FROM MOTION TO DATA TO KNOWLEDGE

Analyzing a Golf Swing with ProAnalyst®

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Abstract

This tutorial explains how to apply multiple analysis tools to different types of motion in the same video sequence by analyzing a golf swing.

Files Needed for This Tutorial

Click here to download these files.

outdoor 5 iron 1.au3	*outdoor 5 iron 1.ftk*
outdoor 5 iron 1. avi	*outdoor 5 iron 1.ltk*
outdoor 5 iron 1. cfg	*golf.mpj*

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 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.

Begin by clicking 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].
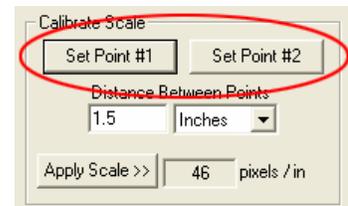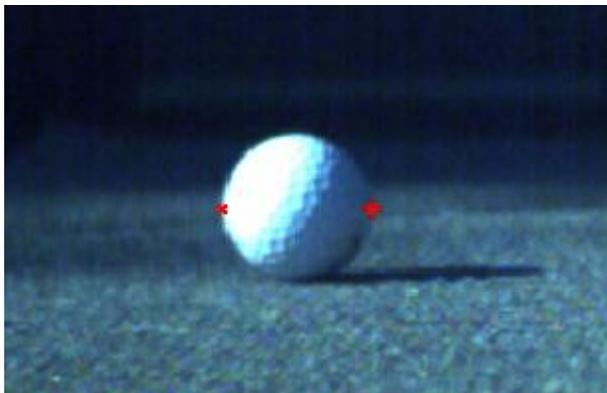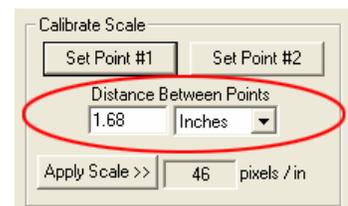

Figure 2:

Position the reticle along one side of the golf ball and press the Set Point #1

Figure 3:

Document Number 110

Figure1:

button. Reposition the reticle at a point on the other side of the golf ball and
press the Set Point #2 button [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 unit in the dropdown menu [Figure 3]. Click the **Apply Scale >>** button to set the new scale factor.

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.
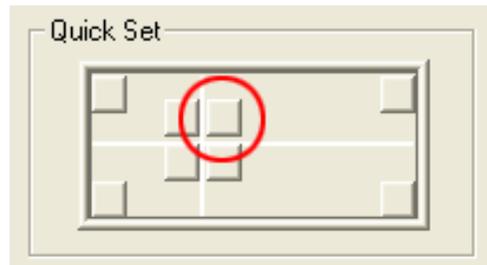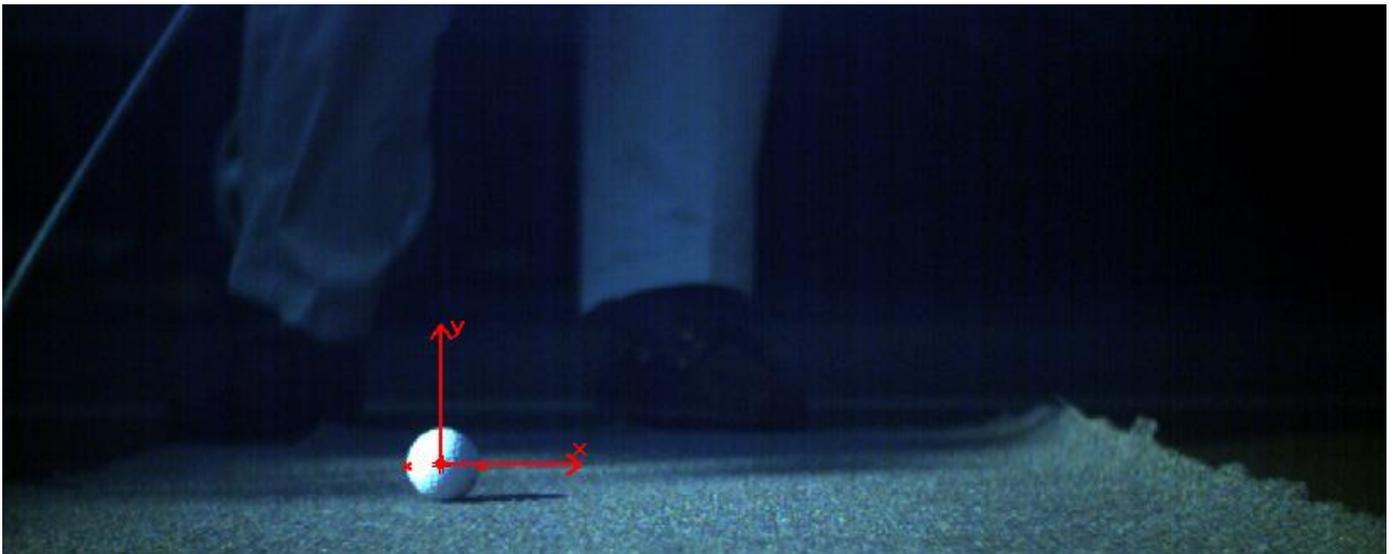

Figure 4:

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.

Figure 6:

Begin by clicking the 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 un-checking the Circle Fit box in the Options frame [Figure 6].
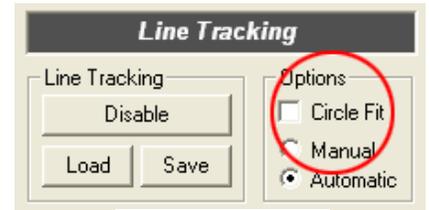
When the **Line Tracking** control panel was enabled, one line was automatically added to the project. This line must be repositioned so that it covers the entire range of motion of the golf club. Click the **Modify Line** button to activate the line editing mode. You can change the position and length 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.
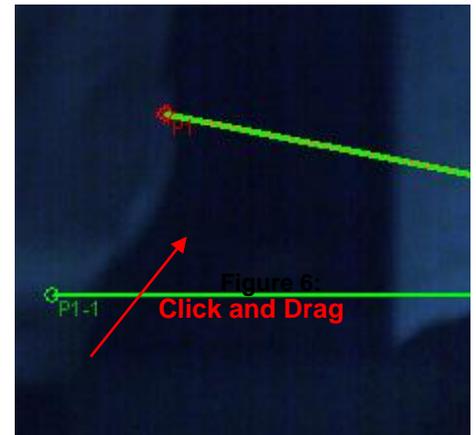

Figure 7:

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.
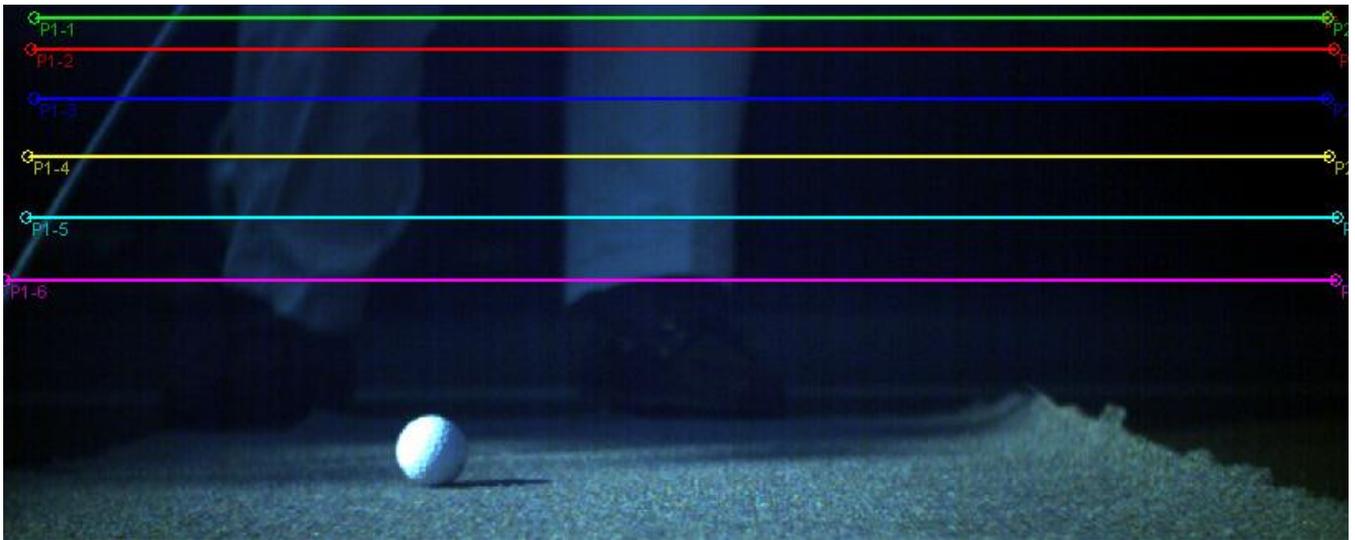

Figure 9:

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.
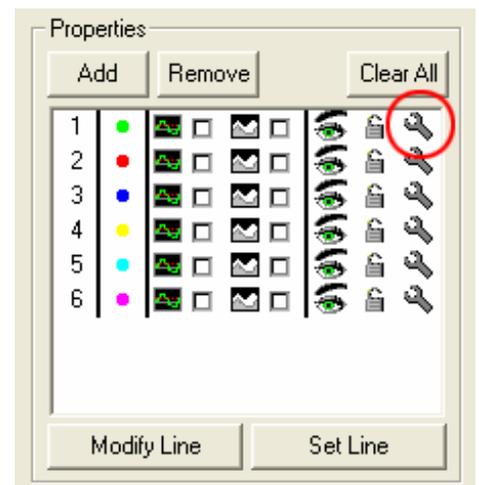

Figure 10:

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. It 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.
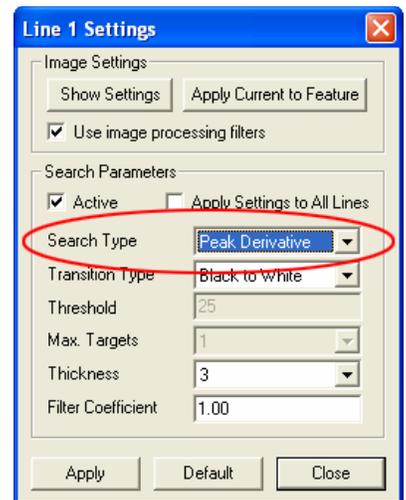
Figure 11:

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].
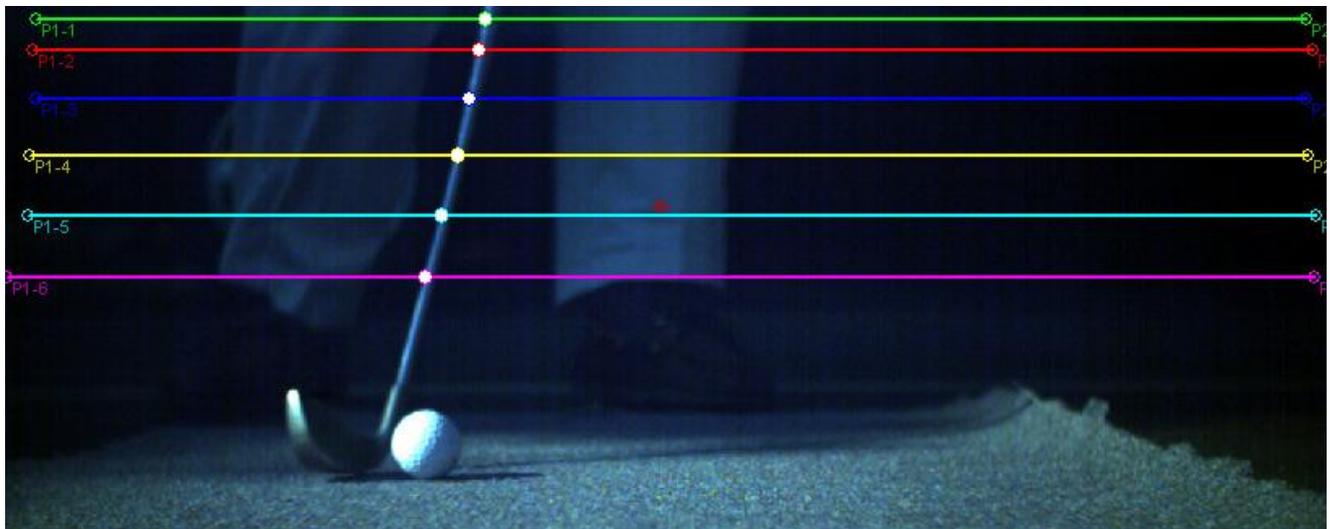

Figure 12:

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 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].
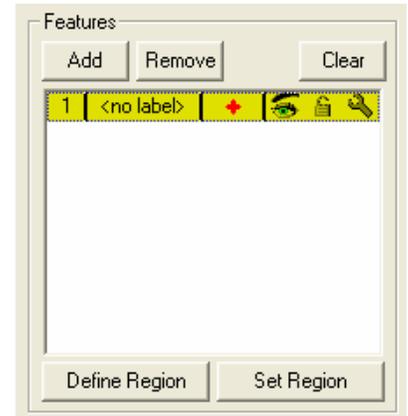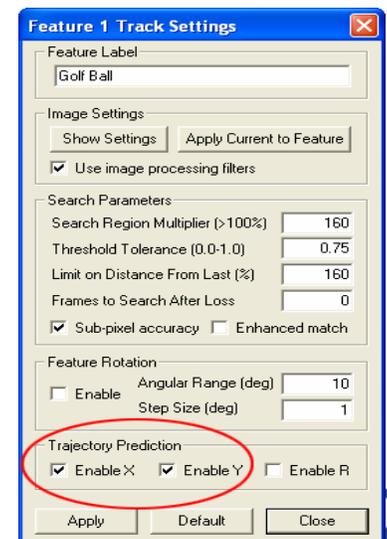
Figure 13:

Figure 12:

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.

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

Figure 15:

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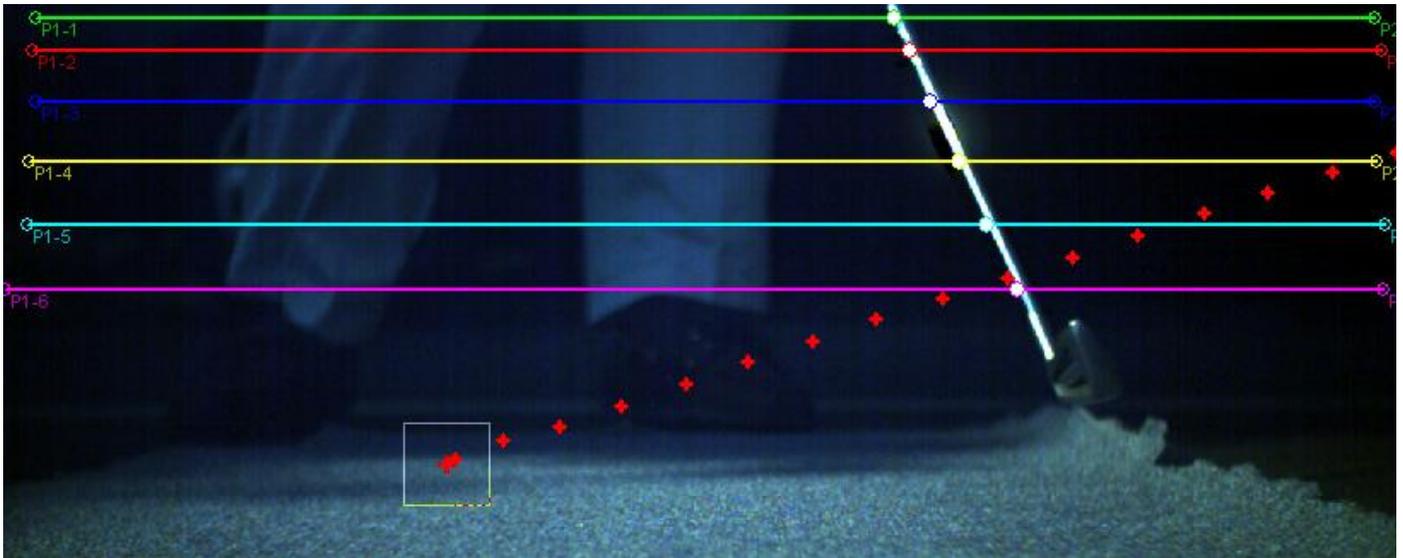

Figure 18:

Step 4 – Graphing and Filtering the Motion 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]. When you click the OK button, a Graph Pane displaying the plots of the selected items will appear in the Measurement Window [Figure 18]. Note that the Y-axis values are currently being displayed in un-calibrated pixel values, not the real-world units that were set earlier.
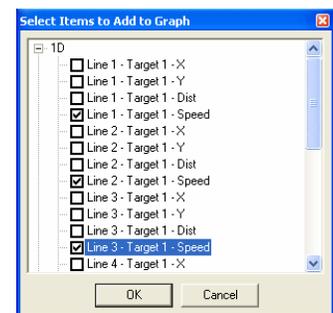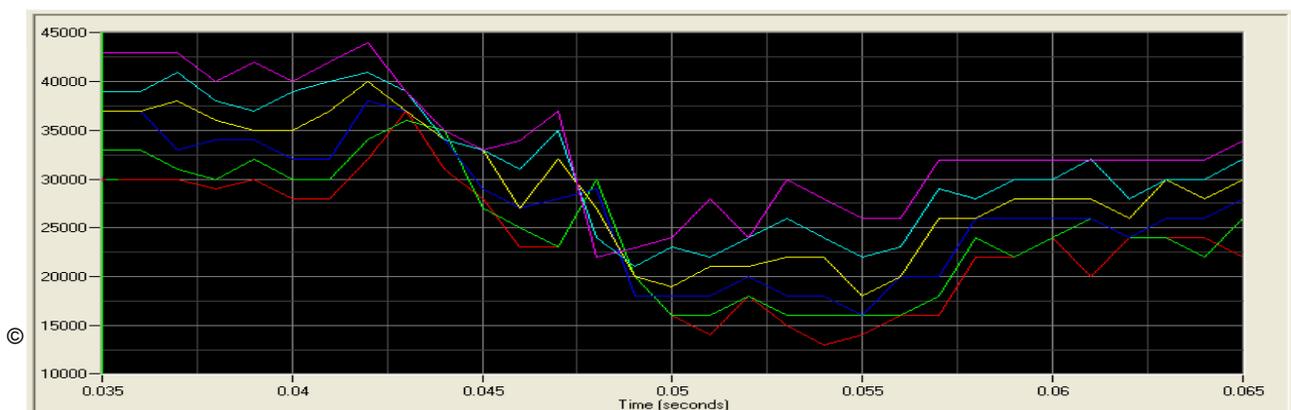

Figure 17:

Figure 18:

Figure 19:

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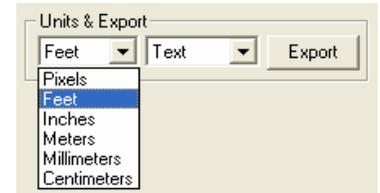
To arrive at a clearer overall picture of the speed of the golf club, a series of noise reduction filters can be applied to the graph lines. To apply a data filter, click the Filter Settings icon [Figure 20] to open the Filtering window associated with a particular graph line [Figure 21].
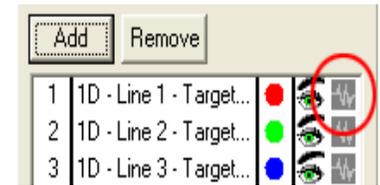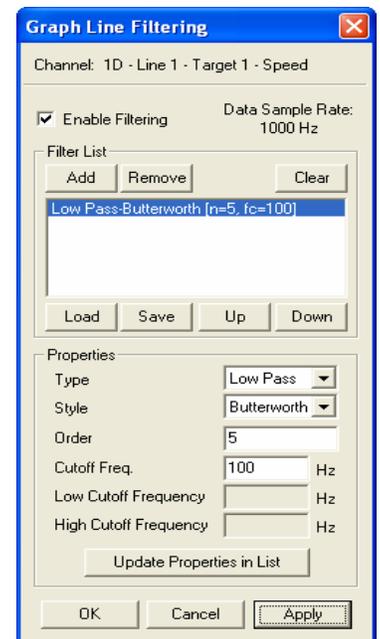

Figure 20:

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.

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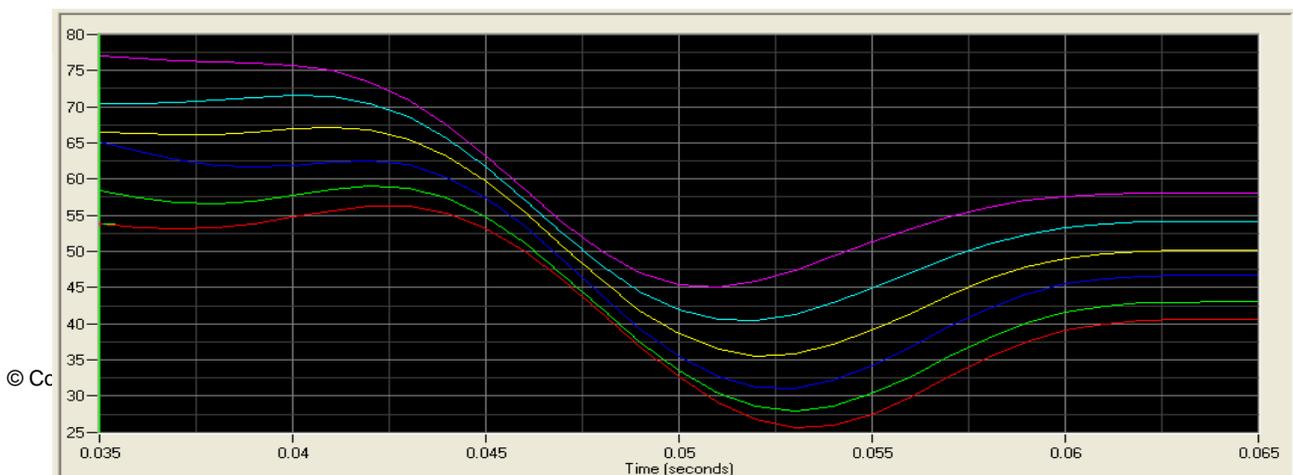

Figure 21:

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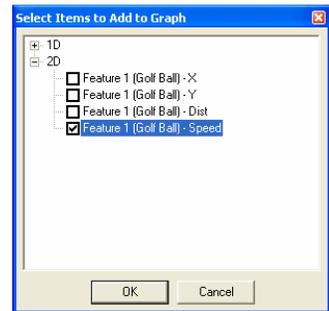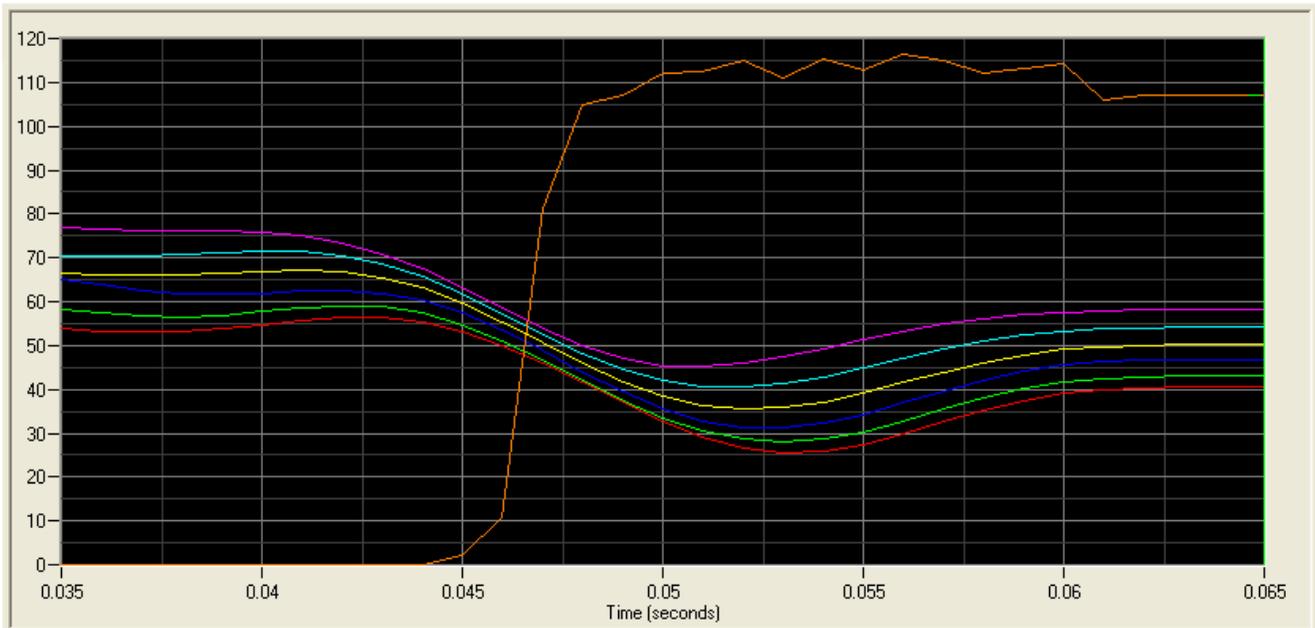

Figure 24:

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 Menus** > **Export Displayed Data** > **<format>** [Figure 26].
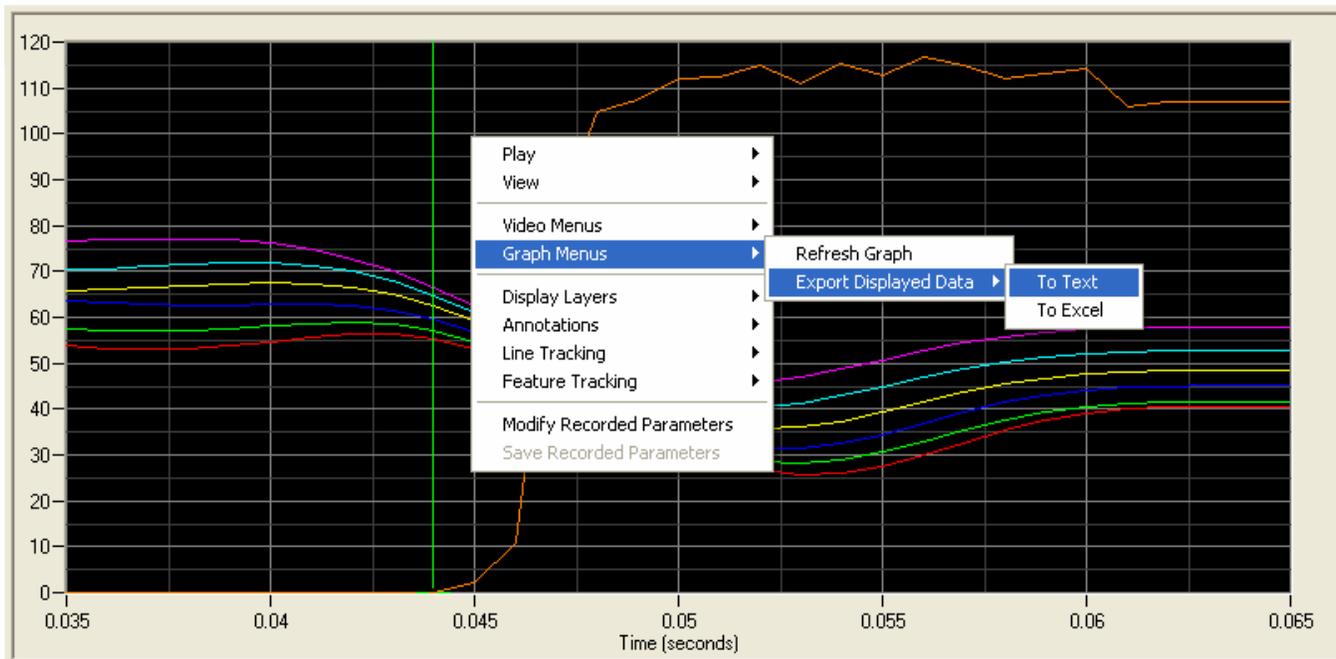
Figure 26:

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