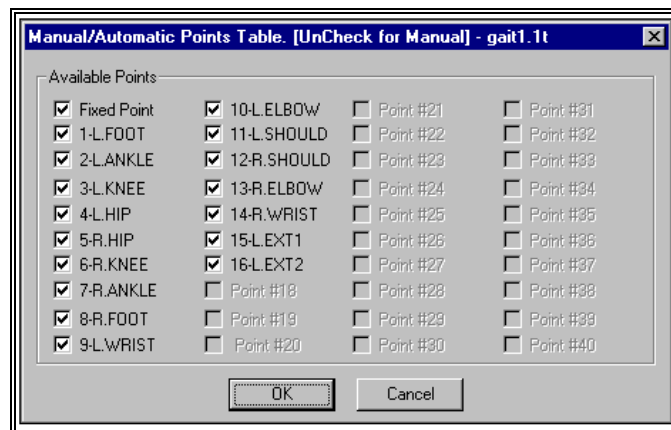
1. AutoDigitizing can be resumed by selecting the **START** command from the **AUTOMATIC** menu.

STOPPING THE AUTODIGITIZING FEATURE

1. Select the **STOP** command from the **AUTOMATIC** menu

POINTS TABLE

The POINTS TABLE can be used to designate whether specific points should be digitized automatically or manually. A list of the Point Id's is displayed in the POINTS TABLE. Points that are marked with the X are to be digitized automatically (depending on the marker contrast) while points that are not marked with the X will require manual entry by the user. Points can be altered at anytime during the AutoDigitizing process by selecting the SUSPEND option. If the Auto-Advance feature is not activated, points can also be altered when the current image has been completely digitized.



LOCATOR TABLE

This table shows the parameters for each point used in the AutoLocating feature. These are:

Joint	Active	#Pix[Min]	#Pix[Max]	Threshold	Peak	Width	Height
FixedPt	Yes	22	66	130	254	50	36
1-L.FOOT	Yes	12	36	127	229	50	36
2-L.ANKLE	Yes	12	36	134	224	50	36
3-L.KNEE	Yes	16	48	117	253	50	36
4-L.HIP	Yes	12	36	104	206	50	36
5-R.HIP	Yes	10	500	0	0	50	36
6-R.KNEE	Yes	13	39	107	213	50	36
7-R.ANKLE	Yes	5	30	118	197	50	36
8-R.FOOT	Yes	11	33	100	190	50	36
9-L.WRIST	Yes	12	36	110	200	50	36
10-L.ELBOW	Yes	5	27	140	210	50	36
11-L.SHOULD	Yes	5	30	128	218	50	36

#Pix[Min]

This is the minimum percent of spotsize (#Pixels) that will be imposed on the next image for this spot if relative, or absolute number of pixels if not. This number is initially the same as those entered in the Global Options but may be changed point by point in this table.

#Pix[Max]

This is the maximum percent of spotsize (#Pixels) that will be imposed on the next image for this spot if relative, or absolute number of pixels if not. This number is initially the same as those entered in the Global Options but may be changed point by point in this table.

Threshold

This is the pixel brightness that a pixel must have to be considered as part of a spot. Pixel brightness ranges from 0 to 255. The higher the threshold, the fewer pixels will be considered as part of a spot.

Width/Height

The pixel width and height of a search rectangle centered around the expected SPOT center. The detected SPOT must be entirely inside this rectangle.

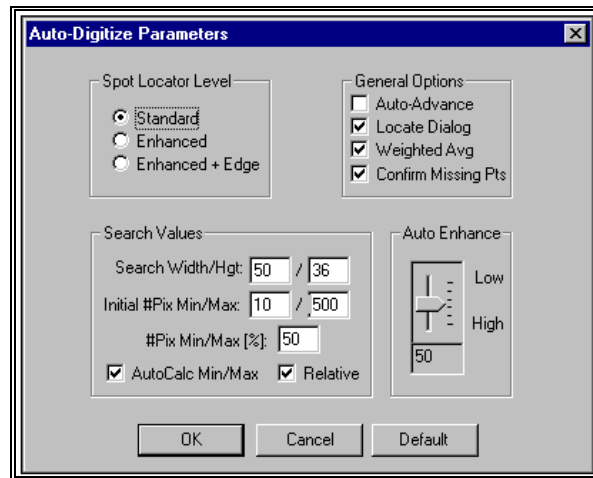
BRIGHT / DARK POINTS

The Bright/Dark command is selected to designate the AutoDigitizing points for each view file. When this option is selected, the following menu will appear. Each view can be independently set for either Bright or Dark markers by selecting the appropriate option under each view title.

Select AutoD Bright/Dark Points	
gait1.1t <input checked="" type="radio"/> Bright <input type="radio"/> Dark	gait1.3t <input checked="" type="radio"/> Bright <input type="radio"/> Dark
gait1.2t <input checked="" type="radio"/> Bright <input type="radio"/> Dark	gait1.4t <input checked="" type="radio"/> Bright <input type="radio"/> Dark
<input type="button" value="OK"/> <input type="button" value="Cancel"/>	

GLOBAL OPTIONS

The AutoDigitize Parameters box is listed below. These parameters provide global options for use in the AutoLearn and AutoDigitize features. Each item is described below:



SPOT LOCATOR LEVEL

Image enhancement algorithms have been incorporated to the automatic digitizing algorithm to aid in the process of locating markers. There are three levels of complexity as described below. The initial default value for the autodigitize algorithm level is “Standard”. This means the program defaults to the algorithm previously implemented until the user changes the level. This level is stored permanently and will retain its value until the user actively changes it. This is true even if the program is shutdown and the computer system is turned off. NOTE: This value can only be changed prior to starting the automatic digitizing process.

Standard

This is the standard locating algorithm that has been used in previous versions of APAS. No image processing is applied to the image when the spot locating takes place. This algorithm attempts to distinguish markers against the immediate background based on a user adjustable threshold value.

Enhanced

The Enhanced algorithm employs a series of image enhancement filters to the image which make the markers more easily and reliably recognized. The following series of filters is applied to the image area of interest before the spot locating takes place: Median followed by Gamma, with the Gamma factor being selected using the AutoEnhance slider bar. **NOTE: Since the software is automatically applying a series of filters to the image, it is very important that the user does NOT specify additional image enhancement filters.** The filters that are automatically applied while locating the markers do not affect the image as it appears on the screen.

Enhanced + Edge

The “Enhanced + Edge” algorithm employs the “Enhanced” algorithm described above and additionally calculates the derivative of the image to detect any edges in the image. This algorithm detects all prospective marker spots in the image using “Enhanced” algorithm and then rejects any markers that do not have well defined edges. The enhancements are applied to the region of the image where the spot is

expected so one does not see the whole image transformed. However, the before/after images shown in the Auto-Locate Properties are indeed the filtered images.

GENERAL OPTIONS

Auto-Advance

Auto-Advance is used to automatically advance to the next image when all the points in the current image have been completely digitized. An X in the box activates the Auto-Advance feature while the unmarked box deactivates the Auto-Advance feature.

Locate Dialog

Locate Dialog, if activated, the program will display a dialog showing the auto-location information as each point is traced during the learning phase of AutoDigitizing. The user can modify any of the parameters and re-locate in the dialog information.

Weighted Average

The auto-digitizing software locates the center of a marker using a Weighted Average by brightness. This option can be turned on/off using the check box. If selected, the program will weight each pixel according to intensity. If not selected, all pixels above the threshold value are treated the same.

Confirm Missing Points

Confirm Missing Points, if selected, the program will prompt the user to manually digitize points that AutoDigitize fails to locate. If not selected, the program will automatically set these points to MISSING.

SEARCH VALUES

Search Width/Height

Search Width/Height specifies the size of the rectangle in pixels centered at the expected location which defines the search area for spot locating. Any spot must lie entirely inside this rectangle. It must be large enough to allow for spot motion frame-to-frame, but if so large that it includes many spots, the program may get bogged down sorting out which spots belong to which points.

Initial #Pix Min/Max

When the software performs the initial locating of a spot, these numbers set minimum and maximum limits on the size a spot can be during this initial locate phase. If the spot is very small and one sets the minimum too high, the software may reject an obvious spot because it does not contain a sufficient number of pixels. This would also be the case for large spots and setting the maximum too low. These are outer limits and should be set with a large margin of error. Since the user points to the image location before this initial locate operation takes place the default setting is Min#=2 and Max#=500. If the spots are very small, the Min# should be set to 1.

#Pix Min/Max [%]

#Pix Min/Max [%] is used when the "Auto-Calculate Min/Max#" option is selected and represents the percentage that a spot may grow or shrink when advancing to the next image. For example, if this is 50% and in one image the spot has 50 pixels, then in the next image the spot cannot have more than 75 pixels or less than 25 pixels. This means that the software will reject any spot that is outside these limits. If this percentage is too large, the software may find extraneous spots that are closer to the expected location. If it is too small, the software may reject an obvious spot because lighting changes or motion relative to the camera has resulted in the spot growing/shrinking by too much. This is particularly important for small spots where a few pixels of change may be a sizable percentage.

Auto-Calculate Min/Max

Auto-Calculate Min/Max, if selected, the program will calculate the min/max# of pixels allowed in a spot as a percentage (%) above/below the number of pixels in the spot located in the learning phase of AutoDigitizing. The percentage (%) is specified by the user.

Relative/Absolute

When ABSOLUTE is active (unmarked box) the minimum and maximum number of pixels is static for each spot. These numbers remain unchanged until the user explicitly changes the values. If RELATIVE is active (marked box), then for every image, the software dynamically calculates a new Min/Max# pixels based on the size of a spot in the previous image.

AUTO ENHANCE

Low/High

The Auto Enhance slider bar allows the user to select the GAMMA value applied to the image when using the "Enhance" or "Enhance + Edge" spot locator levels. On the slider bar, a value of zero corresponds to a GAMMA[100] and results in no change in the image. A value of 100 corresponds to GAMA[200]. This information is stored by the program and remains set until changed by the user.

CORRECTING / MOVING POINTS

Digitized points can be corrected or adjusted in any of several manners.

CORRECTING DIGITIZED POINTS

Points that have been digitized incorrectly can be corrected by:

1. Advance/Reverse to the image that contains the point(s) to be corrected.
2. Use one of the three options below to reverse to the desired point(s). Each time one of the options is selected, the current digitized point will be erased and the cursor will reverse to the previous point. For example, in order to "back-up" three points, the CORRECT option would need to be selected three times. Then all three points would need to be digitized again.
 - a. Select the **CORRECT** command from the **IMAGES** menu
OR
 - b. Select the **CORRECT** icon from the **TOOL BAR**
OR
 - c. Press the **MIDDLE** button on the three button mouse
3. Redigitize the desired point(s)

MOVING DIGITIZED POINTS

Digitized points can be moved without affecting any other points using the Drag/Drop feature:

1. Place the cursor on top of the digitized point to be moved.
2. Simultaneously press the **CONTROL** key and the **LEFT** mouse button.
3. Drag the point to the desired location on the screen and release the mouse button.

The Drag/Drop feature can be aborted by Dragging the cursor off the image area and releasing the mouse button.

INVISIBLE POINTS

A feature that is often helpful in both manual and automatic digitizing is the ability to "mark" a point as invisible. For example, a golf ball might be digitized while analyzing a golf swing. If the ball proceeds beyond the boundary of the video field, it would be nice to "eliminate" the ball from this point forward instead of using the MISSING option in every image. This can be accomplished using the INVISIBLE POINT options. When points are labeled as "Invisible" the software will skip the point and proceed to the next sequential point for digitizing.

1. Select the **INVISIBLE PTS** command from the **VIEW** menu. You will be presented with the Invisible Points Table. All the points in the current sequence are listed in the table.
2. Points should be designated as INVISIBLE by removing the checkmark next to the desired point.

AUTODIGITIZING & INVISIBLE POINTS

When points are initially labeled as Invisible and the Autodigitizing feature is utilized, the user must be aware of the steps required to make the point visible again. For example, if a gait analysis is being performed and the heel marker is not visible for the first several images, the heel point can be marked as invisible. When the heel marker becomes visible again, the following steps should be performed to resume autodigitizing with the heel point included.

1. When the point becomes visible again, select the INVISIBLE PTS command from the VIEW menu to mark the point as visible.
2. When it becomes time to digitize the "new" point, digitize the point with the "SHIFT" key pressed down while Left-Clicking the mouse. This is the RE-LOCATE function.
3. Proceed with the digitizing process.

VIDEO ENHANCEMENT OPTIONS

Several filters and adjustments have been added to the DIGITIZE module to enhance detection of markers and aid in the digitizing process.

FILTER OPTIONS

The FILTER options allow the user to apply image processing filters to the AVI image. Filters are applied to the active image using the following steps.

1. Use the mouse to select the image to apply the filter. If only one image is open, it is already active.
2. Select the **FILTER** command from the **ENHANCE** menu. A list of available filters will be displayed.
3. Select the desired filter by left clicking the name with the mouse. A list of available filters is described below.

Prewitt

The Prewitt filter is an edge detection technique that is used to detect horizontal or vertical edges. All pixels not on the detected edges are changed to black.

Sobel

The Sobel filter is an edge detection technique that is used to enhance edges in all directions. All pixels not on the detected edges are changed to black. The usage is the same as Prewitt, but the algorithm is different.

Laplacian

The Laplacian (high-pass) filter is an edge detection technique that is used to detect lines by weighting the difference between the center pixel and its neighbors. There are three omnidirectional filters and three bi-directional ones. All pixels not on the detected lines are changed to black.

Gaussian

The Gaussian filter is a low-pass spatial filter that is used to reduce random noise. It performs a weighted sum (center pixel highest weight) of each pixel's neighborhood. The result is normalized by the total neighborhood weight. Neighborhood size can be selected as 3x3 or 5x5.

As the Gaussian filter removes noise, it has the side-effect of generally smoothing or blurring images and reducing edge information.

Highpass

The High-Pass filter allows the high-frequency variability associated with noise, to remain (pass through the filter) while removing the low frequencies corresponding to the gradual overall variation in brightness. Fine details in the frequency domain correspond to high frequencies.

As the High-Pass filter enhances the fine details, it has the side effect of enhancing noise.

In High-Pass filtering, the objective is to get rid of the low frequency or slowly changing areas of the image and to bring out the high frequency or fast changing details in the image.

The simplest method of implementing a high-pass filter is to take a pixel and subtract it from its neighbors. If the pixel is in an area of little change, the difference between the pixel and its neighbor will be zero. However, if the pixel is in an area of rapid change (such as an edge), the difference will be large.

Sharpen

The Sharpen filter is based on the Laplacian filter and includes/adds the original image.

Median

When using the Median filter, each pixel is determined by the median value of all pixels in a selected neighborhood. The median value of a pixel neighborhood is that value in which half of the population has smaller values and the other half has larger values.

The Median filter belongs to a class of edge preserving smoothing filters which are non-linear filters. This filter smoothes the data while keeping the small and sharp details. In contrast to low-pass filters, the Median filter keeps edges and completely removes single pixel errors (like hot pixels).

ADJUST OPTIONS

The ADJUST option allows the user to adjust various aspects of the AVI image.

Brightness

The Brightness adjustment allows the user to vary the amount of light intensity at each point in the image.

Contrast

The Contrast adjustment is used to vary the range of light and dark values in a picture.

Highlight

The Highlight adjustment is used to add luminance. The lighter the pixels, the more luminance is added.

Midtone

The Midtone adjustment is used to shift the middle of the luminance scale either up or down.

Shadow

The Shadow adjustment is used to remove luminance. The darker the pixels, the more luminance is removed.

Gamma

The Gamma adjustment is used to compensate for the nonlinear response of the display device. The light intensity produced by display devices is not proportional to the input voltage. This non-linearity follows an exponential function called “gamma.” Gamma correction can be thought of as the process of compensating for this non-linearity in order to achieve correct reproduction of intensity.

Hue

The Hue adjustment allows the types of color to be varied. Red, yellow, blue etc are hues of color or types of color. Hue is the parameter of color that allows us to distinguish between colors.

Saturation

The Saturation adjustment allows the intensity of a color to be adjusted. For example, a lightly saturated red looks pink. Fully saturated red is like the red of a crayon. Not to be confused with brightness, saturation is the amount of pigment in a color and not the intensity. Low saturation is like adding white to the color.

RESTORE

The RESTORE option is used to restore the image to the original condition by removing all filters and/or adjustments that have been applied. Images can be restored to original condition using the following steps.

1. Use the mouse to select the image to restore. If only one image is open, it is already active.
2. Select the **RESTORE** command from the **ENHANCE** menu.

AUTO

The AUTO option is used to automatically apply the specified filters and/or adjustments to all other images. This command acts as a toggle switch and is “on” when the check mark appears next to the command in the menu bar. When this option is off, the specified enhancements will only apply to the currently active image. When this option is on, the enhancements will automatically be applied to all images in the file. For example, when the forward or reverse command is given, the next image will automatically have the same enhancements applied. The AUTO function is selected/deselected using the following steps.

1. Use the mouse to select the desired image. If only one image is open, it is already active.
2. Select the **AUTO** command from the **ENHANCE** menu to activate this function. Select the **AUTO** command again to turn it off.

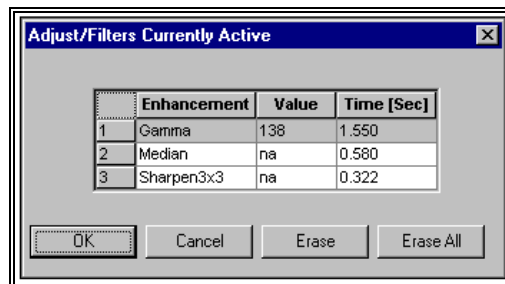
EDIT

The EDIT option allows specified enhancements to be edited on an individual basis. When this option is selected, a menu will be presented with the current list of enhancements. Current video enhancements can be edited using the following steps.

1. Use the mouse to select the image to edit. If only one image is open, it is already active.
2. Select the **EDIT** command from the **ENHANCE** menu. A menu box similar to the one shown below will be displayed. Individual selections can be deleted by highlighting the desired item and selecting the **ERASE** button. All the selections can be removed by selecting the **ERASE ALL** button. Select **OK** to save the current changes or **CANCEL** to exit the Edit menu without saving changes.

The menu is divided into four columns. The first column shows the sequence of video enhancements that have been applied to the currently active image. The second column lists the specific Filter or adjustment that has been made. The third column list the value used with the Adjustment command. Since the Filter command has no specific value, an **NA** will be displayed next to any filters. The last column indicates the time required to perform the particular filter.

NOTE: Applying filters and adjustments can be computationally intensive and the time required for each image can add up quickly!



ZOOMING OPTIONS

The Digitize module incorporates both static and dynamic Zooming options to enhance the digitizing process and improve digitizing accuracy.

ZOOM

The ZOOM command is used to expand the selected image up to four times the original size. Expanding single pixels into many allows the Zoom function to achieve sub-pixel accuracy for both manual and automatic digitizing.

1. Select the **ZOOM** command from the **VIEW** menu. You will be presented with a list of Zooming values ranging from 0.5x up to 4x.
2. Select the desired Zooming value.

When a zooming value has been selected, the entire image will zoom to the selected size inside the View Window. It may be necessary to use the scroll bars to readjust the image to the desired area. Zooming factors can only be used on the active window. The DIGI4 program will “remember” points that are digitized with a zooming factor in all subsequent frames.

3. Select the **1x** Zooming factor to restore the image to the original captured size.
4. Select the **RESET ALL** command to remove all Zooming commands.

ZOOM WINDOW

The **ZOOM WINDOW** command is another option available for improved digitizing accuracy. This command is used to open either a Static or Dynamic Zoom Window.

1. Select the **ZOOM WINDOW** command from the **VIEW** menu. You will be presented with the option to choose Static or Dynamic zoom and a list of Zooming values ranging from 1x up to 10x.

STATIC ZOOM

1. Select the **STATIC** command in the **ZOOM WINDOW** options menu.
2. Select the **ZOOM WINDOW** command from the **VIEW** menu a second time to specify the zooming factor. You will notice a checkmark next to the Static command. Specify the desired zooming value and a Zooming Window will be opened to display the zoomed image.
3. Initially, the user will have to manually adjust the desired image in the Static Zoom Window. This image can be adjusted by pressing (and holding) the **CONTROL** key on the keyboard and simultaneously **Right-Clicking** the mouse on the desired location of the original image. This point will now be centered in the Static Zoom Window and expanded using the specified zooming value. The desired point(s) can be digitized from either the original View Window or from the Static Zoom Window. Digitize the desired point and proceed to the next point in the digitizing process.
4. Repeat Step #3 above for all desired points. After a point has been digitized using the Static Zoom Window, the APAS software will remember the location and position the Zoom Window automatically for subsequent images in the same sequence. The user still has the option to adjust the image using the **CONTROL-RIGHT CLICK** command.

5. The ZOOM WINDOW can be removed by clicking the X in the upper right corner of the Static Zoom Window or by selecting **VIEW, ZOOM WINDOW** and **NONE**.

DYNAMIC ZOOM

1. Select the **DYNAMIC** command in the **ZOOM WINDOW** options menu.
2. Select the **ZOOM WINDOW** command from the **VIEW** menu a second time to specify the zooming factor. You will notice a checkmark next to the Dynamic command. Specify the desired zooming value and a Zooming Window will be opened to display the zoomed image.
3. The image displayed in the Dynamic Zoom Window is adjusted by changing the cursor position on the original image. The zoomed image can be "locked" in place for digitizing by pressing (and holding) the **CONTROL** key on the keyboard and simultaneously **Right-Clicking** the mouse on the desired location of the original image. This point will now be centered in the Dynamic Zoom Window and expanded using the specified zooming value. The desired point(s) can be digitized from either the original View Window or from the Dynamic Zoom Window. Digitize the desired point and proceed to the next point in the digitizing process.
4. Repeat Step #3 above for all desired points. After a point has been digitized using the Dynamic Zoom Window, the APAS software will remember the location and position the Zoom Window automatically for subsequent images in the same sequence. The user still has the option to adjust the image using the CONTROL-RIGHT CLICK command.
5. The ZOOM WINDOW can be removed by clicking the X in the upper right corner of the Dynamic Zoom Window or by selecting **VIEW, ZOOM WINDOW** and **NONE**.

DIGI4 QUICK REFERENCE

CREATING A NEW SEQUENCE

1. CREATE A NEW SEQUENCE FILE

- a. Select **FILE**, **SEQUENCE**, and **NEW** to create a new sequence file.
- b. Select the Drive, Folder and specify a Name for the Sequence File. **NOTE:** Make certain the file name has the *.CF extension. Select **OK** to proceed.

2. ENTER SEQUENCE PARAMETERS

- a. Enter **Sequence Title**, **Units**, **#Points**, **#Control**, **Type**, **Height** and **Weight** in the data fields. If Type is set to USER-DEFINED, you must select the **SEGMENTS** button and define the point connections and segment parameters. The **READ** button can be selected to retrieve this information from a previously created file.
- b. Select **POINT ID's** button and enter the point names to be digitized. Select **OK** to proceed.
- c. Select **CONTROL XYZs** button and enter the Cartesian coordinates for the control points. The **READ** button allows you to read coordinates from a previously created file. Select **OK** to proceed.
- d. Select **OK** when all sequence parameters have been completed.

3. CREATE A NEW VIEW FILE

- a. Select **FILE**, and **NEW VIEW** to create a new view file.

4. ENTER VIEW INFORMATION

- a. Enter **View Title**, **Frame Rate**, **Camera ID**, **Camera X,Y,Z**, and **View**. Be certain to enter an accurate value for Frame Rate. Select **OK** to proceed.

5. OPEN IMAGE FILE

- a. Select **FILE**, and **OPEN AVI IMAGES** to open the desired image file that contains the view to be digitized. Make certain that the image corresponds to the View Information entered above.
- b. Select Primary AVI File For Digitizing by clicking once on the desired file. The file will open in a small preview window in the lower right corner of the menu box. Select **OK** to accept

and open the file. Double-clicking the desired file name will automatically accept and open the file.

6. OPEN ADDITIONAL VIEW FILES (OPTIONAL)

- a. Repeat steps 3 through 5 above to open additional camera views. Up to 4 views can be digitized simultaneously.

DIGITIZE CALIBRATION/CONTROL POINTS

1. OPEN CORRESPONDING CALIBRATION/CONTROL FILE

- a. When more than one view file window is open at once, the window you are currently working with is the *active window*. Make a note of which View window is currently active in order to associate the corresponding calibration file.
- b. **PANNING VIEWS ONLY**: Select **CONTROL, PAN RIGHT** to indicate that the Right calibration points will be digitized.
- c. Select **CONTROL, DIGITIZE** to change to the Control Point mode.
- d. Select **CONTROL, OPEN VIDEO, AVI File** to select the AVI file for the control point image.
- e. Select AVI File For Control Points by clicking once on the desired file. The file will open in a small preview window in the lower right corner of the menu box. Select **OK** to accept and open the file. Double-clicking the desired file name will automatically accept and open the file. Make certain that the control file corresponds to the *active window* from step a listed above.
- f. Select desired Control Image Frame by clicking on the desired image. Click **OK** to proceed.

2. DIGITIZE CONTROL POINTS

- a. Digitize Control Points as requested in the Status Bar of the *active window*. Proceed until the Status Bar indicates **Complete**.

3. CHANGE THE ACTIVE WINDOW AND REPEAT FOR ALL OPEN VIEW FILES

- a. Click the cursor in the next open View window and repeat steps 1 and 2 listed above to digitize the control points for each of the View files. When the control points from all views have been digitized, you are ready to exit the control point mode.
- b. Select **CONTROL** and **FINISH** to exit the control point mode and return to digitizing the data file. The first image of the data file will automatically be displayed.

- c. **PANNING VIEWS ONLY:** Select **CONTROL, PAN LEFT** and repeat the steps 1b through 3b listed above to digitize the Left calibration points.

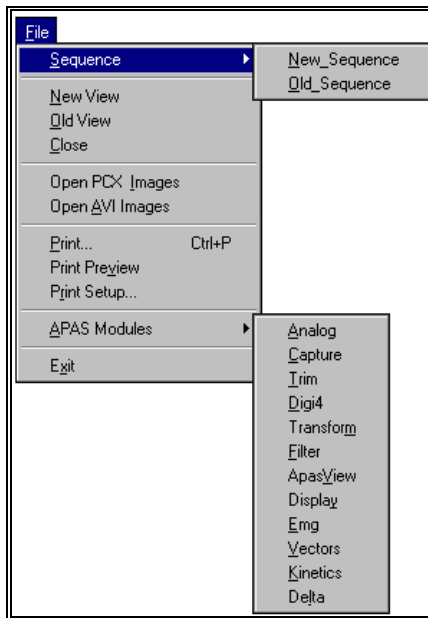
DIGITIZE DATA POINTS

1. LOCK MULTIPLE VIEW FILES TOGETHER (OPTIONAL)
 - a. When more than one view file window is open at once, it is often helpful to LOCK the images together. Select **IMAGES** and make certain that the **LOCK** command is checked. If not, select **LOCK** to enable the LOCK function. The LOCK status is also indicated in the Status Bar of the DIGI4 window.
2. DIGITIZE DATA POINTS
 - a. Digitize Data Points as requested in the Status Bar of *the active window*. Proceed until the Status Bar indicates **Complete**
 - b. Click the cursor in the next open View window and repeat step *a* listed above to digitize the data points for each of the View files.
 - c. Advance to the next image in the View file(s) by one of three methods: Double-clicking the right mouse button, selecting the advance icon in the Tool Bar, or by holding the ALT key and simultaneously press the right arrow key.
 - d. Repeat the Digitizing process until ALL points from ALL views are digitized.
3. EXIT THE DIGI4 PROGRAM
 - a. Select **FILE** and **EXIT** to exit the DIGI4 program.

DIGI4 MENUS

Listed below are the various menus for the DIGI4 program. Select the desired menu to see a description of the available commands for each menu.

FILE MENU COMMANDS



Sequence

The SEQUENCE command is selected to start a NEW sequence or retrieve an OLD sequence. When this option is selected, you will be presented with two commands:

NEW is selected to create a NEW digitizing SEQUENCE.

OLD is selected to retrieve a SEQUENCE that was previously created.

New View

NEW VIEW is selected to begin a new view for digitizing. Each time the NEW VIEW is selected, a new *.xt file will be created where x is the sequential number of view for this sequence. For example, the first time NEW VIEW is selected, a file will be created with the *.1t extension. The second time creates a file with the *.2t extension etc.

Old View

OLD VIEW is selected to retrieve a view that has been previously created using the NEW VIEW command.

Close

Closes the currently active file.

Open PCX Images

Selected to OPEN a file saved in *.PCX format.

Open AVI Images

Selected to OPEN an image file saved in *.AVI format.

Print

Print the current file on the selected printer.

Print Preview

Selected to check or examine the positioning on one or more pages. When you give the Print Preview command, a new window will be open showing the document position as it would appear on paper. To close the Print Preview window, select the Cancel button to go to the previous mode.

Print Setup

Selected to examine or change the Printer, Orientation and Paper options for the PRINT function.

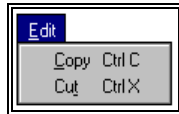
APAS Modules

Selected to open additional APAS modules while keeping the current program open. When this command is selected, the user will be presented with a list of APAS modules.

Exit

Selected to EXIT the DIGI4 program and return to Windows.

EDIT MENU COMMANDS



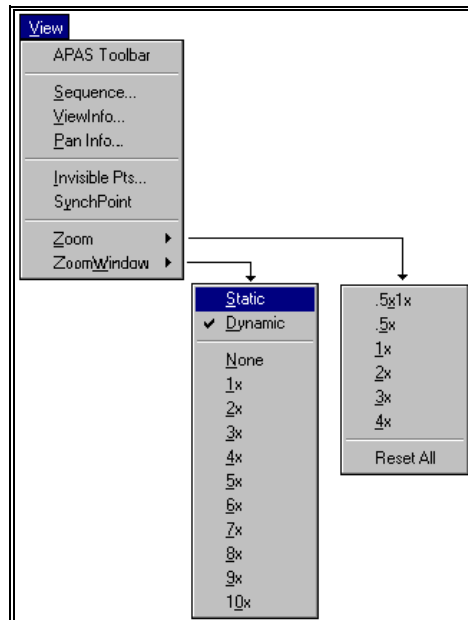
Copy

Selected to COPY the selected items to the clipboard.

Cut

Selected to CUT the selected items and place them in the clipboard.

VIEW MENU COMMANDS



APAS Toolbar

Selected to toggle on/off the APAS toolbar. When this option is active, the APAS toolbar will be displayed and allow the user to select additional APAS modules while keeping the current program open. The toolbar can be positioned to the desired position by dragging it with the mouse.

Sequence

SEQUENCE is selected to access the SEQUENCE information. This command can be used for reviewing the SEQUENCE parameters, changing/reviewing the Point ID's or Control Point locations.

ViewInfo

VIEW INFORMATION is selected to review/change the information associated with the currently active view.

PanInfo

PAN INFORMATION is selected to review/change the information associated with the currently active "panning" camera view.

Invisible Pts

INVISIBLE POINTS is selected to designate specific points as "invisible" during the digitizing process. This command is often useful for points that may become obscured for periods of time during digitizing. When a point is designated as "invisible," it will be skipped during digitizing. When (and if) the point(s) become visible again, the invisible designation can be removed and the point(s) will become active again.

SynchPoint

The SYNCHRONIZING POINT command can be utilized to designate the Synchronizing Point in each camera view. For example, if a golf swing is being analyzed and the club head impact with the ball is used for the Synch Point, at the image closest to the impact, you would give the SYNCH POINT command and enter the Frame Offset from the current position.

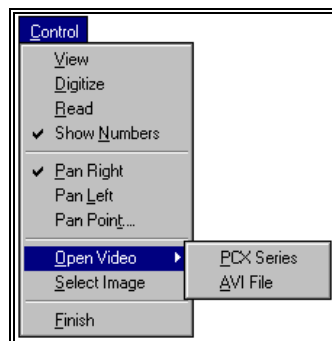
Zoom

The ZOOM command can be issued at any time to enlarge a specified portion of the image. When this command is given, you will be presented with a menu of zooming values.

Zoom Window

The ZOOM WINDOW command can be issued at any time to open a Static or Dynamic zoom window to aid in the digitizing process.

CONTROL MENU COMMANDS



View

The VIEW command is selected to VIEW the image of the control frame. If the control points have been previously digitized, the digitized points will be superimposed on the video image. If the points have not been digitized, only the captured image will appear.

Digitize

The DIGITIZE command is selected to Digitize the control frame for the active view.

Read

The READ command is given to READ the digitized information for the control frame from another sequence. This command should only be used if you are certain that the camera is in the EXACT same location with respect to the calibration fixture.

Show Numbers

Selected to SHOW the Control Point Numbers on the display of the digitized control frame.

Pan Right

Selected to make the RIGHT PANning points active. This option should be selected when digitizing or viewing the RIGHT PAN calibration points.

Pan Left

Selected to make the LEFT PANning points active. . This option should be selected when digitizing or viewing the LEFT PAN calibration points.

Pan Point

Selected to designate the PANning POINT used for the current frame. While digitizing the Panning view, the original PAN POINT may only be visible for a short period of time. Select PAN POINT to re-define the PAN POINT when the subsequent point is no longer visible and you must change to another PAN POINT.

Open Video

The Open Video command is given to select a secondary video file for digitizing the control point locations. When this option is selected, you must specify whether the file is PCX or AVI format. The format is determined when capturing the images. After the format is selected, you will be allowed to select the drive, directory and file name to retrieve the image for digitizing.. The first image will be used for the CONTROL points only. As soon as Advance/Reverse is selected, the primary image file will be restored.

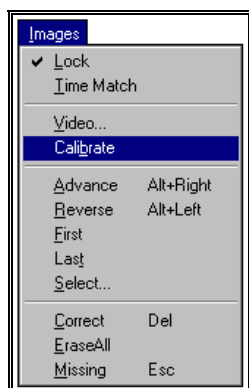
Select Image

The Select Image command is used to access the Select Image menu to specify a particular image for digitizing.

Finish

The FINISH command is selected when the Control Points have been digitized or viewed. When this command is selected, the primary image file will be restored (if previously opened) and the digitizing process can be started or continued.

IMAGES MENU COMMANDS



Lock

The LOCK feature can be selected to toggle the LOCK status of the view windows. When the images are LOCKed, the commands to advance/reverse images affect all open images (regardless of which window is currently active). When this feature is set to Un-LOCK, the advance/reverse commands only affect the active image (regardless of how many images are open). The current status of the LOCK feature is indicated in the lower right corner of the DIGI4 window.

Time Match

The TIME MATCH command can be selected to “re-synchronize” the images on the display. If the separate view files have been advanced/reversed independent of each other, the TIME MATCH command can be selected to adjust all open views to a synchronized point. When this command is selected, all open images will be adjusted to the view with the smallest time value. Time values are determined by frame rate and the synch point.

Video

The VIDEO command is selected to specify the image order of the MJPEG video file.

Calibrate

The CALIBRATE command is selected to “adjust” the horizontally and/or vertically split video file image when using the JVC High-Speed camcorders.

Advance

The ADVANCE command is selected to advance to the next image in the captured file.

Reverse

The REVERSE command is selected to reverse to the previous image in the captured file.

First

The FIRST command is selected to “jump” to the first image in the captured file.

Last

The LAST command is selected to “jump” to the last image in the captured file.

Select

The SELECT command is selected to jump to the desired image number. When this option is selected, you will be prompted to enter the desired image number.

Correct

The CORRECT command is selected to correct previously digitized points. The digitized location is erased and the cursor will reverse one point at a time for each time the CORRECT command is selected. All erased points will need to be redigitized to complete the current image.

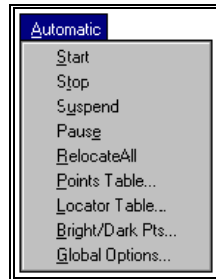
Eraser All

The ERASE ALL command is selected to ERASE all digitized points for the current frame. This option is useful when the entire image is to be re-digitized instead of selecting the CORRECT option for every digitized point in the current image.

Missing

The MISSING command is selected when a point to be digitized has moved completely out of the image field. For example, a ball that has been thrown or hit may be visible for only a few frames. When the point proceeds out of the image field and can no longer be digitized, this point should be marked as MISSING.

AUTOMATIC MENU COMMANDS



Start

Selected to activate the AutoDigitizing feature.

Stop

Selected to STOP the AutoDigitizing feature and resume with the Manual/Semi-Automatic digitizing process.

Suspend

Selected to pause the AutoDigitizing feature. This option is often useful when the Auto-Advance feature is activated. The SUSPEND command can be given to pause the AutoDigitizing and "adjust" any of the desired points. The SUSPEND command can also be issued by selecting the SUSPEND icon from the Digi4 Toolbar.

Pause

Selected to pause the current image prior to advancing to the next image when using the AutoDigitizing feature. This option is often useful to confirm the accuracy of the digitizing.

RelocateAll

Selected to RELOCATE ALL the points in the current image. When this option is selected, all digitized information for the current image will be erased and the cursor will begin at the first point of the image.

Points Table

The POINTS TABLE is used to mark points for either Automatic or Manual digitizing during the AutoDigitizing process. By default, all points are marked for AutoDigitizing. If you desire a point to be manually digitized, the point can be "un-checked" using the mouse. Selecting the joint again will mark the point for AutoDigitizing.

Locator Table

The LOCATOR TABLE shows the parameters for each point used in the AutoLocating process.

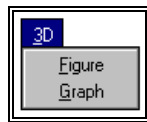
Bright / Dark Points

The Bright/Dark Points command is selected to designate whether the points for autodigitizing each view are Bright (against a darker background) or Dark (against a lighter background).

Global Options

The GLOBAL OPTIONS command can be given to access parameters associated with locating points for the Auto-Locate and AutoDigitize features of DIGI4. When this command is given, you will be presented with a table of options that can be used to adjust the Auto-Digitizing Parameters.

3D MENU COMMANDS



The 3D feature can be activated to simultaneously generate “.3D” files while digitizing multiple views of a sequence. As each point is digitized for each of the active views, a graphical display is created with a position data for up to 6 curves, a 3D stick figure, or both. Regardless of which type of 3D displays are selected, a *.3D file is generated with a complete set of information for all joints plus the computed Center-Of Gravity. These displays are extremely helpful in verifying that accurate digitizing is being performed.

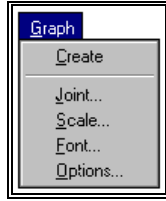
Figure

The FIGURE command can be given to activate the “real-time” stick figure option. When this option is selected, a 3D stick figure will be displayed as the individual view(s) are traced. A *.3d file is generated while tracing thus eliminating the requirement of executing the APAS Transformation module. This option requires that each view have digitized control points and the SYNCH points properly designated. SYNCH points between frames are not accepted by the system.

Graph

The GRAPH command can be given to activate the “real-time” graph option. When this option is selected, a graph with up to 6 curves will be displayed as the individual view(s) are traced. A *.3d file is generated while tracing thus eliminating the requirement of executing the APAS Transformation module. This option requires that each view have digitized control points and the SYNCH points properly designated. SYNCH points between frames are not accepted by the system.

GRAPH MENU COMMANDS



The GRAPH menu commands are only visible after activating the GRAPH and/or FIGURE command from the 3D menu.

Create

The CREATE command can be given to activate the “real-time” 3Dgraph option when the 3D stick figure option has already been activated. When this option is selected, the user will be prompted to select up to a maximum of 6 desired joints for graphically displaying the 3D position data.

Joint

The JOINT command can be given to change any of the currently displayed joints. This option allows the user to add, delete and/or change the currently displayed joints. When this option is selected, the Select Joints Table will be displayed. A maximum of 6 joints are allowed at a single time for the graphing option.

Scale

The SCALE command can be given to change the SCALE of the displayed graphs. When this option is selected, a menu will appear to allow the user to set the Low and High range for both the X and Y axes. The RESET button will restore the X and Y range to the original settings.

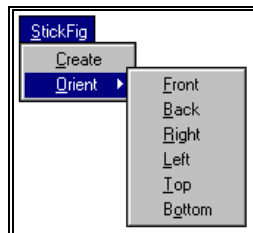
Font

The FONT command can be given to change the FONT of the labels displayed on the graph. When this option is selected, a menu will appear to allow the user select the Font, Font Style, Size and Effects of the text information on the graph.

Options

The OPTIONS command can be given to set the graphing options.

STICK FIGURE MENU COMMANDS



The STICK FIGURE menu commands are only visible after activating the GRAPH and/or FIGURE command from the 3D menu.

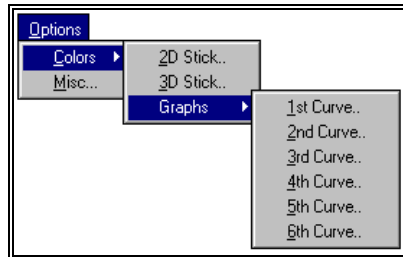
Create

The CREATE command can be given to activate the “real-time” stick figure option when the 3D graph option has already been activated. When this option is selected, the user will be prompted to select up to a maximum of 4 desired views for graphically displaying the 3D stick figure data.

Orient

The ORIENT command can be given to change the viewing axis of the stick figure display. When this option is selected, the user will be asked to select which viewing axis is desired. The desired axis is selected using the left mouse button. The system (by default) will display the XY plane as the FRONT view. All other views are relative to this designation.

OPTIONS MENU COMMANDS

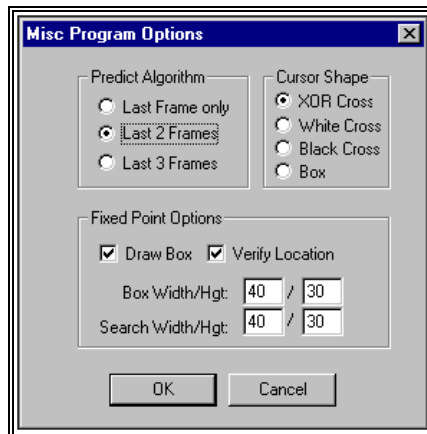


Colors

The COLOR command can be given to change selected colors of the 2D / 3D digitized stick figures and any of the 6 displayed graphs activated by the 3D menu command. When the desired figure/graph is selected, you will be presented with a chart of available colors. Select the desired color for the 2D/3D stick figure and/or graph using the Left mouse button.

Misc

The MISC command can be given to change the prediction algorithm, change the shape of the cursor and set several fixed point options. When this option is selected, you will be presented with the following menu.



Three options exist for the Prediction Algorithm:

Last Frame Only is selected for the program to assume that each point is in the same position as the previous image.

Last 2 Frames is selected for the program to predict the expected location of the point by interpolating the previous two frames of data.

Last 3 Frames is selected for the program to predict the expected location of the point by interpolating the previous three frames of data.

Several options also exist for selecting enhancements to the digitizing cursor:

XOR Cross is selected to change the color of the standard “cross-hair” cursor to a combination of white and black. Occasionally, the “cross-hair” is almost invisible against certain background images. When the “XOR Cross” option is selected, the cross-hair shaped cursor will appear black when placed on top of light colored images and white when placed on dark colored images.

White Cross is selected to change the color of the standard “cross-hair” cursor to white. Occasionally, the “cross-hair” is almost invisible against “dark” background images. When this situation occurs, the “White Cross” option can be selected to increase the visibility of the cursor against the dark background.

Black Cross is selected to change the color of the standard “cross-hair” cursor to black. Occasionally, the “cross-hair” is almost invisible against “light” background images. When this situation occurs, the “Black Cross” option can be selected to increase the visibility of the cursor against the light background.

Box is selected to change the shape of the cursor to a small box shape. The point to be digitized should be placed directly in the center of this box.

Fixed Point Options are available for “proximity checks” of the fixed point.

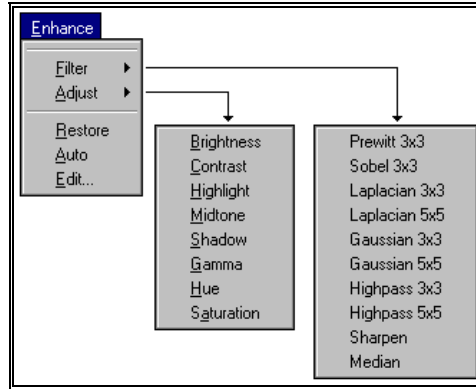
Draw Box is selected to place an optional box around the digitized fixed point. The fixed point will appear as all other digitized points when this option is not selected.

Verify Location when marked, the program will insure that the digitized fixed point falls within the region around the initial fixed point as defined in the Options dialog box. If this is disabled, the program will allow the user to digitize the fixed point anywhere on the image.

Box Width/Height is used to specify the width and height of the optional box centered around the fixed point. These values represent the number of pixels.

Search Width/Height is used to specify the dimensions of the area that the program will search for the fixed point.

ENHANCE MENU COMMANDS



Filter

FILTER is selected to allow the user to apply image processing filters to the AVI image for enhanced digitizing.

Adjust

ADJUST is selected to allow the user to adjust various aspects of the AVI image

Restore

RESTORE is selected to restore the image to the original condition by removing all filters and/or adjustments that have been applied.

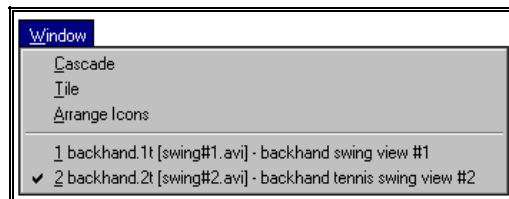
Auto

AUTO is selected to automatically apply the specified filters and/or adjustments to all other images. This option is toggled on/off. A checkmark indicates this option is active.

Edit

The EDIT option allows specified enhancements to be edited on an individual basis.

WINDOW MENU COMMANDS



Cascade

CASCADE is selected to display the open windows in a cascading fashion.

Tile

TILE is selected to display the open windows in a tile format on the screen.

Arrange Icons

The ARRANGE ICONS command is selected to automatically arrange the icons in the currently active Windows group.

View File Names

The View File names will be displayed for all the open view windows. The check mark indicates the currently active window. If the images are **LOCKED** together, VCR commands will affect all open windows regardless of which window is checked.

HELP MENU COMMANDS



Index

Selected to provide an INDEX of Help related topics.

Using Help

Selected to provide instructions on using the Help Windows.

About Digi4

Provides information about the Digi4 program and lists the functions of the Left (L), Middle (M) and Right (R) mouse buttons.

