Ariel Dynamics, Inc.

TRANSFORMATION MODULE

Revision 1.0
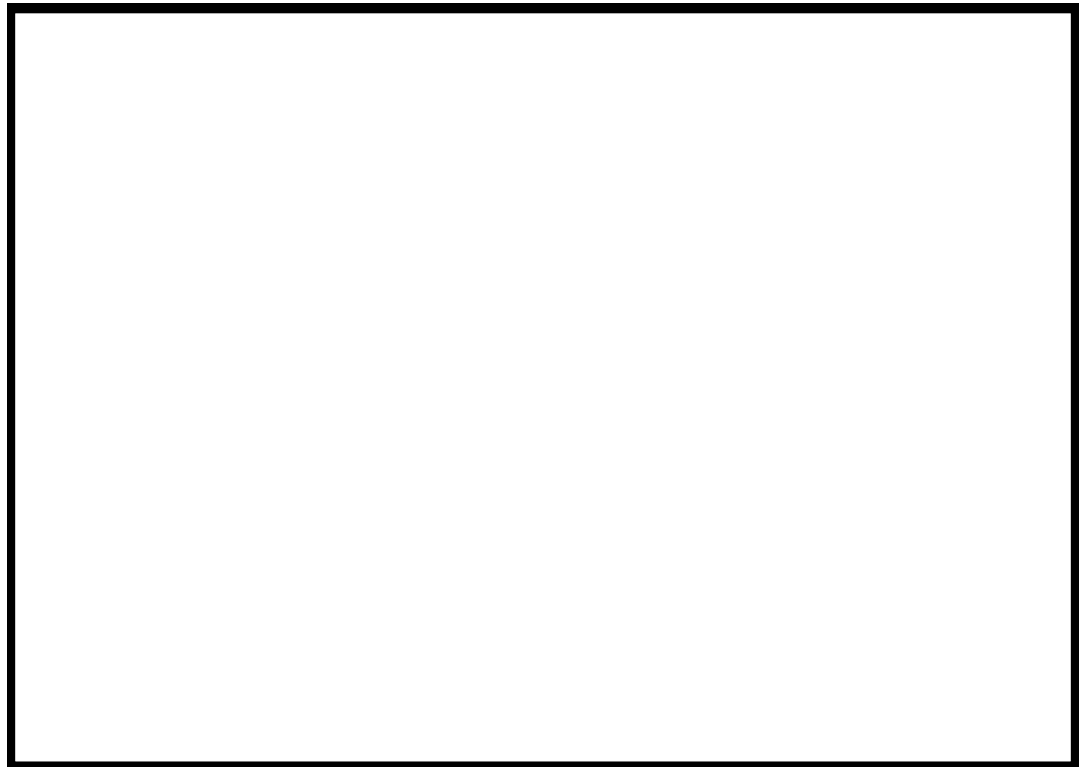
Contents

ARIEL TRANSFORMATION PROGRAM

INTRODUCTION

The computation phase of analysis is performed after all camera views have been digitized. The purpose of this phase is to compute the three-dimensional image space coordinates of the subject's body joints from the relative two-dimensional digitized coordinates of each camera's view. The **ARIEL TRANSFORMATION** software is a Windows based program for performing this conversion process.

Transformation is the process of converting two or more, two-dimensional digitized views into a three-dimensional image sequence. The transformation option is also available to convert a single, two-dimensional digitized view into a two-dimensional image sequence. In either case, the process involves transforming the relative digitized coordinates of each point in each frame to absolute image space coordinates. This process is performed entirely by the computer. Some initial timing information will be requested, after which the transformation will occur automatically.

Although a few of the **TRANSFORMATION's** features may appear complex, they are relatively easy to master once you understand the underlying concepts. This manual is arranged to teach you these concepts in a logical order by showing you, in step-by-step fashion, how to use **TRANSFORMATION**.

WHAT'S NEW IN TRANSFORMATION 1.0

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

1. **Stick Figure Display**. Stick Figures are displayed for each camera view as well as one for each of X, Y, and Z axes.

2. **Transformation Parameters.** Display DLT and PPT transformation parameters for each view.

3. **Support For Panning Cameras.** Views utilizing either the Ariel Panning head or any panning camera can be transformed for analysis.

4. **Synchronizing Algorithm.** A newly developed Synchronizing Algorithm determines relative error in synch time between views.

5. **Automatic Smoothing.** Smoothing can be accomplished automatically using user-defined smoothing values.

6. **APAS Tool Bar**. A toolbar has been added to allow the user to activate individual APAS modules from within the main programs.

SYSTEM REQUIREMENTS

The following table provides the basic guidelines for minimum and recommended hardware to provide the best possible performance. The software requires a minimum of Microsoft Windows 95/98 and APAS-2000 Revision 1.0 or later.

Component	Minimum	Recommended
Pentium Computer	Pentium 233	Pentium II 333 MHz or higher
Video Display	S-VGA (256 Colors)	High Color Display (65,000 colors or more)
RAM	32 MB	64 MB or more

TO START THE TRANSFORMATION PROGRAM

1. Double-click the **TRANSFORM** icon located in the **APAS System** window group. The main TRANSFORMATION window will appear.

SCREEN LAYOUT

Prior to performing the transformation process, you should take the time to familiarize yourself with the format and contents of the various screens listed below:

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.
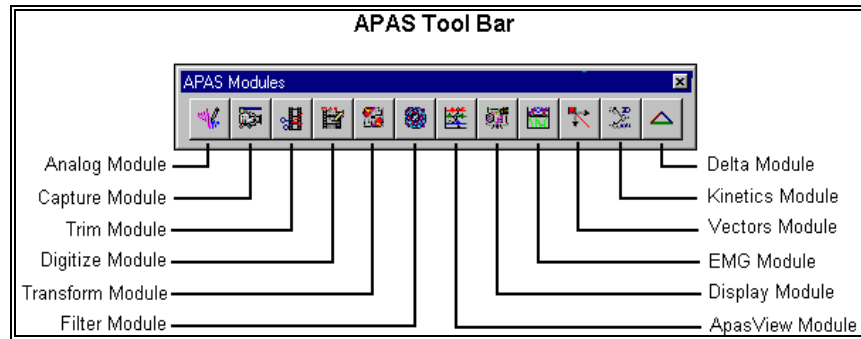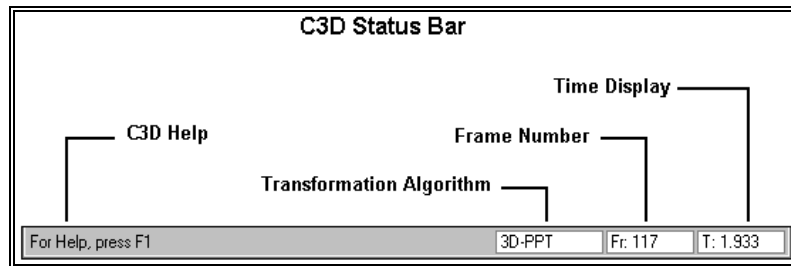

THE TOOL BAR

You can activate many functions by selecting the icons located on the **TRANSFORMATION** 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.
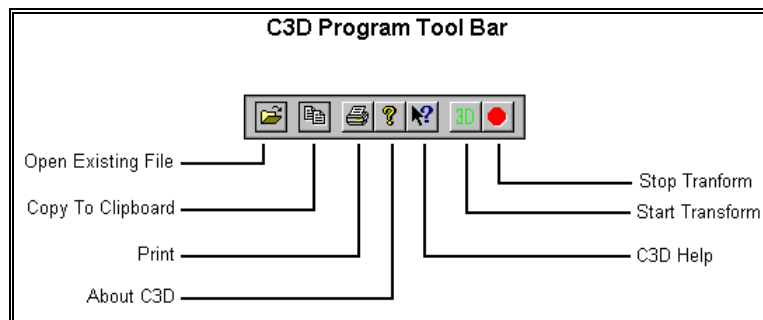
THE STATUS BAR

The status bar provides useful information about the current image status of the file during the Transform process. The status bar is located at the bottom of the **TRANSFORMATION** window. The far-left side of the status bar is divided into three separate fields. The left field displays the transformation algorithm being used. Available options are 2D-Multiplier, 2D-DLT, 3D-DLT and 3D-PPT. The middle field displays the current Frame number as the sequence is being transformed. The right field displays the current Time value as the sequence is being transformed.

C3D Status Bar

Time Display ———

C3D Help ———

Frame Number ———

Transformation Algorithm ———

| For Help, press F1 | | 3D-PPT | Fr: 117 | T: 1.933 |

TRANSFORMING A SEQUENCE FILE

1. Choose the **OPEN** command from the **FILE** menu. The **OPEN File** Dialog box will appear.
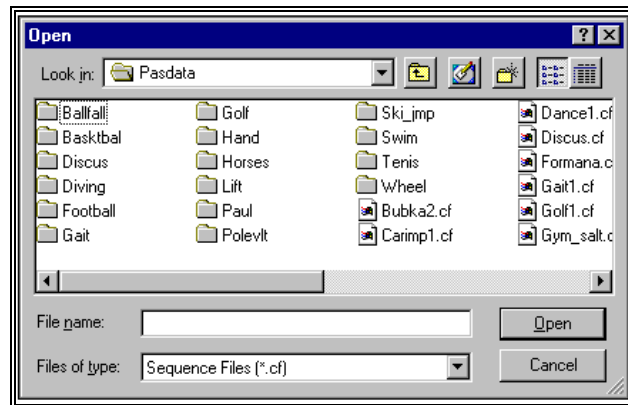
The OPEN File Dialog box looks for a particular type of file (files that have the extension of (***.CF**). This file is automatically created when a New Sequence is established in the APAS DIGI4 module. The OPEN File Dialog box can be used to specify the Drive, Directory, and Name of the sequence file to be retrieved. Select the sequence name to be transformed and then select **OPEN** to proceed.

A small window will appear indicating the path of the *.cf file and the algorithm that will be used for the transformation. The Transform Type is automatically determined by the software and is based on the control point coordinates entered in the Digitizing module.

The **Multiplier** algorithm indicates that only 2 control points have been specified. Only two-dimensional analysis can be performed using this algorithm. NOTE: The Z coordinate must be zero for 2D transformations.

C3D
D:\PASDATA\Gait\gait_mp.cf:
Transform Type: Multiplier
OK   Cancel
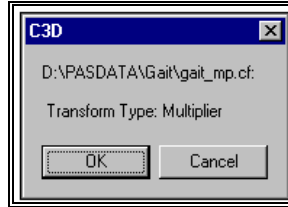
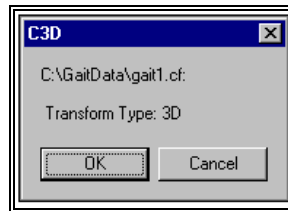The **2D-DLT** algorithm indicates that 4 or more coplanar control points have been specified.

C3D
D:\PASDATA\Gait\gait_2d.cf:
Transform Type: 2D-DLT
OK   Cancel
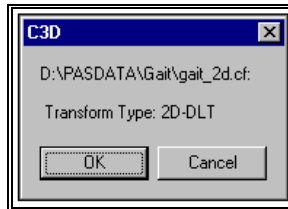
The **3D** algorithm indicates that 6 or more non-coplanar control points have been specified. Three-dimensional transformations require a minimum of two views.


C3D
C:\GaitData\gait1.cf:
Transform Type: 3D
OK   Cancel

Select **OK** to proceed. All the existing views for the associated *.CF file will be displayed one per row in a grid.

2. Select the views to be Transformed by double-clicking anywhere on the grid row of the desired view to toggle the "SEL" state for the row. A "YES" entry in the SEL column indicates that particular view will be included in the Transform process. If the SEL column is blank, the view will not be used in the Transform process.
NOTE: At least 2 views must be selected for 3-Dimensional data.

Sel	View#	Title	1st Time	Last Time	Rate	Pan
Yes	gait1.1t	Front Camera, Gait#1	0.000	1.917	60.000	
Yes	gait1.2t	Left Camera Gait#1	0.000	4.983	60.000	
Yes	gait1.3t	Right Camera, Gait #1	0.000	5.483	60.000	
	gait1.4t	Side Camera, Gait#1	0.000	1.917	60.000	

3. Select the **TRANSFORM** command from the **3D** menu (or select the 3D icon in the tool bar) to start the Transformation process. A menu box will be displayed where the user may select 1st/Last times and a data rate. Select OK to proceed with the transformation process using the values specified in the Transformation Parameter menu.
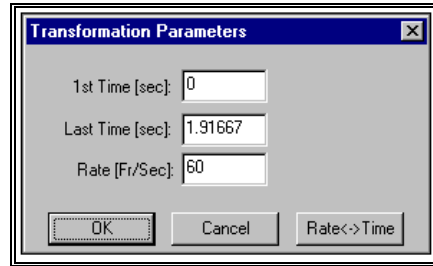
Stick figures will appear on the monitor, one for each view and one for each of the X, Y, and Z-axes as the transformation takes place. A confirmation screen will appear when the 3D Processing is complete.
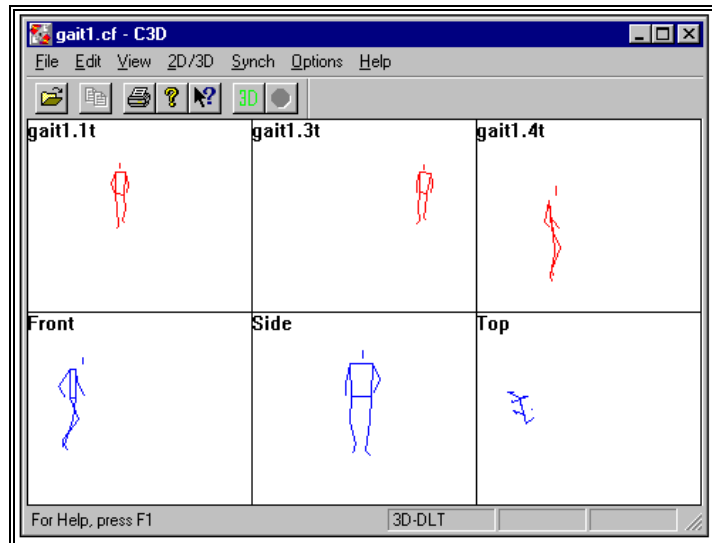
5. The **STOP** command can be selected from the **3D** menu to abort the transformation process. **STOP** can also be activated from the Tool Bar icon.

6. Upon completion of the Transformation, select the **DLTs_**etc command from the **3D** menu to see the actual transformation parameters.
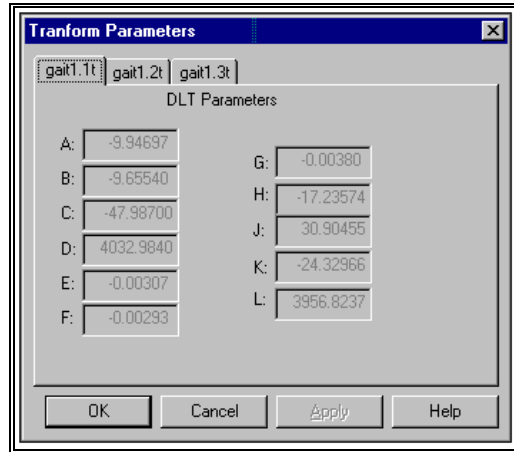
TIME MATCHING INFORMATION

If a three-dimensional transformation is being performed, an additional operation must be performed on the individual camera views to synchronize them. This process is called time matching. Since each digitized camera view may start at a different point in time, frame one of the first view may not correspond to frame one of the second view. The transformation will only yield accurate results if digitized coordinates from simultaneous frames are used. The **TRANSFORMATION** software utilizes the synchronizing event from each of the views as a basis for time matching. The time for each frame in each view is adjusted relative to the synchronizing event so that all the synchronizing events occur at the same absolute time.

1st Time (sec)

The 1st Time is the starting point in time for the resulting image sequence. Since the image sequence is created by combining information from each of the views, the sequence should not start until the view with the highest 1st-Time value starts. It is possible to specify that the image sequence should begin at a later time if the information from the beginning of the digitized views is to be omitted. In most cases, the image sequence is captured and digitized from a synchronized point, so this field will be zero.

Last Time (sec)

The Last Time is the ending point in time for the resulting image sequence. This value is computed by multiplying the number of images captured minus 1 by the frame rate entered in the DIGI4 module. For example: A sequence of 30 images captured at a Frame Rate of 60 images per second would have a Last Time of 0.483333 seconds.

Last Time = (30-1) * (1/60) = 29/60 = 0.483333 seconds

It is recommended that the default value be used unless a specific data interval is required for analysis.

Rate (Fr/Sec)

The Rate is the time between data points for the resulting image sequence. Image sequences do not have to have the same frame rate as the individual views. The **TRANSFORMATION** module will automatically interpolate linearly between digitized frames to create any resulting frame rate desired. For example, suppose views were recorded at the standard video rate of 60 Hz (1/60 = .0166 sec), but it is desired that the resulting image sequence has an apparent frame time of 0.01 seconds (100 images/second), then a value of 0.01 would be entered for Rate.

NOTES:

First, setting Rate to a very small value will create a large number of frames that will slow the analysis process and can possibly exceed the capacity of some of the analysis modules. It is NOT recommended to create sequences with more than 1000 frames.

Second, the analysis system cannot manufacture data. A higher frame rate will produce more stick figures; however, there will be no more actual information available than in the original digitized data. A tennis swing recorded at 60 images/second cannot be used to analyze the impact interval at 500 images/second. The information is just not there! For this reason, it is recommended that a time interval close to the digitized data interval be selected.
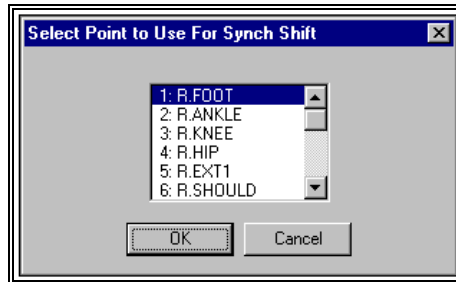
SYNCHRONIZING

One major contribution to error in 3D studies is the inability to accurately determine the synchronization between cameras that are not gen-locked. This is often achieved by trying to locate a synchronizing event or impact, a process that is accurate to .5 frames at best and may actually be several frames. The "**SYNCH**" command added to **ARIEL TRANSFORMATION** is a software feature that employs a newly developed algorithm to determine the relative error in the synch time.

SYNCHRONIZING VIEWS

The steps to synchronize multiple camera views utilizing the **ARIEL TRANSFORMATION** algorithm are listed below. For the Synch algorithm to work correctly there must be a single data point with a large amount of vertical (Y) motion. For example, include as an extra point, a ball falling that is simultaneously visible from all camera views.

1. Open the desired Sequence File and select the individual views to be used for the Transformation process.

2. Select the **AUTO-SYNCH** command from the **SYNCH** menu.

3. Select the point to be used for the Synch Shift. As stated above, this should be a single point with a large amount of vertical displacement. Select **OK** to proceed.

Select Point to Use For Synch Shift
1: R.FOOT
2: R.ANKLE
3: R.KNEE
4: R.HIP
5: R.EXT1
6: R.SHOULD

OK   Cancel

4. A table of time shifts for the different views is displayed to the user. The user can accept the values by selecting **OK**. This will update the view files with the new synch times. **Cancel** is selected to reject the computed values.

Saving Synch Shifts to View Files

View#	View	Shift[sec]	Shift[frame]
1	gait1.1t	0.000	0.000
2	gait1.2t	-0.033	-2.000
3	gait1.3t	0.033	2.000
4	gait1.4t	0.006	0.338

OK   Cancel
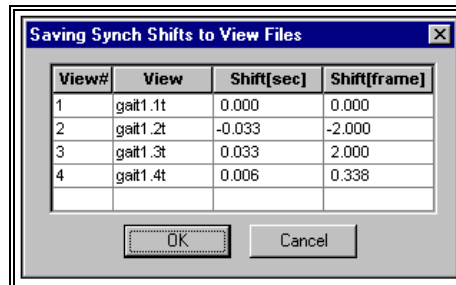
SYNCHRONIZING ALGORITHM

The **ARIEL TRANSFORMATION** synchronizing algorithm uses the fact that when calculating 3D from two 2D views the situation is over-constrained. Four numbers are used to calculate three unknown numbers using a least squares criteria. In such a situation the fit is not likely to be exact and there is a residual left over from the fitting calculation. The better the fit the smaller the residual. Think of fitting 3 points to a line. The "best" fit may not go through any of the three points. The deviation from the "best-fit" line is the residual.

In the case of 3D reconstruction, each camera determines a line in 3D space on which the point lies. In a perfect world the two lines, one for each camera, would intersect, the point of intersection being the 3D point of interest. In the real world, the lines don't actually intersect but there is a point of closest approach with the distance of closest approach being related to the residual.

Consider the "ideal" situation of a normal lab setup consisting of two cameras recording a falling object. As the object falls, the two lines of projections track the falling object intersecting exactly at the falling object. Now think of introducing a synch error so that one camera is now "seeing" the falling object at an earlier time from the other. For this camera the line of projection will point too high and the two lines will not intersect. The earlier the camera "sees" the falling object relative to the second camera, the greater the "miss" and the larger residual.

For this algorithm to work properly there must be a single point with a large amount of motion out of the plane that contains the camera projection centers. In most cases, this relates to VERTICAL (Y) motion. **NOTE: If everything is in one plane this approach will not work!**

The **Ariel TRANSFORMATION Synch algorithm** utilizes a point with large vertical motion and calculates a total residual value for this point summing over all frames as follows:

**ResidualSQ = SUM(Res[i]**2) for all frames "i"of interest**

Then the program finds the time shift that minimizes the above "ResidualSQ". The time shift that produces a minimum value is the **synch error**.

Several studies have been performed that suggests the data improves when this analysis is performed. However other factors could contribute which have nothing to do with a synch error. For example, suppose one view always has the falling object digitized low due to the person's digitizing inability to estimate the point center. This would appear as a synch shift because the program could improve the ResidualSQ by making that view slightly earlier thus raising slightly the projection line causing it to more closely intersect the other camera's projection line. Then for all other points in the study the data would be moved to this slightly earlier time as well.

OPTIONS

Selecting the OPTIONS command from the OPTIONS menu accesses the ARIEL **TRANSFORMATION** program options. Available options allow for the selection of the transformation algorithm and user-selectable colors for the "stick figure" displays.
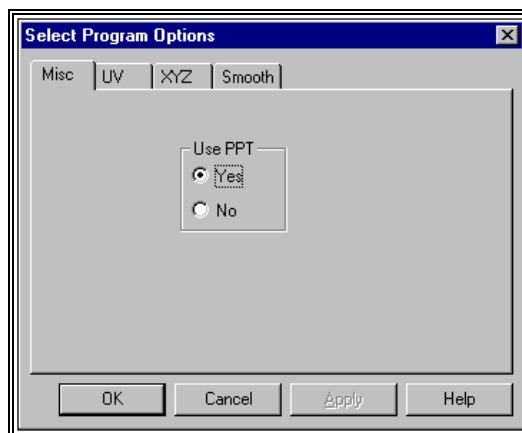
TRANSFORMATION ALGORITHMS

The ARIEL **TRANSFORMATION** program converts digitized coordinate locations to image space coordinate locations through a process known as "transformation." The **TRANSFORMATION** program provides two possible algorithms for performing the transformation process: **Direct Linear Transformation (DLT) and Physical Parameter Transformation (PPT).** The desired algorithm can be set by selecting the **Options** command from the **Options** menu. The PPT algorithm will automatically be used for Panning Camera views.

DIRECT LINEAR TRANSFORMATION (DLT)

The traditional method used to convert digitized coordinate locations to image space coordinate locations utilizes a widely used method known as the **Direct Linear Transformation or DLT**. In this "mapping" process, the known image coordinates, as well as the digitized coordinates of the control points, are used to solve a set of simultaneous linear equations that relate one set of coordinates to the other. This set of equations is solved using a linear least squares method that yields the image space coordinates of each point, given the digitized view coordinates of that point.

Colinearity photogrammetric relations provide the mapping from spatial coordinates to image coordinates. This mapping is a function of 16 physical parameters that describe the central projection model of a camera. The **DLT** is obtained from the colinearity relations. The colinearity conditions may be rearranged into a form requiring 11 coefficients. These 11 coefficients are functions of the 16 physical parameters. Minimization of residual error with respect to these 11 coefficients is linear; thus, the calibration procedure is simplified. The 11 parameters are the coefficients of the widely used **DLT** method.

The advantage of this transformation method over more traditional methods is that one does not need to know the location or orientation of the cameras, the distance of cameras to the subject, or any information about the camera or projections lenses such as focal length and magnification. Instead, by directly determining the relationship between the image space and each of the digitized views, all the intervening image changes are eliminated, and need not be considered.

In order to utilize this method, there must be a known set of control points in the video recording of each view. At least six non-coplanar control points are required (though more can be used) for a three-dimensional analysis. This is the minimum number of points required to solve the set of simultaneous linear equations that produce the transformation. For a two-dimensional analysis using a single camera, at least four co-planar but non-colinear control points must be used. It is possible to use more than the minimum number of control points, as this will increase the accuracy of the transformation. The control points should be distributed to fill as much of the image space as practical. If the control points all occur in a small portion of the image space, then image distortion is likely to increase as the distance from the image to the control points increases.

PHYSICAL PARAMETER TRANSFORMATION (PPT)

The **Physical Parameter Transformation (PPT)**, like the Direct Linear Transformation (DLT), is built upon the colinearity photogrammetric relations. The rotational orientation matrix of the camera with respect to the spatial coordinate system provides 9 of the 16 physical "mapping" parameters. If the rotational orientation matrix of the camera is expressed as a function of three suitable angles, the number of physical parameters reduces to 10. Minimization of mapping error with respect to these 10 physical parameters automatically insures that the resulting orientation matrix is orthogonal. The minimization is still nonlinear; thus numerical optimization technique is required along with an initial estimate for the 10 physical parameters. The 10 physical parameters may be expressed as functions of the 11 DLT coefficients; thus, the DLT provides a good initial estimate for the 10 parameters.

This photogrammetric procedure involving 10 physical parameters is called the **Physical Parameter Transformation (PPT).** Like the DLT, once the mapping parameters are known for two or more cameras, spatial locations of points whose digitizer coordinates are known may be obtained by solution of a linear system.

The **PPT** may easily accommodate panning cameras if the displacement of the camera relative to its calibration position is known. In addition to the camera's orientation matrix, the location of the projection center provides three physical parameters that may vary with the panning angle. Both camera orientation and projection center are transformed via the displacement yielding the **PPT** coefficients for a panned camera position. View files designated as "Panning Views" will automatically use the PPT algorithm for the Transformation process. This algorithm is optional for stationary cameras.

PANNING CAMERA VIEWS

Camera Views designated as "Panning Views" will automatically use the Physical Parameter Transformation (PPT) algorithm for the 3-D transformation. The Direct Linear Transformation (DLT) is not an option with Panning views.

UV/XYZ COLORS

During the transformation process, stick figure images will be displayed; one for each camera view (UV) and one for the X, Y, and Z-axis view (XYZ). Selecting the UV and XYZ tabs allows the user to select the color of the stick figure display for the UV and XYZ views. The box around the color indicates the current color setting. **NOTE: Be aware that the stick figure image will not be visible when the stick figure color is set the same as the background color.**
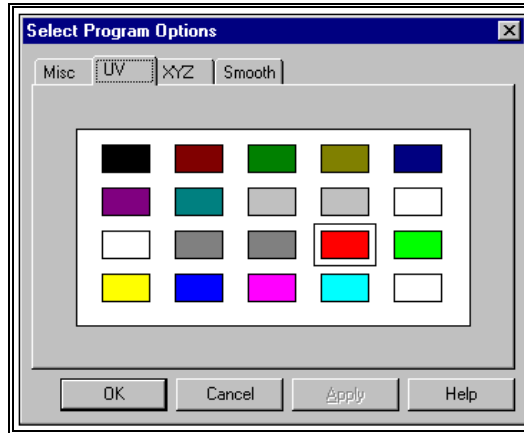
SMOOTH

During the transformation process, it is possible to specify that when performing the Transformation that smoothing be done automatically using some user selected default values. If further smoothing is required, it is recommended to use the FILTER program.
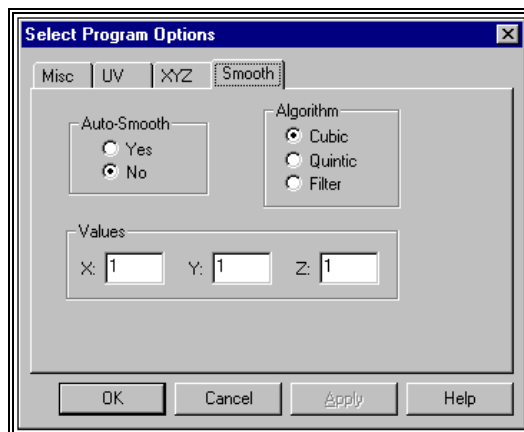
Auto-Smooth

The Auto-Smooth option is used to turn the Automatic Smoothing option either ON or OFF. When this option is set to YES, smoothing will automatically occur during the Transformation process. If this option is set to NO, automatic data smoothing is not performed and the settings for Algorithm and Values are irrelevant.

Algorithm

The Algorithm option is used to specify the default algorithm for automatic smoothing. The available options are Cubic Spline, Quintic Spline, and Digital Filter. Please refer to the FILTER program for additional information.

Values

The Values option is used to specify the default smoothing values for the X, Y and Z data curves. For the spline algorithms, these values represent the allowable variance between the "raw" data and the smoothed data. Larger values will approximate a straight line while smaller values will approximate the "raw" data curve. For the Digital Filter algorithm, these values represent

the cut-off frequency. Please refer to the FILTER program for additional information.

TECHNICAL ASPECTS OF TRANSFORMATION

The Ariel Performance Analysis System (APAS) computes true three-dimensional image space coordinates of objects from two or more sets of two-dimensional digitized coordinates by a method knows as Direct Linear Transformation. The mathematical basis for this transformation is described in this section. In addition, the APAS can alternately compute two-dimensional image space coordinates from a single set of two-dimensional digitized coordinates using the same method. Since the two-dimensional transformation is actually a subset of the three-dimensional problem, a separate derivation will not be provided.

The APAS considers the image space (the space in which the activity being studied occurs) to be described by a right-handed Cartesian coordinate system with a fixed origin and orthogonal X, Y and Z coordinate axes. An arbitrary point in the image space is described by its coordinates (x, y, z). When a film or video recording of an object in the image space is projected or displayed on a flat screen, the original three-dimensional image is reduced to a two-dimensional projection. If a device such as a video digitizer is employed to measure the location of points on this plane of projection, an arbitrary point can be described by its horizontal and vertical digitizer coordinates (U,V). The general form of the transformation between these coordinate systems may be expressed as:

$$U = \frac{Ax + By + Cz + D}{Ex + Fy + Gz + 1} \qquad (1)$$

The coefficients, A through L, represent various physical parameters defined in the configuration of the camera and the playback or projection system. In general, it is a difficult process to determine the values for these coefficients by measurement of camera orientation, distance of camera to subject, magnification of camera and projection lenses, etc. If, however, the image space contains an adequate number of points (control points) whose coordinate locations are accurately known, the coefficients can be determined through the solution of a set of simultaneous linear equations relating the image space coordinates of the control points to the digitized coordinate of the control points.

[A]	x1 y1 s1 1 - U1x1 - U1y1 - U1z1 0 0 0 0 U1	(2)
[B]	x2 y2 x2 1 -U2x2 - U2y2 - U2z2 0 0 0 0 U2	
[C]	x3 y3 z3 1 - U3x3 - U3y1 - U3z3 0 0 0 0 U3	
....		
[G]	0 0 0 0 -V1x1 - V1y1 - V1z1 x1 y1 z1 1 V1	
[H]	0 0 0 0 -V2x2 - V2y2 - V2z2 x2 y2 z2 1 V2	(3)

Equations (1) and (2) can be rewritten in matrix form as shown in equations (3) to express the sets of simultaneous equations that must be solved to determine the coefficients A through L. Subscripts are used to denote the image space and digitizer coordinates of individual control points. A minimum of six non-coplanar control points are required to solve equations (3), although additional points may be used as indicated by the ellipses. If more than six points are used, the set of equations becomes over-determined and may be solved using a standard linear least squares technique.

For a given unknown image space point (x, y, z), equations (1) and (2) can be rearranged as:

$$\{A - EU\}\{B - FU\}\{C - GU\}x = \{U - D\} \qquad (4)$$
$$\{H - EV\}\{J - FV\}\{K - GV\}y = \{V - L\}$$
$$z$$

The digitizer coordinates (U,V) are known as the coefficients A through L from the solution of equation (3). However, equation (4) cannot be solved for (x, y, z) since this set of linear equations is underdetermined. Digitized information from one camera is therefore not sufficient to determine three-dimensional image space coordinates. This problem can be resolved by the addition of a second camera.

For film or video recordings, each joint location (x, y, z) is a function of time, and therefore, digitized camera information must be combined for the same moment in time. This is the purpose of the "Time-Matching" step in the transformation process. The requirement for simultaneous digitized information underscores the importance of accuracy in knowing the camera speed and measuring the synchronizing event for each camera view.

TRANSFORMATION QUICK REFERENCE

1. Select **FILE**, **OPEN** (or the **OPEN** icon in the Toolbar) to Open desired Sequence.

2. Select desired sequence from displayed files.

3. Double-click on the individual views to **SET** them for Transformation.

*4. Select **VIEW**, **STATUS BAR** to toggle the Status Bar On/Off.

*5. Select **OPTIONS**, **OPTIONS** and **MISC** tab to select the desired Transformation algorithm (DLT or PPT).

*6. Select **OPTIONS**, **MISC** and the **UV** and/or **XYZ** tabs to select colors for stick-figure display during the transformation process.

7. Select **OPTIONS**, **MISC** and the **SMOOTH** tab to activate/de-activate the automatic smoothing option.

8. Select **SYNCH, AUTOSYNCH** for the optional **TRANSFORMATION** Synchronizing program. (Skip to step #9 to bypass this step).

9. Select the desired point with large vertical (Y) movement.

10. Select **OK** to update Synch times or **Cancel** to proceed without any changes to the Synch information.

11. Select **3D** and **TRANSFORM** (or the 3D icon in the ToolBar) to start the Transformation process.

12. If necessary, adjust the **TRANSFORMATION PARAMETERS** and select **OK** to proceed.

13. Select **OK** when **3D PROCESSING COMPLETE**.

14. If desired, select **3D**, **DLTs etc...** to examine the DLT and/or PPT transformation parameters.
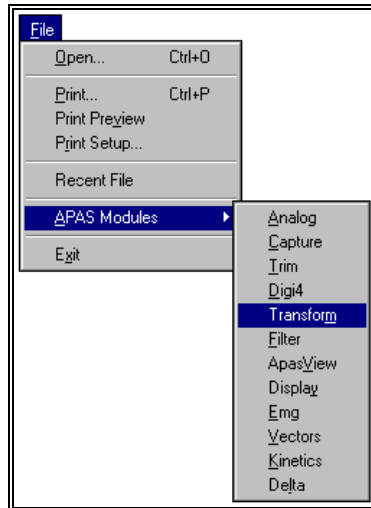
15. Select **FILE** and **EXIT** to exit the **Ariel TRANSFORMATION** program.

* These are only required to be selected once. The program will remember the current settings unless changed by the user.

TRANSFORMATION MENUS

FILE COMMAND MENU

Open
   Selected to open an existing sequence file that has previously been digitized.

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 adjust the printer settings prior to issuing the PRINT command.

Recent Files
   Displays a list of the most recent files that have been used in the Transformation module.

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
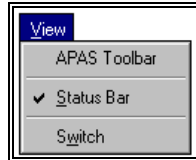   Selected to EXIT the TRANSFORMATION program.

EDIT COMMAND MENU

Copy
   Selected to Copy the currently selected items to the Windows clipboard. This feature can also be activated using the keyboard by simultaneously selecting the Ctrl and C keys.

VIEW COMMAND MENU

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.
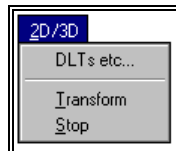
Status Bar
   Selected to alternately display the status bar located at the bottom of the TRANSFORMATION window. The check mark indicates that the Status Bar will be visible.

Switch
   Selected to alternately Switch between the View Information grid and the Stick figure displays.

2D/3D COMMAND MENU

DLTs etc...
   Selected to display the Direct Linear Transformation (DLT) and/or Physical Parameter Transformation (PPT) transformation parameters for each view.
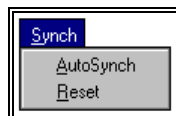
Transform
   Selected to Transform the selected views into 3-dimensional image space.

Stop
   Selected to Stop the Transformation process prior to completion.

SYNCH COMMAND MENU

AutoSynch

Selected to Automatically Synchronize the selected views using the Synchronize algorithm.

Reset

Selected to remove any synchronizing information added by the AutoSynch command. This command will return the sequence to the original condition.

OPTIONS COMMAND MENU

Options

Selected to set various program options. When this command is selected, a new menu will be displayed on the screen. Select the **MISC** tab to indicate if the Physical Parameter Transformation (PPT) algorithm should be used. **NOTE: The PPT algorithm is required for Panning camera views.** It is optional for stationary camera views. Select the **UV** tab to specify the color of the stick figure diagram for each of the digitized views. Select the **XYZ** tab to specify the color of the transformed "stick-figure" image. Select the **SMOOTH** tab to activate/de-activate the automatic smoothing parameters.

HELP COMMAND MENU

Index

Selected to provide an INDEX of Help related topics.

Using Help

Selected to provide instructions on using the Help Windows.

About TRANSFORMATION (C3D)

Provides program information, version number and copyright for the TRANSFORMATION program.