

ProAnalyst[®]

Motion Analysis Software

Getting Started Guide



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Introduction

Digital video has become a new standard for conducting research in areas ranging from engineering and scientific research to crash testing, human and animal biomechanics, and sports analysis. As some experiments can be very costly or difficult to set up and conduct, the greatest advantage video analysis offers is its non-contact and non-destructive nature. But how does one extract the relevant information from a video and turn that into usable data?

Welcome to the world of ProAnalyst.

Most motion analysis applications exist as part of a proprietary video acquisition package, or with a specific industry or application in mind. ProAnalyst breaks that mold by providing a series of video processing and motion analysis tools that can be applied to any video or image sequence, regardless of content or acquisition method. Analysis results can be instantly graphed and reviewed, overlaid with and compared to external data, and exported to a variety of output formats for further analysis or presentation purposes.

For all of its capabilities, learning to use ProAnalyst effectively can seem like a daunting or overwhelming process. This guide, which has been divided into two sections, should reduce the learning curve, and allow you the user to start utilizing ProAnalyst's capabilities to their fullest potential.

Section 1: ProAnalyst Essential Concepts provides a detailed breakdown of the important concepts and most commonly used toolkits in ProAnalyst. ProAnalyst Essential Concepts is not as in depth as the ProAnalyst User Guide, but rather is structured to provide a simple reference and answers to many basic questions about motion tracking options, data analysis, and outputting of results.

Section 2: ProAnalyst Tutorials provides a series of practical step-by-step lessons that cover all of the major features and toolkits in ProAnalyst. The principles covered will provide you with a solid foundation and working knowledge of ProAnalyst from which to approach your own imaging applications.

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Part 1: ProAnalyst Essential Concepts



Working with Projects

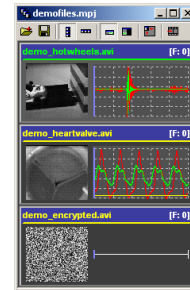
1

What is a Project?

Projects provide a convenient and easy way to manage multiple video and data sources, as well as any associated calibration, analysis, and processing files. Files associated with a particular project are displayed in an interactive thumbnail view, allowing the project itself to serve as a sort of book-keeping mechanism for keeping track of large amounts of video and/or data.

Opening a Project

1. In the Menu Bar, select **File → Open Project...**
2. Browse for a project file (*.mpj), and click Open.
3. The Project Window will appear in the upper left corner of the ProAnalyst screen.



Creating a Project

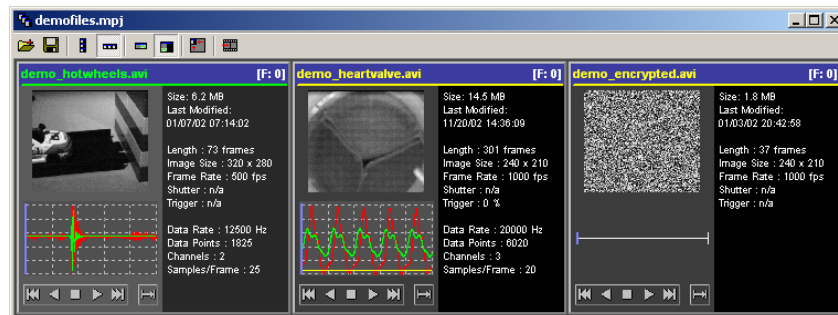
1. In the Menu Bar, select **File → New Project.**
2. An empty and untitled Project Window will launch.

Compact vs. Normal View

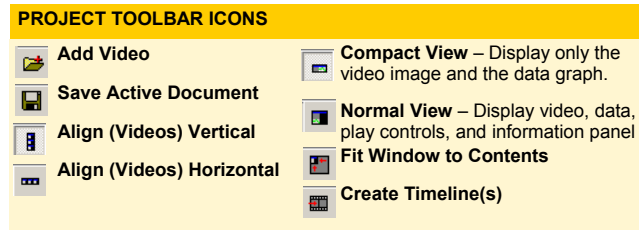
Project Windows can be displayed in one of two formats:

Compact View (above right) – Displays only the video image and the data graph. Play controls are accessible in the Compact view by right-clicking on each video.

Normal View (below) – Displays information about the video and data files and provides play controls for navigation in each video.



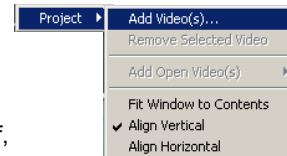
To switch between the Compact/Normal and Horizontal/Vertical views, click on the appropriate icons on the Project Toolbar (Icon details are described on the right.) or use the context menu by right-clicking anywhere in the Project Window.



The default viewing mode for all newly opened project windows can be set by selecting **Edit → Program Options**.

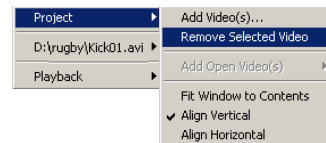
Adding Videos

1. Right-click the Project Window to open a pop-up menu.
2. Select **Project → Add Video(s)...**
3. Browse for a video file (*.avi) or image sequence (*.bmp, *.tif, *.jpg), and click Open.
4. The video file will appear as a thumbnail in the Project Window.



Removing Videos

1. Right-click the video thumbnail you wish to remove.
2. Select **Project → Remove Selected Video**.
3. Click YES to confirm that you would like the selected video removed from the project.
4. The video file is no longer displayed in the Project Window.



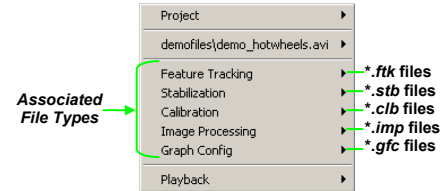
Adding Associated Files

1. Right-click the video thumbnail for which you wish to ADD an Associated File.
2. Select **<Video> → Add Associated File(s)...**
3. Browse for an Associated File you would like to add, and click **Open**.



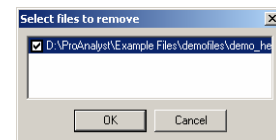
Launching Associated Files

1. Right-click the video thumbnail for which you wish to launch an available/existing Associated File.
2. Select **<Associated File Type>** → **Associated File** from the pop-up menu.
3. The Measurement Window will appear with the Associated File selected.



Removing Associated Files

1. Right-click the video thumbnail for which you wish to remove an Associated File.
2. Select **<Video>** → **Remove Associated File(s)...**
3. Select the Associated File(s) to remove, and click **OK**.



Understanding Layers

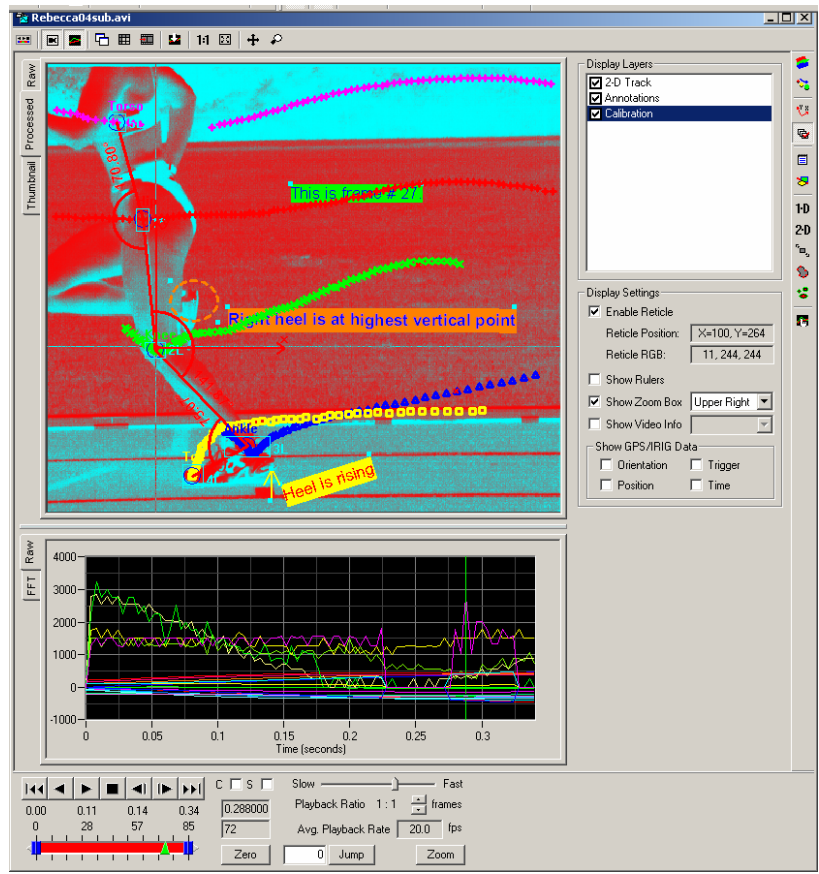


What is a Layer?

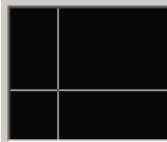
There are many different overlays that may be drawn over the video image. Controlling the location and display of each of these items is done by using the Display Layers control panel.

There are a number of options that can be set in this control panel:

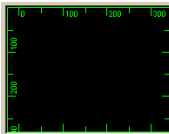
Display Layers – The upper portion of the control panel lists whatever overlays are currently available for drawing, this may include calibration results, analysis results, annotations, etc. Check/Uncheck the box next to each item to have it displayed/ hidden.



Overlay Video – Check/Uncheck this box to display a second video overlaid on the currently active video. Click the **Browse** button to open a file selection window from which you can load the video to be overlaid. The Alpha slider can be used to control the transparency level of the overlaid video.



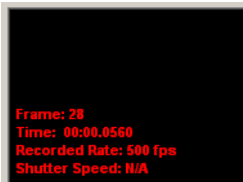
Enable Reticle – Check/Uncheck the box to enable/disable the reticle. When the reticle is enabled, crosshairs will be drawn over the video image. The crosshairs will be placed wherever the mouse is clicked in the image. The control panel displays the coordinates and the value of the pixel underneath the crosshairs.



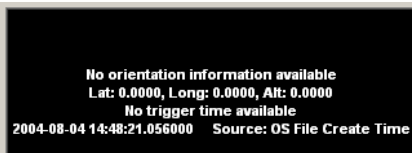
Show Rulers – Check/Uncheck the box to enable/disable rulers. Rulers are drawn along the border of the video display region.



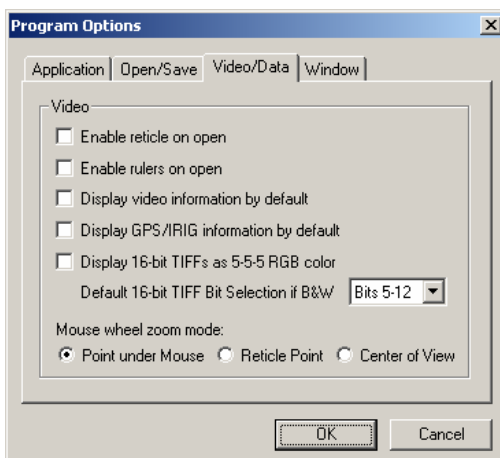
Show Zoom Box – Check/Uncheck the box to enable/disable drawing of the zoom box when panned or zoomed. The zoom box can be drawn in any of the four corners of the image, or may be hidden altogether. Use the drop down box to select the location for the zoom box.



Show Video Info – Check/Uncheck the box to enable/disable drawing of video information. The video information is a set of text that is drawn over the video image that indicates the current frame, recorded rate, shutter speed, etc. It can be drawn in any of the four corners of the image, or may be hidden altogether. Use the drop down box to select the location for the video information.



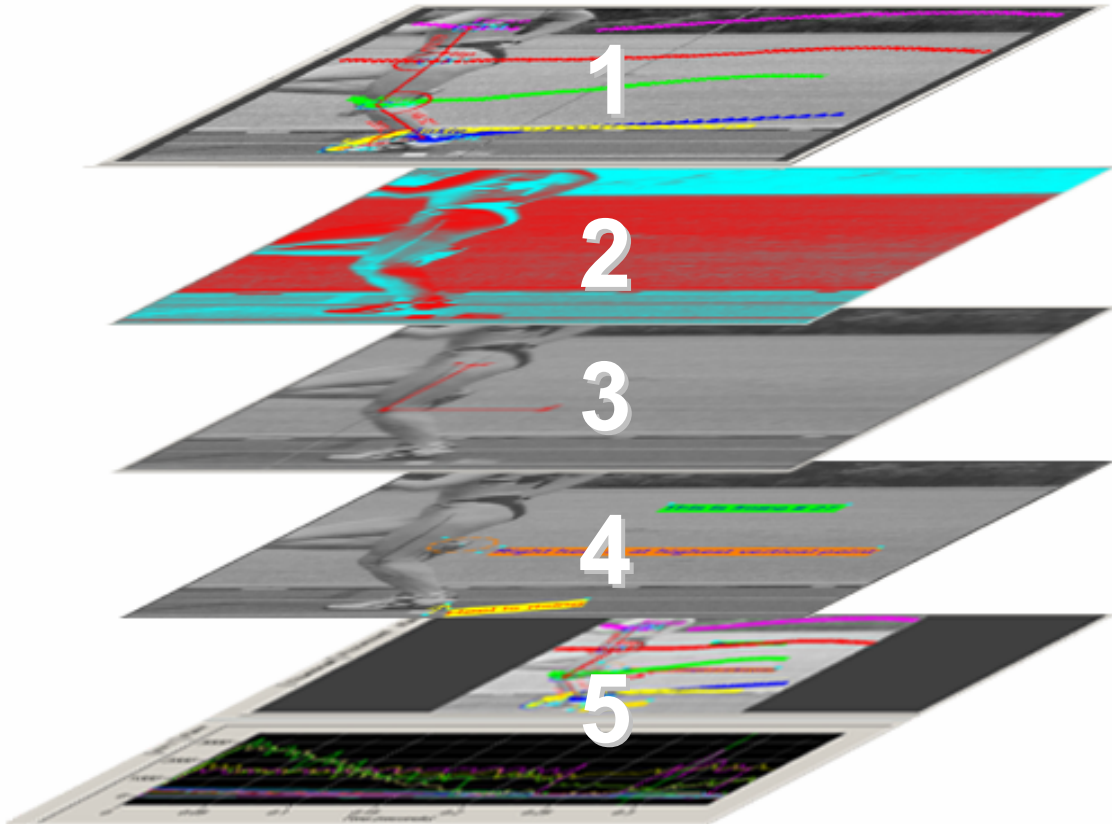
Show GPS/IRIG Data – The four different components of the GPS/IRIG information can each be enabled or disabled independently. Check/Uncheck each box to enable/disable drawing of the GPS/IRIG information, if present. The GPS/IRIG information is always drawn at the bottom of the video image.



The reticle, rulers, video information, and GPS/IRIG information can all be turned on automatically every time a new video window is opened by setting the default options in the Program Options window.

In the Menu Bar, select **Edit → Program Options...**

The following is a breakdown of individual layers. The resulting video image would be the previous screen picture.



1. **Analysis Results** (e.g. 1D Feature Tracking, 2D Feature Tracking, Stabilization, Contour Tracking, or Particle Tracking)
2. **Image Filters:** A sequence of image processing filters can also be applied to the video images
3. **Calibration:** Settings/ Measurements that convert and scale the recorded video image to real-world dimensions and orientations.
4. **Annotations:** Video, data, and global notes and graphical annotations.
5. **Graph Configuration** (See Section 5): A compilation of various tracked points/features within the video displayed on a graph.

Tracking Features and Measuring 2-D Motion

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What is Feature (2-D) Tracking?

Tracking is the ability to select a distinct feature and determine its frame-by-frame motion characteristics (e.g. position, velocity, etc.) over time, with respect to the plane of the image.

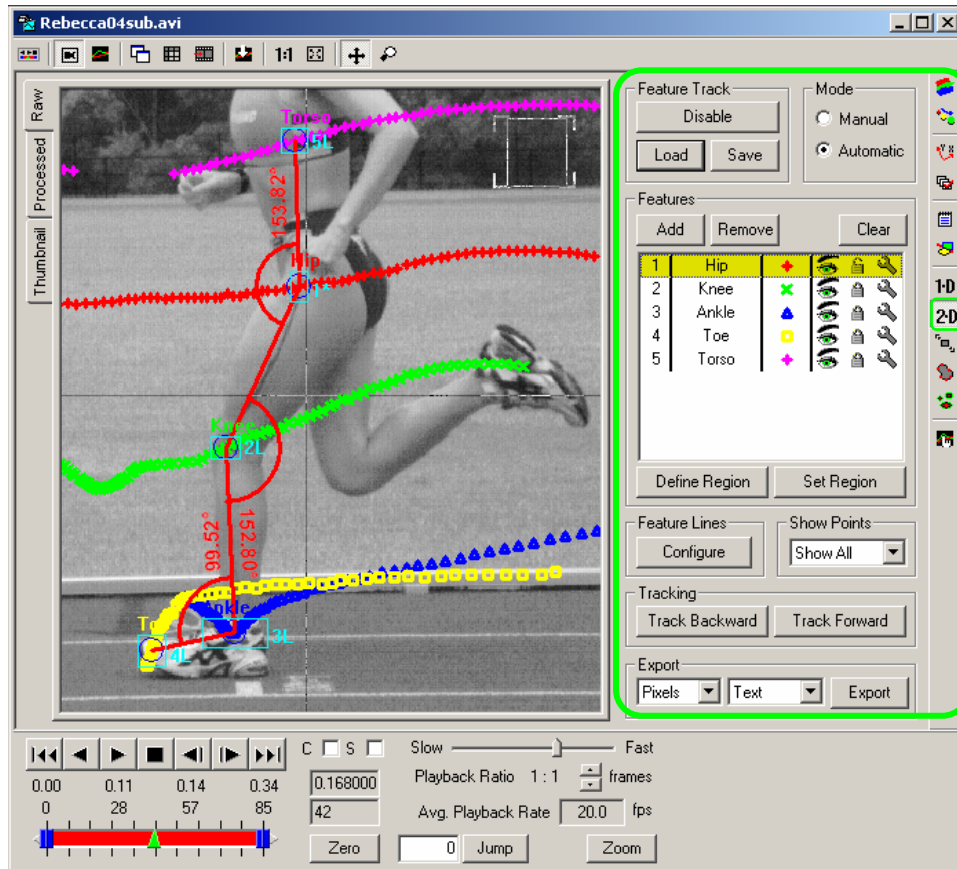
There are two methods available for tracking 2D motion. Automatic (Auto) Tracking asks the user to select the feature location in a single initial frame. The feature is defined as a rectangular region of pixels in the initial frame. Auto Tracking then does all the work of stepping through subsequent frames, while automatically finding and tracking the feature along the way. This method is effective for most applications.

Manual Tracking requires the user to step through the video one frame at a time, using the mouse to select the location of the feature in each frame. This method is preferable for low-quality images or very irregular feature paths not suitable for Auto Tracking.

A total of 64 features can be defined for tracking. Points can be defined for each of these features using automatic tracking or manual tracking or both.

Accessing Feature (2-D) Analysis Tools

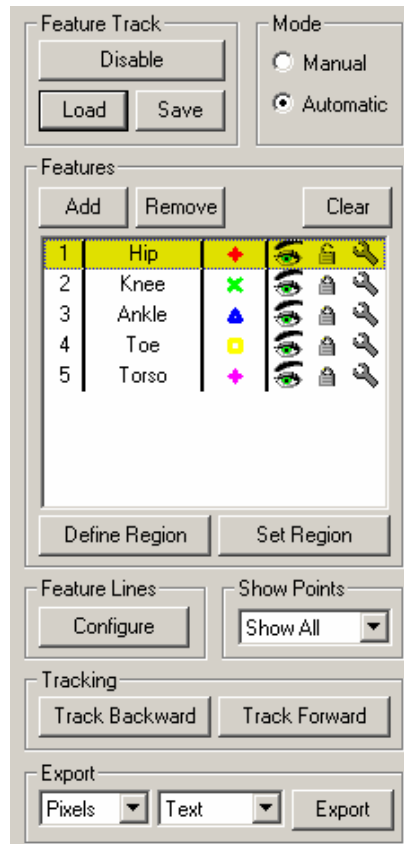
To access the Feature (2-D) Analysis tools, click on the Feature Tracking icon **2D** on the toolbar on the left side of the Measurement Window.



Feature Track Panel

The Feature Track Panel follows the standard layout of analysis modules.

1. **Enable/Disable** – The first step in any Feature Track analysis is pressing the **Enable** button in the upper left of the panel. This initializes memory and sets up configuration information. This must be done for each video that you wish to analyze. When you are done with the analysis, you can press this button again to disable the Feature Track analysis and free the associated memory.
2. **Load** – Saved Feature Track analysis files can be loaded using this button. All tracking results and feature configuration will be reloaded from the saved file. Feature Track files are saved with the FTK file extension.



- Save** – Save Feature Track analysis configuration and results to a file. All tracking results and feature configuration will be saved to the file. Feature Track files are saved with the FTK file extension.
- Manual/Automatic Mode** – Select whether the tracking module should operate in Manual or Automatic mode. The mode only affects how new track points are added to the analysis. You can switch between Manual and Automatic mode at any time.
- Add** – Add a new feature to the analysis. Use the **Define Region** and **Set Region** buttons to define a template for the feature.
- Remove** – Remove a feature from the analysis. Select the feature to remove by clicking on the appropriate row in the properties section. Then press the **Remove** button.
- Clear** – Clears all analysis results for the selected features. A message box will appear to confirm that you wish to delete the track points.
- Define Region** – When in automatic mode, click on this button to define a region for a feature. Click and drag a rectangle in the image to be used as a template for a feature. After dragging a rectangle, it may be repositioned by clicking and dragging it in the image. Click on the **Set Region** button when you are satisfied with the region you have defined, or click on **Define Region** again to redraw another rectangle.
- Set Region/Set Point** – When in automatic mode, click on **Set Region** when you are satisfied with the feature region you have defined after pressing **Define Region**. When in manual mode, click on **Set Point** when the reticle is located over the point in the image where you would like to add a tracking point.
- Configure Feature Lines** – Lines can be configured to be drawn between tracked features. Click on this button to display the Line Configuration dialog.
- Show Points** – The track points from all frames, past frames, the current frame, or no track points can be shown in the video.
- Track Forward** – Perform the automatic feature track analysis from the current frame backward in the video. When tracking is in progress, you can click this button again to abort tracking.
- Track Backward** – Perform the automatic feature track analysis from the current frame backward in the video. When tracking is in progress, you can click this button again to abort tracking.

14. **Export** – Exports the results for the feature tracking. The export units are specified by the left most drop-down selection. The export format is specified using the middle drop-down selection.

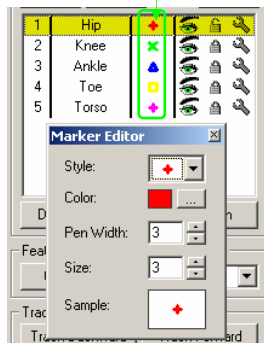
The feature properties' listing is composed of six columns...

15. **Feature Number** – Indicates the feature number. Double-clicking on this column will also bring up the Track Settings dialog for the given feature.
16. **Feature Label** – Displays the label for the feature. The label is set in the Track Settings dialog that appears when the Settings column is clicked.
17. **Marker** – Displays the marker for the feature. The marker can be modified by double-clicking on this column to bring up the Marker Editor.
18. **Visibility** – Each feature can be displayed or hidden individually. Click on this column to hide or display track points for this feature.
19. **Lock/Unlock** – Lock or unlock this feature. If a feature is locked, the tracked points and settings will not be modifiable.
20. **Settings** – Click on this icon to show the Track Settings dialog for this particular feature.

AUTO TRACKING

Marker Editor

The appearance of each feature marker can be modified using the Marker Editor dialog. This dialog appears when you double click on the **marker** (*third column from the left*) in the feature properties listing in the control panel.



Style – Four different marker styles are available:




Color – Click on the button next to the color square to bring up the color selection dialog. Select the desired color for the marker.













Pen Width - Sets the thickness of the lines that are used to form the markers.

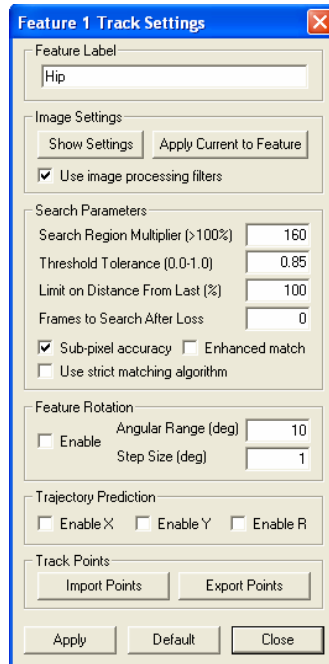
Size – Sets the overall size of the entire marker.

Sample – Provides a sample of the resulting marker using the settings that have been configured above.

Track Settings

The Track Settings dialog can be displayed by clicking on the Settings icon  or by double-clicking on the feature number (1st column) in the feature properties listing. The Track Settings dialog is where parameters can be set that control how automatic tracking is performed.

1	Hip				
2	Knee				
3	Ankle				



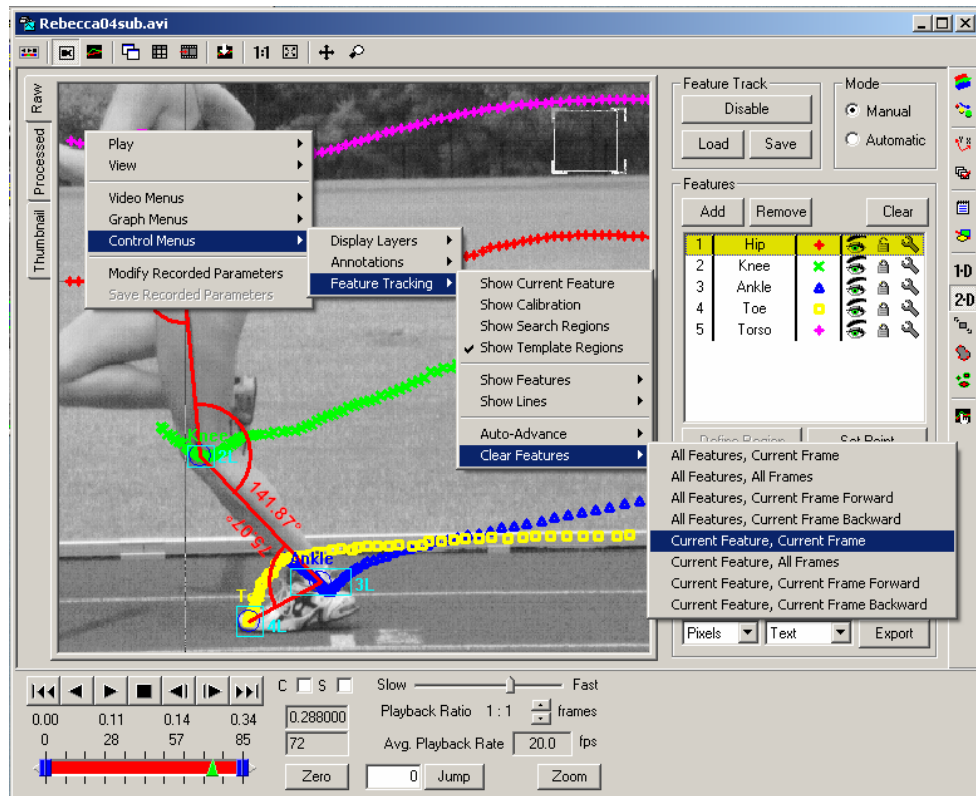
feature when analyzing.

- Feature Label** – Enter a label for the feature that is displayed in the feature properties listing and over the feature region in the video image.
- Show Settings** – Each feature can maintain its own set of Image LUT settings. These LUT settings are typically the settings that were active when the feature was added. Click on this button to display the image using the image LUT settings associated with this feature.
- Apply Current to Feature** – This button allows the image LUT settings for a given feature to be changed to whatever settings are currently active. In order to change the LUT settings associated with a feature, change the LUT settings so that the desired appearance is achieved and then press this button.
- Use image processing filters** – While each feature can have its own set of Image LUT settings, all features share the single set of Image Processing Filters defined for the video. However, each feature can be set to use the image processing filters or to not use them. Check this box to have the image processing filters applied to the video for this particular feature when analyzing.
- Search Radius Multiplier** – Configure how large of an area to search for template matches. This is a percentage of the initial region size that was defined for this feature. A value of 100 (%) indicates that the algorithm should search in a region as large as the initial region size. Larger values will result in larger search areas, which will take a longer time to search. A typical value for this parameter is 160. This parameter is related to the Limit on Distance From Last parameter. If you increase the search radius, you should also increase the limit on the distance.
- Threshold Tolerance** – Configure the sensitivity of the matching algorithm. The tracking algorithm assigns a value between 0 and 1 is given to all points within the search region indicating how well they match the template region. All values below a set threshold are ignored. A threshold value of 1.0 indicates that only a perfect match will be accepted. Lower this value if the tracking algorithm fails to track a feature. A typical value for this parameter is 0.85.
- Limit on Distance From Last** – Configure how far a track point can move from one frame to the next, expressed as a percentage of the feature size. A value of 100 (%) indicates that the track point can move a distance of up to the full size of the feature. A typical value for this parameter is 100. This parameter is related to the Search Radius Multiplier parameter. If you increase the limit on the distance, you should also increase the search radius.

8. **Frames to Search After Loss** – Configure if the tracking algorithm should continue to try searching for a match beyond a frame where the feature was lost. This parameter sets how many frames the algorithm should continue beyond the frame where it lost the feature. If the feature is found again, the tracking will continue as normal.
9. **Sub-pixel accuracy** – Enabling sub-pixel accuracy attempts to estimate the best fit match to the template at a sub-pixel level. This option is typically always enabled, however, if only pixel accuracy is preferred, uncheck this option.
10. **Enhanced match** – Enabling enhanced matching attempts to improve the matching by enhancing the template image and search region. This option is only available if sub-pixel accuracy is also enabled. Enabling this option will increase the processing required for tracking and may result in a noticeable increase in the time required for tracking. Do not enable this for large search templates unless your system has a large amount of available memory.
11. **Enable (Feature Rotation)** – Enable feature rotation when tracking. The algorithm will try comparing rotated versions of the template with the search region to find a match. The best match over all the rotation range will be returned as the final match.
12. **Angular Range** – The rotation range in degrees to search for matches. The template will be rotated plus or minus this value in degrees in intervals of the step size.
13. **Step Size** – The step size to use over the rotation range to search for matches. For example, a rotation range of 10 degrees with a step size of 1 will examine the range of -10 to 10 degrees in 1 degree increments.
14. **Enable X Trajectory Prediction** – Enable trajectory prediction in the horizontal direction. The trajectory is predicted using an estimated velocity and acceleration of the previous track points. The search area is then centered on the predicted location (rather than the last location). Enabling prediction will allow you to reduce the search radius multiplier for faster searching.
15. **Enable Y Trajectory Prediction** – Enable trajectory prediction in the vertical direction. The trajectory is predicted using an estimated velocity and acceleration of the previous track points. The search area is then centered on the predicted location (rather than the last location). Enabling prediction will allow you to reduce the search radius multiplier for faster searching.
16. **Enable R Trajectory Prediction** – Enable trajectory prediction for rotation. The trajectory is predicted using an estimated velocity and acceleration of the previous track points. The search area is then centered on the predicted location (rather than the last location). Enabling prediction will allow you to reduce the search radius multiplier for faster searching.
17. **Import Points** – This button allows you to import tracking points from a text file that will be added to the currently active feature. These track points are treated as if they were manually placed by the user. The text file must be formatted such that each line contains an X value, followed by a comma, followed by a Y value. All values must be in declared in pixel coordinates, with the origin in the upper left of the screen, and the X-axis running to the right, the Y-axis running down.
18. **Export Points** – This button will export any tracking data associated with the currently selected feature to an external text file, formatted as described above.

19. **Apply** – Apply the settings to the feature. Changes will not be applied unless this button is pressed.
20. **Default** – Load the default settings for the feature properties into this dialog. The settings are not applied until the Apply button is pressed.
21. **Close** – Close the dialog. Settings will not be applied unless the Apply button was pressed.

MANUAL TRACKING



Adding and Removing Points

Manual tracking is performed on a per-frame basis; the user cycles through each relevant frame and manually marks the feature locations by clicking the mouse. Manual tracking mode is selected by clicking on the Manual mode in the upper left corner of the Feature Tracking control panel.

To manually **ADD** a point or to **MODIFY** the location of a point:

1. Select the feature in the feature properties list that you wish to add a track point to by clicking on the corresponding row.
2. Click in the image window to place the reticle in the desired position.
3. Click on the **Set Point** button in the Feature Tracking control panel or hold down the Control key and right-click.

To **REMOVE** a point:

1. Right-click inside the Measurement Window to open a pop-up menu.
2. Select **Feature Tracking** → **Clear Features** → **< delete option >**.

Automatic Advance

When doing manual tracking, using the automatic frame and feature advancing features are very helpful in speeding up the process. These features when enabled will automatically advance to the next unlocked feature after you have set a point manually. If the current feature is the last feature in the list, then the frame will advance to the next frame and the feature will be set to the first unlocked feature.

To **ACCESS** the Automatic Advance features:

1. Right-click inside the Measurement Window to open a pop-up menu.
2. Select **Feature Tracking** → **Auto-Advance** → **< advance option >**.

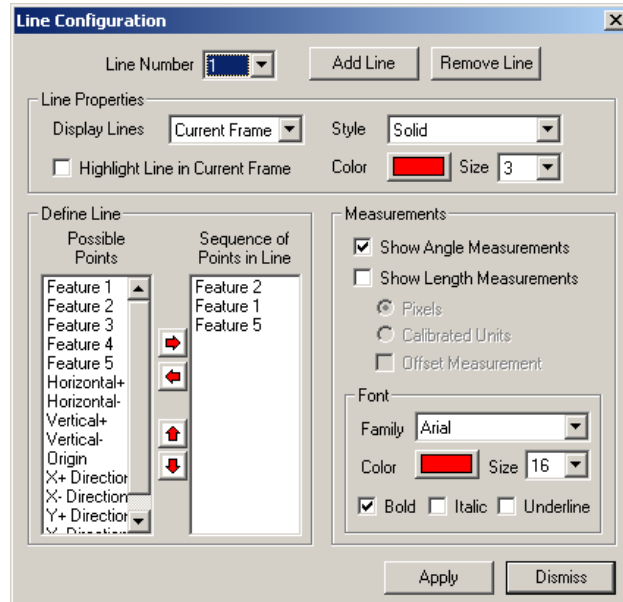
If automatic feature advancing is enabled without automatic frame advancing, then when the last feature is reached, the feature will stop advancing. If automatic frame advancing is enabled without automatic feature advancing, then the frame will only advance when you set a point for the last feature in the list.



Other Operations

Line Configuration

Once features have been tracked, lines can be configured to be drawn between features. These lines are configured by clicking the **Configure** button in the Feature Lines section of the Feature Tracking control panel to open the Line Configuration dialog.

To ADD a new line:



1. Click on the **Add Line** button.
2. Select whether you want the line to be drawn in the currently displayed frame only, past frames, all frames, or in none of the frames. Also, select whether you would like to highlight the line in the current frame. This is useful for distinguishing the line in the current frame from the other lines in past or all frames.
3. Set the line style, color, and thickness (size).
4. Select which points should be connected by the line. All possible features and points are listed in the left column. Select which points to add and hit the right arrow  button. The left arrow  button can be used to remove selected points from the right column. The up and down arrows allow you to reorder the sequence of points in the line.
5. Lines can also be configured to display active measurements of the angle between line segments or the lengths of line segments. Select whether you wish to have angle or length dimensions drawn with the lines.
6. If measurements are enabled, configure the units, and appearance of the measurement label.
7. Click the **Apply** button to apply the changes.

To MODIFY the properties of a line:

Select the line number that you wish to modify in the top drop down box. Make the changes, and then click the **Apply** button.


To REMOVE a line:

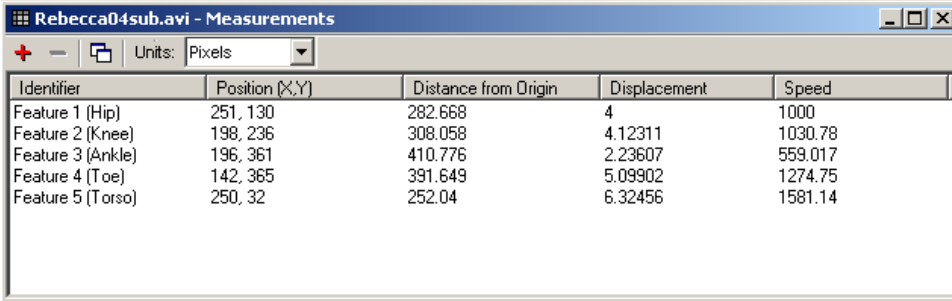
Select the line number to remove in the top drop down box. Click the **Remove Line** button.

Line configurations are saved with the entire Feature Track settings when stored to a file. They will be automatically restored when the saved file is reloaded.

Measurements

Immediate simple measurement results such as position and velocity can be displayed for each feature using the Measurements Window associated with a video window.

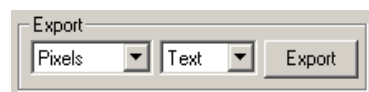
Click on the Show Measurements icon  on the top of the Measurement Window to display results.



Identifier	Position (X,Y)	Distance from Origin	Displacement	Speed
Feature 1 (Hip)	251, 130	282.668	4	1000
Feature 2 (Knee)	198, 236	308.058	4.12311	1030.78
Feature 3 (Ankle)	196, 361	410.776	2.23607	559.017
Feature 4 (Toe)	142, 365	391.649	5.09902	1274.75
Feature 5 (Torso)	250, 32	252.04	6.32456	1581.14

Exporting Tracking Results

After a successful track is completed, you can export the data to a variety of formats to perform any additional custom analysis or graphing.



Units – You can select what set of units to use for exporting the tracking results. If no calibration has been done on the video, then this selection is ignored and the values are output in Pixels.

Format – Select an output format: Text, Excel Blank, Excel Template, or Diadem. Results for feature tracking will be exported to the resulting file.

The feature track data is composed of the following information: **frame number**, **time** (if we know the record rate of the video), and the **X and Y coordinates** of each of the tracked feature points.

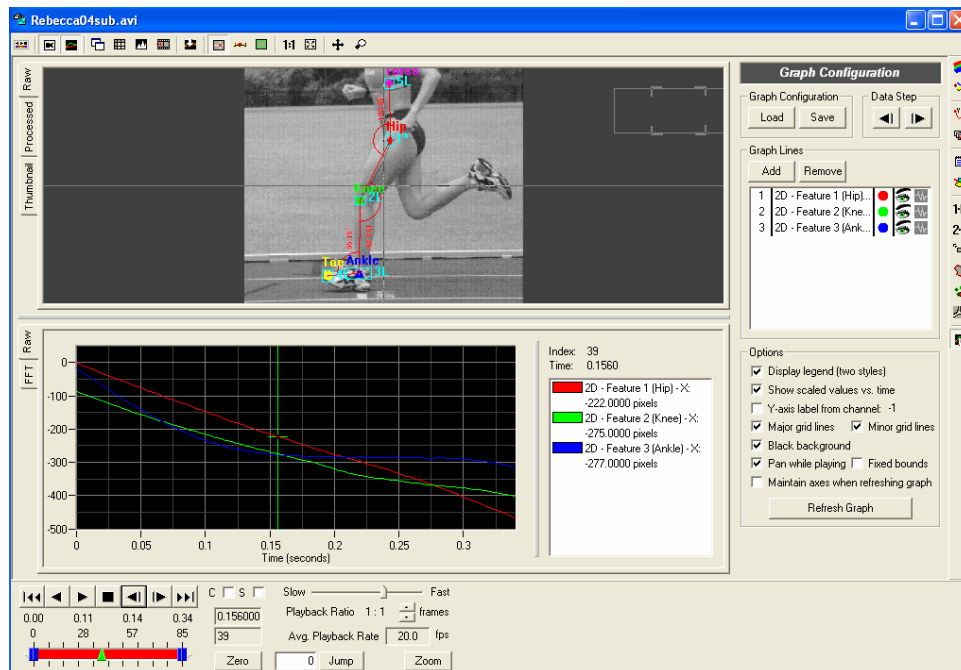
The **Excel Blank** and **Excel Template** options both export the same data. However, Excel Template exports the data into an existing Excel file that is used as a template. Any formulas and graphs in the template file will be recomputed and regenerated for the exported data.

Export – When you are satisfied with your tracking results, and have selected your export units and format, click on the **Export** button to export the results.

Graphing Tracking Results

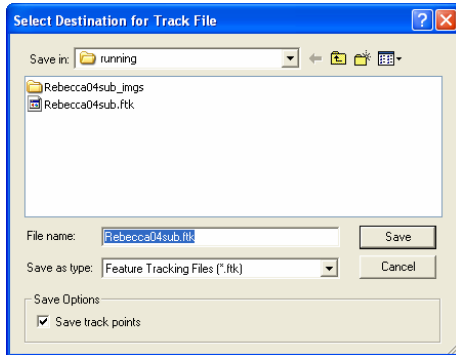
Feature tracking results can be immediately displayed in the Measurements Window graph section. Once tracking is complete, use the Graph Configuration control panel to add feature tracking results to the graph section.

Measurements and tracking information can be added to a graph in much the same way that new items are added for feature tracking. Clicking the **Add** button will bring up a dialog box which displays every item that can currently be graphed, sorted by module. Click the check box next to the measurement you wish to add to the graph and press the **OK** button. The graph will automatically update to display the newly added items. To remove a graph line, select the item from the Graph Lines list and click the **Remove** button.



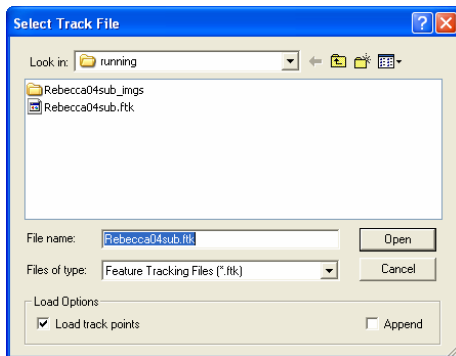
Saving and Loading

All Feature Track settings and results can be saved to a file for later use. This allows you to do multiple analyses on the same video file, store the configuration and results, and later load the appropriate analysis whenever you need it. Feature tracking settings saved from one video can also be loaded on another video. This allows you to configure features and settings for one video, then load and apply these settings to any other videos in which the same type of analysis is to be conducted.



To **SAVE** the analysis settings and results, click the **Save** button at the top of the Feature Tracking control panel. Feature Track settings and results are stored to files with the FTK file extension.

If you only want to save the feature settings, uncheck the “Save track points” checkbox in the Save Options. This is useful if you intend to use this file to define feature settings for different videos.



To **LOAD** a saved analysis file, click the **Load** button at the top of the Feature Track control panel.

Uncheck the “Load track points” checkbox in the Load Options if you do not want to load the track points stored in the file. This is useful if you only want to use the feature settings contained in a track file that may have been saved from a different video.

Check the “Append” checkbox to append the tracking points in a file onto the existing video. This allows you to compare tracking points from different analyses on top of each other.

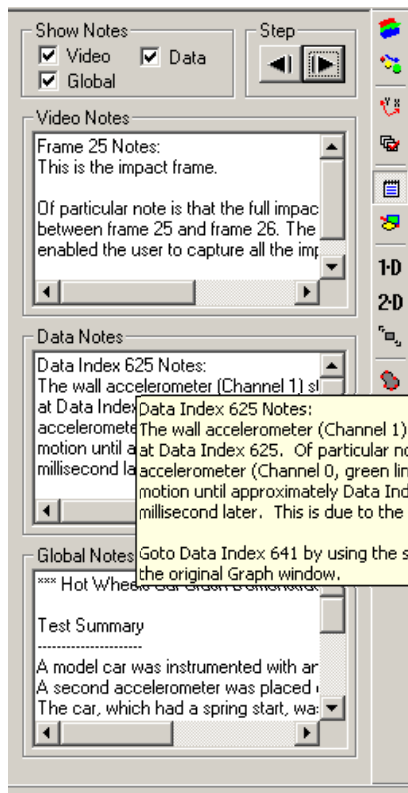
Annotating Measurements

4

Video and Data Notes

The Notes control panel allows you to enter comments for each video frame and each data point in an event. It also allows for one global comment for the entire event. These comments are stored in a binary file along with other data such as GPS/IRIG information.

The Notes control panel is composed of **five (5)** sections:



1. **Show Notes** – Check boxes to selectively display the video, data or global comment fields. Each of these boxes can be selectively displayed or hidden so that the remaining boxes have more room to display their contents. To enable or disable display of each item, check the check box next to each type. For comments that are larger than the text box, tooltips are also provided. When the mouse is moved over each of the boxes, a tooltip window will appear displaying the full contents of the text box.

2. **Step** – To review comments saved with an image sequence or with a data sequence, simply click on left arrow button or right arrow button. You will

be automatically advanced to the next sequential comment (video or data). The corresponding video frame or data point will automatically be displayed.

This provides an easy mechanism for stepping through your measurement to find all frames

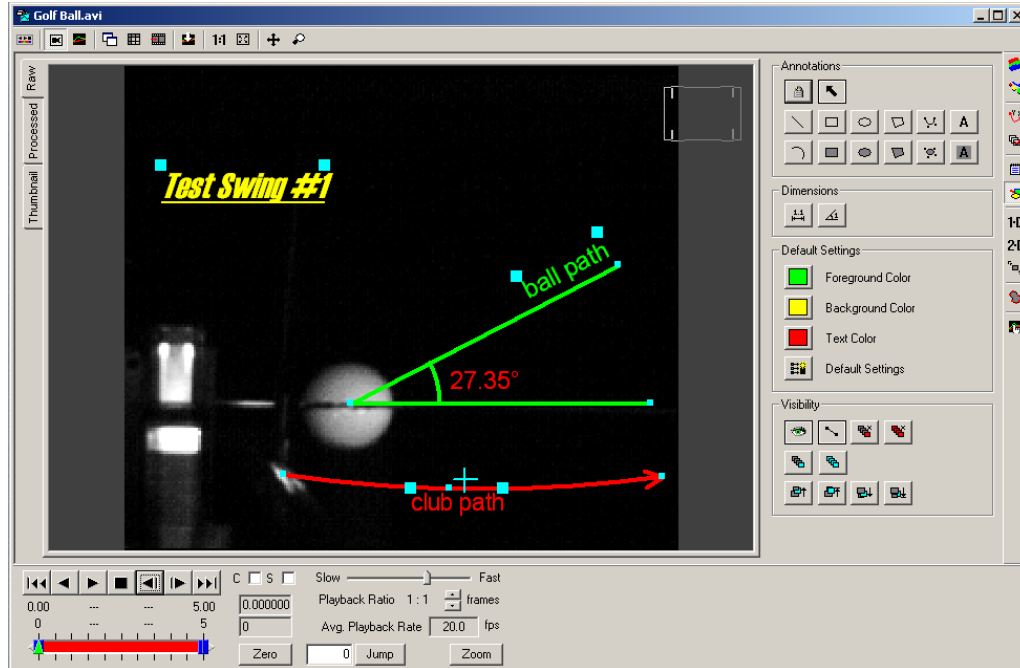
and data points that have been marked with notes.

3. **Video notes** – These comments are saved for each frame of video.
4. **Data notes** – These comments are saved for each data point in the data sequence.
5. **Global notes** – These comments are free form - not assigned to any particular frame or data point

Graphical Annotations

Graphical annotations allow you to draw lines and text and other objects directly on the video images. These annotations can be made so that they only display on specific frames or they can be set to always display on all frames.

The annotations controls are available on the application toolbar or in the Annotations control panel in the main video window as shown.



Standard Annotations

In this section, the standard annotations, settings, and visibility tools are documented. There are also two special annotations that can be used to perform static length and angle measurements. The standard annotations available are:



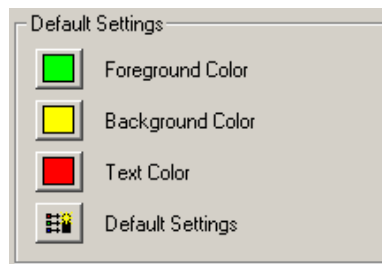
to create new annotations.

1. **Lock Annotations** – Lock annotations so that they cannot be modified.
2. **Select Annotations** – Mouse clicks will select and drag any existing annotations. This is the default mode. Select Lock Annotations to prevent any mouse interactions from modifying existing annotations. Select any of the other buttons
3. **Draw Line** – Start drawing a line in the Measurement Window.
4. **Draw Arc** – Start drawing a three-point arc in the Measurement Window.

5. **Draw Rectangle** – Start drawing a rectangle in the Measurement Window.
6. **Draw Filled Rectangle** – Start drawing a filled rectangle in the Measurement Window.
7. **Draw Ellipse** – Start drawing an ellipse in the Measurement Window.
8. **Draw Filled Ellipse** – Start drawing a filled ellipse in the Measurement Window.
9. **Draw Polygon** – Start drawing a polygon in the video window. Each mouse click will add another point to the polygon. End the polygon by right-clicking on the last point. Points may be added and removed from a polygon by using the **Insert** and **Delete** keyboard keys when the mouse is over a drag handle.
10. **Draw Filled Polygon** – Start drawing a filled polygon in the video window. Each mouse click will add another point to the polygon. End the polygon by right-clicking on the last point. Points may be added or removed from a polygon by using the **Insert** and **Delete** keyboard keys when the mouse is over a drag handle.
11. **Draw Spline** – Start drawing a spline in the video window. Each mouse click will add another point to the spline. End the spline by right-clicking on the last point. Points may be added or removed from a polygon by using the **Insert** and **Delete** keyboard keys when the mouse is over a drag handle.
12. **Draw Filled Spline** – Start drawing a filled spline in the video window. Each mouse click will add another point to the spline. End the spline by right-clicking on the last point. Points may be added or removed from a polygon by using the **Insert** and **Delete** keyboard keys when the mouse is over a drag handle.
13. **Draw Text** – Start drawing text in the video window at the location of the next mouse click.
14. **Draw Filled Text** – Start drawing text with a filled background at the location of the next mouse click.

Default Settings

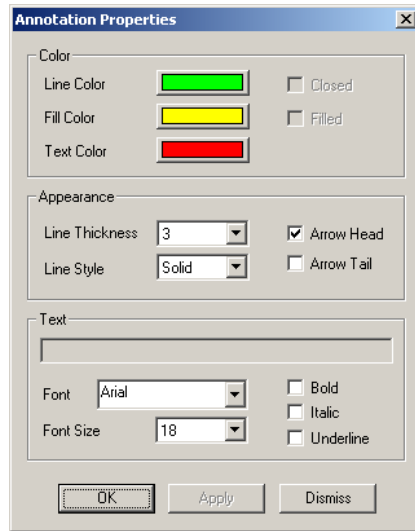
The default settings for newly created annotations can be set using the Default Settings portion of the control panel.



Foreground Color – Sets the default foreground color for all new annotations. Click on the colored button to display a color selection popup window.

Background Color – Sets the default background color for all new annotations. Click on the colored button to display a color selection popup window.

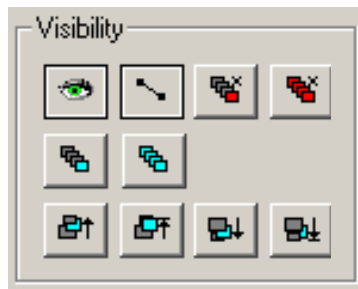
Text Color – Sets the default text color for all new annotations. Click on the colored button to display a color selection popup window.



Default Settings – Displays a default settings dialog where the default colors, line styles, and font styles may be set for all new annotations. To modify the settings of an existing annotation, double-click on the annotation in the video window.

Visibility Settings

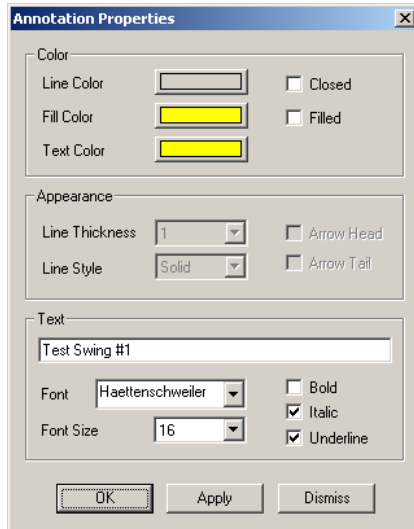
The visibility settings for the selected annotation or all annotations can be set using the Visibility portion of the control panel.



1. **Show/Hide Annotations** – Shows/hides all annotations for the active video.
2. **Show/Hide Drag Handles** – Shows/hides the square drag handles used to modify annotations.
3. **Show in Current Frame** – Set the currently selected annotation to display only in the current frame.
4. **Show in All Frames** – Set the currently selected annotation to display in all frames.
5. **Bring Forward** – Move the currently selected annotation forward in the display order.
6. **Bring to Front** – Move the currently selected annotation to the top of the display order.
7. **Send Backward** – Move the currently selected annotation backward in the display order.
8. **Send to Back** – Move the currently selected annotation to the back of the display order.
9. **Delete Annotations in Current Frame** – Delete all annotations for the current frame only. Does not delete annotations that are set to display in all frames.

10. **Delete All Annotations** – Delete all annotations for the active video.

Properties



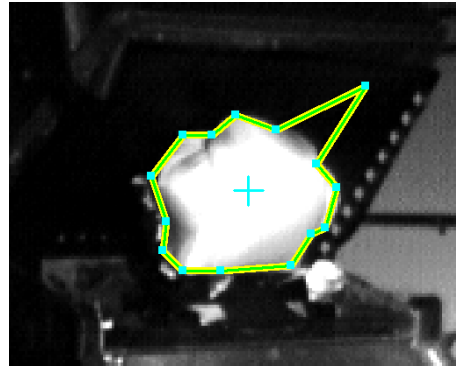
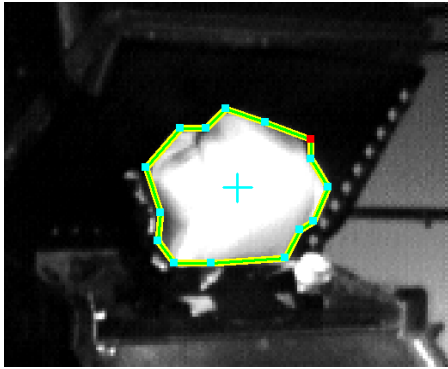
If you double-click on an existing annotation, the annotation properties dialog will appear.

For different types of annotations, different properties will be available to be modified. Make the desired changes and press **Apply** to apply them to the drawing. Click **OK** when you are satisfied, or **Cancel** to cancel your changes.

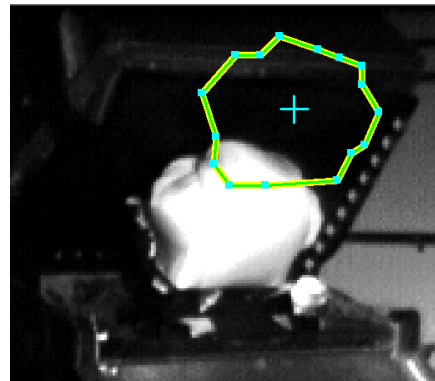
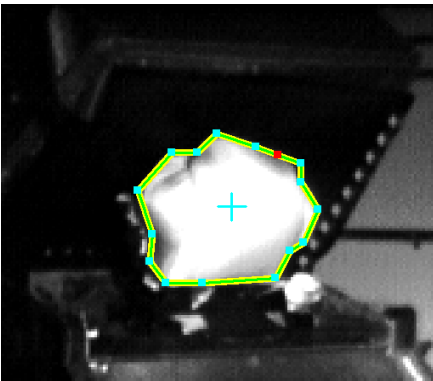
Deleting Annotations

Click on the annotation that you wish to delete. The annotation should be highlighted in yellow. Click the **Delete** key on the keyboard and the annotation will be deleted.

Moving and Adding/Removing Points



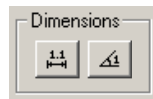
1. Every annotation has "handles". The location of these handles may be modified to change the shape or position of each annotation. When the mouse passes over a handle, the handle should become highlighted in red.
2. Click and drag the handle to move it to another location.



3. For annotations that support an arbitrary number of points (polygons, splines), new points can be added by selecting the annotation and pressing the **Insert** key on the keyboard.
4. A new point (handle) will be added on the segment that is closest to the current mouse location. To remove a point, move the mouse over the point (handle) that you wish to remove. Make sure that it is highlighted in red, then press the **Delete** key. Be careful, this only works for polygons and splines and only if a drag handle is highlighted. If you hit **Delete** for any other type of annotation or not over a highlighted drag handle, the whole annotation will be deleted.

Static Measurements

There are two special types of annotations that perform basic dimensioning functions. These are the length and angle dimension annotations. They are located in the middle of the Annotations control panel and on the Annotations toolbar

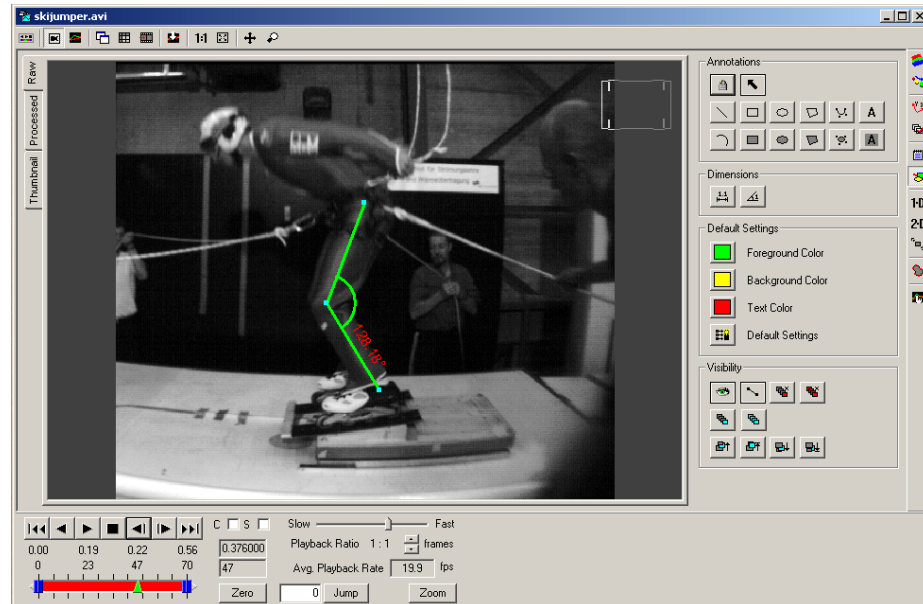


Draw Length Dimension – Start drawing a static length dimension in the video window. The length dimension will be shown in the units that the video was calibrated in. If no calibration has been applied, the length dimension is shown in pixels.


Draw Angle Dimension – Start drawing an angle dimension in the video window. The angle is defined by the location of the next three mouse clicks in the video window. The angle measurement is shown in degrees and is the angle between the lines connecting the first and last point to the middle point.

Angle Dimension

The angle dimension annotation provides a simple means for measuring an angle in the video image. The units for the angle dimension are always given in degrees.



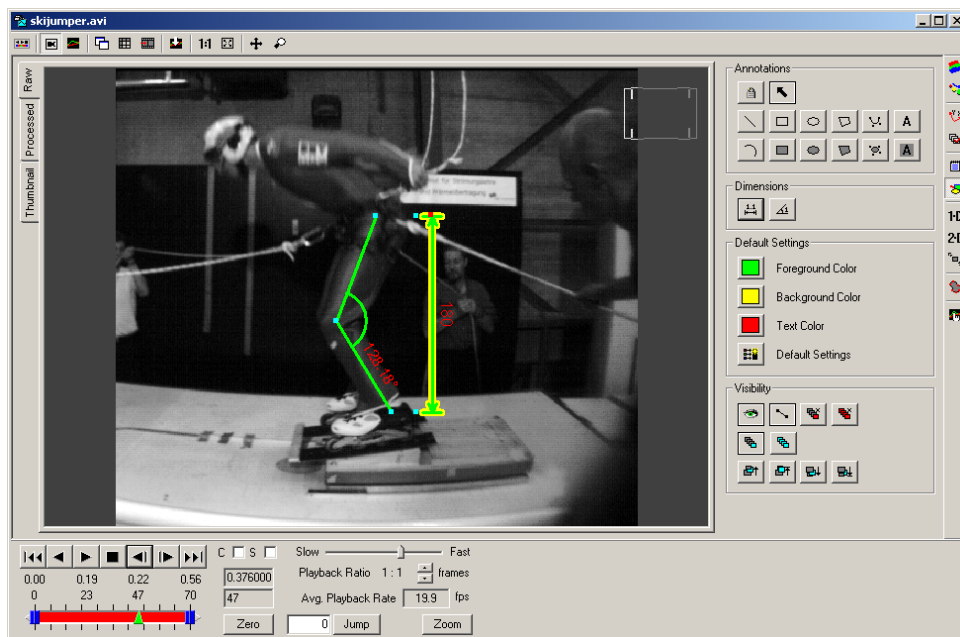
To draw an angle dimension:

1. Click on the **Draw Angle Dimension** button  on the annotation toolbar or control panel.
2. Click on the first point in the image (ankle).
3. Click on the second point in the image which will be the center of the angle (knee).
4. Click on the third and final point in the image (hip).


5. Click and drag any of the drag handles to fine tune the location of the angle dimension.
6. Double-click on the new angle dimension and modify any settings if necessary.

Length Dimension

The length dimension annotation provides a simple means for measuring a length in the video image. The units for the length dimension will be given in the same units that were used for calibration. If no calibration has been done, the length dimension will be given in units of pixels.



To draw a length dimension:

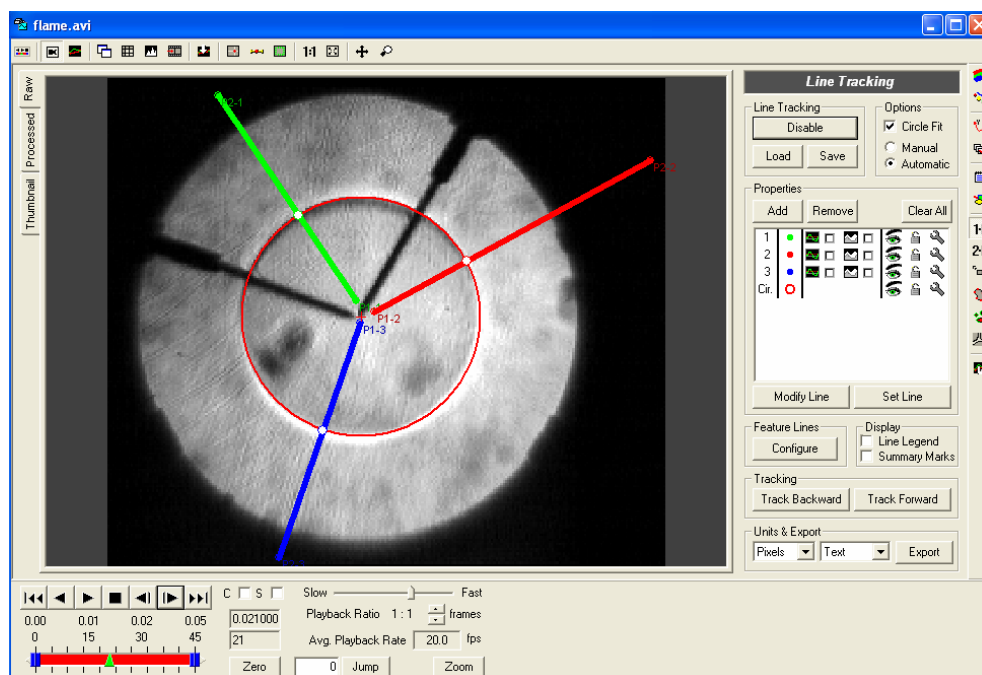
1. Click on the **Draw Length Dimension** button  on the annotation toolbar or control panel.
2. Click and hold down the mouse button starting at one end point of the length you wish to dimension.
3. Drag the mouse and release at the other end point of the length you wish to dimension.
4. Click on the additional drag handle at the end of the dimensioning line (shown in red here) and drag the dimensioning line to the desired position.
5. Click and drag any of the drag handles to fine tune the location of the length dimension.
6. Double-click on the new length dimension and modify any settings if necessary.

Tracking and Measuring 1-D Motion



Line (1-D) Tracking

The Line Tracking control panel enables you to do automatic one-dimensional (1-D) motion tracking. This analysis module allows you to place up to 64 lines in arbitrary locations within your video frame and detect motion that match a given set of user-defined criteria.



The Line Tracking module is capable of detecting peaks in intensity or derivative of intensity along a line and detecting points of transition that exceed a configurable threshold value for intensity or derivative of intensity. You can limit your search to black-to-white transitions or white-to-black transitions or search for both. Up to 20 targets that satisfy the specified criteria can be found for each line in each frame of your video.

The Line Tracking control panel can also use the resulting data to compute a best-fit circle. A fixed center point for the circle may be specified, or a least-squares optimization method can be used to find the best center location.

The resulting line and circle information can be exported to Excel for reporting or more exhaustive analysis. The video scene scale and orientation can be calibrated to use real world units that can be used when exporting.

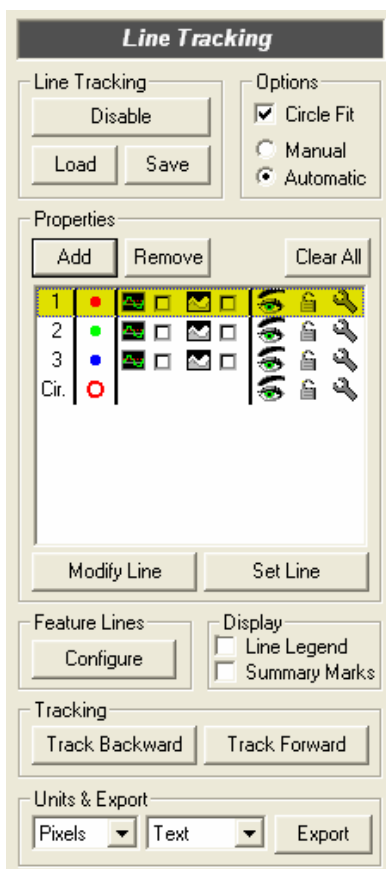
In this next image, the Line Tracking module is used to find the leading edge of a flame front that is expanding out from the center. The lines are set to detect changes in intensity

from black to white to detect the edge of the flame. A circle fit is also enabled to estimate the radius of the flame front.

Many tools for enhanced visualization of line information are provided. The Line View window provides instant feedback for configuring the location, threshold, thickness, and other settings that will produce the best results for your tracking needs. The Summary View generates a bitmap image of the pixels or their derivative along a given line as a function of time, giving you a snapshot of your complete video in a single image.

Line Tracking Panel

The Line Tracking Panel follows the standard layout of analysis modules.



Brief summary of the various controls on this panel:

1. **Enable/Disable** – The first step in any line tracking analysis is pressing the **Enable** button in the upper left of the panel. This initializes memory and sets up configuration information. This must be done for each video that you wish to analyze. When you are done with the analysis, you can press this button again to disable the line tracking analysis and free the associated memory.
2. **Load** – Saved line tracking analysis files can be loaded using this button. All tracking results except for the summary view contents will be reloaded from the saved file. Line tracking files are saved with the LTK file extension.
3. **Save** – Save line tracking analysis configuration and results to a file. All tracking results except for the summary view contents will be saved to the file. Line tracking files are saved with the LTK file extension.
4. **Circle Fit** – Enable circle fitting for this analysis. This will add another row, labeled 'Cir.', in the Properties section of the panel through which the circle fitting parameters can be set.
5. **Manual/Automatic Mode** – Select whether the tracking module should operate in Manual or Automatic mode. The mode only affects how new track points are added to the analysis. You can switch between Manual and Automatic mode at any time.
6. **Add** – Add a new line to the analysis. The line will be added in the default location (horizontal across the center of the video). Use the **Modify Line** and **Set Line** buttons to change the location of the line.
7. **Remove** – Remove a line from the analysis. Select the line to remove by clicking on the appropriate row in the properties section, and then press the **Remove** button.

8. **Clear All** – Clears all analysis results for all lines. A message box will appear to confirm that you wish to delete all analysis results. The line locations and properties will remain the same.
9. **Modify Line** – Modify the location of the line in the video. Press this button and then click and drag the mouse over the video image at the location where the line should be placed. If you would like to keep one endpoint fixed and modify the other, you can move your mouse over the endpoint (marked P1 or P2) and drag just that end point to a new location. When you are satisfied with the line that you have placed, click on the **Set Line** button.
10. **Set Line** – This button is only used to complete a Modify Line operation. Click on **Modify Line** and set the line location as desired, then press **Set Line** to accept the new location of the line.
11. **Line Legend** – When enabled, displays a legend in the upper left corner of the video image indicating the coordinates of each of the analysis lines.
12. **Markers in Summary View** – When enabled, red markers will be displayed in the Summary Views to show the location of the tracked points on each line. Since the Summary Views are regenerated each time a video is tracked, you must re-track the video in order for a change to take effect.
13. **Track Backward** – Perform the line tracking analysis from the current frame backward in the video. When tracking is in progress, you can click this button again to Abort tracking.
14. **Track Forward** – Perform the line tracking analysis from the current frame forward in the video. When tracking is in progress, you can click this button again to Abort tracking.
15. **Export** – Exports the results for the line tracking and circle fit. The export units are specified by the left most drop-down selection. The export format is specified using the middle drop-down selection.

The properties listing is composed of seven (7) columns.




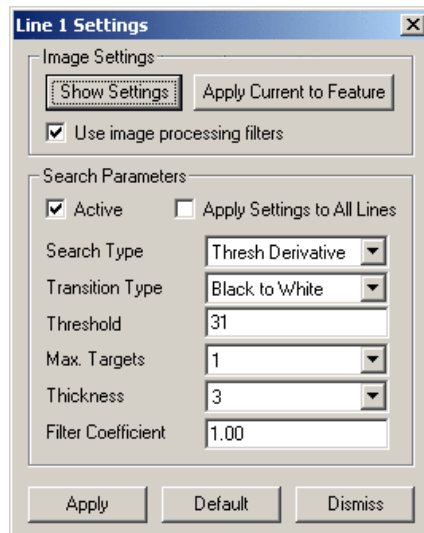
1. **Line Number/Circle** – Line number or circle indicator for each line. Double-clicking on this column will also bring up the settings dialog for the given line or circle.
2. **Line Color** – Each line is automatically assigned a color when added, however, if you wish to change the color for any reason, click on this column and a color selection dialog will appear.
3. **Line View** – Click on the check box next to the graphic icon to display the line view for the given line.
4. **Summary View** – Click on the check box next to the graphic icon to display the summary view for the given line.
5. **Visibility** – Each line can be displayed or hidden individually. This does not affect whether or not a line is used in tracking (for that, use the Active check box in the

settings dialog). This setting only affects whether or not the line is drawn in the image.

6. **Lock/Unlock** – Lock/Unlock this line. If a line is locked, the tracked points and settings will not be modifiable.
7. **Settings** – Click on this icon to show the settings dialog for this particular line or circle.

Line Properties

The Line Properties dialog allows configuration of how tracked points are determined for each line. The Line Properties dialog is accessed by double-clicking on the line number or clicking on the  icon in the Properties section of the Line Tracking control panel.



1. **Show Settings** – Each line can maintain its own set of Image LUT. These LUT settings are typically the settings that were active when the line was added. Click on this button to display the image using the image LUT settings associated with this line.
2. **Apply Current to Feature** – This button allows the image LUT settings for a given line to be changed to whatever settings are currently active. In order to change the LUT settings associated with a line, change the LUT settings so that the desired appearance is achieved, and then press this button.
3. **Use image processing filters** – While each line can have its own set of Image LUT settings, all lines share the single set of Image Processing Filters defined for the video. However, each line can be set to use the image processing filters or to not use them. Check this box to have the image processing filters applied to the video for this particular line when analyzing.
4. **Active** – This box indicates whether or not this line will be included in the tracking. If the line is not active, no points will be tracked. This is useful if you wish to temporarily disable a line without having to remove it.
5. **Apply Settings to All Lines** – If this box is checked, then any modifications you make to the line properties will be applied to all lines that are currently present. Any lines that are added later will not automatically have these settings. Instead, newly added lines will start off with the default properties.
6. **Search Type** – There are four (4) possible search types:
 - **Peak Intensity** – The peak intensity setting returns the point of highest intensity along the line.

- **Peak Derivative** – The peak derivative setting returns the point of highest derivative along the line. These two settings always return a single target. The threshold value is not applicable for these search types.
 - **Threshold Intensity** – The threshold intensity and threshold derivative settings require a threshold value and can return multiple matches for each frame. For threshold intensity, the search will return points where the pixel intensity crosses the threshold value in either the positive or negative direction or both depending on the transition type selected.
 - **Threshold Derivative** – For the threshold derivative, the search will return points where the magnitude of the derivative (change in pixel intensity) exceeds the specified threshold. The threshold will apply to positive or negative derivative values or both depending on the transition type selected.
7. **Transition Type** – There are three (3) possible transition types:
- **Black to White** – For the threshold intensity search type and a black-to-white transition type, the program will search for points where the intensity value crosses the threshold value from a darker pixel to a lighter pixel. For white-to-black transitions, the program will search for points where the intensity value crosses the threshold value from a lighter pixel to a darker pixel. If a selection of both is made, then both darker-lighter and lighter-darker threshold crossings will be found.
 - **White to Black** – For the threshold derivative search type and a black-to-white transition type, the program will search for points where the derivative (change in intensity) exceeds the threshold in the positive direction. This is because a black-to-white transition would have a positive derivative value. For a white-to-black transition type, the program will search for points where the magnitude of the derivative (absolute value) exceeds the threshold in the negative direction, since white-to-black transitions would have negative derivative values.
 - **Both** – If a selection of both is made, then the program searches for any points where the absolute value of the derivative exceeds the threshold. Not all points that exceed the threshold are returned, only the points at which a transition is made from before the threshold to beyond the threshold.
8. **Threshold** – The threshold value is used for the threshold intensity and threshold derivative search types. In general, the threshold value is always positive and the transition type dictates which direction of crossing is examined for intensity and which sign of the derivative is examined. See the previous section on transition type for more details.

A negative threshold does not make sense for a threshold intensity search type. However, for the threshold derivative search type, one case in which the threshold value could be negative would be if your image had regions of large derivative and you wish to find regions of small derivative. For instance, if the derivative along a line is primarily negative and then approaches zero in the region of interest, you could select a black-to-white transition type and specify a negative threshold value.

The Line View window discussed in this section will greatly aid in specifying an appropriate threshold value for each case.

9. **Max. Targets** – The maximum targets setting specifies how many matches should be detected for each line in each frame. The value can range from 1 to a maximum of 20. For the peak intensity and peak derivative search types, only a single point can be returned. Therefore, the Max Targets setting is only applicable for the threshold search types. In the threshold cases, multiple points may satisfy the threshold and transition criteria. The setting of maximum targets allows you to limit your consideration to a fixed number of points.

10. **Thickness** – Two techniques are provided to handle noisy image data. The thickness of each line is configurable, up to a maximum width of 20 pixels. The program will average the pixel values along a direction perpendicular to the line. In addition to specifying thickness for each line, you are also able to specify the coefficient for a first order filter that is applied to smooth the pixel data before processing.

The thickness of each line can be set from between 1 and 20 pixels. Increasing the thickness of a line can be used to smooth the intensity values used by the program for detecting transitions. For a line thickness greater than 1, the intensity value for a given point is computed as the average of the intensity values at neighboring points along a line perpendicular to the P1-P2 line. The thickness of the line governs how many neighboring points to use when computing the average.

The thickness of the line drawn in the video image will reflect the actual thickness setting. You can use this to visualize which pixels will be used for the averaging computation.

11. **Filter Coefficient** – Two techniques are provided to handle noisy image data. The thickness of each line is configurable, as described above. In addition to specifying thickness for each line, you are also able to specify the coefficient for a first order filter that is applied to smooth the pixel data before processing.

The filter coefficient provides another means to smooth the pixel data prior to searching. The filter is a first-order filter applied to the intensity values from P1 to P2. A value of 1.0 produces the exact unfiltered intensity values. Values less than 1.0 will smooth the data and values greater than 1.0 will introduce more noise.

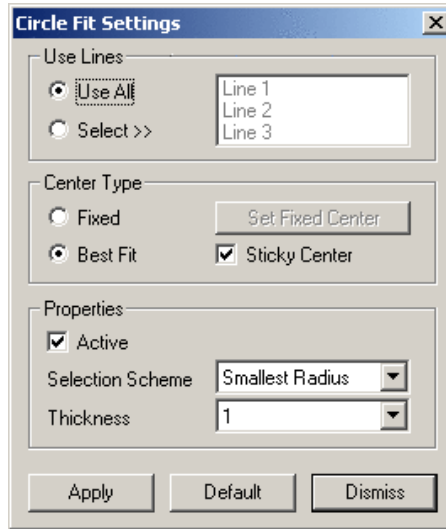
12. **Apply** – Apply the settings to the line or all lines. Changes will not be applied unless this button is pressed.

13. **Default** – Load the default settings for the line properties into this dialog. The settings are not applied until the **Apply** button is pressed.

14. **Dismiss** – Close the dialog. Settings will not be applied unless the **Apply** button was pressed.

Circle Properties

The Circle Properties dialog allows configuration of the circle fit. The Circle Properties dialog is accessed by double-clicking on the "Cir." label or clicking on the wrench icon in the Properties section of the Line Track control panel. To enable circle fitting, check the Circle Fit box in the upper left of the Line Track control panel.



1. **Use Lines** – Not all of the lines that have been added may be intended for use by the circle-fitting algorithm. You can selectively choose which lines will be used by checking the appropriate boxes. If not all the lines will be used, you must uncheck the 'Use All' box before un-checking the boxes for the lines that will not be used.
2. **Fixed Center** – When computing the best-fit circle, a fixed center location can be used or a variable center can be used. When using a fixed center, the algorithm tries to find the best radius that will fit all the points.

The fixed center will default to the center of the video image. If a different center should be used, click your mouse in the video image

at the desired point and then click on the **Set Center** button. A red '+' mark will be shown when the fixed center type fit is being used, to indicate the location of the center.

3. **Best Fit Center** – When using three or more lines, the best location (in a least-squares sense) for the center and the corresponding value for the radius of the circle can be computed for each frame. A gradient descent approach is used to compute the location of the center and the radius.

When using the best-fit center, the quality of the line track results will greatly affect the circle-fitting algorithm. For instance, if you are using three lines and at a particular frame only two of the lines found suitable transition points, then best-fit circle for two points would place the center at their midpoint and have a radius of half the distance between them. This will likely be nowhere near the center found for the case when all three lines found suitable transitions. For these situations, it may be helpful to check the "Sticky Center" box. When this is checked, if the number of transition points drops from three or more down to two or one, then the previously computed center is used as if it were a fixed center until three or more transition points are found again.

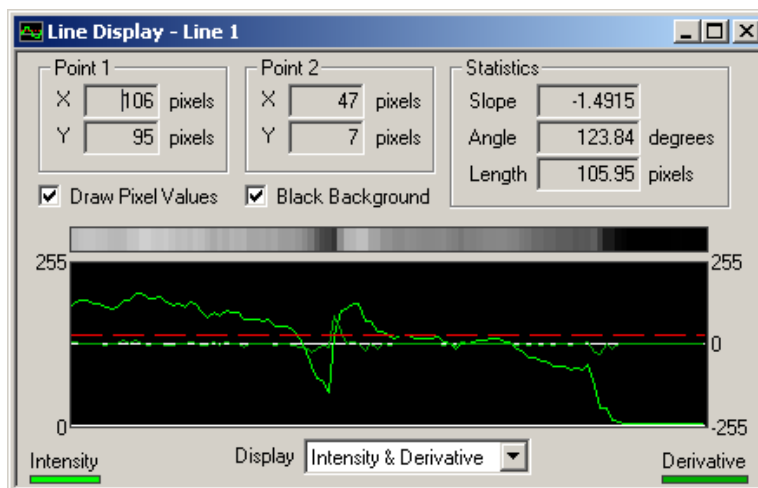
4. **Active** – The circle-fitting algorithm can be activated or disabled using this checkbox. If the circle fitting is disabled, then new fit values are not computed during tracking. Any prior circle fit values or circle fit settings will remain. This is equivalent to locking the circle in the Line Tracking control panel.
5. **Selection Scheme** – When multiple targets are available for a given line, the circle-fitting algorithm must decide which among these multiple targets to use for the fit.

There are four (4) different possible techniques for the algorithm to use in selection. These are:

- **Smallest Radius** – The Smallest Radius option would select the point that is closest to the last computed center.
 - **Largest Radius** – The Largest Radius option would select the point that is farthest from the last computed center.
 - **Closest to Previous** – The Closest to Previous option would select the point that is closest to the last point that was selected for this line.
 - **Closest to Predicted** - The Closest to Predicted would use the selected points from the last frame and the frame before to predict where the point would be in the current frame and then selects the point which is closest to this prediction.
6. **Thickness** – This option allows you to specify how thick the circle is drawn. It is only used for visual representation of the resulting circle and has no impact on any part of the algorithm.
 7. **Apply** – Apply the settings to the line or all lines. Changes will not be applied unless this button is pressed.
 8. **Default** – Load the default settings for the line properties into this dialog. The settings are not applied until the Apply button is pressed.
 9. **Dismiss** – Close the dialog. Settings will not be applied unless the **Apply** button was pressed.

Line View

The Line View provides valuable information for selecting appropriate line properties to produce the best tracking results. There are separate Line View windows for each line.



Across the top of the window, the line view shows the coordinates of the end points P1 and P2 and basic statistics for slope, angle, and length of the line. The slope is the change in X divided by the change in Y from P1 to P2. The angle is the angle relative to horizontal, with 0 degrees corresponding to P2 located to the right of P1. The length is the length of the line from P1 to P2 in pixels.

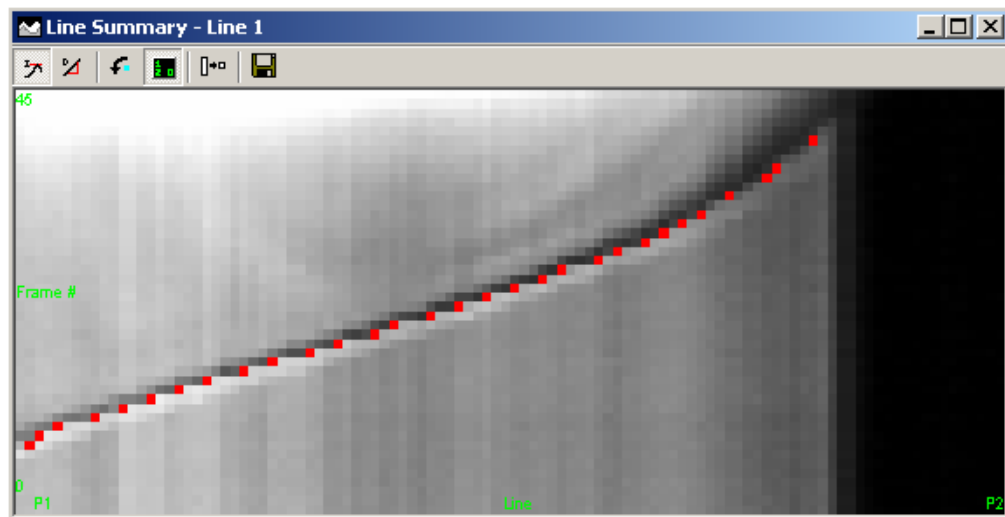
The main portion of the line display window is a graph of the intensity and derivative of the pixels of the image corresponding to the particular line. The Display selection beneath the graph allows you to select whether to view just the intensity, derivative, or both. The units for intensity are along the left side of the graph and the units for derivative along the right. The threshold line is shown as a red dashed line.

Two check boxes are provided to display the pixels values and to use a black background. Displaying the pixel values will draw the intensity values of the pixels corresponding to the line in the rectangular bar above the main graph. The intensity values used are values after the averaging from the thickness of the line and after filtering. Use the “Black Background” option if you have chosen a light color for your line which is difficult to see with the white background.

To aid in visualization, you can change the vertical scale of the main graph by clicking on the graph and either rolling your mouse wheel or pressing **A** or **Z** on your keyboard. You can pan the graph in the vertical direction by either clicking--and--dragging with your left mouse button, or pressing **S** and **X** on your keyboard. Double-clicking in the graph window will reset the zoom and pan to the default values.

Summary View

After (or during) a tracking run, you can bring up a Summary View for each of the lines. The Summary View contains images that are composed from the intensity and derivative values under the line for each frame in the video.



One axis represents the pixels from P1 to P2 and the other axis represents frame number (or a measure of time). If you have selected Markers in Summary View in the Line

Tracking control panel, then red pixels will be drawn at the locations where points were found that match your specified transition criteria.

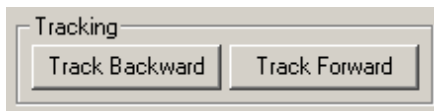
All **options for the Summary View** are accessed via the toolbar or context menu. You can bring up the context menu by right-clicking in the window. The same options are available from both the toolbar or context menu:

1. **Show Intensity** – View the intensity summary image. Each line in the image represents the value of the pixels underneath the line in each frame of the video.
2. **Show Derivative** – View the derivative summary image. Each line in the image represents the derivative of the pixels underneath the line in each frame of the video.
3. **Show Rotated** – View the image as pixels versus frame number or frame number versus pixels.
4. **Show Axis Labels** – Shows or hides the axis labels shown in green at the left and bottom of the image.
5. **Make Pixels Square** – The summary view window can be resized arbitrarily. This will sometimes distort the pixels so that they are rectangular, not square. Pressing this button will use the current width of the window and adjust the height of the window such that the pixels are drawn square. Note that this may result in the window being resized off the bottom of the screen. In this case, either drag the window to a smaller width and perform this operation again or rotate the image and then make the pixels square.
6. **Save Image to File** – Use this button to save the currently displayed image can to a bitmap file.

The summary view can be a useful tool for analyzing tracking results. For instance, in the previous image, the flame front edge is shown by the red markers. We can measure the angle of the line formed by the markers to estimate the velocity of the edge. We can also note that the red markers form nearly a straight line in the center of the image, but deviate from the line at the beginning and end. This indicates that the edge is speeding up or slowing down during those periods.


Tracking

After lines have been placed and properties defined, in order to obtain results, tracking must be run. All tools described so far are used for setting up the parameters for tracking but do not actually execute any of the line search or circle-fitting algorithms.



When you are satisfied with your line and circle properties, click on the **Track Forward** or **Track Backward** button to begin tracking.

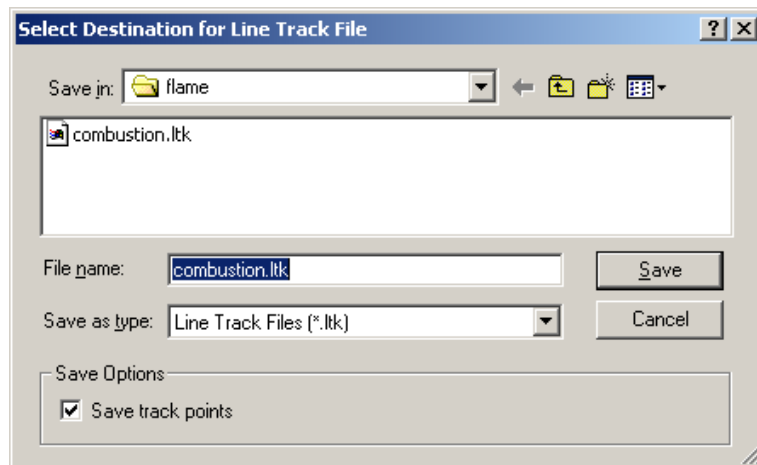
Tracking will commence from the currently displayed frame until the end or beginning of the video. When tracking is running, the track buttons will change to an **Abort** button. Clicking on **Abort** will stop the tracking.

Since tracking begins from the currently displayed frame, in most situations, you will want to jump to the first frame of the video before beginning tracking. You can do this by clicking on the double-backward arrow button  in the **Play Controls**.

If you begin tracking forward from an intermediate frame of the video, all tracking results prior to that frame will be preserved. In this manner, you can use one set of tracking parameters for the first portion of a video and a different set for the second portion. The same principle applies to tracking backward from the current frame.

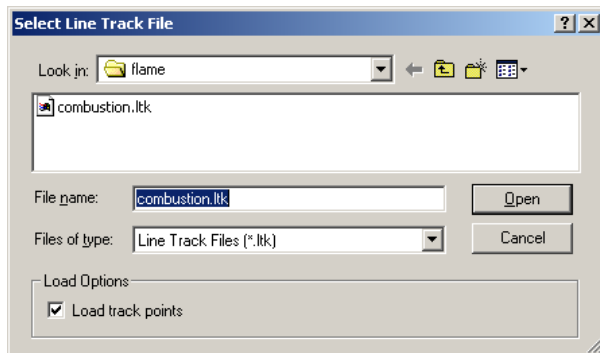
Saving and Loading

All line tracking settings and results can be saved to a file for later use. This allows you to do multiple analyses on the same video file, store the configuration and results, and later load the appropriate analysis whenever you need it. Line tracking settings saved from one video can also be loaded on another video. This allows you to configure the line track lines and settings for one video, then load and apply these settings to many more videos where the same type of analysis is to be conducted.



To SAVE the analysis settings and results, click the **Save** button at the top of the Line Tracking control panel. Line tracking settings and results are stored to files with the LTK file extension.

To SAVE THE FEATURE SETTINGS ONLY, uncheck the “Save track points” checkbox in the Save Options. This is useful if you intend to use this file to define line and circle settings for different videos.

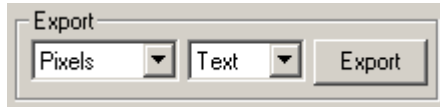


To LOAD a saved analysis file, click the **Load** button at the top of the Line Tracking control panel.

To LOAD A SAVED ANALYSIS FILE WITHOUT THE TRACK POINTS, uncheck the “Load track points” checkbox in the Load Options. This is useful if you only want to use the line and circle settings contained in a track file that may have been saved from a different video.

Export

After a successful tracking run, you can export the data to a variety of formats to perform any additional custom analysis or graphing.



1. **Units** –You can select what set of units to use for exporting the tracking results. If no calibration has been done on the video, then this selection is ignored and the values are output in Pixels.
2. **Format** –You can select what format to export to: Text, Excel Blank, or Excel Template, or Diadem. Results for each of the lines and for the circle fit will be exported to the resulting file.

In all formats, the line settings and the line track data will be output for each line and the circle fit settings and circle fit data will be output.

- The **line track data** is composed of the following information: frame number, time (if we know the record rate of the video), the X and Y coordinates of the tracked point, the distance from the tracked point to P1 along the line, whether the transition was white-to-black or black-to-white, and the intensity level of the image at the tracked point. If multiple targets were allowed for each line, then for every frame, there will be multiple rows in the output, one for each target. Values of 1 indicate that a tracked point was not found for that frame.
 - The **circle fit data** is composed of the following information: frame number, time, the X and Y coordinates of the center, and the radius. If a fixed center was selected, then the X and Y coordinates of the center will always be the same.
 - When exporting to a **text file**, information for each line and for the circle fit is appended to the single output text file. WordPad will be launched on the text file that was just exported.
 - For **Excel Blank**, a new workbook will be created that contains multiple sheets. The first set of sheets will correspond to each of the lines that have been added. The last sheet will contain the circle-fitting results. **Excel Template** produces the same results; however, the data is imported into an existing Excel file that is used as a template. You can put in any formulas and graphs into the template file, and these will be recomputed and regenerated when the new data is exported into it.
 - For **Diadem**, the results are exported to a DAT file that can be loaded by Diadem.
3. **Export** – When you are satisfied with your tracking results, and have selected your export units and format, click on the Export button to export the results.

Graphing

Line tracking results can be immediately displayed in the Measurements Window graph section. Refer to the graphing subsection of chapter 3.

Saving and Loading Projects, Videos and Files

6

Saving Video Files


Video files analyzed with ProAnalyst may be from one-time events or require complex conditions to setup. Therefore, ProAnalyst always avoids modifying pixels in an original image, such that they are always identical to what was acquired. Analysis results, image processing and filtering, and other operations are stored separate data files so that they do not require overwriting or rewriting the video image.

There are occasions where the video itself will need to be saved to another file, for instance:

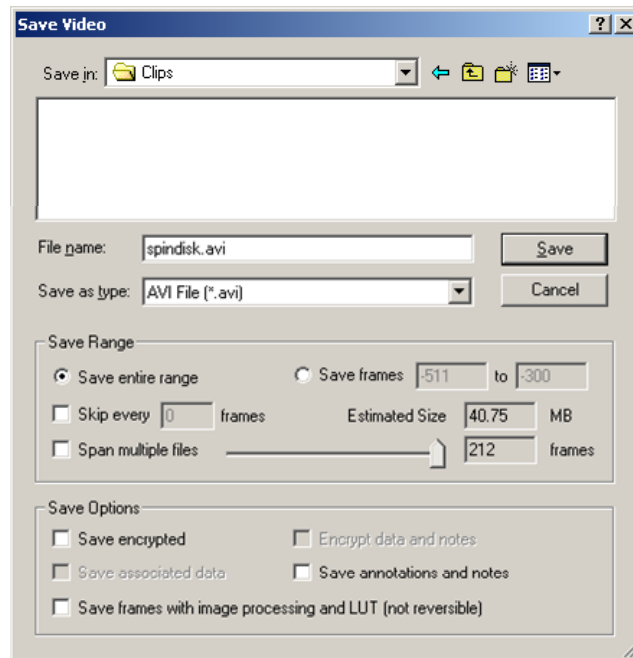
- Saving a subset of frames to a new file.
- Splitting a long recording into smaller pieces.
- Changing the save format from AVI to bitmap files or any other format conversion.
- Saving processed results to another file for easier processing.
- Saving processed videos with all overlays (tracking, annotations, etc.).
- Saving a sub-region of the video images.

In all these operations, the original file is kept intact and a new file is created with the modified images and information.

Save Dialog

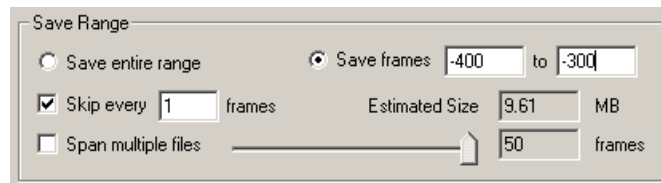
The Save Video dialog is similar to the standard Windows save dialog, with additional options beneath the standard controls. The Save Video dialog can be brought up in several ways. Click on the Save button  on the main toolbar when the active window is a Measurement Window, use the **File** → **Save As** menu option, or use the keyboard shortcut **Ctrl+S**.

Select the directory to save in and enter the filename to save as in the upper sections of the dialog. The lower sections of the dialog provide advanced save options that are explained below.



Saving Subset of Frames

To shorten a video or to focus on one section of the video, you can save a subset of frames or skip frames.



1. **Save entire range** – This option will save the entire set of frames from the original video. This is the default behavior.

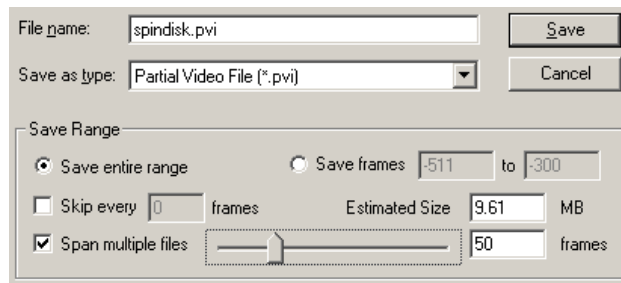
2. **Save frames** – A range of frames between a start and end frame can be specified. The start and end frame must be valid frames in the video.
3. **Skip every [x] frames** – A reduced set of frames can be saved by skipping some frames. A skip value of 1 would save every other frame. A skip value of 2 would save one frame, skip 2, save the next frame, and so on. The default is to save all frames (skip value of 0). Skipping frames is not recommended in general unless you know what you are doing since this will alter the apparent frame rate of the video.
4. **Estimated Size** – Displays the estimated size of the total resulting video file(s).
5. **Span multiple files** – This option can be used to split the video into separate video pieces that can be loaded seamlessly as if they were one video.

Spanning Multiple Files

The standard Microsoft AVI file format supports up to a maximum of 2GB per file (with some extensions that can go to 4GB). Occasionally you may need to save a video in smaller pieces to save to a CD-ROM or other device. You can save sub-ranges using the Save Range portion of the Save dialog, or you can use the spanning functionality of this software.

This software will automatically span a video file into smaller pieces of a specified size. The resulting files will be reloaded as if they were one single video file. These partial pieces will be given the PVI file extension.

To SAVE a video to a spanned set of files:



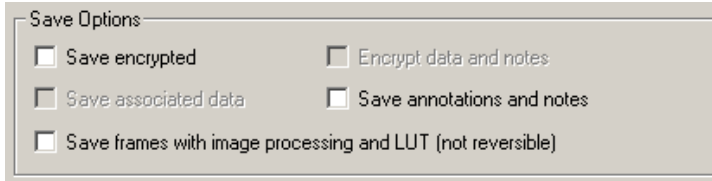
1. Check the Span multiple files checkbox in the Save dialog.
2. Drag the slider until the desired Estimated Size for each partial video file appears in the dialog.

3. Or type in the desired size for each partial video file in the Estimated Size edit box and click **Tab** to update the slider and number of frames.
4. Or type in the desired number of frames for each partial video file in the frames edit box and click **Tab** to update the slider and Estimated Size.
5. Click the **Save** button to execute the save operation.

To LOAD a spanned PVI file, click on any of the PVI portions in the Load dialog and all portions will be automatically identified and loaded.

Saving Processed Video

To speed up playback of processed video, a video can be saved with the processed settings applied to it. The original file should be left on the hard drive. The save processed operation is not reversible.



1. **Save encrypted** – A user supplied pass-phrase can be used to encrypt the video frames of the new video. Anyone wishing to view the encrypted video will be required to type in the identical pass-phrase. Use this option carefully, if the pass-phrase is forgotten, the original video images cannot be retrieved.
2. **Encrypt data and notes** – Along with the video frames, the associated data and notes, if present, can also be encrypted with the same pass phrase.
3. **Save associated data** – If acquired data is present in the current video, this data can be saved with the new video or it can be ignored. Check this box to save a copy of the current data with the new video.
4. **Save annotations and notes** – The annotations and notes associated with the current video can also be saved to the new video. Check this box to save a copy of the current annotations and data with the new video.
5. **Save frames with image processing and LUT** – The Image Processing and Image LUT settings can be applied to the video and the results saved in the new video file. Normally the Image Processing settings and the Image LUT settings are stored in separate files. These settings are loaded and applied to the video image every time the video image is drawn. The original video file is not modified and the Image Processing and Image LUT settings can be turned off at any time. When saving with processing, the newly created file will have the current Image Processing and Image LUT settings permanently applied. This saves computation time when the new processed video is loaded, however the changes cannot be turned off for the new video. Note that this process is not reversible. You cannot obtain the original file back from the resulting processed file.
6. **Include Overlays** – This option is only available if "Save frames with image processing and LUT" is selected. This option will save any overlays that are drawn on top of the video image as displayed on the screen. This includes any analysis track points, annotations, captions, etc.. Note that this process is not reversible. You cannot obtain the original file back from the resulting processed file.

Saving Sub-Regions of Video

Using the zoom window, a sub-region of the video image can be saved to a separate video file. This can reduce the size of the resulting video and remove background sections that are unnecessary.

Importing Data

Data from external sources can also be imported and aligned to video sequences. The external data must be contained in a text file where each line contains one set of data. The text file may also contain comment lines, these comment lines should be indicated by having a special character at the start of each comment line. Blank lines are ignored. All other non-comment lines should contain the same number of values. These values can be separated by spaces, tabs, commas, or any other delimiter. Below is shown an example of a suitable text file. In this file, comments are indicated by the '#' character and each uncommented line contains five (5) values separated by tabs.

```

demo_heartvalve.txt - WordPad
File Edit View Insert Format Help
# Scan Rate: 20000
# Scans Per Frame: 20
# Total Scans: 6020
# ZP: 0      TP: 0
# Number of Channels: 3
# Scaled: No
# Scale Factor:      1.000000e+002      1.000000e+002      1.000000e+000
# Offset:           0.000000e+000      0.000000e+000      0.000000e+000
# Label:           A      B
# Units:           mm      mm
# Index      Time      Ch.00      Ch.01      Ch.03
0      0.0000000      9.766001e-003      1.049800e-001      1.196000e-001
1      0.0000500      4.150400e-002      1.416020e-001      1.221000e-001
2      0.0001000      4.150400e-002      1.416020e-001      1.196000e-001
3      0.0001500      3.906300e-002      1.416020e-001      1.074000e-001
4      0.0002000      3.906300e-002      1.416020e-001      1.855000e-001
5      0.0002500      3.906300e-002      1.416020e-001      3.271000e-001
6      0.0003000      3.906300e-002      1.440430e-001      3.345000e-001
For Help, press F1

```

Importing from Text

To import data, select **File → Import Data**

Enter the name of the text file to load the data from by typing in the name in the Filename box or by clicking on **Browse** to select a file. If you would like to review the contents of the file you have selected, click on the **Edit File** button, and the file will be opened with WordPad.

Import Data

Data File
 Filename

Comment Indicator
 The data file may contain comment lines at any location in the file.
 Each comment line must begin with a comment indicator.
 Pound (#) Percent (%) Slashes (/) Other

Field Delimiter
 All lines that are not comments are assumed to contain data.
 Each data line must contain the same number of fields separated by a delimiter.
 Whitespace () Comma (,) Semicolon (;) Other

Data Information
 Indicate whether any initial columns contain special information not to be graphed.
 First field contains : Sample Number Time*
 Second field contains : Sample Number Time*
 *Time values will be used to verify the zero-th sample, but are not used for alignment.
 The data may have been sampled at a faster rate than the video.
 To align video and data, indicate the samples per frame and the zero-th sample.
 Samples per Frame Zero-th Sample

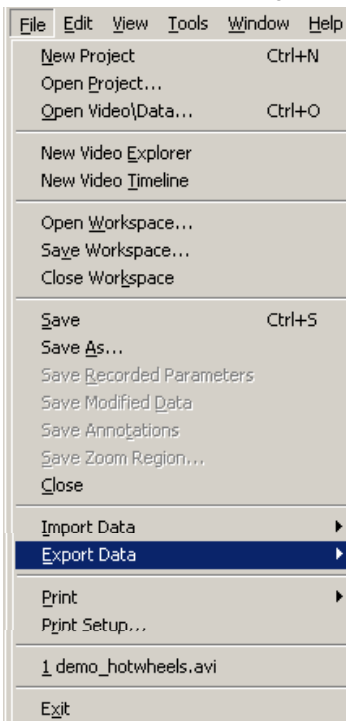
1. In order to properly interpret the contents of the text file, information about the formatting of the file must be provided.
2. Specify the Comment Indicator used in the text file. Typical characters are listed for convenience. You may use one of these or you may enter your own character(s) by selecting Other and typing in the correct value.
3. Specify the Field Delimiter used in the text file. This is the character(s) that are used to separate data values on each line. Typical values are listed for convenience. You may use one of these or you may enter your own character(s) by selecting Other and typing in the correct value.
4. Often data files contain special data in the first few columns that should be treated differently than the other columns. If the first and/or second column contains information that should not be graphed, then check the appropriate box and indicate what is contained in that column. Note that these values are not used to perform alignment. The Time value will be used to verify the zero point, but otherwise, these values are discarded.
5. In order to properly align the data to the video, information about the sampling rate and zero position of the data must be provided. The data must have been sampled at an integer multiple of the video rate in order to align properly. Enter in the number of data samples that correspond to one video frame in the

Samples per Frame box. For instance, if the data was sampled at 1000 Hz and the video was recorded at 100 fps, then enter a value of 10 for samples per frame.

6. Next, specify the number of the data line that should be used as the zero-th sample. This data sample will be aligned with the zero frame of the video. For instance, if the 100th data line in the text file represents the zero point, enter 100 in the Zero-th Sample box. If the first or second field was specified to be a Time value and the data line where the Time value is zero differs from the value you have entered for the zero-th sample, you will be asked which value to use in alignment.
7. If the data does not align as you had expected, try importing the file again with different samples per frame and zero-th sample values until you achieve the desired alignment.

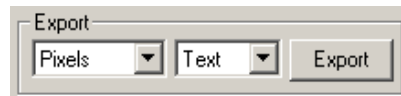
Exporting Data or Analyses

Data and analysis results can be exported to multiple file formats: Text, Excel (with or without a template), or Diadem. This selection of export formats was chosen to try to support the widest variety of customer's needs. Using one of these formats, it should be possible to directly, or with a small amount of modification, load the data or analysis results into most popular graphing or data analysis software packages.



To export data, use the **File → Export Data** menu.

To export analysis results, use the Export section of each analysis control panel, if present. Only analysis modules that support exporting will have this section present on the lower portion of their control panel.

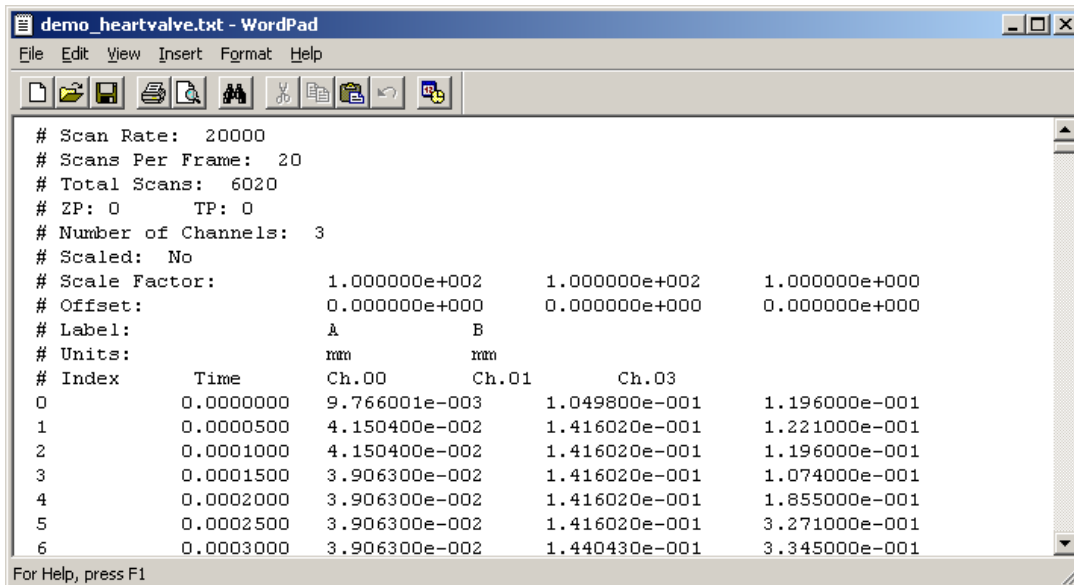


To Text
To Excel
To Diadem

Exporting to Text

Text files are suitable for loading into any program that can load data in a comma delimited format (e.g. Matlab or Excel). Some small formatting may be required to have the text files load properly depending upon the application you are using to load. Lines in the text file that do not contain the explicit data are prefaced with a # to indicate that the line is a comment or information line rather than a data line.

When exporting to Text, WordPad is opened with the newly created file.



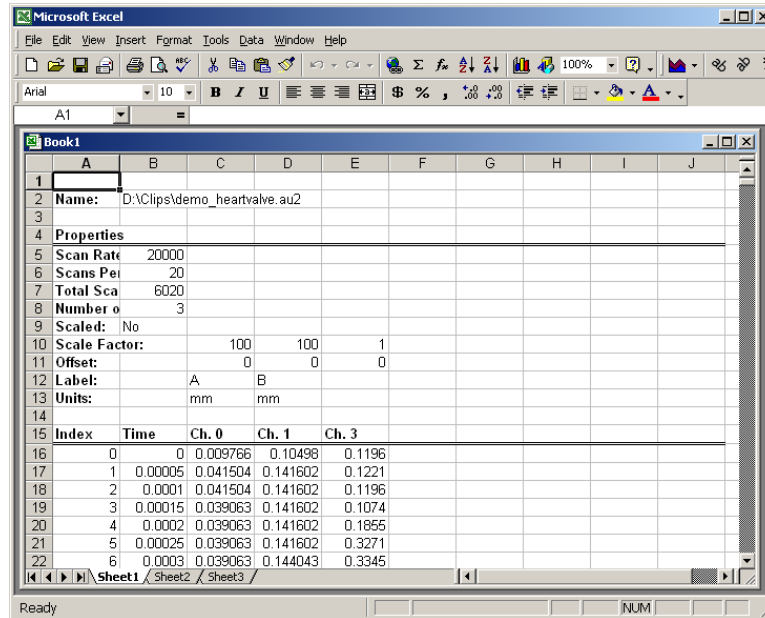
```

demo_heartvalve.txt - WordPad
File Edit View Insert Format Help
# Scan Rate: 20000
# Scans Per Frame: 20
# Total Scans: 6020
# ZP: 0 TP: 0
# Number of Channels: 3
# Scaled: No
# Scale Factor:      1.000000e+002    1.000000e+002    1.000000e+000
# Offset:           0.000000e+000    0.000000e+000    0.000000e+000
# Label:            A                B
# Units:            mm              mm
# Index      Time      Ch.00      Ch.01      Ch.03
0           0.0000000  9.766001e-003  1.049800e-001  1.196000e-001
1           0.0000500  4.150400e-002  1.416020e-001  1.221000e-001
2           0.0001000  4.150400e-002  1.416020e-001  1.196000e-001
3           0.0001500  3.906300e-002  1.416020e-001  1.074000e-001
4           0.0002000  3.906300e-002  1.416020e-001  1.855000e-001
5           0.0002500  3.906300e-002  1.416020e-001  3.271000e-001
6           0.0003000  3.906300e-002  1.440430e-001  3.345000e-001
For Help, press F1

```

Exporting to Excel

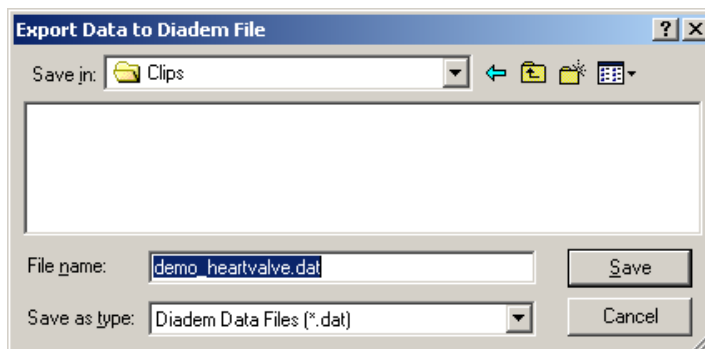
Exporting to Excel requires the workstation to have a version of Excel currently installed. An instance of Excel is launched and the data is directly written into the Excel spreadsheet. In order to save the results, you must save the resulting spreadsheet from inside of Excel. To export to a blank Excel sheet, use the Excel Blank format option.



You may export to Excel with a template file. When using a template file, Excel creates a new document that contains everything that is in the template file. The portion of the Excel sheet(s) that normally contain the exported data is overwritten. All graphs and formulas that are based on the exported data will automatically be redrawn and computed using the newly exported values. This is an easy way to reproduce any graphs or calculations made in Excel when doing similar tests. To export to Excel using a template, select Excel Template from the export format options.

Exporting to Diadem

Exporting to Diadem does not require the presence of Diadem on the workstation. Two data files are generated when exporting to Diadem, one has the R64 file extension and the other has the DAT extension. When exporting to the Diadem format, you will be asked to specify the DAT file and the R64 file will be named with the same base filename, but with the R64 extension. Both files are required for loading into Diadem.



An instance of Diadem is not launched when exporting.

File Management

Saving

One of the most important aspects of this software is the ability to save and load all the components of your work. The following information may be saved (and later reloaded):

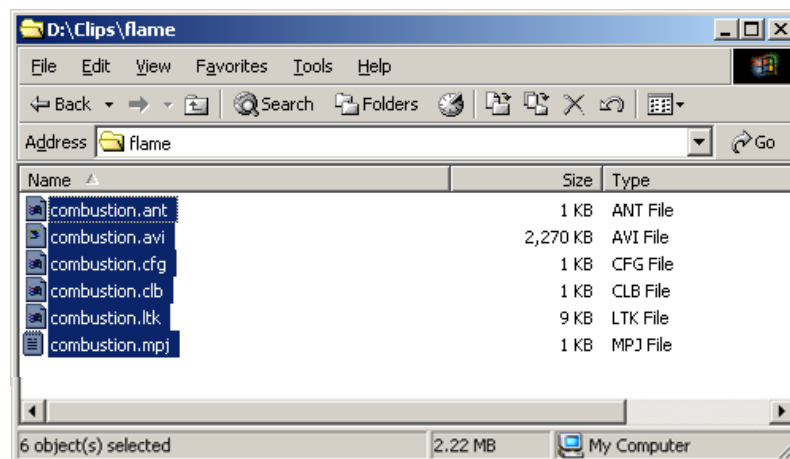
- Video
- Data
- Motion Analysis
- Image Processing
- User Notes and Annotations
- Calibration Information
- GPS/IRIG Timing Data

This software uses a video-centric file naming convention. That is, you name the video file during the save procedure and all the other files are saved with the same filename, but different suffix. During the **Save As...** process, you are asked for one filename. All the various pieces of your test are named this filename with a different 3-letter suffix (e.g. filename.avi, filename.cfg, filename.ant, etc.).

Image processing settings, calibration information, analyses, and most other saved files can be saved and reloaded independently through their respective control panels. For more information on saving and reloading saved settings, consult the corresponding sections of this user guide.

Moving Files

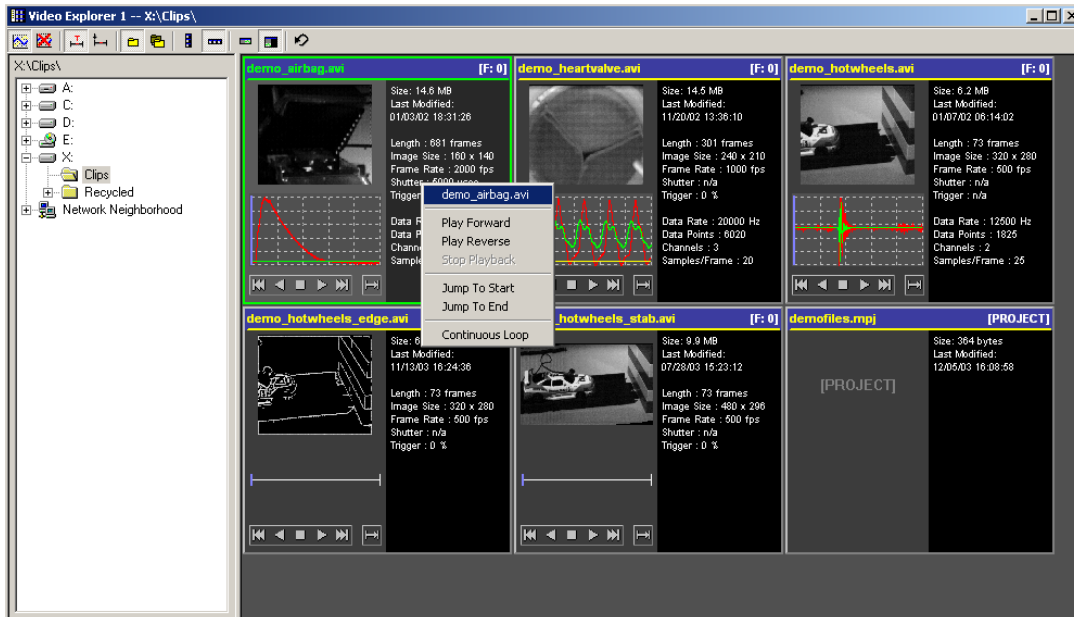
When copying or moving files, it is very important to move all files of the same name. Critical information or user-added content may not appear if all files are not moved together.



Also, be aware of projects that many contain references to a video you are moving. If you move the videos without moving or changing the contents of a project, the project will no longer be able to locate the video.

Browsing Through Files

A quick and easy way to browse through video files is to use the Video Explorer Window.



This window allows you to see and interact with thumbnail versions of the video and data for each recording in a directory or in sub-directories.

File Extensions

Many different files are created to store various portions of your measurement and analysis. A complete listing of possible file extensions and their contents is provided here.

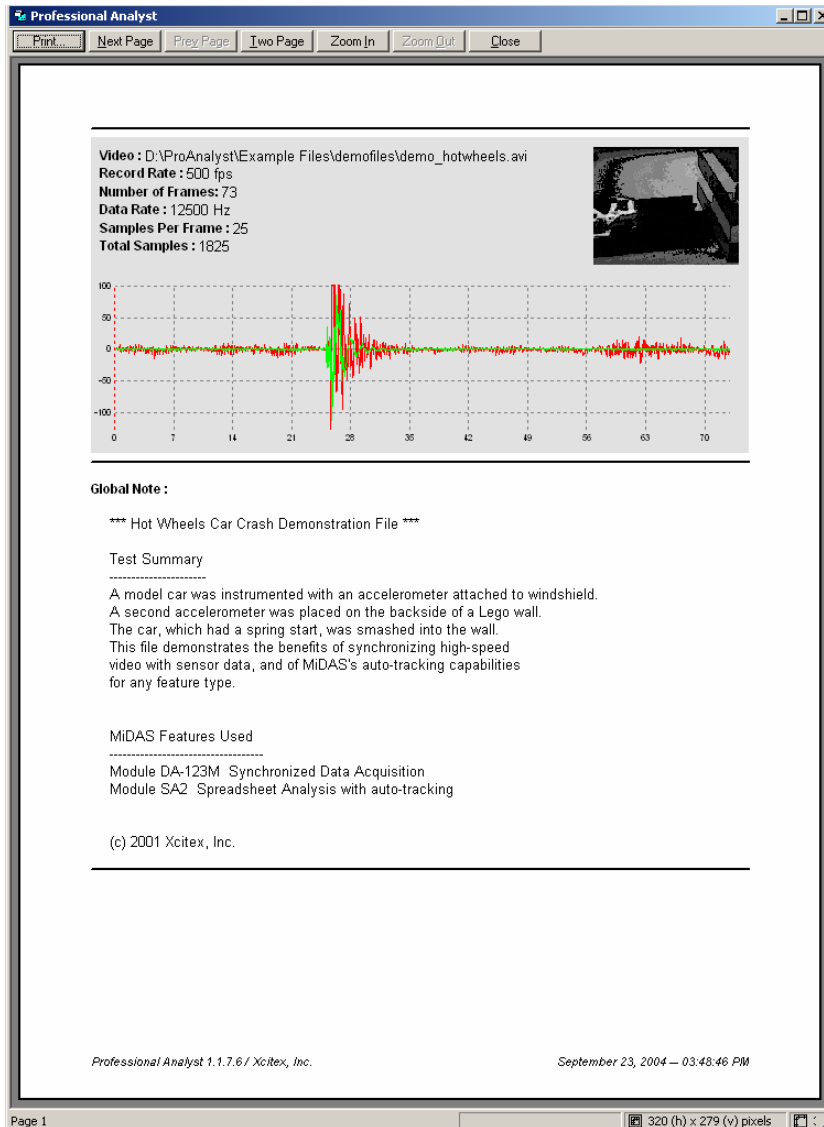
- **AVI, BMP, TIF, JPG** – Standard save formats for video files. Either saved as a single video file (AVI) or as a sequence of images (BMP, TIF, JPG).
- **PVI** – Partial Video file. This file is an AVI file that is a portion of a larger video consisting of sequentially named PVI files. These files load seamlessly as one large video file.
- **ANT** – Annotations file. Contains all annotations associated with the video. This file is loaded automatically if present when the video is loaded.
- **AU2** – Data file for acquisitions done with MiDAS software. This file is loaded automatically if present when the video is loaded.

- **AU3** – Binary data file for MiDAS software. Contains user notes, GPS/IRIG time information, and other per frame information. This file is loaded automatically if present when the video is loaded.
- **CFG** – Configuration file for MiDAS software. Contains record rate, shutter speed, zero frame and other record settings for a video. This file is loaded automatically if present when the video is loaded.
- **CLB** – Calibration file. Contains the calibrations settings saved via the Calibration panel.
- **CLR** – Bayer Color Coefficients file. Contains color coefficients for decoding Bayer formatted video files. This file is loaded automatically if present when the video is loaded.
- **FTK** – Feature (2-D) Track file. Contains the settings and analysis results for the Feature Track panel.
- **GFC** – Graph Configuration file. Contains a listing of all data display and filtering settings from the Configure Graph panel.
- **GFL** – Graph Filter List file. Contains a list of filters saved from the Filtering sub-panel of the Configure Graph panel.
- **IMP** – Image Processing file. Contains the list and settings of the chain of image processing filters to apply to a video from the Image Processing panel.
- **LTK** – Line (1-D) Track file. Contains the settings and analysis results for the Line Track panel.
- **LUT** – Image LUT file. Contains the brightness, contrast, gamma, and other LUT settings from the Image LUT panel.
- **MPJ** –Project file. Contains a listing of all video and associated files contained in the project.
- **MWK** – Workspace file. Contains a list and layout of various windows in a workspace.
- **R64, DAT** – Diadem Data files. These files are generated when exporting to Diadem using any of the analysis modules or the data export features.
- **STB** – Stabilization file. Contains the settings used to stabilize a video using the Stabilization panel.
- **TXT** – Text file. This file is a plain text file and is generated when exporting to Text using any of the analysis modules or the data export features.
- **XLS** – Excel Spreadsheet file. This file is generated when exporting to Excel using any of the analysis modules or the data export features.

Report Generation



Report Contents



Automatically generated reports obtain their content from the video, data, analysis, notes, and annotations. These are assembled and output in a structured format suitable for printing or web distribution. The Print and HTML formats have essentially the same options and are built from the same content material.

Reports are composed of a cover page, which displays video and data information, an image of the first video frame, a data graph of the acquired data if present, and the global note associated with a video.

All subsequent pages are composed of blocks of video images and comments or data plots and comments.

The screenshot displays the Professional Analyst software window. The title bar reads "Professional Analyst". The menu bar includes "Print...", "Next Page", "Prev Page", "Two Page", "Zoom In", "Zoom Out", and "Close". The main content area is divided into sections for "Frame 0" and "Frame 1", each with a video frame image and a list of instructions. A graph titled "Datum 0 [Frame 0 / Datum 0]" is also visible, showing data points over time. The status bar at the bottom indicates "Page 2" and "320 (h) x 279 (v) pixels".

Video : D:\ProAnalyst\Example Files\demofiles\demo_hotwheels.avi Page 2

Frame 0 : Time : 00:00.0000000

Frame 0 instructions:

Step 1: Select View, then Tab Manager. Select Analysis Tab SA2

Step 2: Select the general purpose Excel template:
 -- On the SA2 tab, click on Select button.
 -- Select the SA_Template.xls Excel template.

Step 3: Click on the New button.
 Set the "Number of Features to Track" to 2

Step 4: Select Show "All Frames"

Step 5: Calibrate the image
 -- Click on the Calibrate button.
 -- Move the crosshairs to the front of the car
 -- Select Set Point #1
 -- Move the crosshairs to the base of the wall
 -- Select Set Point #2
 -- In the Scale Factor field, type 6.00 inches. Click OK

Step 6: Options:
 -- Click on the Options button.
 -- Un-select "Draw a line between features"
 -- Select "Auto-Advance to next feature"
 -- Select "Auto-Advance to next frame".
 -- Select "Two step process: left click select and right click".

Click OK

Datum 0 [Frame 0 / Datum 0] : Time : 00:00.0000000

Data Index 0 instructions:

Step 1: Select the Play tab

Step 2: Data was recorded at 12,500 samples/second-channel or 25 points per video frame per channel.

Step 3: Expand the graph
 -- Click on Tools, then Create New Graph
 -- Separate the two graphs on the screen.
 -- On the new Graph, click on the Zoom button
 -- Draw a box around the impact region of the data

Step 4: Using the slider bar on the video window, move throughout the image and view the relationship between video and data.

Step 5: Go to Data Index: 625 (Frame 25).

Frame 1 : Time : 00:00.0020000

Frame 1 instructions:

Step 1: Click on Enable

Step 2: Create the tracking template
 -- Click on Create
 -- Draw a box around the box surrounding the number '3' on the car door. The zoom box automatically appears to help adjust the location.
 -- Click on Accept

Professional Analyst 1.1.7.6 / Xcitex, Inc. September 23, 2004 - 03:48:46 PM

Page 2 320 (h) x 279 (v) pixels

Blocks are added to the report and formatted according to the guidelines specified in the Report Options.

Adding Content

Any frame that contains a comment or annotation will automatically be included in the generated report unless specified otherwise in the Report Options dialog. In addition, the Report Options can be changed to include other frames that do not have comments or annotations.

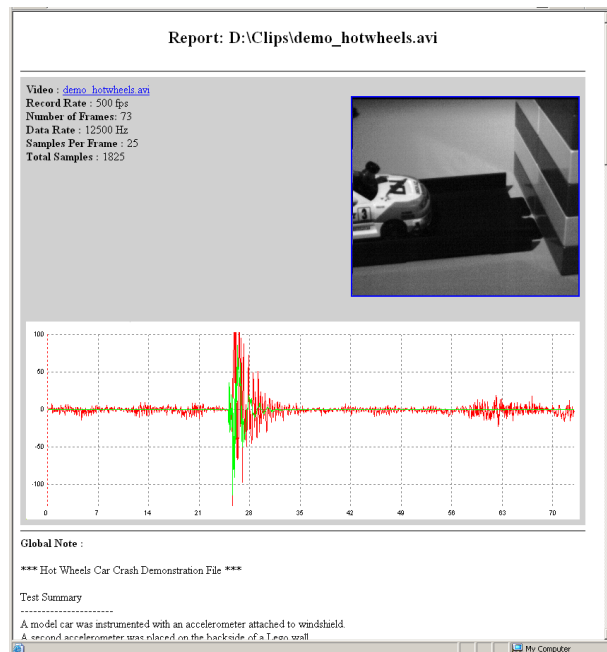
The content that is displayed in the report comes from many sources:

- To add video or data comments, use the Notes control panel. Comments can be added for each video frame, each data point, or for the entire video.

- To add annotations, use the Annotations control panel or toolbars to draw annotations over the video images. Annotations can be set to appear in a single frame or in all frames. Annotations that appear in a single frame will cause that frame to be included in the report generation. Annotations that appear in all frames will not force every frame to be included in the report.
- Changes to the image appearance using the Image LUT or Image Processing will be visible in the report if the "Processed" tab is selected in the Measurement Window when the report is generated. If the "Raw" tab is selected in the Measurement Window, then the raw video images will be used in the report.
- All visible analysis results that are shown in the Measurement Window will also be shown in the report (unless disabled in the Report Options).

Using the Report

The results from the Report Generator can be used to supply content to a wide variety of productivity applications. HTML versions of the report can be imported into other typical word processing applications such as Microsoft Word. HTML versions can also be saved as plain text files using standard web browsing applications. These text files combined with the set of image files automatically generated with the report can be incorporated into a wide variety of word processing or presentation applications. HTML reports are output to a single HTML file that is specified in the I. The video images and the data plots are created as bitmap files that are stored in an images directory. The image directory is located in the same directory as the HTML file. The directory is named after the video filename with a "_imgs" appended to it. For example, for the *demo_hotwheels.avi* video, the HTML file was named *demo_hotwheels.html* and the image directory was named *demo_hotwheels_imgs*.



Report Options

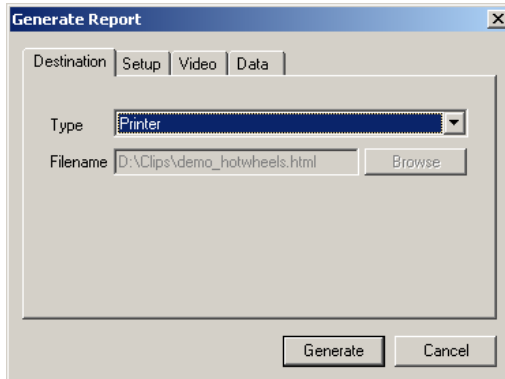
Options Dialog

When the report generator is started, an initial options dialog window is displayed. The various configurable options for the report generator are described in this section.

Destination

Select the type of output for the report:

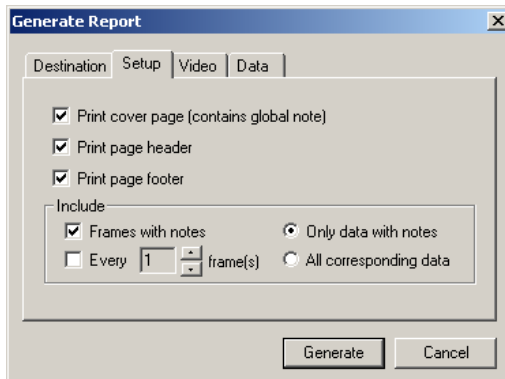
- Printer will send directly to a printer,
- Print Preview will display a preview window, and
- HTML generates an HTML page and associated images.



Depending upon the type that is selected on this tab, the contents of the Setup, Video, and Data tabs will change appropriately.

Setup

The setup options allow you to configure the overall format of the report.



- **Print cover page** – The cover page provides a summary of the video and data. It includes an image of the first video frame, a graph of the complete data, and the contents of the global note if present. Select this checkbox to include the cover page.
- **Print page header** – The page header includes the name of the file and the page number. Select this checkbox to include a header on every page.

- **Print page footer** – The page footer includes the application name and the date and time. Select this checkbox to include a footer on every page.

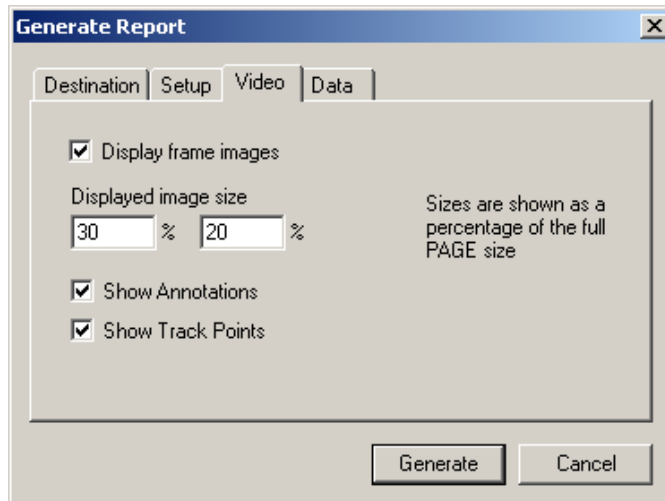
After the cover page, the remaining document is composed of blocks of frames with notes or data with notes. In the default setting, only frames or data that contain notes or annotations will be included in the generated report. Additional frames that do not contain notes can also be included in the report by modifying the Include options.

- **Frames with notes** – Check this box to include every frame that contains a note or annotation.
- **Every [x] frame(s)** – Check this box and specify an interval to automatically include equally spaced frames throughout the entire video.
- **Only data with notes** – Select this option to only include data graphs if the data has an associated data comment.
- **All corresponding data** – Select this option to include the associated data graph that corresponds with a video frame that is displayed regardless of whether the data itself has an associated data comment.

Future versions will have greater flexibility in what is included in the generated report.

Video

The video options control how the video frames are displayed in the generated report.



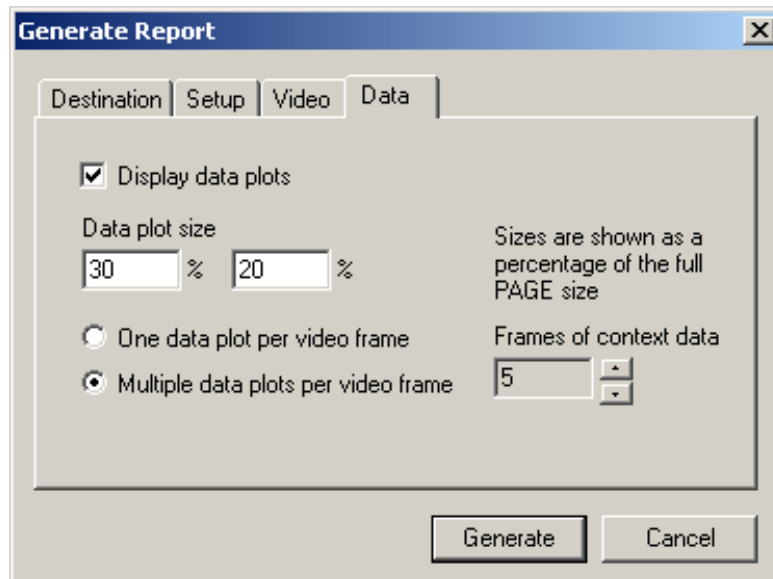
- **Display frame images** – Check this box to include frame images. If this box is not checked, video images will not be included in the generated report.
- **Displayed image size** – Specify the maximum image size on the page. For the Print and Print Preview destinations the size is given as a percentage of the total page size. The image will be resized to fill the specified size while maintaining the same aspect ratio. The image width cannot exceed 50 percent of the page size in order to leave room for user comments. For the HTML destination, the size is given as dimensions in pixels.

- **Show Annotations** – Check this box to include annotations in the frame images that are displayed. The annotations must be visible in order to be displayed.
- **Show Track Points** – Check this box to include analysis track results in the frame images that are displayed. Analysis must have been completed and visible in order to be displayed.

Frame images are displayed in the raw or processed form depending upon which tab is currently selected in the Measurement Window when the report is generated. If the Raw tab is selected, the raw frames will be incorporated. If the Processed tab is selected, the processed frames will be incorporated.

Data

The data options control how the data graphs are displayed in the generated report.



- **Display data plots** – Check this box to include data plots. If this box is not checked, data plots will not be included in the generated report.
- **Data plot size** – Specify the data plot size. For the Print and Print Preview destinations the size is given as a percentage of the total page size. The image width cannot exceed 50 percent of the page size in order to leave room for user comments. For the HTML destination, the size is given as dimensions in pixels.
- **One data plot per video frame** – A single video frame may contain multiple data points that have associated user comments. A single data plot can be generated for this video frame or multiple data plots can be generated for each data point that has an associated user comment. Select this option to generate a single data plot per video frame.
- **Multiple data plots per video frame** – A single video frame may contain multiple data points that have associated user comments. A single data plot can

be generated for this video frame or multiple data plots can be generated for each data point that has an associated user comment. Select this option to generate separate data plots for each data point that has an associated comment.

- **Frames of context data** – For every data point that is plotted, a range of data points before and after the point of interest is included in the data plot. The amount of data shown before and after the data point of interest can be specified here. The amount is given as the number of frames worth of data to be displayed in each graph. For instance, if the data is sampled at 10 samples per frame, 5 frames of context data would generate plots that have 50 data points each.

Only data that was acquired with the video is included in the data plots. Graphing of analysis results is not included in the generated report. Future versions will incorporate analysis graphing in the report generation

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Part 2: ProAnalyst Tutorials

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Tutorial 1: Learning to Use ProAnalyst

If you are new to ProAnalyst, this tutorial, which can be completed in 15 minutes or less, will provide you with a strong foundation from which to further explore the capabilities of this powerful video analysis package.

This lesson will provide inexperienced or first time users with a step-by-step walkthrough of ProAnalyst's general usage. Included is an explanation of the most important aspects of the ProAnalyst interface, as well as a step-by-step guide to creating and managing project, importing data, calibrating and processing an image, motion tracking, user-defined content, and report generation.

Files Needed for This Tutorial

1. *demo_hotwheels.avi*
2. *demo_hotwheels_data.txt*
3. *demo_heartvalve.avi*
4. *demo_switchblade.avi*

Step 1 – Creating a New Project

Begin by launching ProAnalyst. You may either double-click the mouse on the ProAnalyst desktop shortcut, or select ProAnalyst from the Windows Start menu.

Select **File → New Project** from the main menu to create a new project file. An empty Project Window [Figure 1] will appear in the upper left-hand corner of the screen.

Projects are used to manage video and data files as well as their associated calibration, analysis, and processing configuration files. Project uses can vary from keeping track of multiple views of the same object, to running comparisons between different videos or analyses. Projects are strictly

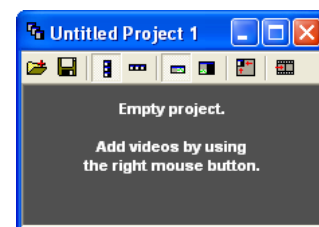


Figure 1

bookkeeping files – they do not actually move or alter any files on the computer or network.

New videos can be added through a pop-up menu, accessible by right-clicking the mouse inside the Project Window. Select **Project → Add Video(s)...** from the pop-up menu [Figure 2], and load the *demo_hotwheels.avi* video file.

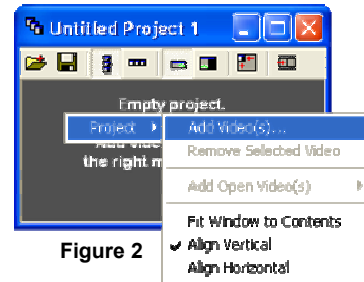


Figure 2

The Project Window can contain and manage multiple video files. As an example, repeat the previous step to add the *demo_heartvalve.avi* and *demo_switchblade.avi* videos.

Step 2 – Navigating the ProAnalyst Interface

The ProAnalyst interface consists of 4 primary windows. Currently the Project Window, Workspace View, and Active Timeline are visible. The Measurement Window can be launched by double-clicking the mouse on the *demo_hotwheels.avi* video thumbnail. Your workspace should resemble Figure 3.

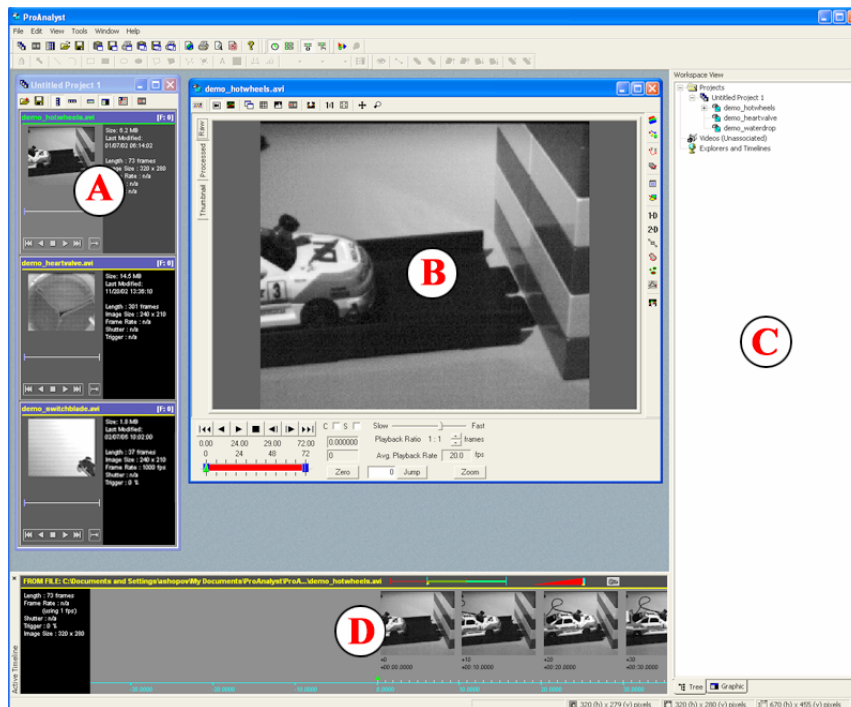


Figure 3

- A. The Project Window manages multiple video and data files, and provides thumbnail views of project video clips.

- B. The Measurement Window is used for video processing/analysis and graphing actions. The majority of ProAnalyst work takes place in this window.
- C. The Workspace View displays active projects, as well as their associated video, data, and configuration files in either tree or graphical format.
- D. The Active Timeline provides synchronization and visualization of multiple video tracks, data, and graphs. Data patterns and subtle events can be easily viewed from this window.

This tutorial will focus primarily on the Measurement Window. The Workspace View and Active Timeline will not be used. These windows may be closed by clicking the 'X' button in the top right or left hand corner.

The Measurement Window in Depth

The majority of video and data analysis takes place in the Measurement Window. Across the top of the Measurement Window is the Main Toolbar [Figure 4], which controls the viewing options and appearance of the video controls, video image, and displayed data.



Figure 4

The Video View tabs [Figure 5], located along the left side of the Measurement Window, provide different viewing options for the video image.



Raw displays the original, unaltered video image directly from the source file.

Processed shows the results of any Image Processing or Image Filtering operations on the video image.

Thumbnail displays a thumbnail summary of the entire video sequence.

Figure 5

Along the right side of the Measurement Window is a toolbar that contains a column of icons [Figure 6]. Each icon in the toolbar opens a control panel representing an operation that can be performed on a video. Note that the specific icons that appear will depend on which version of ProAnalyst you are using.

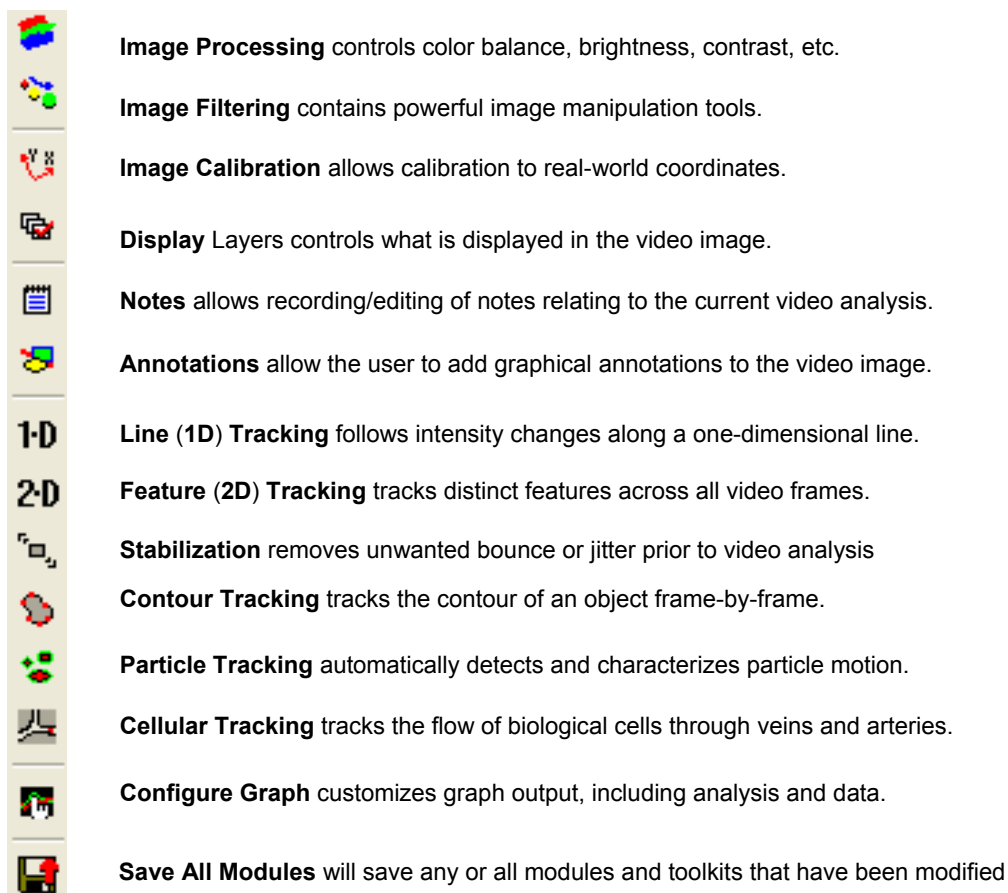


Figure 6

A set of video play controls [Figure 7] are located at the bottom of the Measurement Window.

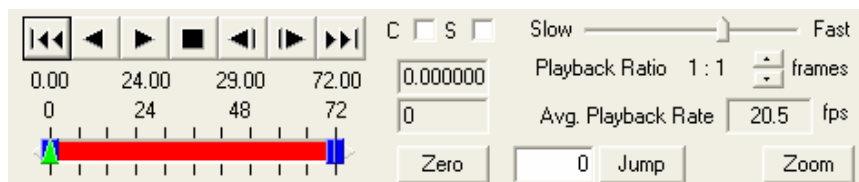


Figure 7

The Play Controls allow for forward or reverse video playback or frame-by-frame stepping. The video length, current frame, and current time are displayed, as well as frame jump, frame skip, and continuous playback options. Refer to the ProAnalyst User Guide for more details.

Step 3 – Importing and Synchronizing External Data with Video

Known as “sensor fusion”, the synchronization of video and sensor data provides a much richer understanding of events than either technology alone. ProAnalyst allows users to import data streams from external sensors and gauges, and then synchronize the data streams with video(s). If video and data were recorded together in one of ProAnalyst’s supported formats, the data would be automatically read and synchronized.

To import external data contained in an ASCII text file, open the Import Data dialog box [Figure 8] by selecting **File → Import Data → From Text**. Click the **Browse** button at the top of the dialog, and select the *demo_hotwheels_data.txt* file.

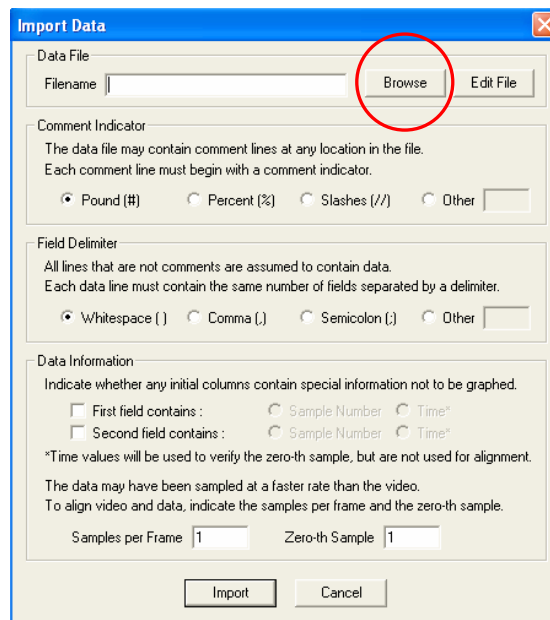


Figure 8

In the Data Information frame [Figure 9], check the boxes marked **First Field Contains:** and **Second Field Contains:**. Leave the other dialog properties at their default values.

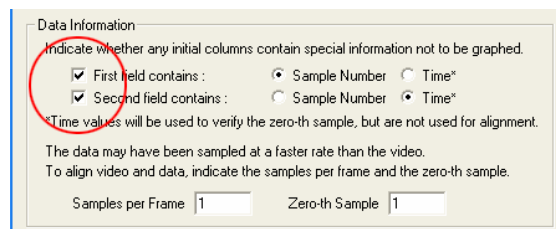



Figure 9

Confirm your import settings by clicking the **Import** button located at the bottom of the dialog. The Measurement Window will automatically update to display a graph of the imported data in the Graph window pane.

Press the  button and take note of the movement of the tracking line through the Graph window. You will see that it only proceeds a short distance through graph before the video ends. This is because by default, ProAnalyst synchronizes data to the video frame rate. However, in this example, the data was recorded at a higher rate than the video. Fortunately, it is possible to synchronize video with external data that was recorded at a different rate.

Reopen the Import Data window. ProAnalyst will ask if you would like to replace the currently existing data. Click **Yes**. When the Import Data window opens, repeat the previous steps taken to import and configure the data file, but do not click the **Import** button yet.

Above the **Import** and **Cancel** buttons, you will notice two text boxes labeled “Samples per Frame” and “Zero'th Sample”. The values contained in these boxes are used to determine how imported external data should be synchronized with the current video. As the accelerometer data in this example corresponds to 25 data points for each frame of video, change the “Samples per Frame” field to “25” [Figure 10].

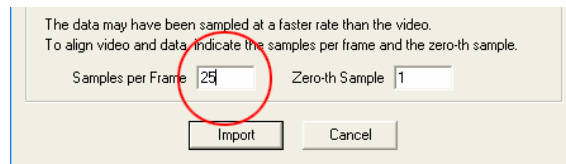





Figure 10


Clicking the **Import** button now will cause ProAnalyst to properly synch up the video and data. This can be confirmed by pressing the  button on the video controls. You will see that the frame tracking line moves through the graph at the same rate as the video playback. Click the  icon on the Measurement Window toolbar to close the graph window for the time being.

Step 4 – Calibrating an Image

By default, all position, velocity, and distance data associated with a tracked feature is calibrated to pixel scale. ProAnalyst is able to calibrate a video to real world scales (feet, meters, etc) based on either Normal (i.e. orthographic) or Perspective calibration models. In this example, the default Normal calibration will be used to transform the video coordinates into meaningful real-world coordinates.

Open the Multi-Plane Calibration control panel by clicking on the  button located on the Analysis Modules/Tools toolbar.

A Normal calibration requires the specification of two points of reference within the video that have a known distance between them. The distance between these two points is specified in calibrated units, and ProAnalyst converts the pixel length to calibrated units appropriately. In this example, the bottom of the car's chassis will be used as a reference object for scale calibration.

Click the  icon to open the Calibration Settings window. At the top of the Calibration Settings window, you will see two buttons labeled **Set Point #1** and **Set Point #2** [Figure 11]. Below these two buttons is a text field in which a calibration value can be input, as well as a dropdown menu containing different real-world units of measurement that can be applied to the video image.

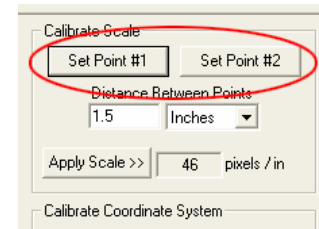
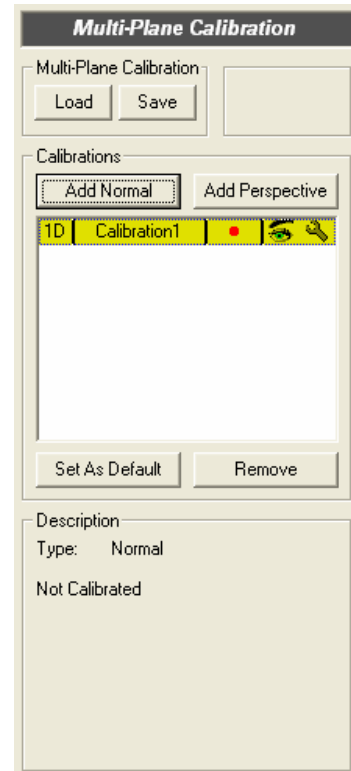


Figure 11

Advance the video to frame 21. Position the reticle by clicking at the bottom rear corner of the car's chassis [Figure 12]. When it is positioned, click the **Set Point #1** button.



Figure 12

Reposition the reticle at the bottom front corner of the chassis [Figure 13], and click the **Set Point #2** button.

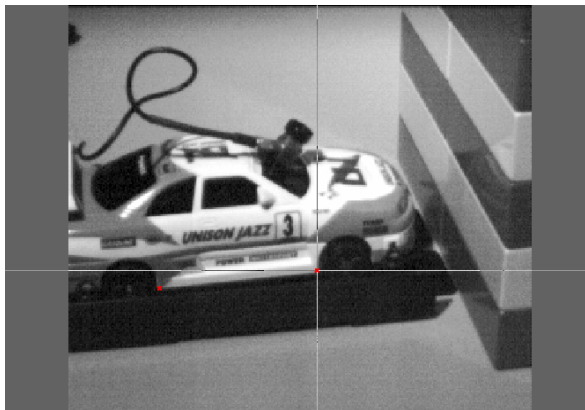


Figure 13

After both calibration points have been set, input “2.25” (the approximate width in inches of the car’s chassis) into the **Distance Between Points** text field [Figure 14], and click the **Apply Scale >>** button to set the new calibration value. You will see the “pixels / in” value change to reflect the new calibration scale factor, and ProAnalyst will automatically apply the new calibration to any measurements that are recorded.

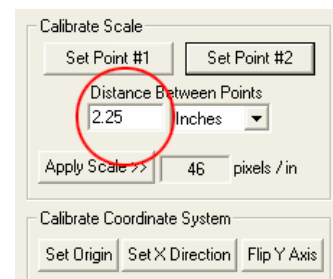



Figure 14

Step 5 – Manipulating an Image with Processing and Filters

Before tracking the motion of an object, it is often advantageous to apply a series of processing or filtering operations to an image. This example will demonstrate how the application of only two operations can significantly enhance the video image, such that several distinct features of the car can be easily tracked in the next section of this tutorial.

Image Processing

The Image Processing (LUT) control panel allows you to modify the display settings of an image. Two identical sets of sliders are available, one for Color Image Settings, and one for Black and White Image Settings (B&W). The B&W Image Settings sliders are grayed out by default, and will not be used in this example.

Open the Image Processing (LUT) control panel by clicking the  icon on the Analysis Modules/Tools toolbar. Move the “Exp./Log.” slider [Figure 15] to the left by clicking and dragging it with the mouse. This has the effect of making dark regions in the image darker, while simultaneously bringing out more detail in the lighter regions.

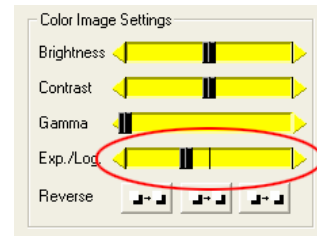



Figure 15

Image Filtering

The Image Filtering control panel allows you to apply a series of image processing filters to a video image. This process is analogous to applying signal processing filters to electronic circuits. The Image Filter List portion of the panel lists in descending order the current filters that have been applied to an image. Filter results are calculated in the order in which the filters are added.

Open the Image Filtering control panel by clicking the  icon on the Analysis Modules/Tools toolbar. Filters can be added to the list through the Select Filters to Add dialog [Figure 16]. Click the **Add** button to open the selection window, and expand the “Convolve” list by clicking on the + sign next to it.

Click inside the box labeled “Sharpening (3x3 Center)”, and then press the **OK** button to apply the filter. Clicking **Cancel** will close the window without implementing any filters that may have been checked.

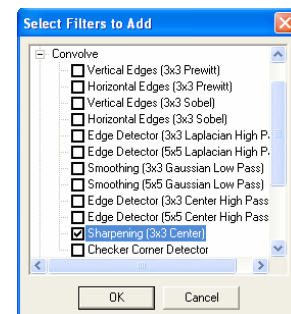


Figure 16

You may compare the original [Figure 17-A] and the processed and filtered [Figure 17 -B] versions of the video by clicking back and forth between the **Raw** and the **Processed** tabs.

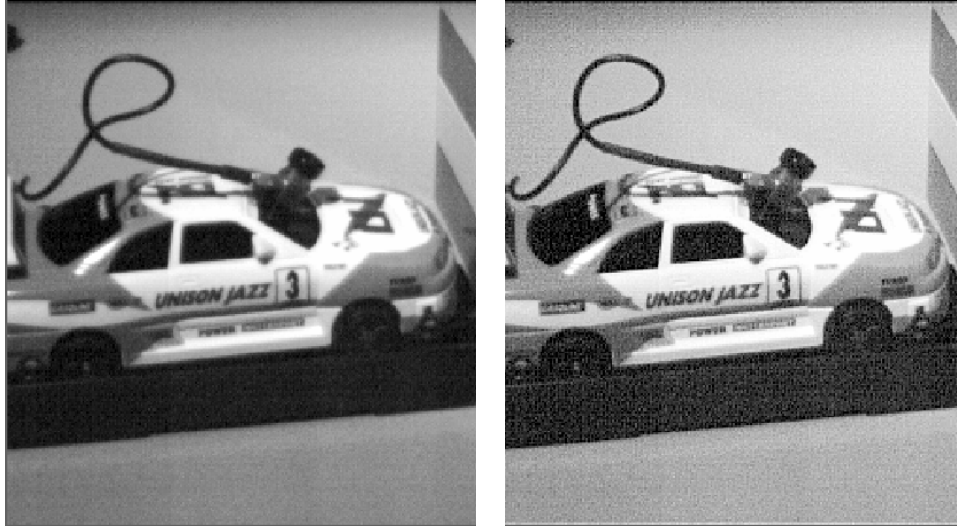


Figure 17-B


Step 6 – Tracking a Simple Feature

“Tracking” is the ability to select a distinct feature and determine its motion characteristics over time. A feature is defined as a rectangular region within the initial frame of a video. The Feature Tracking control panel allows users to specify whether they would like to track a feature manually, or allow ProAnalyst to conduct an automatic track of a feature.

Manual tracking allows a user to step through the video one frame at a time while using the mouse to select the location of the feature in each frame. This method is generally employed for low-quality images, or when highly irregular motion paths are present.

Auto-tracking is the ability of ProAnalyst to automatically find and track user defined features, and then determine frame-by-frame motion characteristics with respect to the image plane. This automatic tracking capability will be demonstrated by tracking two features on the car as it moves through the video – in this case, the number “3” painted on the car door, and the accelerometer mounted on the windshield.

To track the “3”, begin by clicking the **2D** icon to open the Feature Tracking control panel, and then click the **Enable** button at the top of the control panel to activate the panel. Notice that one feature is automatically added to the Features list.

ProAnalyst will begin auto-tracking on the currently displayed video frame. Click the  button to move the video to frame 0, if it is not there already.

The next step is the definition of a template representing the object you wish to track. Click the **Define Region** button, located at the bottom of the Features frame, and then click and drag the mouse to draw a box around the number “3” [Figure 18]. After the box is drawn, it can be repositioned by clicking and dragging it to a new location on the image.

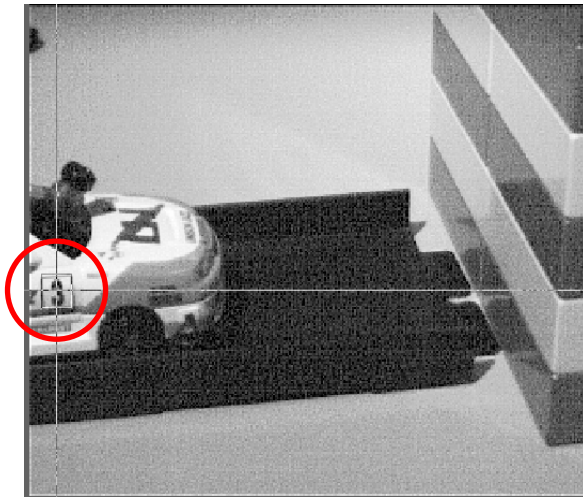


Figure 18


With the tracking template defined, click the **Set Region** button. The box will change color and display a small number 1, indicating that it is the first feature in the feature list. In the feature list, you will note that the new feature is titled “<no label>” [Figure 19]. A feature settings window can be opened by clicking the  icon associated with a feature.



Figure 19

The Track Settings window provides access to all the parameters involved in auto-tracking. Type some text (for example, the word “Three”) in the “Feature Label” text field to define a label for the feature. The other parameters in the window may remain at their default values. Click the **Apply** button, followed by the **Close** button at the bottom of the dialog. The new title will now be displayed above the bounding box surrounding the selected feature.

New features can be added to the window by clicking the **Add** button. Add a new feature to the list, and then define and set a template for the accelerometer mounted on the windshield of the car. Open the Track Settings window for this feature, and type a label

(“Accelerometer”, for example) in the “Feature Label” field. Your image should now resemble Figure 20.

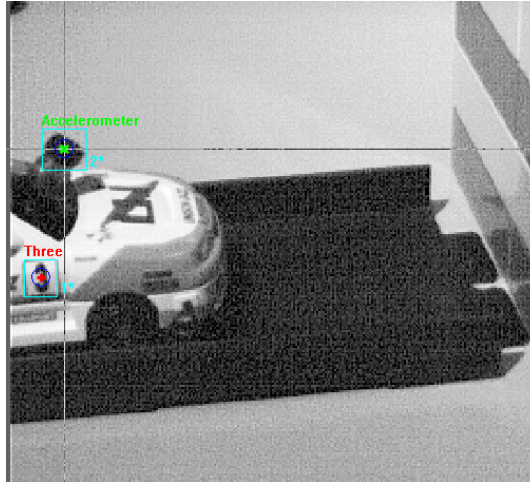


Figure 20

When you have defined and set both template regions, click the **Track Forward** button. The video will advance frame-by-frame as ProAnalyst tracks the selected features and marks their positions on the screen [Figure 21].

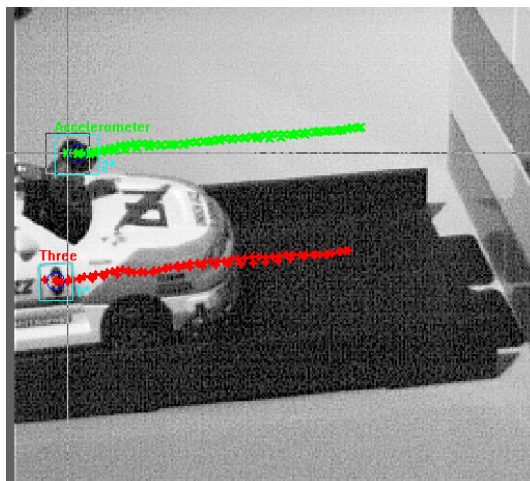


Figure 21

By default, ProAnalyst will display every tracked point on the screen simultaneously. Depending on what frame you are on in the video, seeing all of the tracking marks can be visually confusing. Below the “Features” frame is the “Show Points” pull-down list [Figure 22]. Click on the pull-down list and select the “Show Past” option. This option will only display the tracking

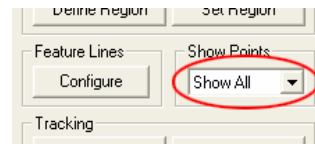




Figure 22

points associated with the current frame, as well as any previous frames.

Viewing Real-time Measurements

The Show Measurements window provides real-time motion analysis results, such as current position and velocity, for each feature being tracked. It can be opened by clicking the  button on the Measurement Window toolbar.

Measurement values can be added through a selection window that is opened by clicking the  icon on the Show Measurements window. In the selection window, expand the “2D” list and click the boxes next to “Feature 1 (Three)” and “Feature 2 (Accelerometer)” [Figure 23]. When you have selected the values you wish to display, click the **OK** button.

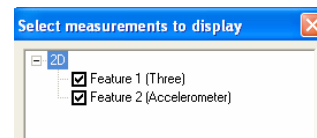


Figure 23

Measurement values are displayed in pixels by default. To view real-world calibrated measurements, select a calibration unit from the **Units:** drop-down menu [Figure 24].

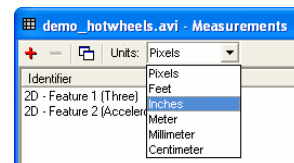



Figure 24

Step 7 - Graphing Video and Data Analysis Results

ProAnalyst allows immediately plotting of any tracked data, as well as associated sensor data. You may open the graph pane by clicking the  icon. When the graph is opened, you will see the data from the accelerometers that was plotted when the external sensor readings were imported into ProAnalyst [Figure 25]. The accelerometer sensor channels are plotted in the same colors (red and green) as the tracked points in the video window. To avoid confusion, the colors used to plot the sensor data will be changed.

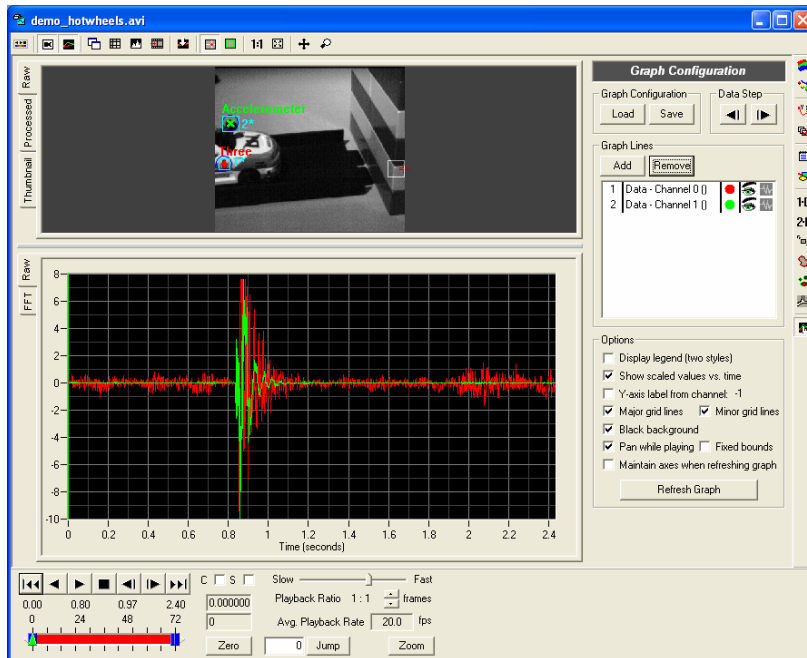

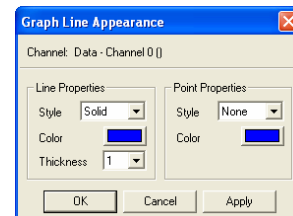


Figure 25

Begin by clicking the  icon to open the Graph Configuration control panel. Double-click the mouse on the red dot next to “Data – Channel 0” in the Graph Lines frame to open the Graph Line Appearance window.

Click on the “Color” box to open a color picker [Figure 26]. Choose a new color for the graph line (blue, for example) and click **OK** to close the color picker. Click **Apply**, and then **OK** to apply the new color.

Repeat the preceding steps to change the plot color of “Data – Channel 1” (to yellow, for example).



In terms of tracked data, it is possible to plot the X and Y positions of any tracked points, as well their instantaneous speed, and distance from the origin. For this example, the speed of both tracked features will be plotted alongside the accelerometer data. Before plotting the tracked points, confirm that the “Units” drop-down menu located in the Feature Tracking control panel is set to the calibration units of your choice, otherwise the graph will be displayed in pixel units by default.

Open the Select Items to Add to Graph window by clicking the **Add** button in the Graph Lines frame. You will note that the selection window is of a similar configuration to the image

filtering window used previously. Expand the **2D** list, and check the boxes next to “Feature 1 (Three) – Speed” and “Feature 2 (Accelerometer) – Speed” [Figure 27], then click the **OK** button.

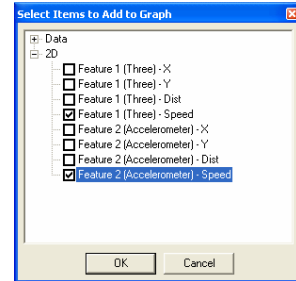


Figure 27

Your graph will now display a plot of the speed in inches/sec of your two tracked features, as well as the imported accelerometer data. However, you will notice that the new graph lines are plotted in the same colors (blue and yellow) as the sensor data plot lines. Follow the steps above to change the colors of the feature speed graph lines so that they match the colors of the tracked points in the video image (red and green) [Figure 28].

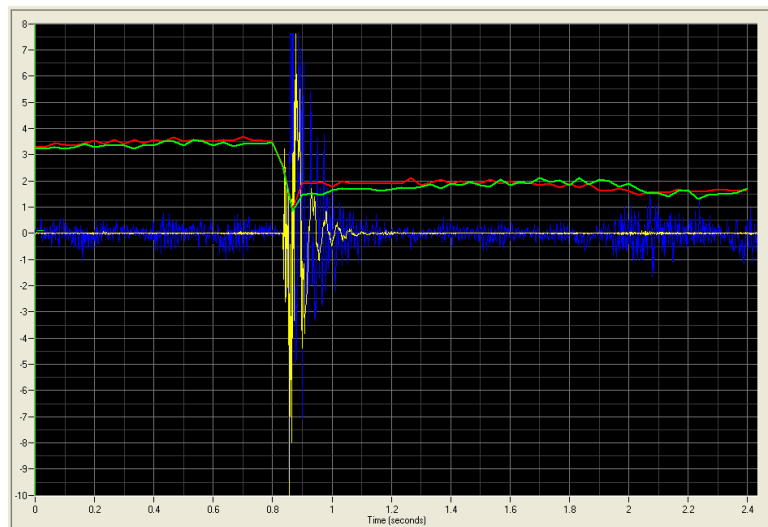




Figure 28

Step 8 – Adding Notes and Annotations to a Video

Video Annotations

Annotations provide the ability to overlay your own labels, measurements, or other objects directly onto a video sequence. These annotations can be configured to display on every frame of a movie, or can be limited to a specific frame or frames. Annotations are managed through a control panel which can be opened by clicking the  icon.

Go to frame 0 of the video, and click the  (Draw Length Dimension) icon. Length dimensions are straight lines drawn between two points within the video. The length of the line

will be displayed in calibrated units. To draw a length dimension, click and drag a line along the bottom of the track from the edge of the screen to the lego wall [Figure 29].

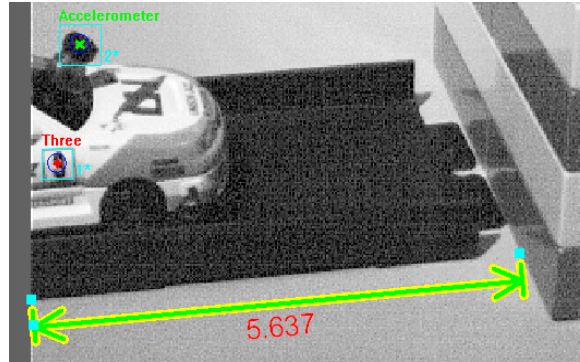


Figure 29

After the line has been drawn, its length and position can be altered by clicking and dragging the control points at either end to adjust the positioning of the endpoints. The length dimension can be moved as a unit as well. Click and drag the Length Dimension to line it up with the bottom of the track [Figure 30]. Click anywhere in the video frame to deselect the Length Dimension.

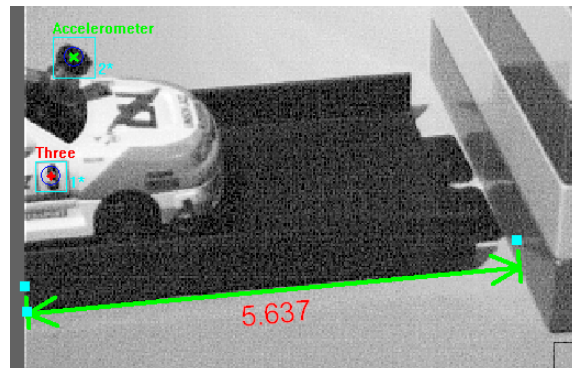


Figure 30

Advance the video to frame 25. Draw another Length Dimension, this time positioned along the bottom of the car [Figure 31].

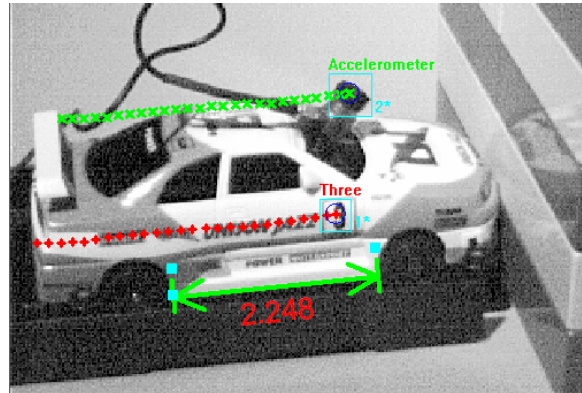



Figure 31

Video and Data Notes

ProAnalyst allows users to keep a running log of notes, journal entries, personal findings, and thoughts in an internal application notepad. This information is stored with the project such that only qualified users are able to edit journal entries. The Notes control panel [Figure 32] may be opened by clicking the  icon.

In the “Global Notes” text frame you may input any descriptive text that applies to the entire video and data sequence. For example, input the date, the video name, the experiment number, and a description of the test.

Set the video to frame 25. Input a comment regarding the impact of the car to the wall in the “Video Notes” text frame. These notes will only be visible when the video is on the frame in which they were input.

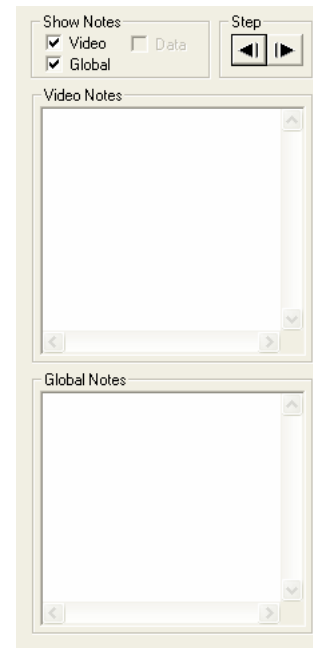


Figure 32

Repeat the previous step for as many other video frames you would like to add notes to. After you have added multiple notes to the video, move to frame 0.

Clicking the **Step** buttons at the top of the control panel will allow you to automatically cycle through each video note, without having to use the video controls.

Step 9 – Generating a Report

ProAnalyst has the ability to automatically generate a report based on video, data, analysis, notes, and annotation content. Reports are assembled and output in a structured format suitable for printing and web distribution. Currently supported formats include Print, HTML, and PowerPoint. HTML reports can be opened in all Office products, including Word, Excel, and Front Page, as well as Internet Explorer, Netscape, and other web browsers. Reports include a cover page that displays the video and data information, an image of the first video frame, a graph of any plotted video or data information, and any global note associated with a video [Figure 33].

To generate a report, select **Tools → Generate Report** from the main menu bar. This menu option will open the “Generate Report” dialog box. The dialog box is comprised of four tabs, each of which handles a different aspect of report generation.

In the Definition tab, select an HTML output format from the “Type” drop-down menu. With an output format defined, click the **Browse** button, located next to the “Filename” text field, to bring up a save box. Input the name you would like your report to be saved under and press the “Save” button.

Click on the Setup tab. Select the All **Corresponding Data** button [Figure 34]. This will output the data points that pertain to each frame that is displayed in the report. Click the **Generate** button. Your report will appear on the screen in your default internet browser (i.e. Netscape, Internet Explorer, etc.).

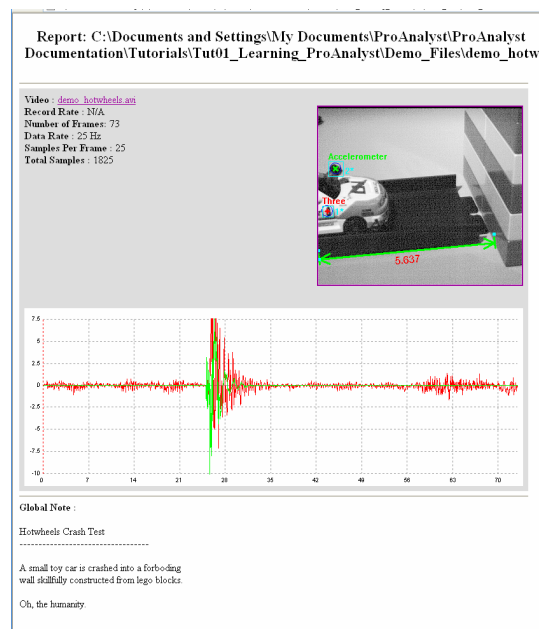


Figure 33

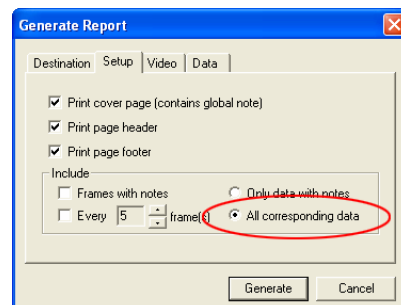


Figure 34


Step 10 – Saving Your Work

The final step in learning ProAnalyst, is an understanding of the way in which ProAnalyst saves and manages tracking data, calibration, etc. As a rule, ProAnalyst does not arbitrarily modify video or data files. Rather, ProAnalyst incorporates a series of individual save files that correspond to analysis, image processing, and other operations.

Click on the Project Window to make it active. Select **File → Save** to save your project file.

Click on the Measurement Window to make it active. Annotations may be saved by selecting **File → Save Annotations**, while notes may be saved by selecting **File → Save Notes**. Notes and Annotations will automatically be loaded when the saved Project file is opened.

Synchronized Data may be saved by selecting **File → Save Modified Data**. This operation *will not* overwrite your original data file.

Image Processing, Image Filtering, Image Calibration, Graph Configuration, and Feature Tracking each have save buttons on their respective control panels. Likewise, the  icon at the bottom of the Measurement Window tools palette can be used to save any files that have been modified over the course of an analysis.

ProAnalyst writes its operation save files into whichever directory your project file is saved. By default, save files take the name of the video they are associated with [Figure 35], but may be renamed at your discretion.

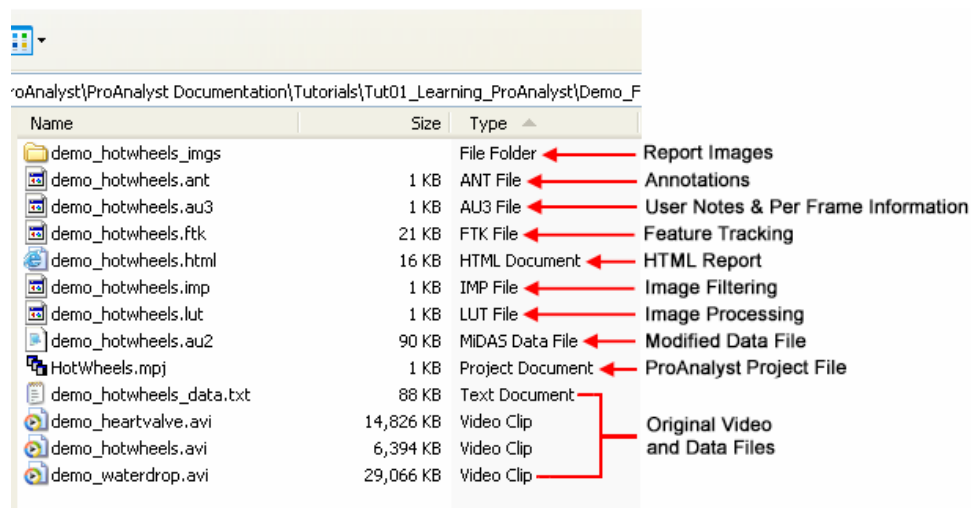


Figure 35

Tutorial 2: Tracking Featureless Motion with the 1D Line Tool

This project showcases the ability of ProAnalyst to analyze what is known as “featureless motion”. In this example, an analysis is performed on the process of fuel combustion in an engine. Combustion has no distinct features, per se, that can be tracked, however, we can use the unique **1•D Line Tool** to track the leading edge of a flame front that is expanding out from the center. Note that the **1•D Line Tool** is not available in the ProAnalyst Lite Edition.

Files Needed for This Tutorial

1. *flame.avi*

Step 1 – 1•D (Line) Tracking

The **1•D Tracking** module is capable of detecting peaks or derivatives of intensity along a line. **1•D Tracking** is also able to detect points of transition that exceed a configurable threshold value for intensity or derivative of intensity. These transition points can then be used to calculate a best-fit circle. We will use this capability to track the leading edge of the flame front by analyzing the black-to-white threshold derivative along three lines, while a circle fit is used to estimate the radius of the flame front as it expands.

Begin by creating a new ProAnalyst project, and add the *flame.avi* movie file. Open the Measurement Window.

Open the **Line Tracking** control panel by clicking the **1•D** icon on the **Analysis Modules/Tools** palette, and then click the **Enable** button to activate the control panel. A tracking line will appear in the center of the video window [Figure 1].

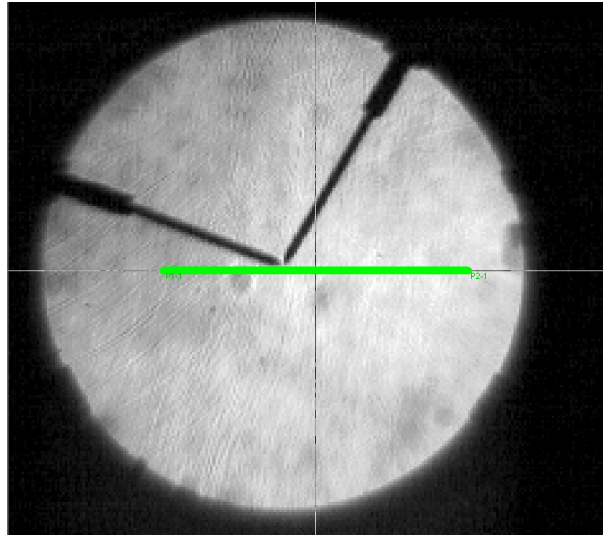


Figure 1

To reposition the tracking line, click the **Modify Line** button. Click and hold down the left mouse button over the position where you want the line to begin. Without releasing the button, drag the mouse along the video image to the position where you want the line to end. You should see the line redraw along the path you followed [Figure 2].

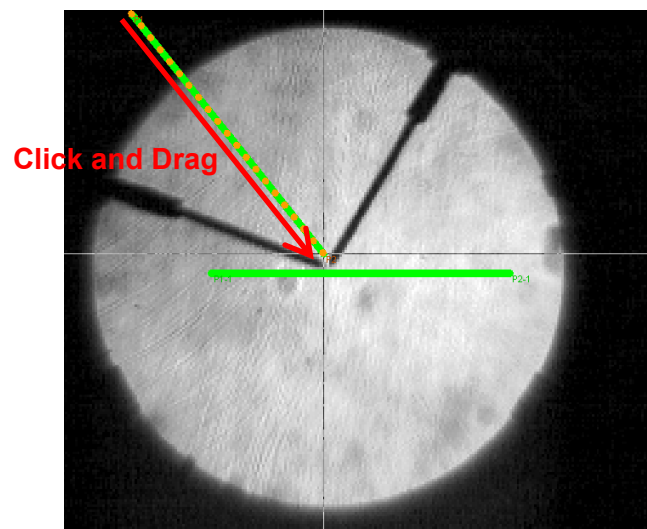


Figure 2

When you reach the end point you want, release the mouse and click the **Set Line** button.

Additional lines can be placed by clicking the **Add** button. Add two more lines to the image and repeat steps 3-6 for each one. Your video image should resemble Figure 3.

Note: The numbers next to the lines in Figure 3 denote the order in which they were added to the project. These numbers do not appear in ProAnalyst.

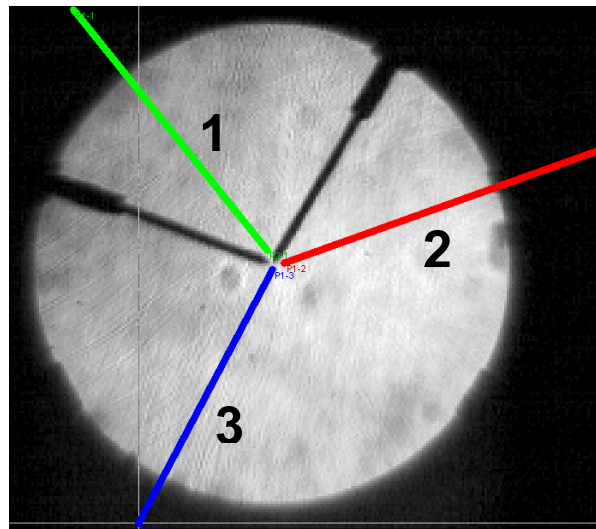


Figure3

Click the **Track Forward** button to begin the line tracking.

In this particular example, the best fit circle can be used to gauge the accuracy of the line tracking. As the video tracks forward, it will be obvious that the default settings for the line track (specifically Line 1) are not adequate for the analysis and must be modified.

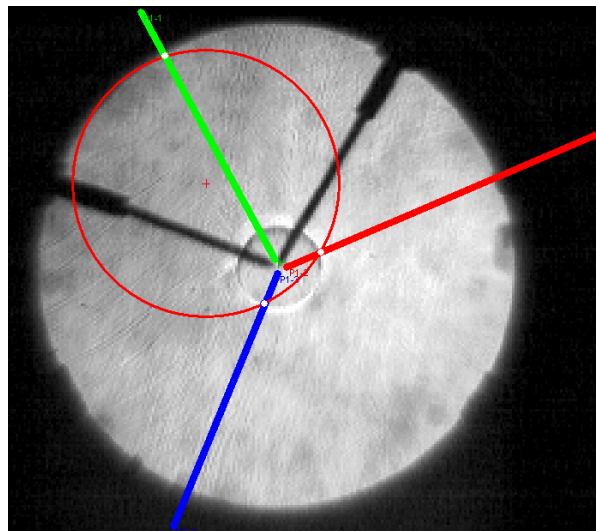



Figure4

To modify its tracking parameters, select Line 1 in the properties frame and click the  icon to open the Line Settings window.

Change the Transition Type from “Black to White” to “White to Black” by selecting it from the dropdown menu [Figure 5]. The other Search Parameters can remain at their default settings. Click the **Apply** button, followed by the **Close** button to confirm your changes.

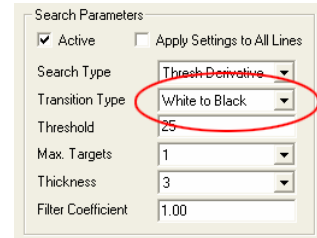


Figure 5

Repeat the previous procedure for Line 2, but do not change the Transition Type option. Instead, set the Threshold value to “40”. Line 3 can remain with its default values.

Click the **Track Forward** button. You should now see a more accurate track of the flame leading edge. Figure 6 shows frame 30.

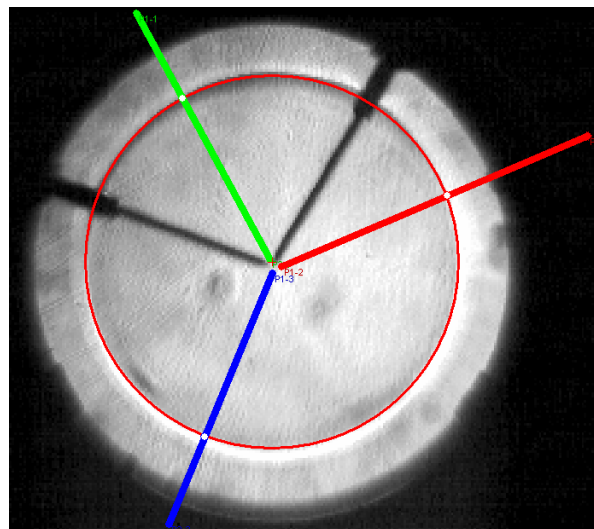


Figure 6

After tracking has been completed successfully, the change in size of the radius, as well as the radial speed of the best-fit circle can be plotted as new graph lines. Refer to Tutorial 1, Step 7 for information on graphing tracking results.

Tutorial 3: Analyzing the Motion of a Rotating Object

This tutorial will explore on one of the most powerful features available in ProAnalyst, namely the ability to rapidly track objects that rotate, as well as, move linearly within the field of view. In this example, the following marks were drawn on a CD ROM: an 'X', a line, and a star pattern. ProAnalyst was used to automatically track both the linear and rotational motion of these objects and graph the results.

Files Needed for This Tutorial

1. *spindisksub.avi*

Step 1 – Automatic Feature Tracking

Create a new project and add the *spindisksub.avi* video file. Launch the Measurement Window, and then click the **2-D** icon to open the **Feature Tracking** palette. Activate the control panel by clicking the **Enable** button.

Define and set a region around the feature you wish to track, in this case the 'X' [Figure 1], and then click the **Track Forward** button. The idea is to take note of the auto-tracking results when feature rotation has not been enabled. It should be apparent by frame 4 or 5 that the rotational motion of the 'X' makes it extremely tricky to track automatically.

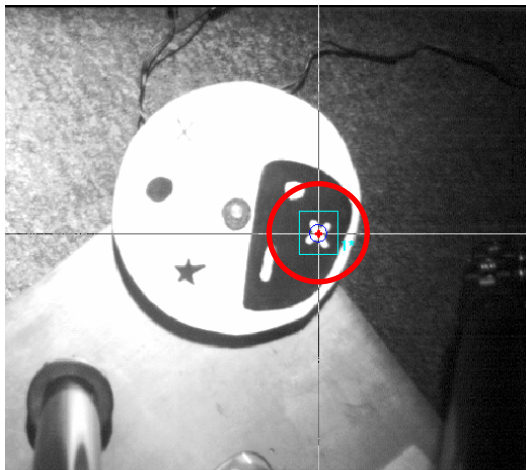


Figure 1


Click the  icon to open the Track Settings window. Activate the Feature Rotation option by clicking in the “Enable” check box [Figure 2].



Figure 2

Input an “Angular Range” and “Step Size” in degrees. The feature template will be rotated plus or minus the Angular Range value in intervals of the step size. For example, a rotational range of 30 degrees, combined with a step size of 5 degrees, will compare the template within a range of -30 to 30 degrees in 5 degree increments [Figure 3]. Click the **Apply** button, followed by the **Close** button to confirm your changes.



Press the **Track Forward** button, and you will see the ‘X’ accurately auto-track [Figure 4].

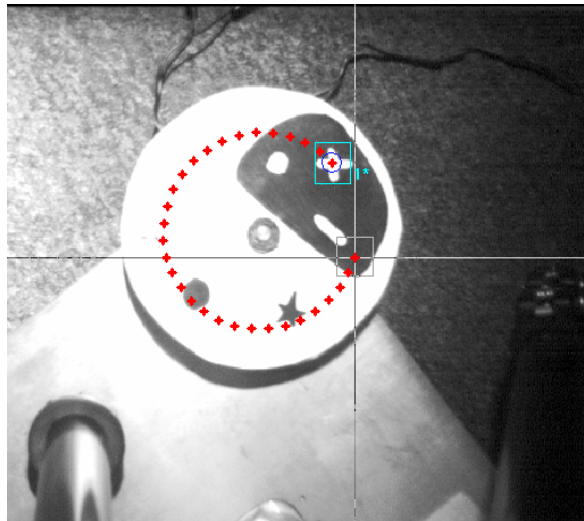



Figure 4

Step 2 – Analyzing the Rotation of the Tracked Feature

To accurately graph the rotational motion of an object, it is necessary to calculate the angle of rotation relative to a central origin point. As the ‘X’ is drawn on the disk, it makes sense to define the center of the disk as the origin.

Click the  icon to open the **Image Calibration** control panel. Position the reticle on the center of the disk. Click the **Set Origin** button, followed by the **Apply Origin and Tilt >>** button, to define the center of the disk as the new origin [Figure 5].

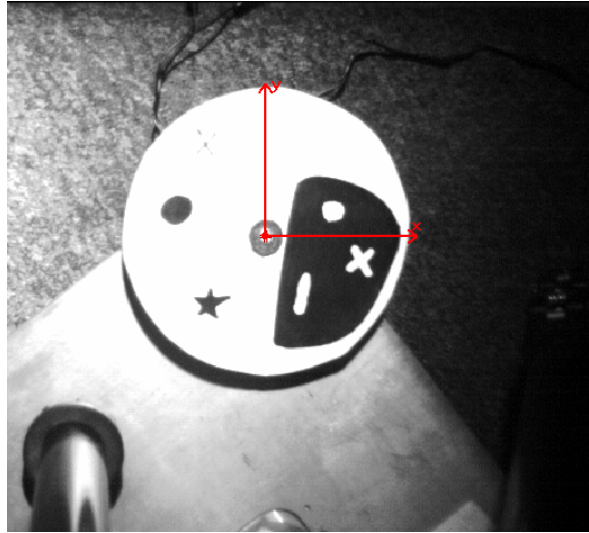


Figure 5

To plot the angle of rotation, reopen the **Feature Tracking** control panel, and then open the Line Configuration window [Figure 6] by clicking the **Configure** button.

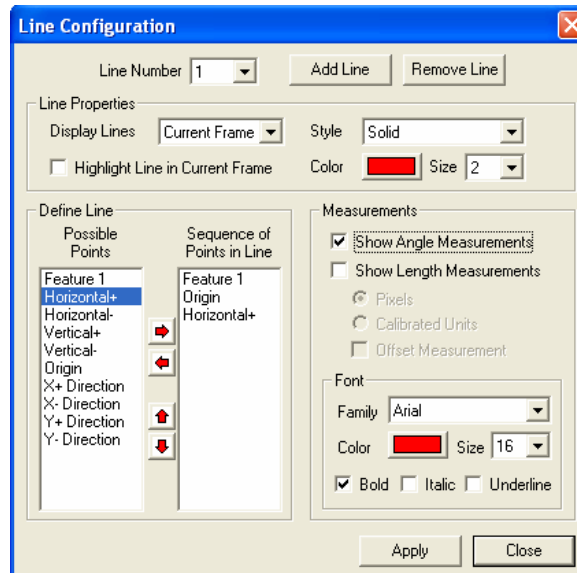


Figure 6

First, click the **Add Line** button. Next, move “Feature 1”, “Origin”, and “X+ Direction” (in that order) from the “Possible Points” list to the “Sequence of Points in Line” list. Finally, check the box labeled “Show Angle Measurements”. Click the **Apply** button, followed by the **Close** button.

When the **Apply** button is clicked, an angle will be drawn between the three specified points. This angle is updated in real time as the video is played back [Figure 7].

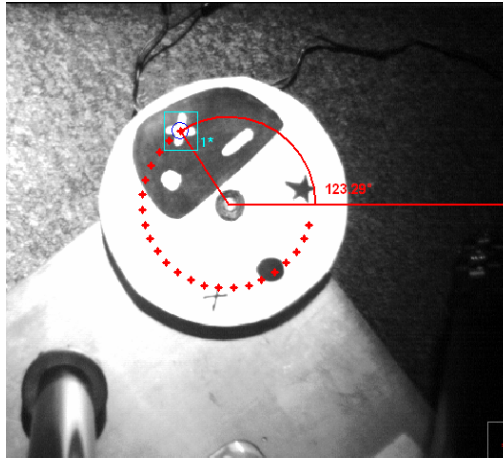



Figure 7

Angle measurements can be graphed in the same manner as speed or position measurements. Begin by clicking the  icon to open the **Graph Configuration** control panel.

Click the **Add** button to open the Select Items to Add to Graph [Figure 8] window. Next, expand the “2D” list, and check the box labeled “Feature Line 1 – Angle”. Click the **OK** button to confirm your selection.

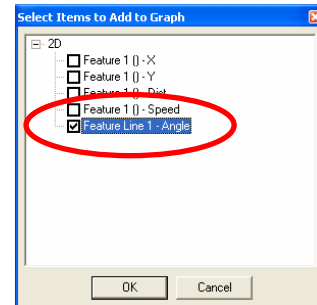


Figure 8

The Graph window pane will appear and display a plot of the Angle Measurement value vs. Time [Figure 9].

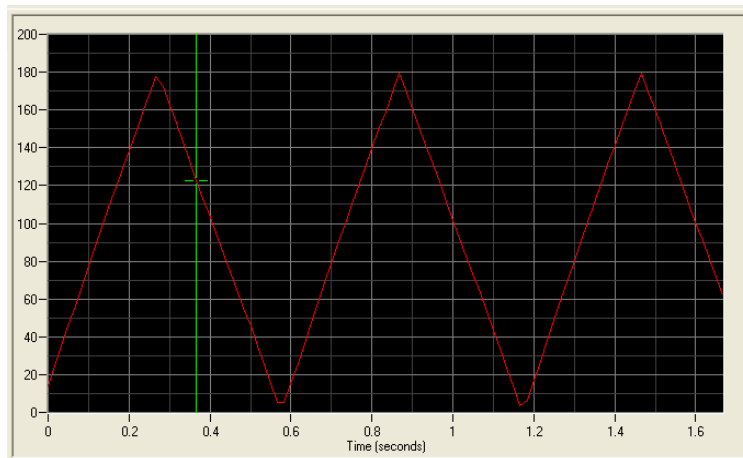


Figure 9

Tutorial 4: Stabilizing a Shaking or Vibrating Video

Camera shake and vibrating objects are common problems faced by many image analysis professionals. The ProAnalyst Stabilization Module provides a solution to this problem by providing the means to stabilize shaking or vibrating video images, simulating video acquisition by a stationary camera. This process is accomplished by locating and tracking video features that should maintain a stationary position. The shift and rotation necessary to maintain the features in a fixed position can then be computed, allowing stabilization to be performed for any combination of unwanted horizontal, vertical, or rotational motion. Note that the Stabilization Module is an optional toolkit, and may not be included in your version of ProAnalyst.

Files Needed for This Tutorial

1. *demo_jittery.avi*

Step 1 – Processing the Image for Feature Tracking


Create a new ProAnalyst project and add the *demo_jittery.avi* video file. Launch the Measurement Window, and then click the  icon to open the **Image Processing** control panel. The first step in processing the video image will be the conversion of the color image [Figure 1] to black and white.



Figure 1

Click the **Display B&W** button. Adjust the **B&W Image Settings** sliders until several features within the image become clearly defined [Figure 2].



Figure 2

Step 2 – Stabilizing the Video Sequence

Many of the features of the **Image Stabilization** module are based on the same underlying concepts as the **Feature Tracking** module. Stabilization requires the definition of a number of high-contrast regions within an image which can be tracked from frame to frame over the course of the video sequence.



Click the  icon to open the **Image Stabilization** palette, and then click the **Enable** button to activate the control panel. Note that a “Stabilized” option has been added to the video view tabs. Add, define, and set three features corresponding to three visually contrasting regions of the image [Figure 3].



Figure 3

Click the  icon associated with Feature 1 to open the Stabilization Feature Track Settings window [Figure 4].

Set the “Search Region Multiplier” and “Limit on Distance From Last” text fields to 700.

Set the “Threshold Tolerance” to 0.85.

Click the **Apply** button followed by the **Close** button to confirm your settings, and then click the **Track** button. If any of your features are lost you may redefine them and hit **Track** again to repeat the process.

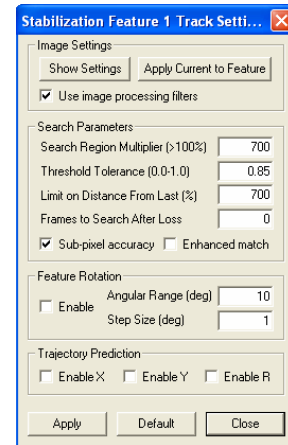


Figure 4

When the feature tracking has been completed successfully click the **Stabilize** button. The Measurement Window will automatically switch to the “Stabilized” view [Figure 5].



Figure 5


Press the  button to view the stabilized version of your video. You will notice that each stabilized frame will be drawn over the top of the previous frames [Figure 6].



Figure 6

Step 3 – Saving the Stabilized Video

Before performing any kind of tracking or analysis on the stabilized video, it must first be saved as a new file. You can then add the stabilized video to a new or existing project to and continue with your analysis.

Click the **Save Stabilized Video** button to open the “Save Video” dialog box [Figure 7]. The default file name will be the name of your video with the suffix “_stab” appended to it. This is not mandatory and may be changed at your discretion.

After modifying any video parameters that you wish to change, click the **Save** button to save your video file. ProAnalyst will automatically open the newly saved video in a new Measurement Window.

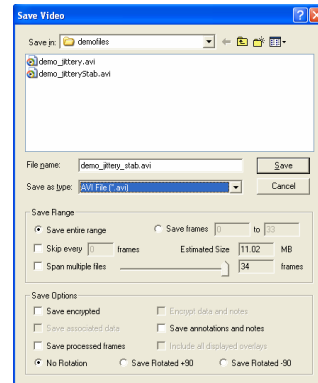


Figure 7

Tutorial 5: Analyzing Particles in a Flow Environment

This tutorial describes the ProAnalyst Particle Toolkit, and the steps necessary to count, size, and analyze particles in a video sequence. Note that this tutorial makes use of features found in the ProAnalyst Professional Edition, as well as the optional Particle Counting and Sizing Toolkit.

Files Needed for This Tutorial

1. *spray_bottle_droplets.avi*

Step 1 – Filtering the Image

Create a new ProAnalyst project and add the *spray_bottle_droplets.avi* video file to it. Open the Measurement Window and play through the video. You will notice that the background is not uniform towards the top of the image [Figure 1]. Likewise, the particles flowing through the video vary in terms of size and visual intensity. In order to accurately analyze this video sequence, it will be necessary to isolate the desired particles in each frame.

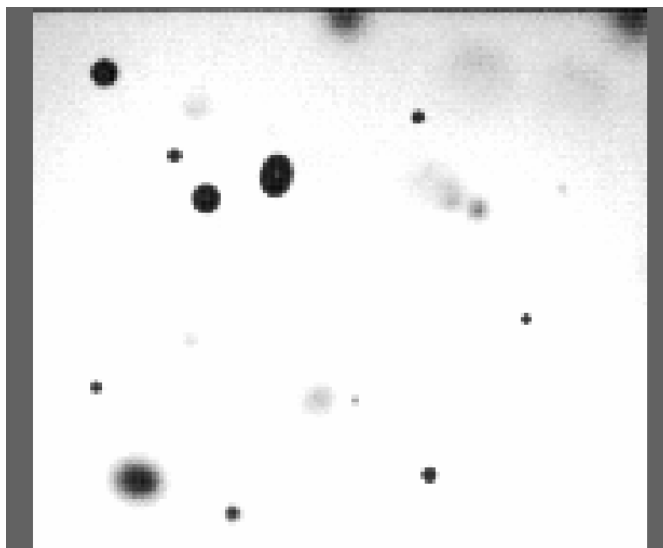



Figure 1

To isolate the desired particles, a series of image processing filters will be applied to the video image. In this example, only the clear, in-focus particles in the video frame are of any interest. Accurately tracking these desired particles will require the elimination of pixel noise

in the image, as well as undesired particles that may be present in any given frame of the video. Refer to the *ProAnalyst User Guide* for more detailed technical descriptions of the filters used in this tutorial.

To begin, open the **Image Filtering** control panel by clicking the  icon. Click the **Add** button to launch the filter selection window. Expand the **LUT** list, and select the **Reverse** filter. Click the **OK** button to add the filter to your project.

A **Reverse** filter inverts the pixel color values in every frame of a video, effectively creating a “negative” version of the video [Figure 2]. The rationale for using this filter is that it will be far easier to isolate and track bright particles on a dark background than vice versa. Likewise, it will be necessary to filter out the background noise present in the upper part of the video image. Applying the **Reverse** filter simplifies this task considerably.

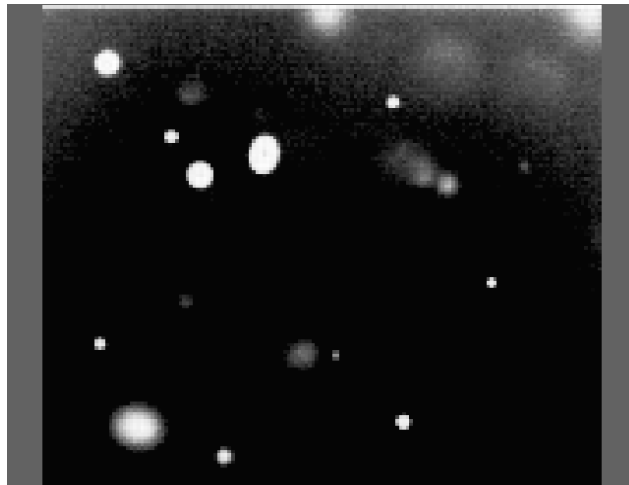



Figure 2

After the application of the **Reverse** filter, isolating the particles and filtering out the background noise can be accomplished by applying a **Common → Threshold (Binary)** filter. This operation creates a black and white version of an image by setting each pixel with a color greater than a certain value (the “threshold” value) to white, while any pixels with a color less than the threshold value are set to black. The threshold values used by this filter may be modified through the Filter Settings window [Figure 3]. This window can be accessed by clicking the  icon next to the threshold item in the filter list.

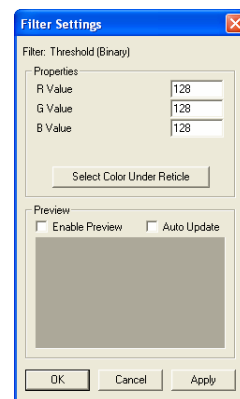


Figure 3


By applying the **Threshold** filter after the **Reverse** filter, the situation is such that the particles of interest remain visible, while any background noise is eliminated [Figure 4].



Figure 4

As effective as the **Threshold** filter is in differentiating the particles of interest from the background, it did leave an artifact in the form of a white line across the top of the video image. Fortunately, another filter is available to eliminate this artifact.

Click the **Add** button, and select the **Common → Zero Border** filter. This filter creates a black border around the edge of an image. The number of pixels along the top, bottom, left, and right of the image that are affected by the filter can be modified in the same way as the threshold value.

Click the  icon to open the Filter Settings dialog box. The default settings for **Zero Border** generate a border five pixels wide. As the white line is only present across the top of the image, change the “Left Border”, “Right Border”, and “Bottom Border” values to 0. The strip at the top of the image is only one pixel wide, therefore the “Top Border” value can be set to 1 [Figure 5]. Click the **Apply** button, followed by the **OK** button.

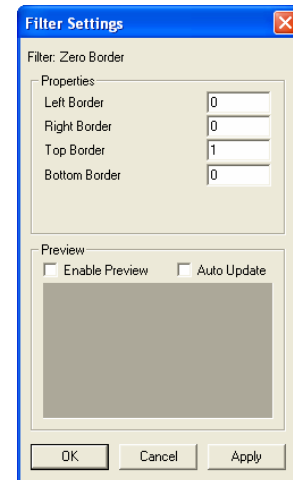


Figure 5

With the application of the **Zero Border** filter [Figure 6], the video is now ready for automatic particle analysis.

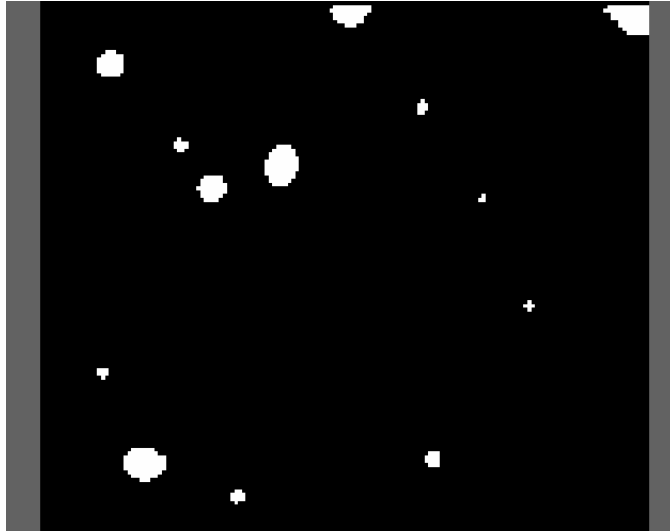



Figure 6

Step 2 – Tracking and Computing Statistics of Particle Flow

Open the Particle Tracking control panel by clicking the  icon, and then click the **Enable** button at the top of the palette to activate it. The Particle Tracking control panel contains several default parameters that can be configured based on specific analysis requirements.

Set the “Minimum Size” field to 5, the “Maximum Angle” field to 180, and the “Maximum Eccen.” field to 200. Click the Label field, located in the **Display** frame [Figure 7], to uncheck it.

When the parameters have been set, press the **Track Forward** button.

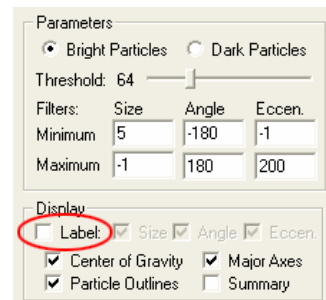


Figure 7

As the video advances frame by frame, ProAnalyst will outline any particles that fall within its defined parameters [Figure 8].

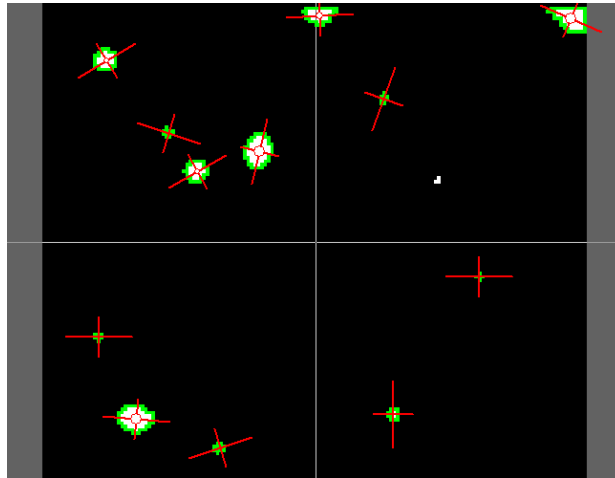


Figure 8

Click the **Raw** video tab to see the results of the particle track on the unprocessed video image [Figure 9].

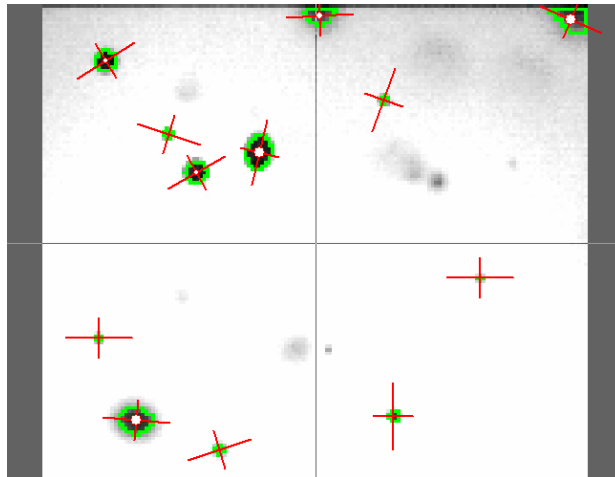



Figure 9

Step 3 – Data Filtering

Data filters are accessible via a popup dialog located within the **Graph Configuration** control panel. A listing of Graph Lines is located within the center frame of the **Graph Configuration** panel. The columns within each listing display the item number, item description, line color, visibility, and filter settings. The filtering options for a given line can be accessed by clicking on the filter settings icon in the last column.

Open the **Graph Configuration** control panel by clicking the  icon. Click the **Add** button to create a new graph object, and then select **Particle** → **Num Particles** from the Items to Add window [Figure 10]. Click the **OK** button to confirm your selection. The graph pane [Figure 11] will immediately update to display the new plot line.

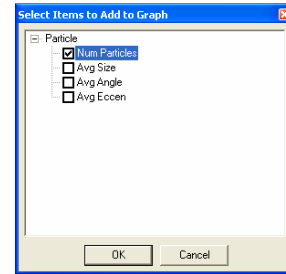


Figure 4

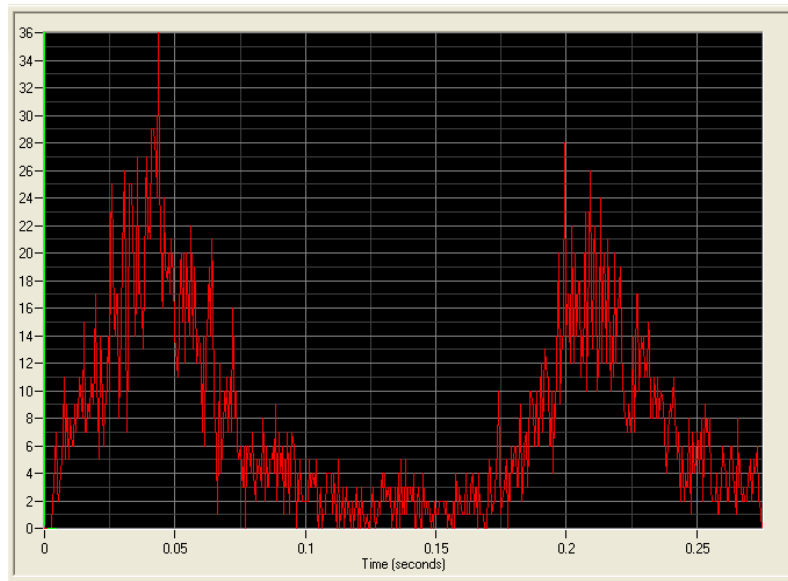



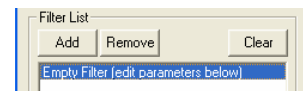
Figure 11

To apply a data filter to the plot line, select the “Particle – Num Particles” channel in the Graph Lines list. Click the  icon to open the Graph Line Filtering window.

Click the checkbox labeled Enable Filtering.

Click the **Add** button to create a new data filter.

Select the “Empty Filter” item [Figure 12].



In the Properties frame, located beneath the Filter List, is a dropdown menu titled **Type**. Open the menu and select **Low Pass** from the list [Figure 13].

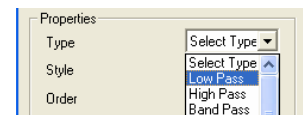


Figure 13

Selecting a Filter type will activate the next dropdown menu, **Style**. From this menu select a Butterworth filter [Figure 14].

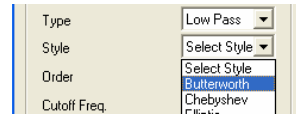


Figure 14

Click the **Apply** button, followed by the **Close** button. Your graph will automatically update to show the results of the filter on your plotted data [Figure 15].

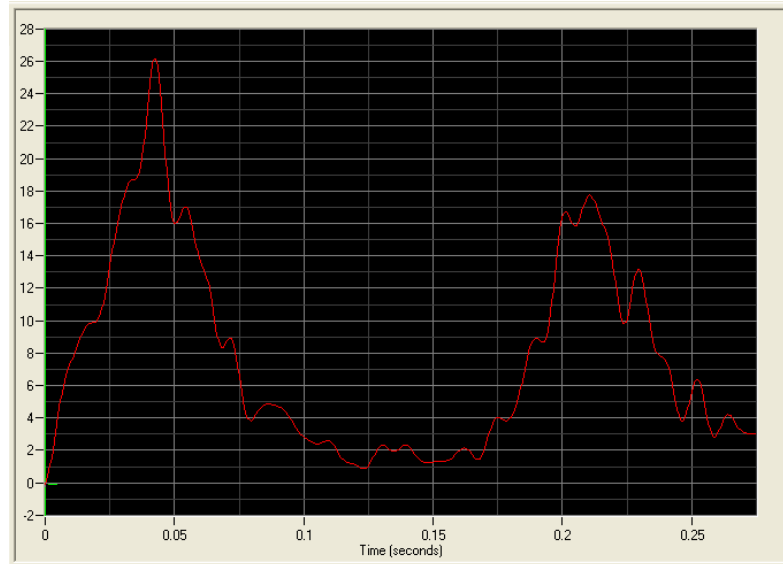


Figure 15

It is possible to compare the filtered graph with an unfiltered version of the same data. To do this, create a new channel by clicking the **Add** button.

Repeat the previous steps to select and display another plot of the number of particles in each frame.

As graph lines are drawn on the screen in the order in which they are added, it is very likely that the filtered plot will be almost completely obscured by the unfiltered plot [Figure 16]. This can be remedied by removing the filter from Channel 1, and applying it to Channel 2 instead.

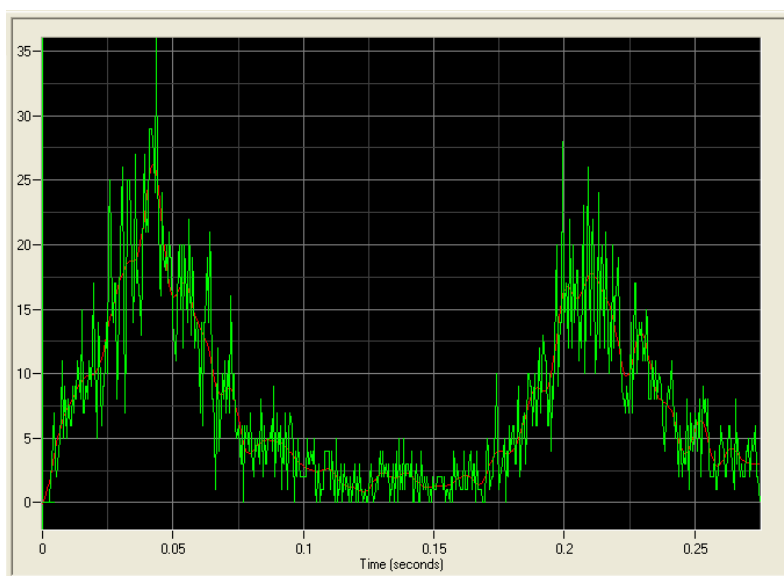


Figure 16

Open the Graph Line Filtering window for Channel 1, and then uncheck the Enable Filtering box. Click the **Apply** and **Close** buttons to confirm this action.

Open the Graph Line Filtering window for Channel 2, and repeat the previous steps to apply a Butterworth filter to the plot line. With the filter applied, you should see a visually less confusing plot of both the raw and filtered graph data [Figure 17].

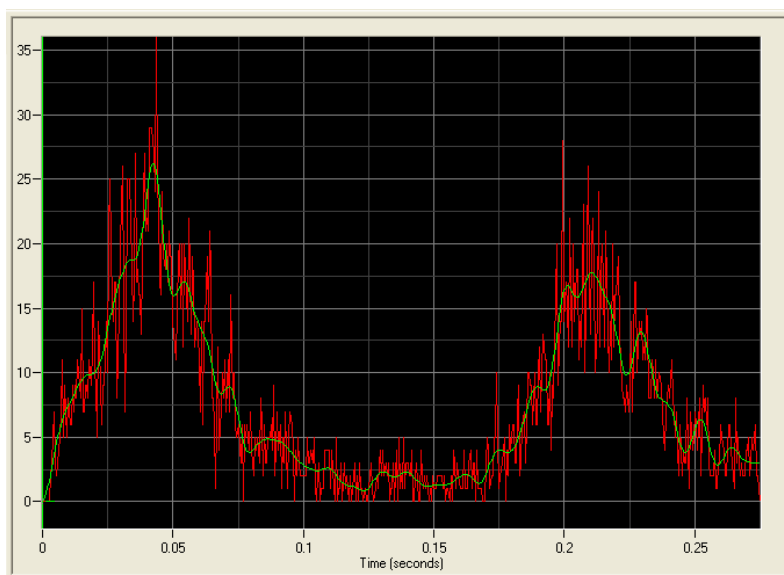


Figure 17

Tutorial 6: Analyzing Size and Shape Changes in Blob Objects

This tutorial describes the ProAnalyst Contour Tracking Toolkit's ability to identify, track, and analyze objects whose shape changes over time. In this example, the surface area, shape, and location of a water drop are analyzed as it falls through the video frame. This method can be used to analyze airbags, blobs, pills, coatings, particles, or other variably shaped objects. Note that this tutorial makes use of features found in the ProAnalyst Professional Edition, as well as the optional Contour Tracking Toolkit.

Files Needed for This Tutorial

1. *testmagdrop1.avi*

Step 1 – Image Filtering

Create a new ProAnalyst Project and add the *testmagdrop1.avi* movie. When you open the Measurement Window, you will notice that the water drop is not visually distinct from the spout [Figure 1]. The first task is to apply a series of image processing filters with the goal of isolating the water drop from the rest of the image.

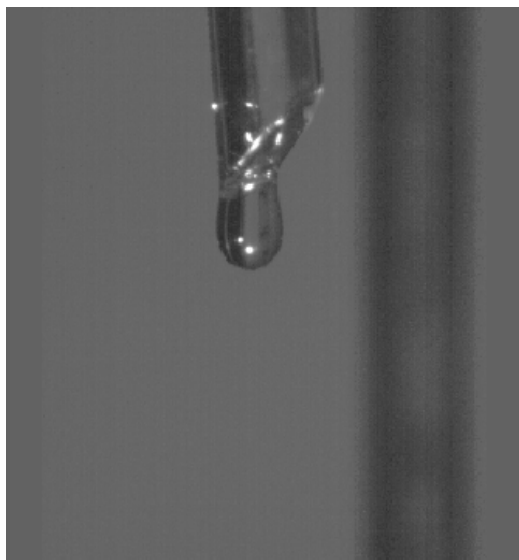



Figure 1

Open the **Image Processing** control panel by clicking the  icon. Image filters are calculated in the order they are applied. As you proceed through this tutorial, feel free to experiment with an alternate sequence of image filters to determine their effect on the overall goal of isolating the water drop.

Discriminating the Spout and Water Drop

The first step in the enhancement of the outline of the spout and water drop from the background will be the application of an edge detector.

Click the **Add** button in the **Image Filter List** frame to launch the **Select Filters to Add** dialog. Expand the **Convolve** list and check the box next to **Edge Detector (5x5 Laplacian High Pass)** [Figure 2]. Press the **OK** button to confirm your selection and apply the filter to the image.

The **Laplacian High Pass** filter is able to accurately highlight the edges of the spout and water drop. The tradeoff, however, is the filter tends to generate a large amount of pixel noise in the image [Figure 3].

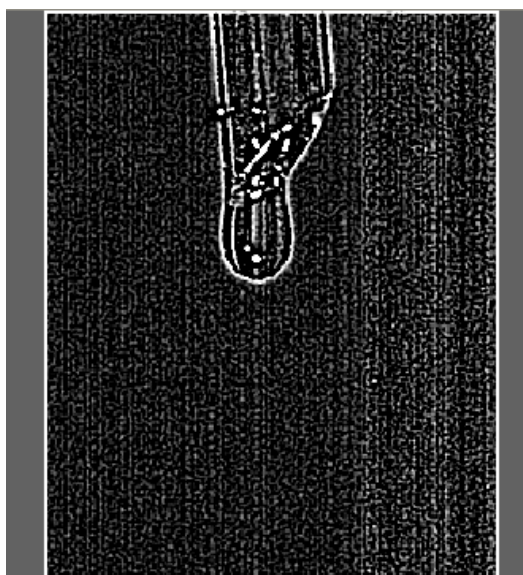
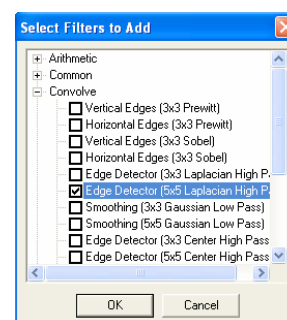



Figure 3

To offset the background noise generated by the Laplace filter, apply a **Convolve: Smoothing (5x5 Gaussian Low Pass)** filter. There will still be some noise present in the frame [Figure 4], but from a computational standpoint, it will be easier to minimize.



Figure 4

Apply a **Common: Despeckle** filter. Unlike the **Edge Detection** and **Smoothing** filters, the **Despeckle** filter allows you to adjust the properties of the filter, thereby altering the effect of it on the image.

Click on the  icon in the **Image Filter List** to launch the **Filter Settings** dialog box [Figure 5].

Change the **Minimum # Pixels** value to “24”. The **Threshold** value should be set to “64”. The **Connectivity** value can remain at “8”.

Press the **Apply** button, followed by the **Close** button to confirm your changes.

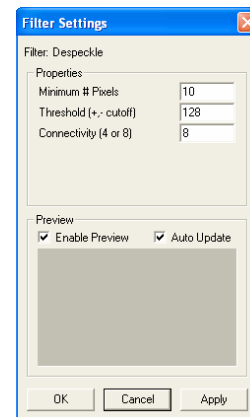


Figure 5

Your image should now appear as an outline of the spout and water drop against an otherwise black background [Figure 6]. The final step will be the elimination of the spout, effectively isolating the water drop in the image.

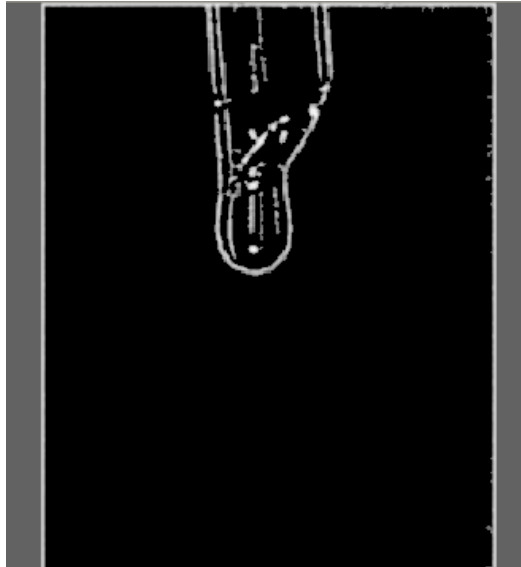


Figure 6

Isolating the Water Drop

You will notice that the filters thus far applied to the image have produced an artificial border around the edge of the image. This can be eliminated by applying the **Zero Border** filter, found under the **Common** list. This filter provides an unforeseen advantage, in that with the setting of one parameter, the filter can also eliminate the spout from the image.

The **Zero Border** settings dialog [Figure 7] allows you to specify the number of pixels along each edge affected by the filter. This provides us with an easy method of eliminating the water spout.

Click on the  icon in the **Image Filter List** to launch the **Filter Settings** dialog box for the **Zero Border** filter.

Change the values of the **Left**, **Right**, and **Bottom** borders to “3”.

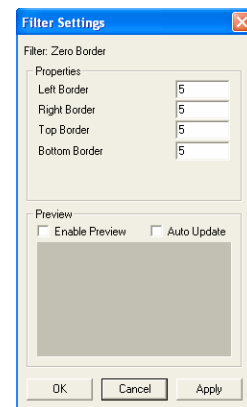


Figure 7

By setting the size of the **Top** border to a large enough value, it is possible to eliminate the water spout from the image [Figure 8]. A value of “100” should be sufficient.



Figure 8

With the outline of the water drop isolated, it is now a matter of filling the outline so that the automatic tracking functions in ProAnalyst identify it as one object. The **Close Connection** filter, located under the **Morphology** list, is capable of connecting neighboring regions of pixels by performing a series of dilation and erosion operations on the image.

Apply the **Close Connection** filter and open its **Filter Settings** dialog box [Figure 9].

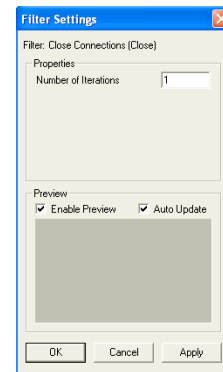


Figure 9

Adjust the **Number of Iterations** value until the water drop has been filled and resembles one solid region [Figure 10].

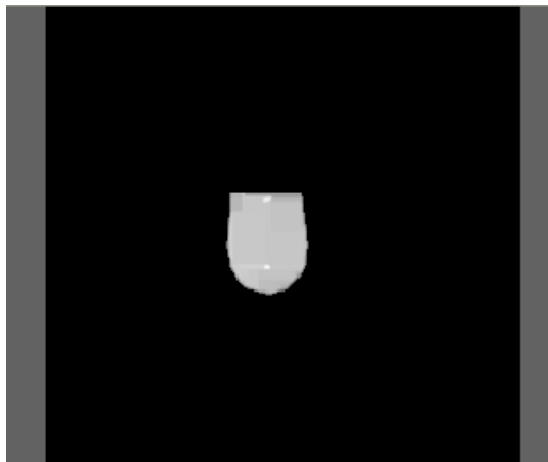


Figure 10

The final step in filtering the water drop for analysis is the application of an image threshold filter. The threshold will set any pixels above a certain value to 255 (white). Pixels below that value will be set to zero (black).


Apply the **Threshold (Binary)** filter from the **Common** filter list to the image. The default filter settings will be acceptable. The final result will be a series of black-and-white frames displaying the shape and motion of the water drop [Figure 11].




Figure 11

Step 2 – Contour Tracking

With the water drop isolated from the rest of the image, it is now possible to apply an automatic contour track to determine the drop's shape, location, and surface area.

Open the Contour Tracking palette [Figure 12] by clicking the  icon, and then click the **Enable** button to activate the control panel.

The Contour Tracking control panel allows you to track the contour of an object based on a number of parameters, including object size, intensity, and last position. Click the  icon to open the Contour 1 Settings window [Figure 13].

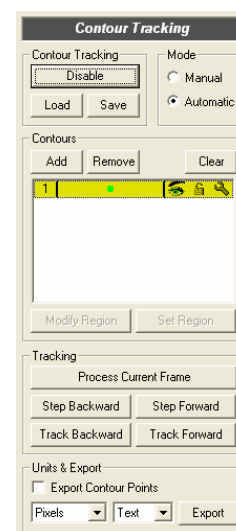


Figure 12

For this example, two parameters will need to be changed. First, select “Largest” from the **Selection Type** dropdown menu. Second, set the **Minimum Size** parameter from “-1” to “300”. Leave the other parameters at their default values. Click the **Apply** button, followed by the **Close** button to confirm the parameter changes.

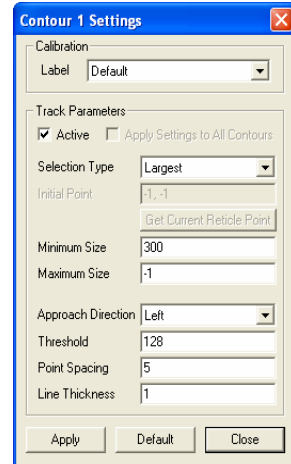


Figure 53

To begin tracking the contour of the water drop, press the **Process Current Frame** button. You will see the water drop perfectly outlined in the frame [Figure 14].

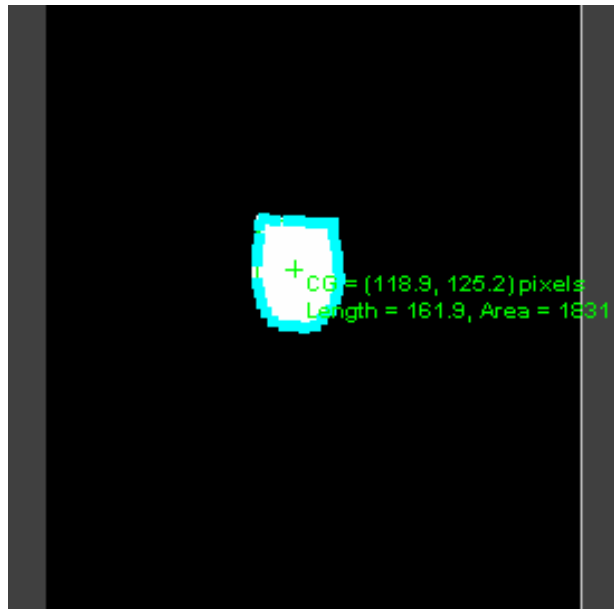


Figure 14

Press the **Track Forward** button. ProAnalyst will now automatically track the water drop until it moves off the bottom of the frame.

You will notice that some frames contain particles that were not detected or tracked by ProAnalyst [Figure 15]. This is due to the **Minimum Size** parameter you specified earlier.

Had that value been left at its default, the next largest object in the frame would have been tracked after the main drop was no longer visible.

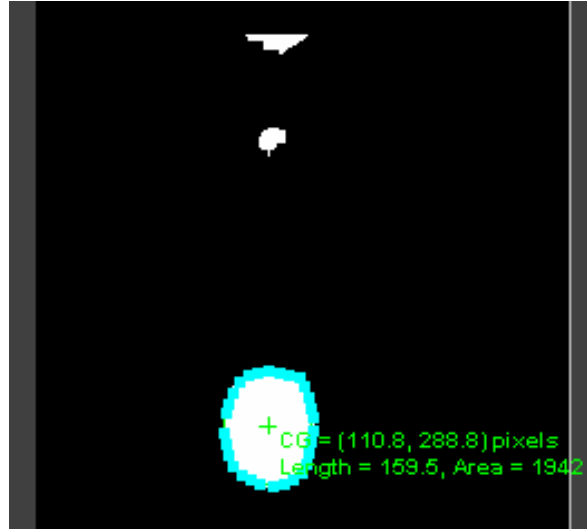


Figure 15

Tutorial 7: Human Biomechanical Analysis: A Rugby Kicker

The feature tracking capabilities available in ProAnalyst make it a powerful tool for biomechanical analysis. In a lab setting, motion tracking markers make the process of capturing an athlete's motion extremely simple and efficient. Combined with ProAnalyst's automatic feature tracking, analysis results can be obtained quickly and efficiently, and may be exported to a variety of output formats. Stick figure rendering provides easy access to joint angle measurements.

Files Needed for This Tutorial

1. *Kick01.avi*

Step 1 - Tracking the Hip Marker

A combination of automatic and manual tracking will be used to track the positions of four markers attached to the rugby player's hip, knee, ankle, and foot [Figure 1]. While not required by ProAnalyst, in many cases, the presence of these markers simplifies the motion tracking process considerably.

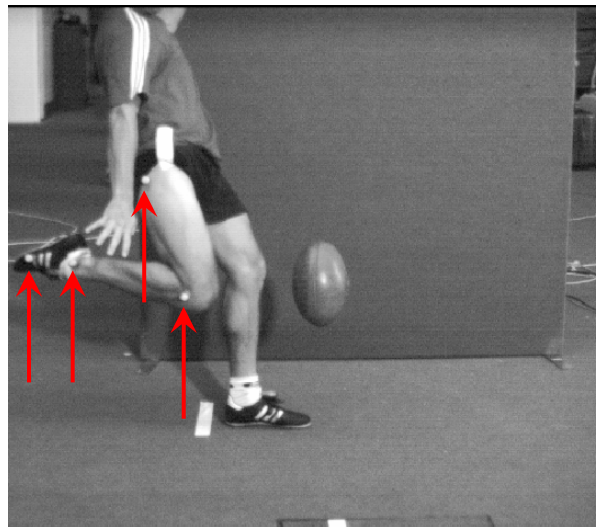



Figure 1

Create a new project and add the *Kick01.avi* video. Open the Measurement Window. Note that the video has been recalibrated so that the first frame is numbered frame -47. Click the  button to advance the video to frame 0.

Open the Feature Tracking control panel and click the **Enable** button. Define and set a region around the marker located on the player's hip [Figure 2]. Keep the region as close to the size of the marker as possible to ensure accurate tracking results.

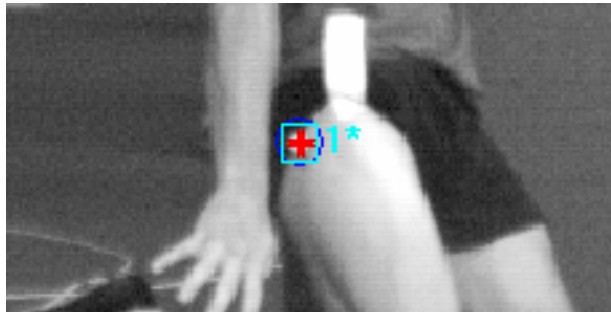



Figure 2

Click the  icon to open the Track Settings window and type "Hip" in the Feature Label text field. Click the **Apply** button, followed by the **Close** button to confirm the new label.

Click the **Track Forward** button.

The hip marker should track accurately the first time through, as shown in Figure 3. If it does not, you may redefine the feature and restart the tracking from the current frame.

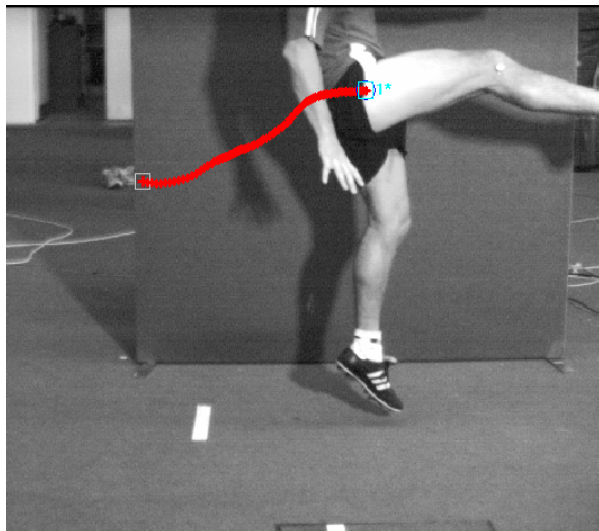



Figure 3

When you are satisfied with the accuracy of the feature track, click the  icon associated with the feature.

Step 2 – Tracking the Knee Marker

The knee marker changes in appearance over the course of the video sequence. We will process the image to enhance the appearance of the marker, and then perform two auto-tracks to ensure the most accurate results.

Advance the video to frame 40 and click the **Add** button to create a new feature. Open the Image Processing control panel and click the **Display B&W** button. Then, adjust the **B&W Image Settings** sliders to enhance the appearance of the knee marker relative to the skin surrounding it [Figure 4].



Figure 4

Define and set a region around the knee marker [Figure 5]. The size of the region is not as critical to a successful track as it was for the hip marker.

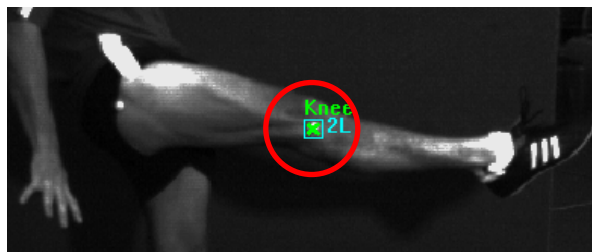



Figure 5

Click the  icon to open the Track Settings window and type “Knee” in the Feature Label text field. Next, check the **Enable** button in the Feature Rotation frame. Click the **Apply** button followed by the **Close** button to set your changes.

Click the **Track Forward** button. After ProAnalyst completes the forward track, go back to frame 40 of the video and click the **Track Backward** button. When the video moves past frame 0 and into the negative frames, click **Abort Tracking**.

To delete these extra points, set the video to frame -1. Right click on the video and select **Feature Tracking** → **Clear Features** → **Current Feature, Current Frame Backward** from the pop-up menu [Figure 6].

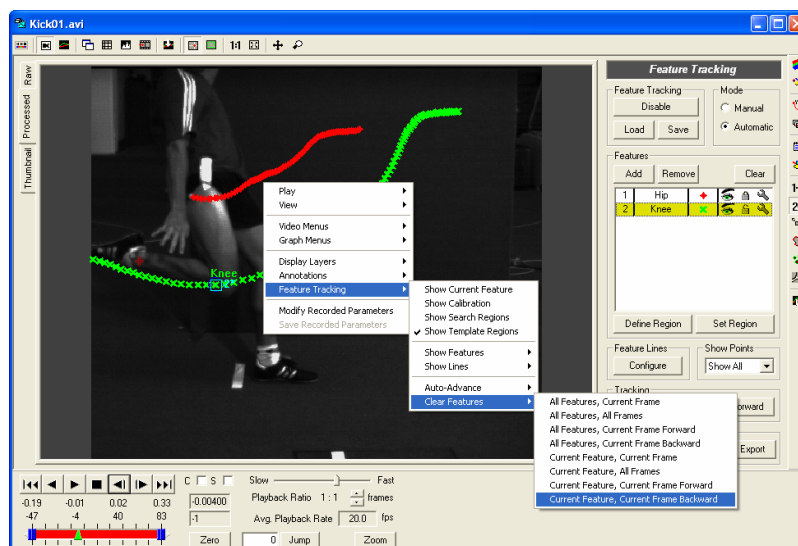


Figure 6

When the tracking has been completed successfully, click the  icon to lock the feature.

Step 3 – Tracking the Ankle and Foot Markers

The foot and ankle markers present a number of difficulties that make accurate auto-tracking extremely difficult to achieve. The ankle marker is positioned on a white sock, and is therefore not visually distinct enough for auto-tracking to pick up. The foot marker, on the other hand, actually separates from the foot in frames 17 – 19, making any attempt at auto-tracking a futile endeavor. In these cases, the features of interest will have to be tracked manually.

Go to frame 0 of the video and click the **Add** button to add a new feature. Label this feature “Ankle”. Set the feature tracking palette to **Manual** mode.

Left click on the ankle marker to position the reticle on that spot [Figure 7].

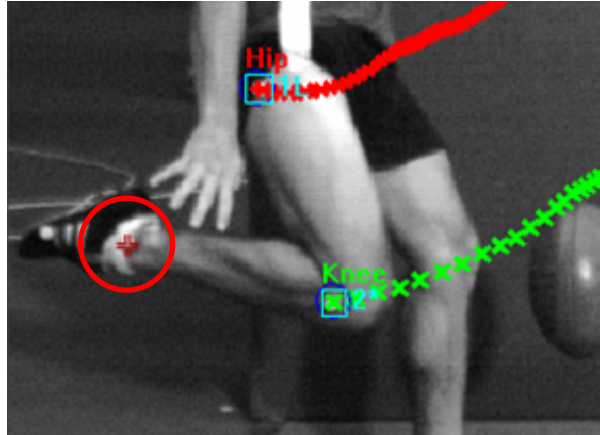


Figure 7

Click the **Set Point** button to set a tracking point. The video will automatically advance to the next frame. Points can also be set manually by holding down the **Ctrl** key and right clicking the mouse. When a large number of points have to be set, this method is more convenient than repeatedly clicking the **Set Point** button.

Continue manually setting points until the ankle marker disappears on frame 78 [Figure 8]. Adjust the Image Processing settings as necessary to most easily visualize the marker.

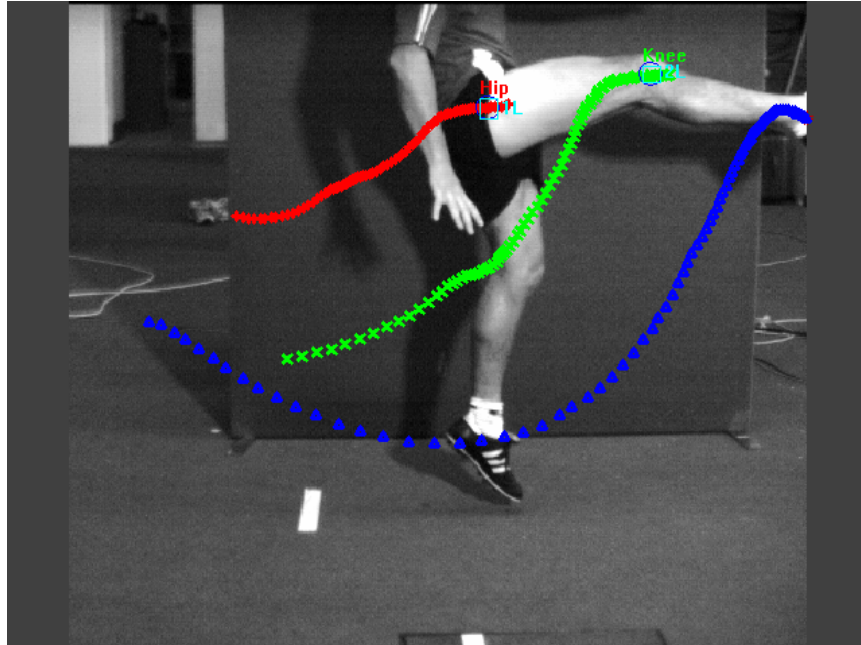


Figure 8

Add a new feature and repeat the previous steps to manually track the kicker's foot until it leaves the video in frame 53 [Figure 9]. An easy way to do this would be to use the foot marker as a guide until it separates from the foot in frame 18. The marker's former position can be easily estimated for frames 19 – 53.

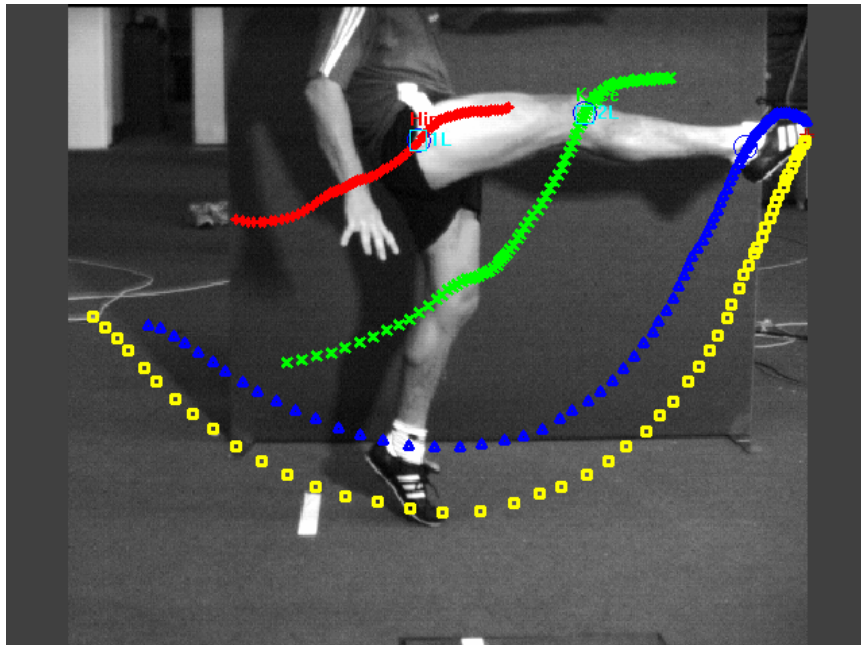



Figure 9

Step 4 – Creating a Stick Figure

Click the **Configure** button to open the Line Configuration window [Figure 10].

First, click the **Add Line** button to create a new feature line. Then select **Feature 1** in the **Possible Points** frame, and click the  button to move it into the **Sequence of Points in Line** frame. Follow this by adding **Feature 2** and **Feature 3** to the sequence, as well.

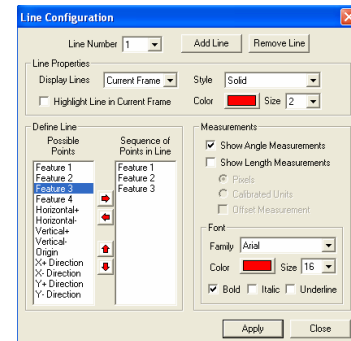



Figure 10

Check the box labeled **Show Angle Measurements**. When you click the **Apply** button, an angle measurement will be drawn between the kicker's hip, knee, and ankle.

Repeat the previous steps to add a feature line between the kicker's knee, ankle, and toe. Click the **Close** button to exit the configuration window.

With the angle lines configured and drawn, click the  icon associated with each feature to hide the tracking points. The lines extending down the kicker's leg from his hip to his toe will remain visible [Figure 11].

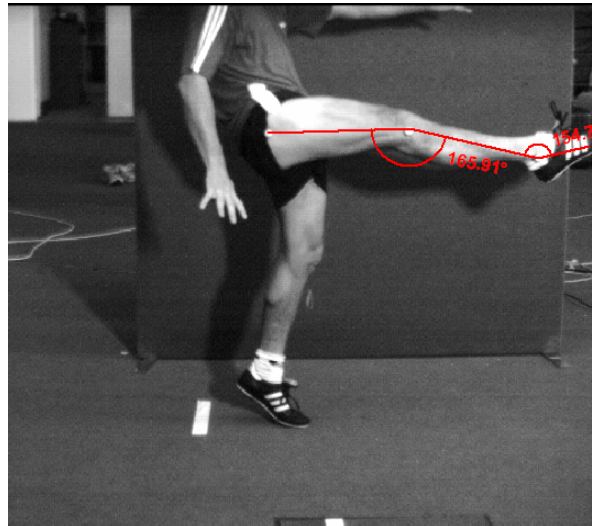


Figure 6

When the video is played back, you will see an accurate stick-figure representation of the kicker's leg overlaid on the original video image. The joint angles (represented by the angle lines) can be graphed in the same way as any other 2D feature.

Tutorial 8: Analyzing a Golf Swing

This tutorial demonstrates how multiple analysis modules and tools can be applied to the same video file. In this example, a close-up shot of a golf swing will be analyzed using both the **2D Feature Tracking** and the **2D Line Tracking** toolkits. Each toolkit has its own purpose and applications, and there may be cases where one toolkit alone does not have the capabilities to perform a full and accurate analysis of a video. Fortunately, combining multiple analysis tools on a single video is no more difficult than applying them individually, as this demonstration will show.


Files Needed for This Tutorial

1. *golfswing.avi*

Step 1 – Image Calibration

Launch ProAnalyst and create a new project. Add the *golfswing.avi* video file to the project and open the **Measurement Window**.

One goal of this analysis is the extraction of the speed of the golf ball after it is struck by the club. Acquiring an accurate measure of this value will require that the video be calibrated to real-world units, and that the origin be placed appropriately.

Click the  icon to open the **Image Calibration** control panel. To establish a pixel conversion value, we will define two points in the image and define the distance between them as a real-world value. The golf ball is a perfect calibration object, as its diameter is a known value, and two points can be easily set on either side of it [Figure 1].

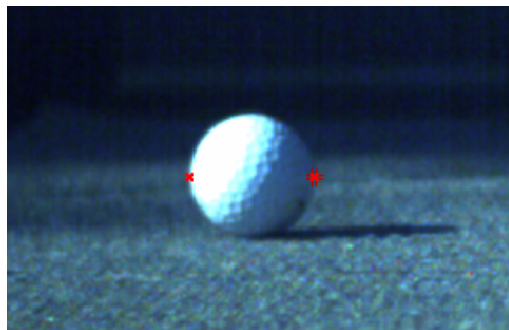



Figure 1

Click the  icon associated with **Calibration 1** to open the **Calibration 1 Settings** window. Position the reticle on one side of the golf ball and press the **Set Point #1** button. Reposition the reticle on the other side of the golf ball and press the **Set Point #2** button [Figure 2].

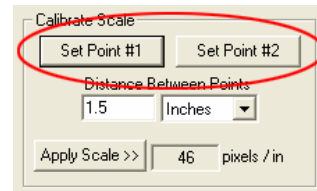


Figure 2

After the two points are set, it will be necessary to input a calibration value for the distance between the points. A regulation golf ball is no less than 1.68 inches (4.27 centimeters) in diameter. Input this value into the Distance Between Points text box, and make sure that “Inches” (or centimeters) is the active scale unit [Figure 3]. Click the **Apply Scale >>** button to set the new scale factor.

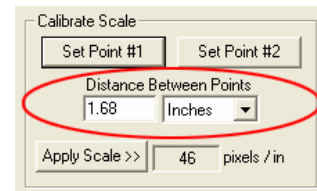


Figure 3

With the scale calibration established, all that remains is to set a new origin point. As distance and speed measurements for the golf ball will be calculated relative to this position, it makes sense to set the origin at the center of the ball.

Click in the center of the golf ball to position the reticle at that point. Press the **Set Origin** button to move the axis lines to the new origin. If the axis lines are not aligned correctly (X pointing to the right, Y pointing up), click the appropriate box in the Quick Set frame to reorient them [Figure 4]. When the origin has been positioned and oriented correctly [Figure 5], click the **Apply Origin and Tilt >>** button.

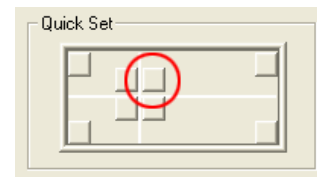


Figure 4

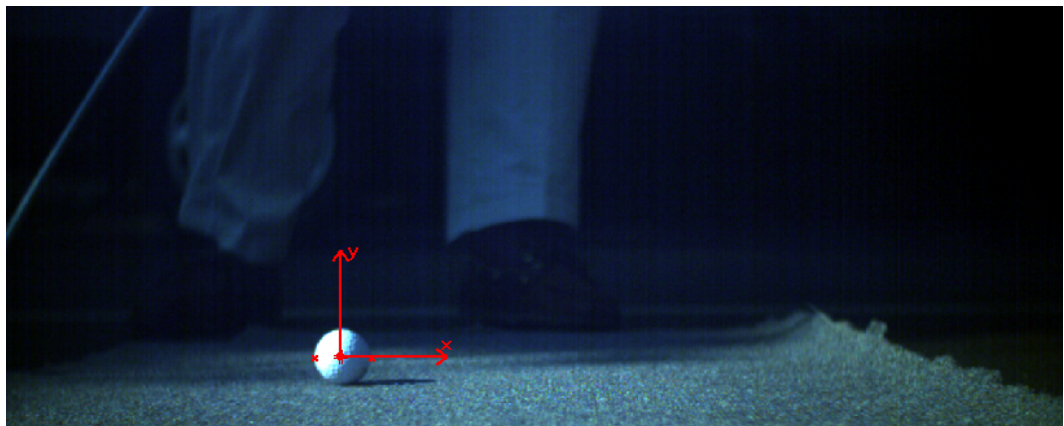


Figure 5

Step 2 – Tracking the Speed of the Golf Club

As a golf club is an object with no distinct features suitable for template tracking, we will use the **1D Line Tracking** tool to calculate the speed at which the club is swung. Different positions along the shaft of the golf club will be moving at different relative rates, so a series of six lines will be used to track the speed of the club along multiple paths.

Begin by clicking the **1D** icon to open the **Line Tracking** control panel, and then click the **Enable** button to activate the panel. It will not be necessary to calculate a best-fit circle for this analysis, therefore that option can be disabled by unchecking the Circle Fit box in the Options frame [Figure 6].

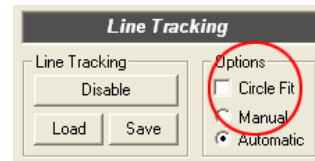


Figure 6

When the **Line Tracking** control panel was enabled, one line was automatically added to the project. This line must be repositioned so that it covers the entire range of motion of the golf club. Click the **Modify Line** button to activate the line editing mode. You can change the position and length of your line by clicking and holding down the mouse over one of the line end-points, and then dragging that end point to a new position on the screen [Figure 7]. The **Modify Line** button can be clicked again to reset the line, allowing you to restart the line editing process if necessary.

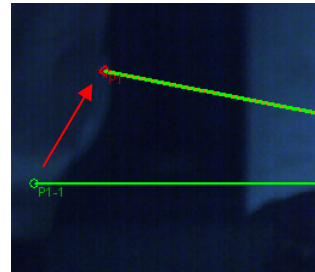


Figure 7

With line editing mode active, click and drag the mouse across the video image from a starting point near the top-left, to an end point near the top-right of the frame [Figure 8]. When you are satisfied with the positioning of the line, click the **Set Line** button to apply the changes.

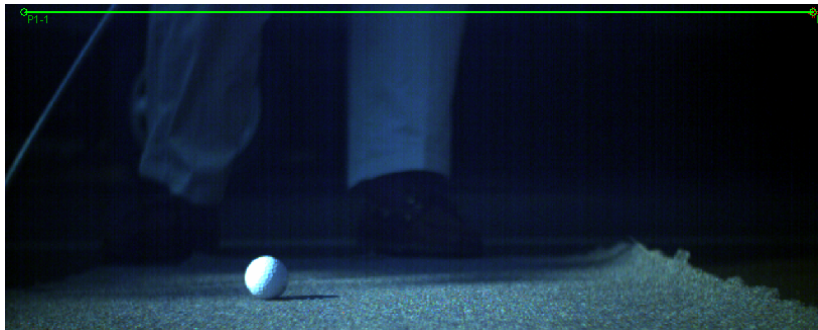


Figure 8

To create an accurate picture of the speed of the golf club, multiple tracking lines will be needed. New lines can be created by clicking the **Add** button, and modified by clicking the **Modify Line** button as described above. Add and position 5 more lines below the existing tracking line [Figure 9]. For the moment, the lines will remain at their default track settings.

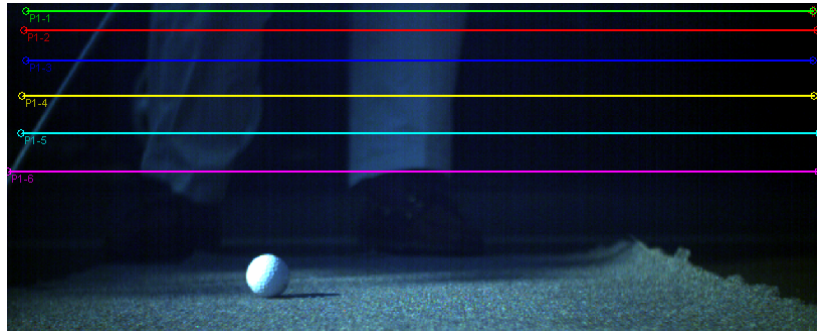



Figure 9

With the six lines positioned down the length of the golf club, you can begin the line tracking process by clicking the **Track Forward** button. As the video advances, it will be obvious that the default settings for the line tracking are not adequate to accurately track the motion of the golf club through each frame. Click the  icon associated with Line 1 [Figure 10] to open the Line Settings window.

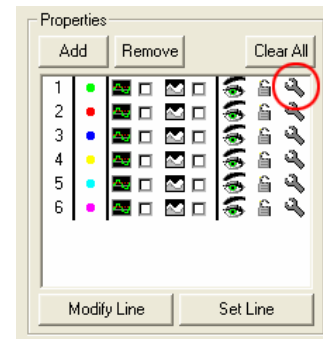


Figure 10

The Line Settings window [Figure 11] provides access to all of the parameters involved in line tracking. From the Search Type dropdown menu, select “Peak Derivative”. This option will return a single point for each frame of video, representing the point of highest derivative along the line.

Each line in the project has its own associated Line Settings, the parameters of which can be modified individually. If the search parameters are identical for every line in a project, it is possible to apply any changes you make to every line simultaneously. To do this, check the “Apply Settings to All Lines” box in the Line Settings window.

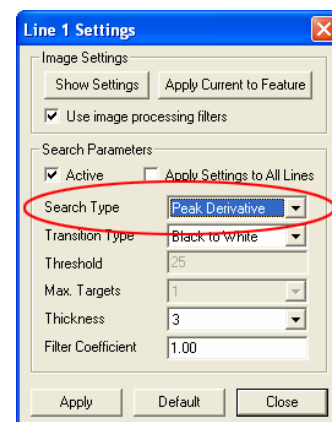



Figure 11

Click the **Apply** button, followed by the **Close** button to apply the new search type to the line. If the **Close** button is pressed without the **Apply** button having been clicked, the window will close but the changed settings will not take effect.

With the new search parameters applied to the lines, press the  button to go to frame 0 of the video. Click the **Track Forward** button to restart the tracking. As the video advances this time, you should see the tracking points on each line accurately follow the motion of the golf club through the frame [Figure 12].

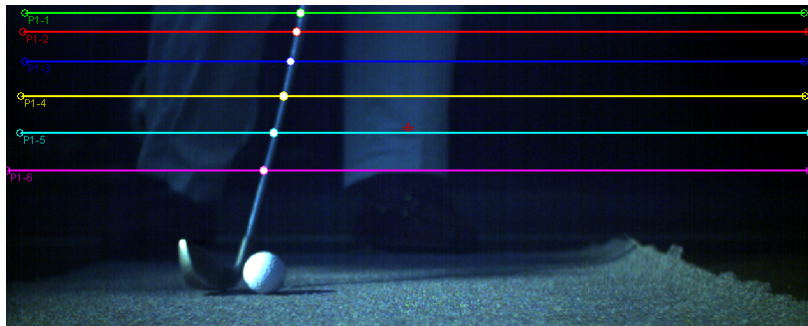


Figure 12

Step 3 – Tracking the Motion of the Golf Ball

Unlike the featureless nature of the golf club, the golf ball is an ideal object for ProAnalyst's **2D Feature Tracking** capabilities. Open the **Feature Tracking** control panel by clicking the **2D** icon on the right side of the **Measurement Window**, and then click the **Enable** button to activate the control panel. Make sure the video is currently on frame 0.

When the **Feature Tracking** control panel was activated, one feature was automatically added to the Features box [Figure 13]. Press the **Define Region** button, and then in the video frame click and drag a box around the golf ball. The size and position of the box will impact the accuracy of the automatic tracking algorithm, so it is recommended that you keep the box as close as possible to the size of the golf ball. If necessary, you may click the **Define Region** button again to reset the region and redraw the box. When you are satisfied with the size and placement of the box, click the **Set Region** button to highlight the golf ball [Figure 14].

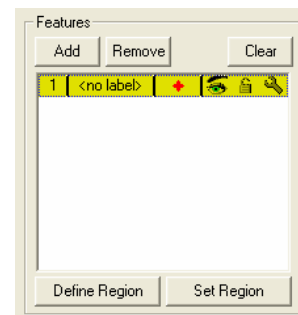


Figure 13

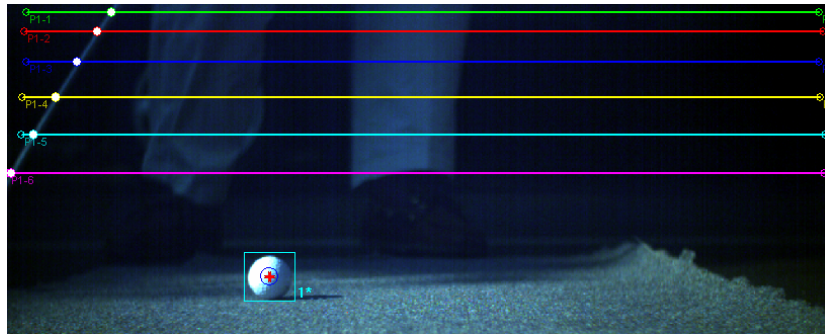



Figure 14

As with the 1D Line Tracking, each feature you track has its own set of customizable parameters. Click the  icon to open the Feature 1 Track Settings window [Figure 15]. You may type a label for the golf ball in the Feature Label text field.

Check the boxes marked “Enable X” and “Enable Y” in the Trajectory Prediction frame. These options have been selected to counteract the changing lighting conditions on the golf ball, and any potential impact that may have on the automatic tracking functions. With these options enabled, ProAnalyst will predict where the most likely position of the golf ball is with respect to its motion in previous frames of the video. It will then begin its search for an object match in that area.

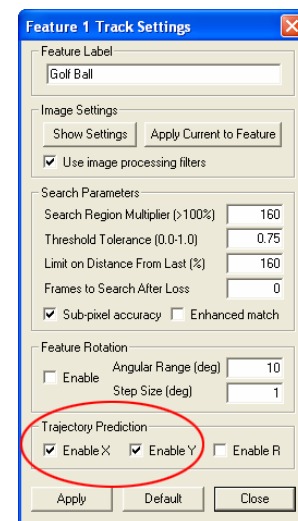


Figure 15

Click the **Apply** button, followed by the **Close** button to confirm the new tracking parameters.

With the search parameters in place, click the **Track Forward** button to begin auto-tracking the golf ball. ProAnalyst will track the ball until it leaves the video in frame 63 [Figure 16].

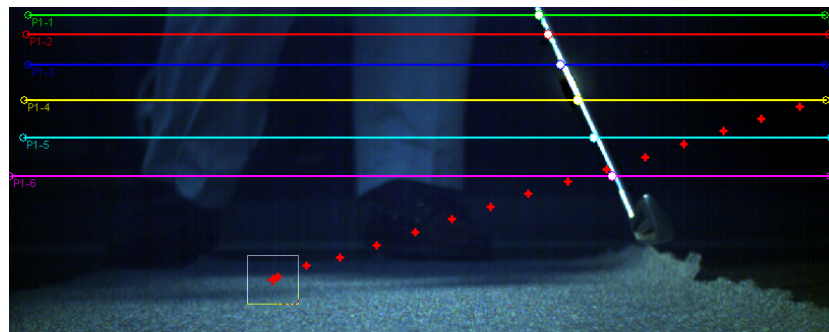



Figure 16

Step 4 – Graphing and Filtering the Tracking Results

Now that the golf club and golf ball have been successfully tracked, the results of the tracks can be graphed and analyzed. Open the **Graph Configuration** control panel by clicking the  icon, located at the bottom of the right-side **Measurement Window** toolbar.

Click the **Add** button to open the Select Items to Add to Graph window. You will see two items in the window, labeled 1D and 2D. Click the **+** sign next to the 1D item to expand the list of items that can be graphed. From this list, check the boxes labeled “Line 1 – Target – Speed”, “Line 2 – Target – Speed”, etc., until you have selected the speed value associated with each of the six 1D tracking lines [Figure 17]. Click the **OK** button.

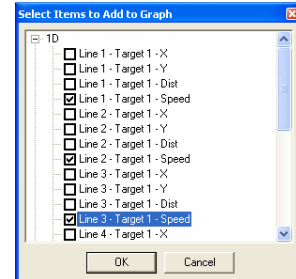


Figure 17

Note that the Y-axis values are currently being displayed in pixel values [Figure 18], not the real-world units that were specified earlier.

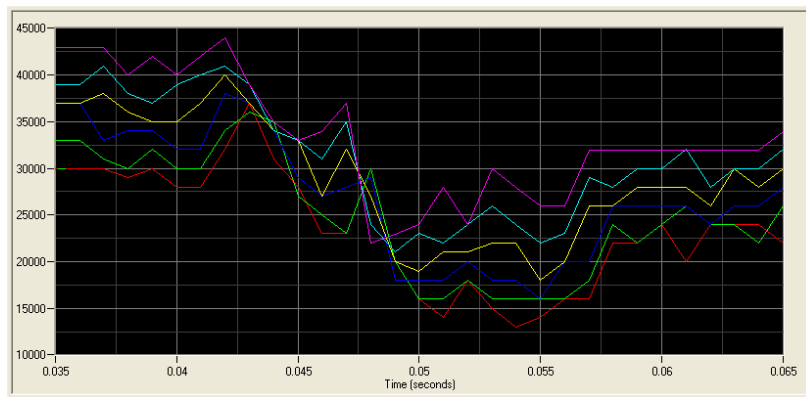


Figure 18

To change the calibration of the Y-axis, you must first reopen the **Line Tracking** control panel. At the bottom of the panel is a frame labeled **Units & Export**. Select “Feet” (or “Meters”) from the dropdown menu [Figure 19], and you will see the graph automatically adjust to display your results in calibrated units.

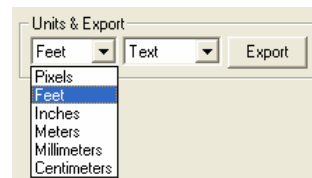


Figure 19

To arrive at a clearer overall picture of the speed of the golf club, a series of noise reduction filters can be applied to the graph lines. To apply a data filter to a graph channel, click the **Filter Settings** icon [Figure 20] to open the Filtering window associated with a particular graph line [Figure 21].

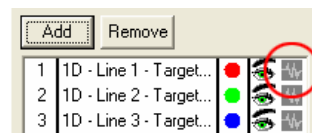


Figure 20

Begin by checking the Enable Filtering box to activate the Filter List panel. Click the **Add** button to create a new filter in the list. Clicking on the newly added filter will select it, as well as activate the Type menu in the Properties frame.

From the Type menu, select “Low Pass”. This will activate the next menu, Style. From the Style menu, select “Butterworth”. The Order and Cutoff Freq. text boxes will now become active, though the default values will be sufficient for this example.

Click the **Apply** button, followed by the **OK** button to apply the new filter to the graph line. Clicking the **Cancel** button will close the Line Filtering window without applying any changes.

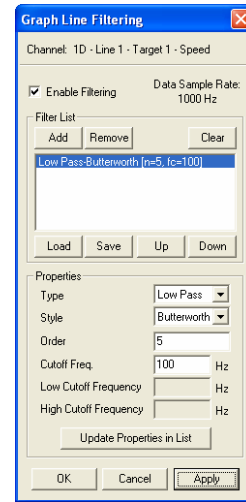


Figure 21

Repeat the preceding steps to apply identical filter settings to the other five graph lines. The graph window will automatically update as each filter is applied [Figure 22].

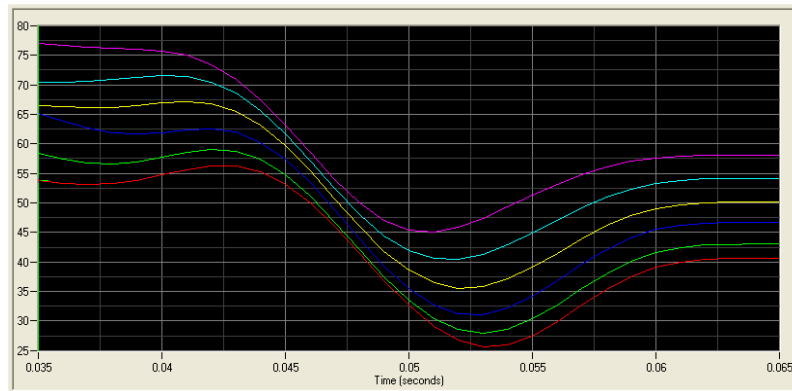


Figure 22

The steps required to plot the speed of the golf ball are virtually identical to those of plotting the speed of the golf club. Begin by reopening the **Feature Tracking** control panel and selecting “Feet” (or “Meters”) from the Units menu [Figure 23].

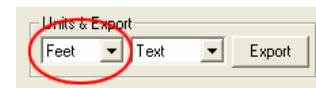


Figure 23

Click the **Add** button, located in the Graph Lines frame, to open the Select Items to Add to Graph window. Expand the **2D** item list by clicking on the + sign. Check the “Feature 1 (Golf Ball) – Speed” box [Figure 24] in the expanded item list. Click the **OK** button to add the new line to the plot.

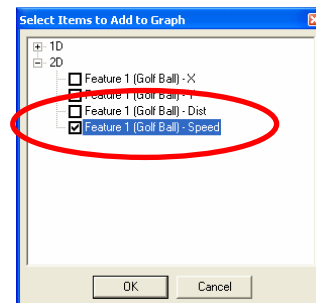


Figure 24

The graph will automatically update to reflect the addition of the ball speed line [Figure 25]. It is not necessary to apply any data filters to the golf ball speed line.

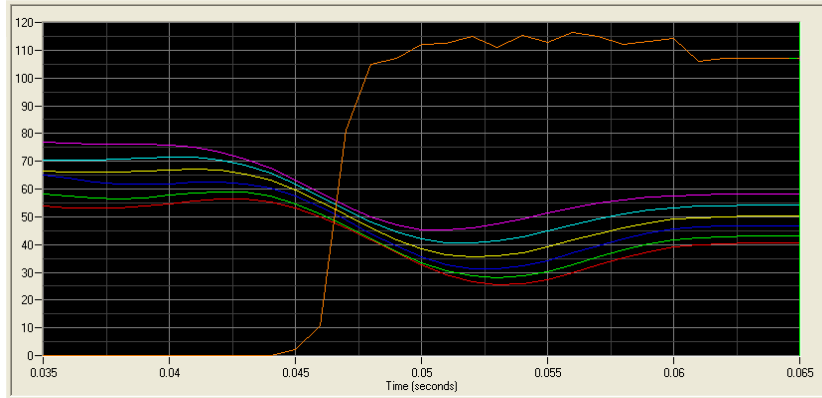


Figure 25

Graphed data can be exported in plain text format, or directly into a blank Excel spreadsheet. Both options can be accessed from a pop-up menu that is opened by right-clicking on the graph window. From the menu, select **Graph Menu** → **Export Displayed Data** → **<format>** [Figure 26].

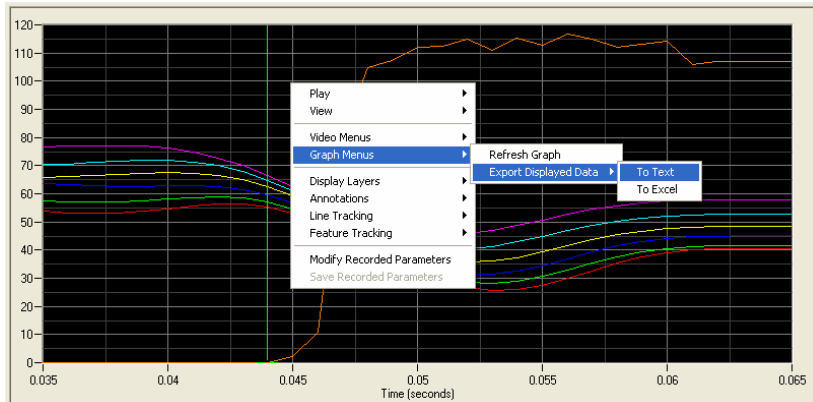


Figure 26

Analyzing Motion in Three Dimensions

9

This tutorial will provide users with a step by step guide to performing an analysis with ProAnalyst 3-D. This lesson will cover the ProAnalyst 3-D Manager, calibration, measurement, and graphing. Prior ProAnalyst experience is assumed, but not required. Where necessary other tutorials have been referenced that explain concepts not covered by this document.

Files Needed for This Tutorial

2. *Robot1.avi*
3. *Robot2.avi*
4. *Cal1_0.bmp*
5. *Cal2_0.bmp*
6. *TutorialFixture.fixt*

Step 1 – Setting Up a Project for 3-D

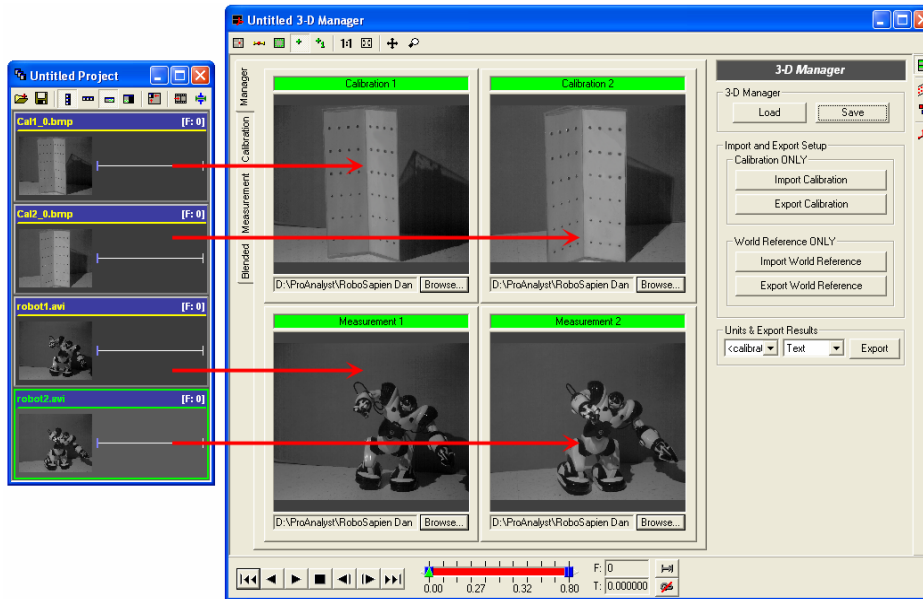
Copy the *TutorialFixture.fixt* file into your Program Files\Xcitex\ProAnalyst\Fixtures directory.

Launch ProAnalyst and create a new Project by selecting **File → New Project**. Add the *Cal1_0.bmp*, *Cal2_0.bmp*, *Robot1.avi*, and *Robot2.avi* files to the Project. For more information on working with projects, please refer to *ProAnalyst Tutorial #1: Learning to Use ProAnalyst*.

The ProAnalyst 3-D Manager

Create a new 3-D Manager by selecting **Tools → New 3-D Manager**.

Drag the *Cal1_0.bmp* file into the **Calibration 1** frame on the 3-D Manager. Repeat this process to drag *Cal2_0.bmp* onto the **Calibration 2** panel, *Robot1.avi* onto the **Measurement 1** panel, and *Robot2.avi* onto the **Measurement 2** panel.

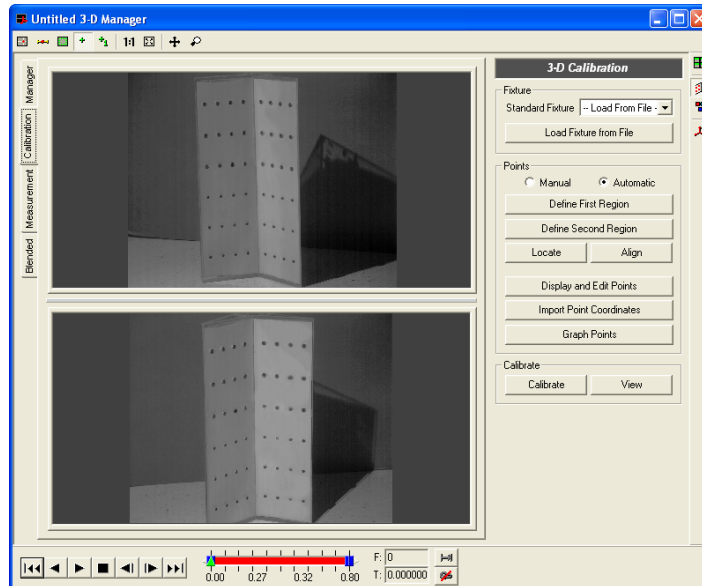


Each time you drop an image or video onto the appropriate panel, the video will open in a new Measurement Window, and immediately minimize to a position on the bottom of the screen. Double-clicking on one of the panels will cause the minimized video to expand to full size for processing or analysis.

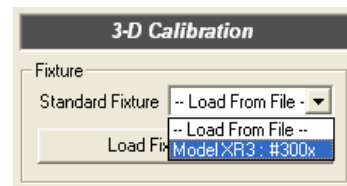
After adding the calibration and measurement videos to the 3-D Manager, click the **Save** button. The 3-D Manager can now be added to your project file in the same way as a video source.

Step 2 - 3-D Calibration

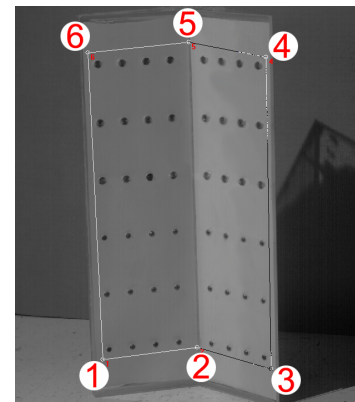
Click the *Calibration* tab on the left side of the 3-D Manager window.



From the **Standard Fixture** dropdown menu select the *Model XR3: #300x* fixture file.



Click the **Define First Region** button. Click six points around the perimeter of the top calibration fixture image. Make sure that the region encompasses all of the points on the fixture, and that the points are clicked in the order shown here.

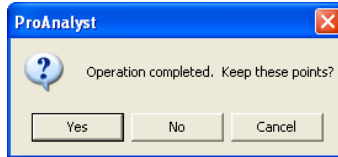


Click the **Define Second Region** button, and repeat the process for the bottom fixture image.

Right-click on the upper calibration image, and select **Locate Point Settings (TOP)** from the pop-up menu. Set the **Maximum Pixel Count** value to 2000. The other settings may remain at their default values.

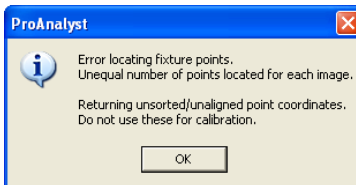
Repeat the process for the lower calibration image by right-clicking on the image and selecting **Locate Point Settings (Bottom)** from the pop-up menu.

Click the **Locate** button. After processing the defined regions, you should see the following dialog box appear:



Click the **Yes** button to continue.

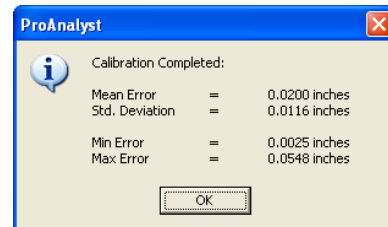
Instead of the **Operation completed** dialog box, you may see the following dialog:



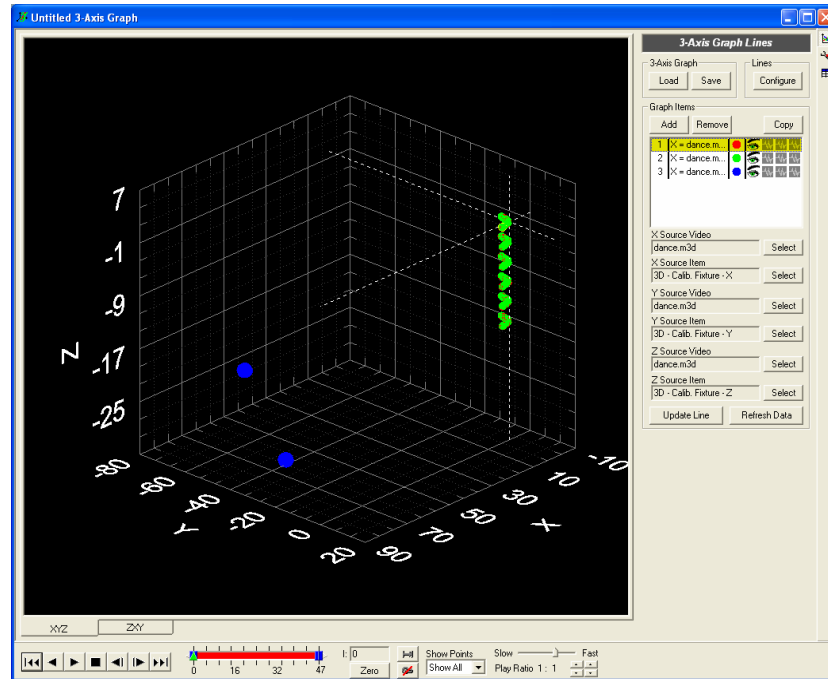
If this is the case, then you may need to redefine the search regions on the calibration images and/or modify the values in the **Locate Point Settings** window.

Once the fixture points have been located successfully, click the **Align** button to straiten out any misalignments that may have resulted from the automatic detection process. After the points have been aligned, click the **Calibrate** button. ProAnalyst will now determine the positions of the two cameras, and create the 3-D world space for the analysis.

After you calibrate, a **Calibration Completed** dialog box will be displayed. This dialog will show the **Mean Error**, **Std Deviation**, **Min Error**, and **Max Error** inherent in your calibration. If you would like to try to reduce any calibration error, you may repeat any or all of the previous steps and click the **Calibrate** button to see the new calibration settings.



After you are satisfied with your calibration accuracy, you may click the **Graph Points** button to see a 3-Axis plot of the fixture. The blue spheres displayed on the plot represent the positions of your cameras relative to the fixture.

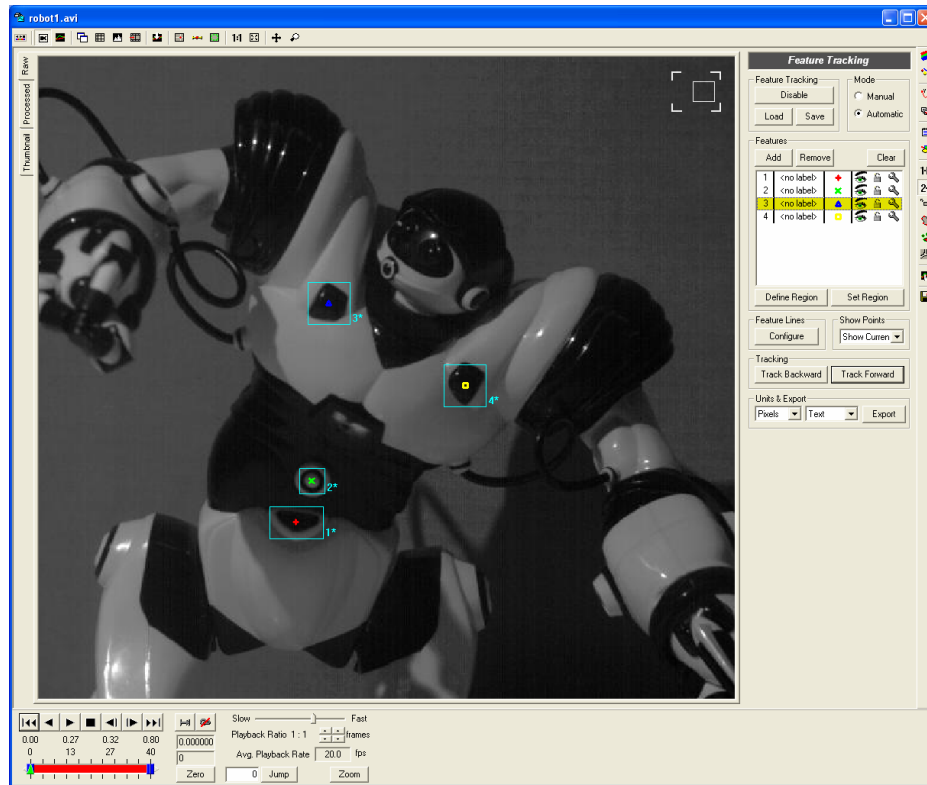


Step 3 - 3-D Measurement

After calibrating the analysis successfully, the next step is tracking the features you wish to analyze. The standard 2-D tracking tools are used on both videos of the event, the results of which are then transformed into 3-D space by ProAnalyst.

When the *Robot1.avi* and *Robot2.avi* videos were added to the 3-D Manager, the videos automatically opened in their own Measurement Windows which then minimized. Restore the *Robot1.avi* Measurement Window, and open the **Feature Tracking** panel.

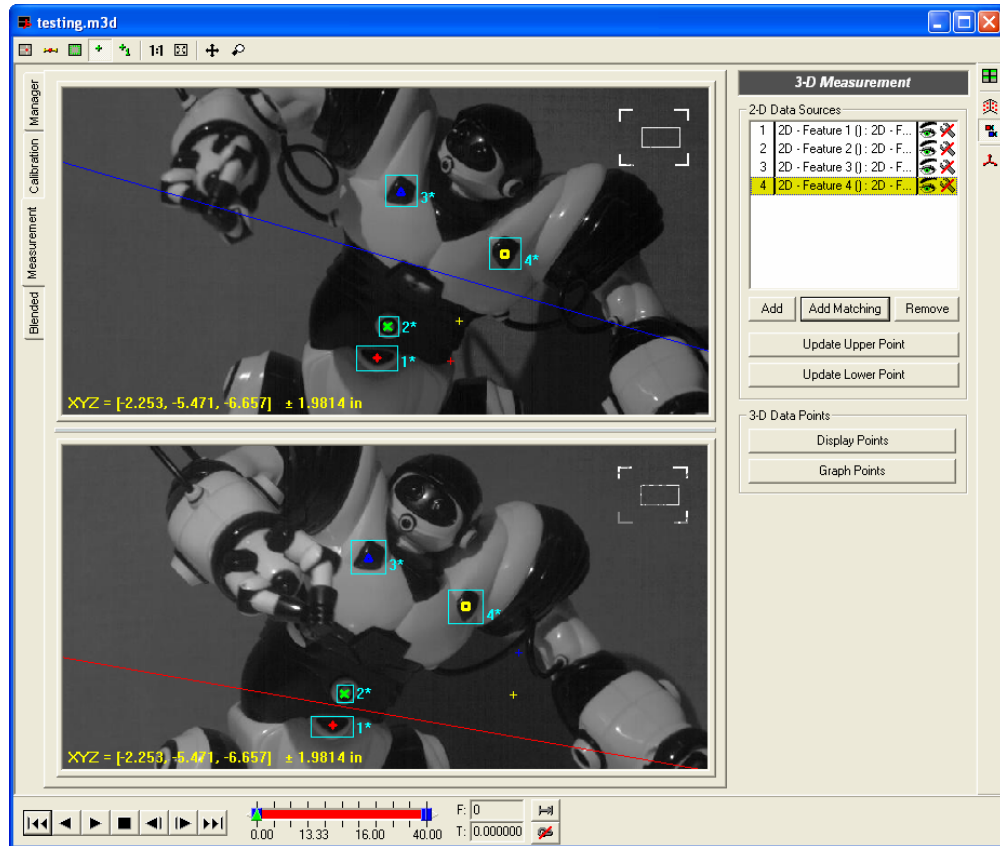
Enable the panel, and then add four features to the list. **Define**, **Set**, and **Track** four features on the robot's body. After the features have been tracked, save the tracking file and minimize the *Robot1.avi* window.



Restore the *Robot2.avi* Measurement Window and repeat the previous steps to track and save the same four features on the robot. When defining features in *Robot2.avi*, be certain that the features correspond to the same features in *Robot1.avi* (i.e. Feature 1 is the belt buckle in both videos).

After the identical features have been tracked on both videos, click the *Measurement* tab on the left side of the **3-D Manager** window.

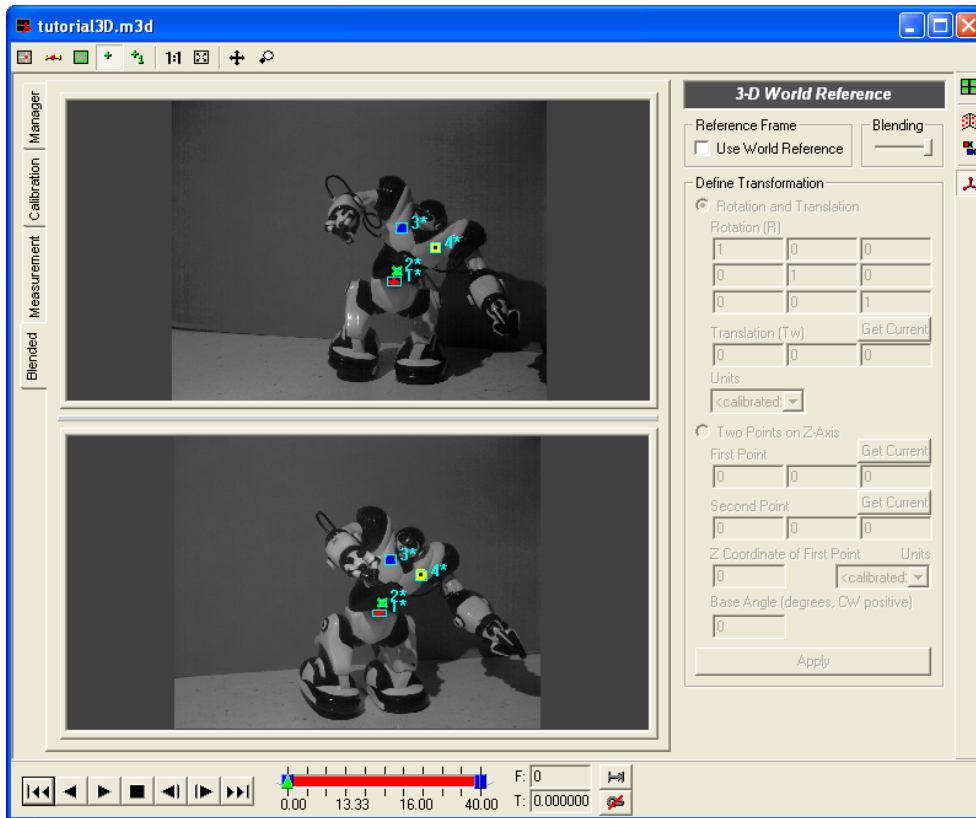
Click the **Add Matching** button to populate the **2-D Data Sources** list with the tracked features from *Robot1.avi* and *Robot2.avi*.



Note: **Add Matching** will pair up tracked features based on the feature number in the Measurement Window **Feature Tracking** list; hence the instruction to match up the features tracked in *Robot1.avi* and *Robot2.avi* matched one another. If the feature numbers in a pair of videos do not match, feature pairs can be manually added by clicking the **Add** button and selecting each feature pair manually.

Regardless of how the feature pairs are added to the 3-D Measurement panel, the two video panels will automatically update to display the tracked points. At this point the matched features can be plotted in a new 3-Axis Graph, but to insure proper orientation of the plot, the World Reference Frame must be modified.

Click the *Blended* tab on the left side of the **3-D Manager** window. By default this panel will display the robot video images overlaid on the calibration fixture images. Drag the **Blending** slider, located in the top left corner of the panel, to the extreme right so that only the robot videos are visible.

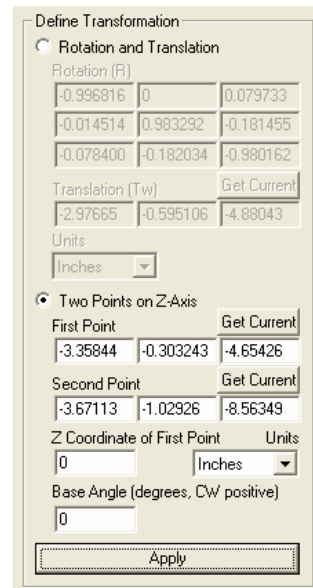


Click the **Use World Reference** checkbox to activate the **Define Transformation** panel. Click the **Two Points on Z-Axis** radio button to enable that control set.

Click on the *Feature 1* in both video panels to position the cursors. Click the **Get Current** button located to the right of the *First Point* label to set the First Point text fields.

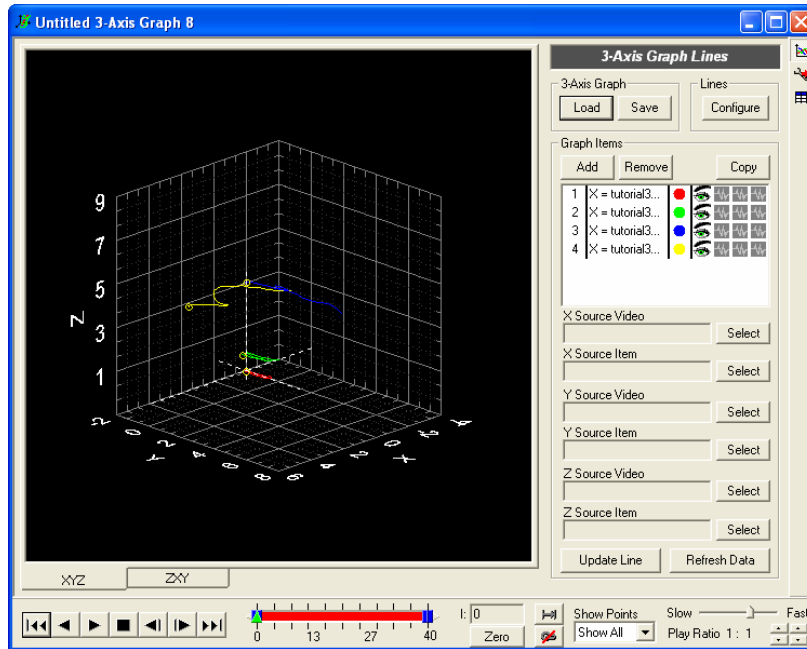
Repeat the previous step to position the cursors and set the *Second Point* coordinates using *Feature 3* as a reference point.

Click the **Apply** button.



Step 4 - 3-D Graphing

After adding the tracked feature pairs to the 3-D Measurement panel, click the **Graph Points** button. A new **3-Axis Graph** will be created with the tracked features automatically added and displayed.

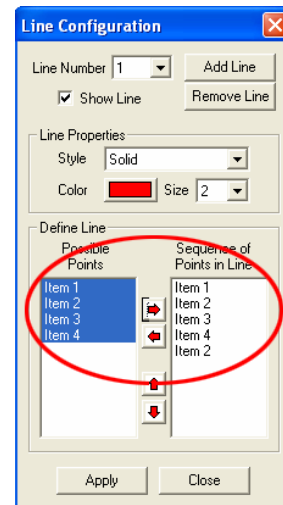



Click the **Configure** button located in the top-left corner of the graph window to open the Line Configuration window.

Click the **Add Line** button.

Select *Item 1* and click the right arrow to move it into the **Sequence of Points in Line** panel. Repeat this step to move *Item 2*, *Item 3*, and *Item 4* into the same panel. Finally, add *Item 2* to the list a second time.

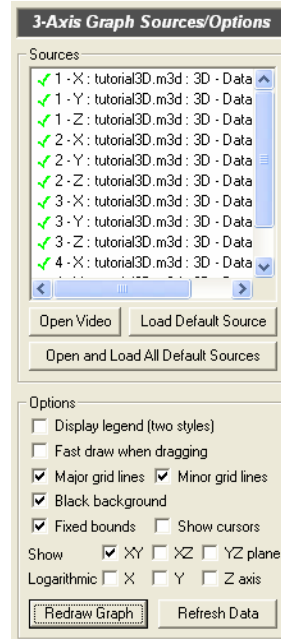
Click the **Apply** button, followed by the **Close** button. The displayed points will now be connected by a closed stick-figure.




The **3-Axis Graph** view can be rotated by clicking and dragging the mouse on top of the graph panel. The view can be zoomed in and out using the mouse wheel. To make the plot easier to see, a number of options can be enabled within the graph window. Click the  icon to open the 3-Axis Graph Sources/Options tool palette.

Click the **Fixed Bounds** check box to open the Additional Graph Options window.

Click each **Fixed #-Axis Bounds** checkbox, as well the **Get Current** button associated with each axis. The values in the Minimum and Maximum value text boxes will update to reflect the bounding area of the plot. Click the **OK** button to close the window.



Finally, select **Show Current** from the Show Points dropdown list and press the  button at the bottom of the graph window to view the tracked event in three dimensions.

