FROM MOTION TO DATA TO KNOWLEDGE

Tutorial

Quantifying Motion in Three Dimensions with ProAnalyst®

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Abstract

This tutorial provides users with a step-by-step guide to performing an analysis with ProAnalyst 3-D Professional Edition. This lesson covers the ProAnalyst 3-D Manager, calibration, measurement, and graphing. Prior ProAnalyst experience is assumed, but not required. Where necessary, we refer to other tutorials that explain concepts not included in the scope of this document.

Files Needed for This Tutorial

Click here to download these files.

Robot1.avi

Robot2.avi

Cal1_0.jpg

Cal2_0.jpg

Robot1.cfg

Robot2.cfg

TestFixture.fixt

Setting Up a Project for 3-D Analysis

1. Copy the *TestFixture.fixt* file into your Program Files\Xcitex\ProAnalyst\Fixtures directory or another location where you have installed ProAnalyst on your computer.

   Note: If you are using a Network licensed edition, create a new folder on your hard drive and place the file in it. You will need to browse to this file location later.

2. Launch ProAnalyst and create a new project by selecting **File > New Project**. Right-click the empty project window and select **Project > Add Video(s)**. Double-click to add the *Cal1_0.jpg* file to the project. Repeat the process to add the *Cal2_0.jpg, Robot1.avi, and Robot2.avi* files to the project. Save the project and give it a title.

   Note: For more information on working with projects, please refer to ProAnalyst Tutorial 100: Learning to Use ProAnalyst.

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

4. Click on the title bar of the *Cal1_0.jpg* window, then drag and drop the *Cal1_0.jpg* file from the project onto the Calibration 1 panel on the 3-D Manager. Repeat the process to drag *Cal2_0.jpg* onto the Calibration 2 panel, *Robot1.avi* onto the Measurement 1 panel, and *Robot2.avi* onto the Measurement 2 panel.

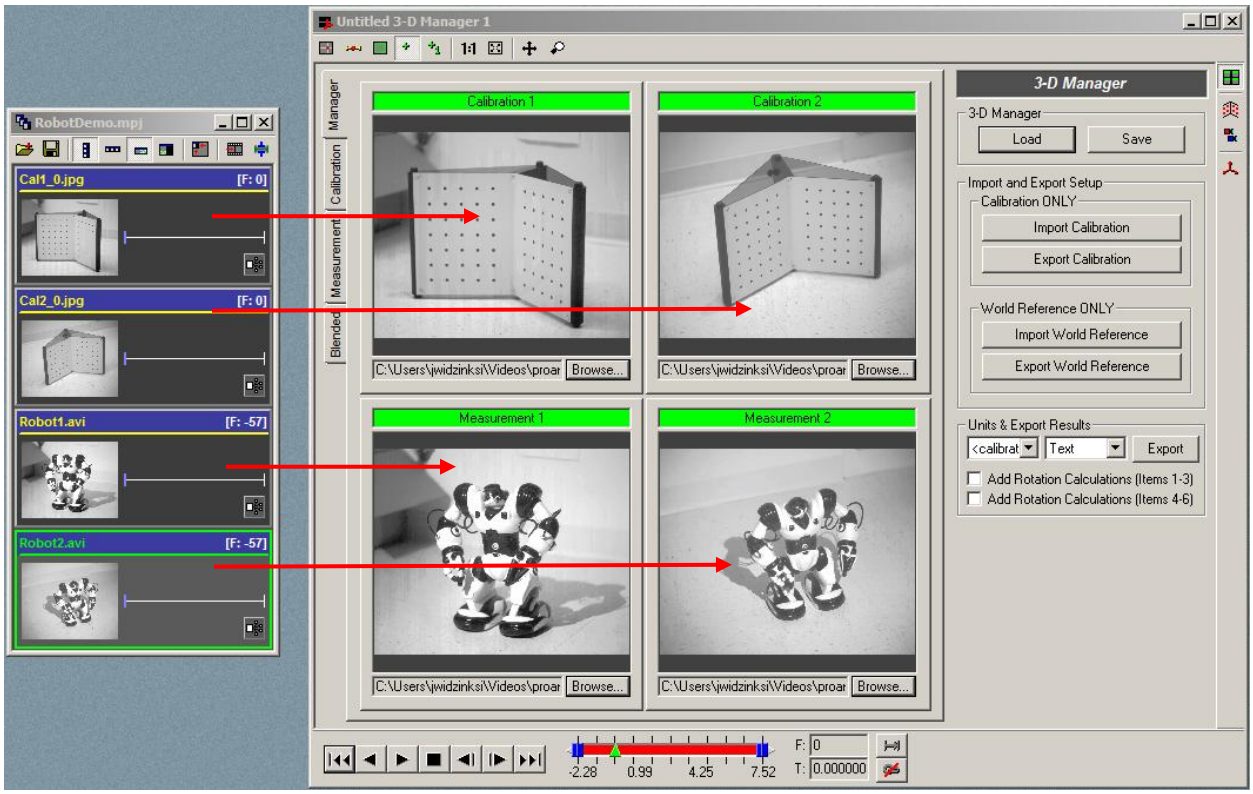

Figure 1. Project and 3-D Manager windows

5. 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 expands the minimized video to full size for processing or analysis. After adding the calibration and measurement videos to the 3-D manager, click the **Save** button and give the 3-D manager file a name. You can now add the 3-D manager to your project file in the same way that you would add a video source by right-clicking on the project window and selecting your newly created 3-D manager.

3-D Calibration

1. Click the **Calibration** tab on the left side of the 3-D Manager window or the Calibration icon on the right side of the window. The 3-D Calibration window is displayed. Figure 2 shows the 3-D Calibration window with the tab and icon circled.

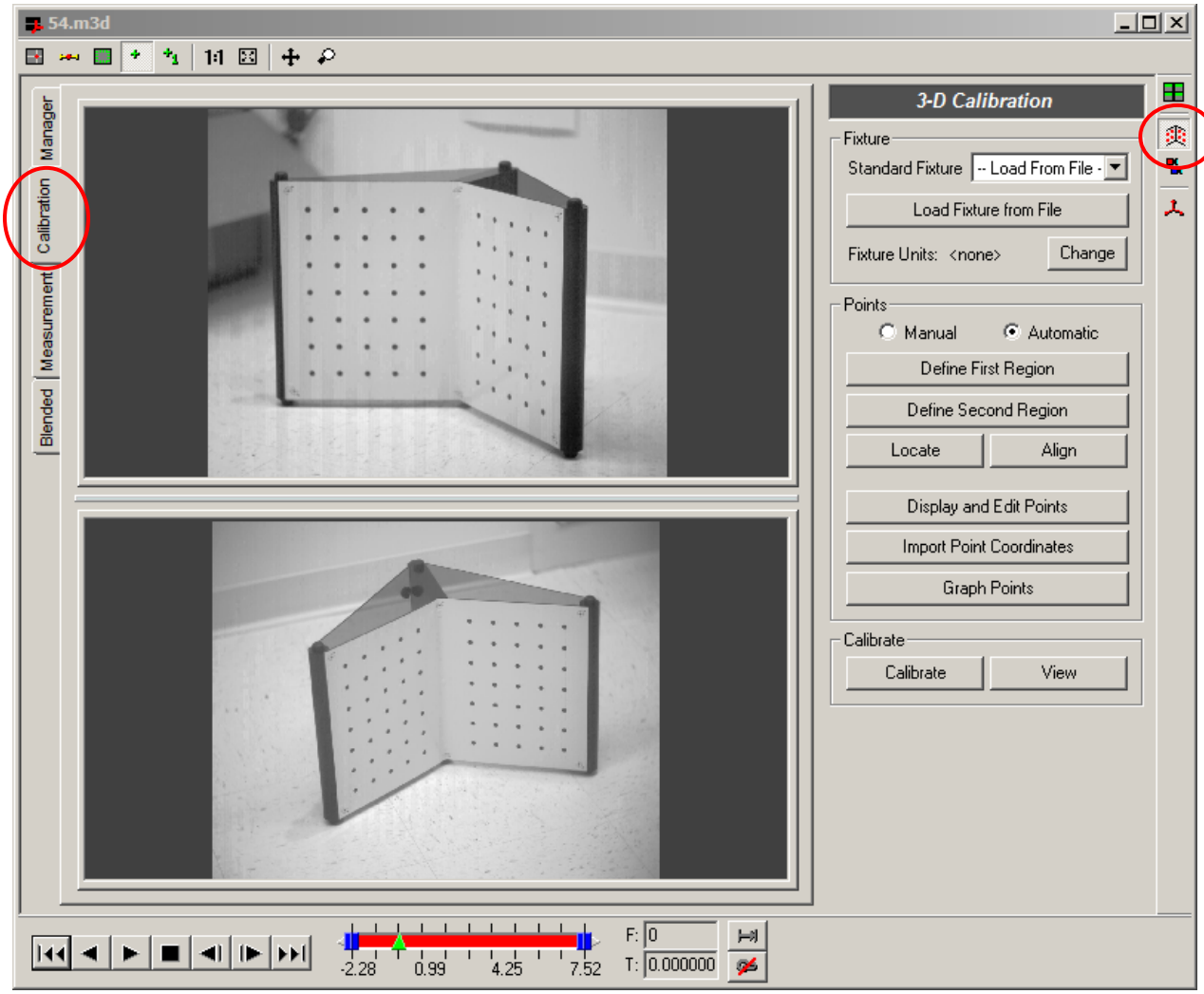

Figure 2. 3-D Calibration window

2. From the Standard Fixture dropdown menu select the *Model VC4: #400x* fixture file. This list includes the files in your default program directory.

   Note: If you are using a network licensed edition of ProAnalyst, click ***Load Fixture from File*** *and browse to the location on your local hard drive where you saved the file in Step 1.*

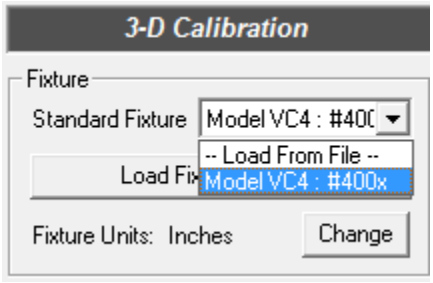

Figure 3. Standard Fixture menu

3. A dialog box will appear indicating that the fixture points have loaded successfully. Click **OK**. The Calibration Points window is displayed. You may close this window without modifying any of the data.

4. Click the **Define First Region** button. A message appears prompting you to click on the 6 corners of the region that you wish to select. Start at the lower left corner, and click six points counter clockwise 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 in Figure 4.

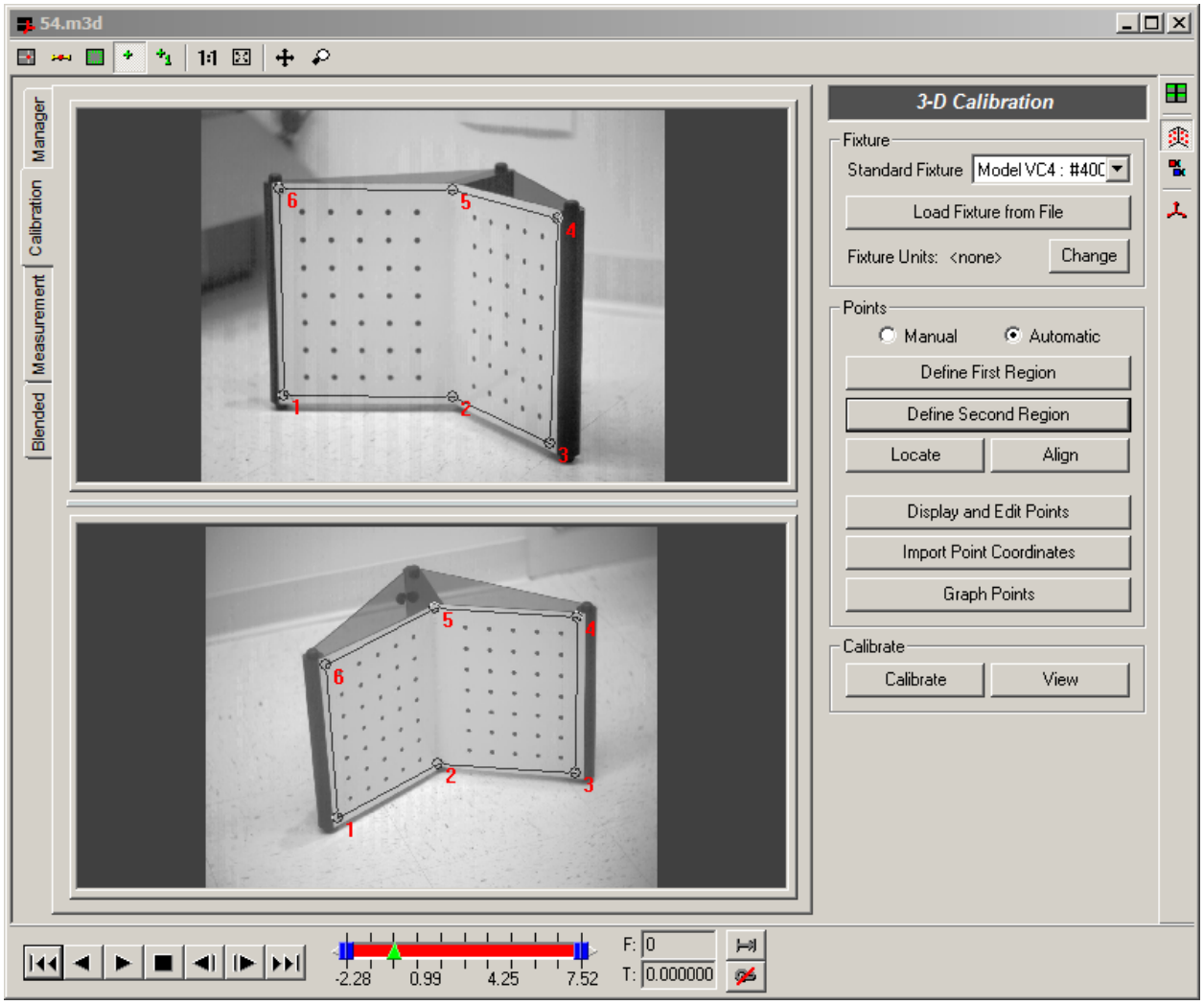

Figure 4. Point definition for first and second regions

5. Click the **Define Second Region** button. Again, a message prompts you to select the six corners of the region. Repeat the process for the bottom fixture image, clicking on the same points in the same order.

   *Note: You can right-click on either of the calibration images and select one of the **Locate Point Settings (TOP)** or **(BOTTOM)** options from the pop-up menu. The Locate Point Settings dialog box appears as shown in Figure 5. Changes in lighting, resolution, field of view, and other factors alter the appearance of the fixture. A number of parameters may be adjusted in order to compensate for these changes. The Locate Point settings control how the image is processed and how the points are identified from the processed image. For more information on this feature, refer to the 3-D Calibration section of the ProAnalyst User Guide. For this tutorial, you may leave the settings at their default values and click **OK**.*

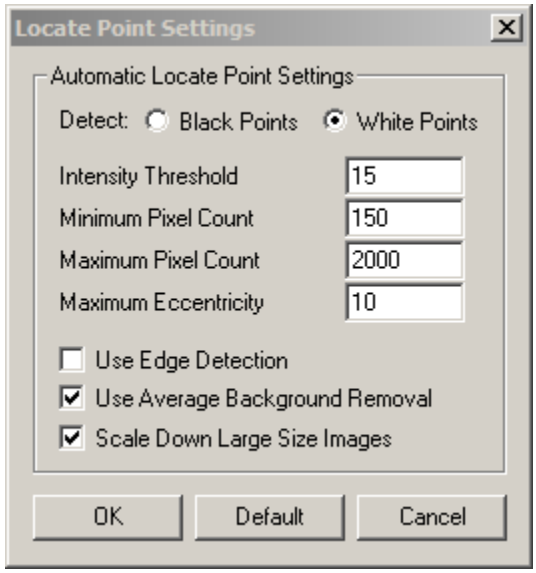

Figure 5. Locate Point Settings dialog box

6. Click the **Locate** button on the 3-D Calibration panel and select **Both Top and Bottom** from the popup menu. Another popup displays a status bar as the fixture points are located within the images. After the defined regions are processed, the dialog box shown in Figure 6 appears. Click the **Yes** button to continue.

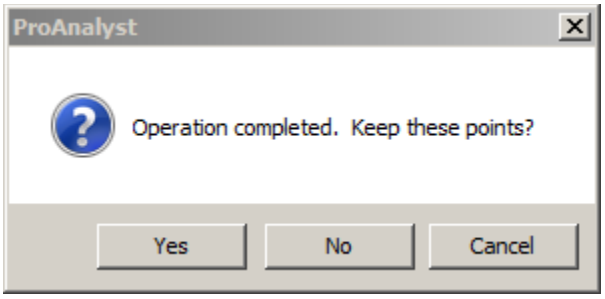

Figure 6. Operation Completed dialog box

*Note: Once the fixture points have been successfully located, you may click the **Align** button and select **Both Top and Bottom** to correct any misalignments that may have resulted from the automatic detection process. Alignment places all the points on straight lines to improve the accuracy of the calibration. The Operation Completed dialog box appears again. Click **Yes**. (This step is optional for this tutorial.)*

If errors occur as the regions are processed, you may see the dialog box shown in Figure 7. You may need to redefine the search regions on the calibration images and/or modify the values in the Locate Point Settings menus. If the search region is too large, the software may pick extraneous black dots as fixture points.

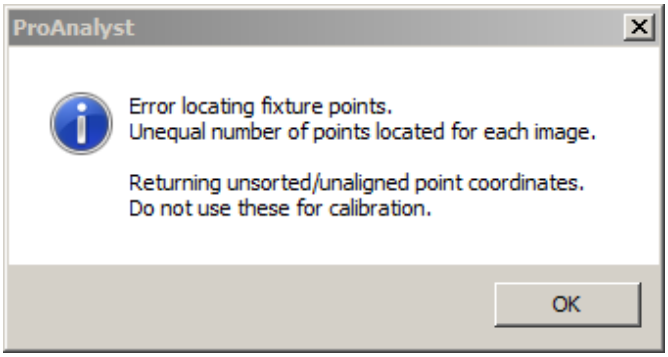

Figure 7. Error Locating Fixture Points dialog box

7. Click the **Calibrate** button on the 3-D Calibration panel. ProAnalyst will now determine the positions of the two cameras, and create the 3-D world space for the analysis.

8. After you calibrate, a Calibration Completed dialog box will be displayed as shown in Figure 8. This dialog will show the Mean Error, Standard Deviation, Minimum Error, and Maximum Error inherent in your calibration. If you are satisfied with the results, click **OK**. 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 again to see the new calibration settings.

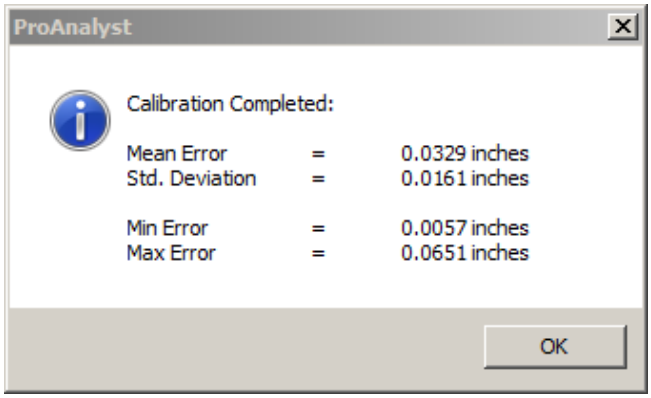

Figure 8. Calibration Completed dialog box

9. Next, click the **Graph Points** button on the 3-D Calibration panel to display a 3-Axis plot of the fixture. The blue spheres displayed on the plot represent the positions of your cameras relative to the fixture.

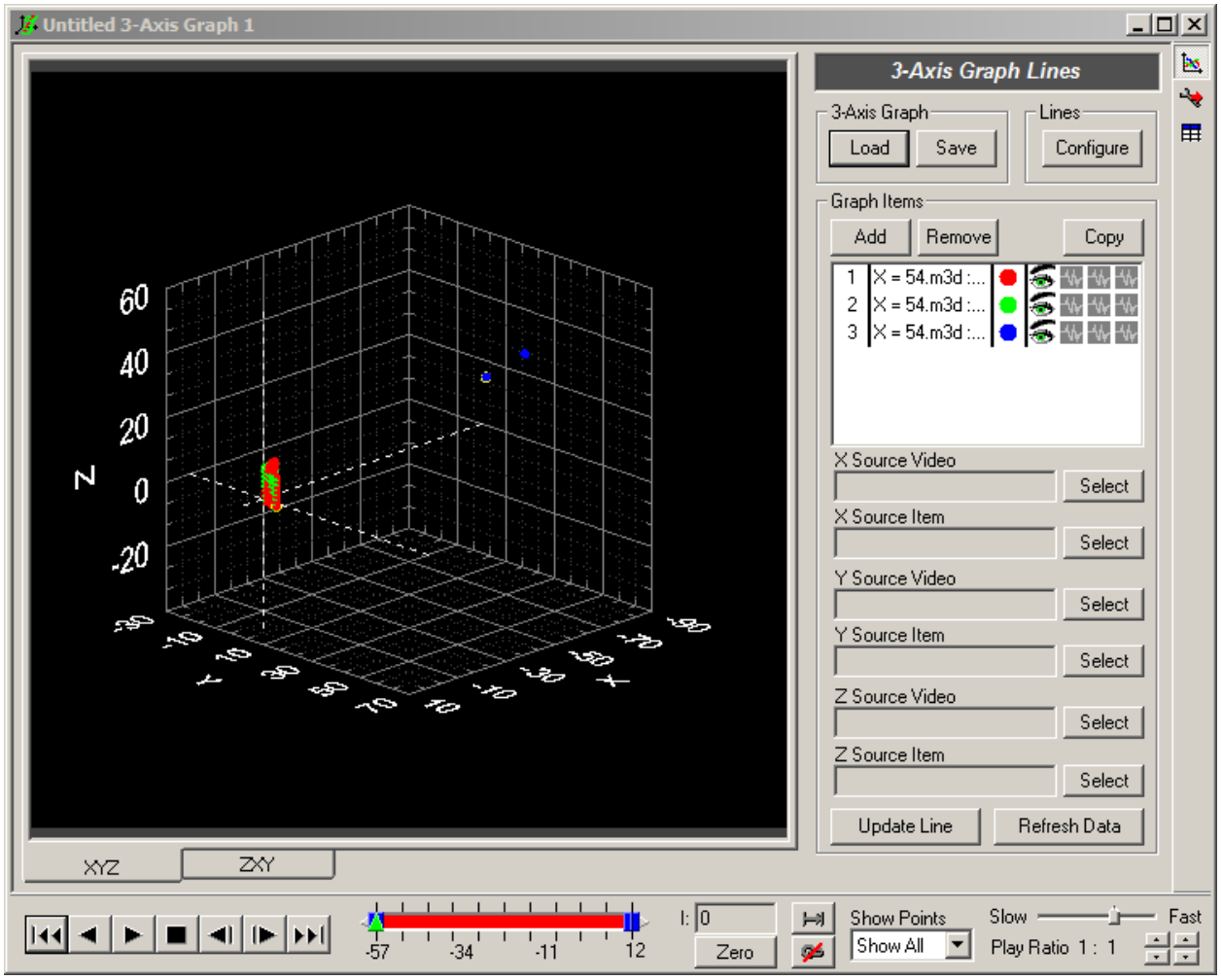

Figure 9. 3-Axis Plot

3-D Measurement

After calibration, the next step is tracking the features you wish to analyze. 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.

1. When you added the *Robot1.avi* and *Robot2.avi* videos to the 3-D Manager, the videos automatically opened in their own Measurement windows, which then minimized at the bottom of the screen. Restore the *Robot1.avi* Measurement window, and open the Feature Tracking panel by clicking the **2-D** icon at the right side of the screen. Next, click the **Enable** button to begin defining the features to track.

2. Click **Define Region**. Position the reticle and draw a box around the robot's belt buckle. Click **Set Region** to set the belt buckle as Feature 1. Next, click the **Add** button to add Feature 2. Repeat the previous steps to define and set regions for three features on the robot's body. The Define Region, Set Region, and Add buttons are shown circled in Figure 10.

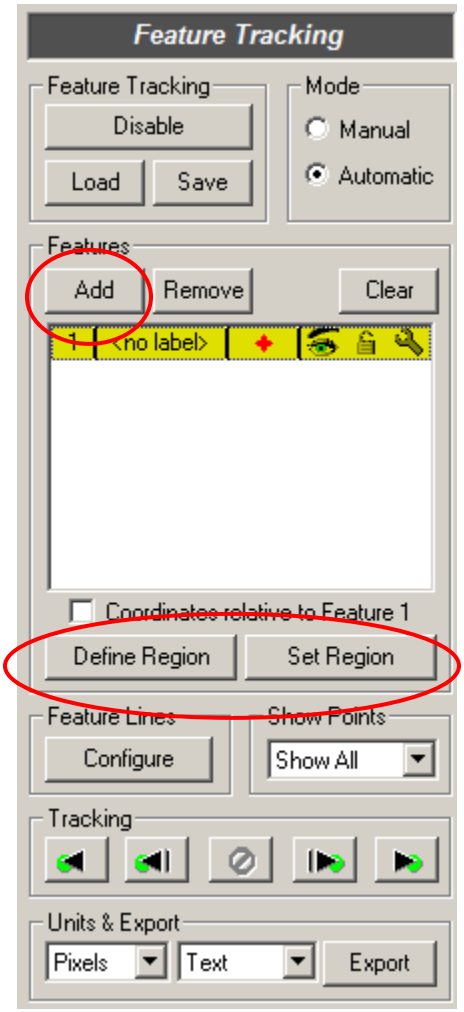

Figure 10. Feature Tracking panel

3. After all three features have been defined as shown in Figure 11, click the **Track Forward** button to see the movement of the features.

4. Click **Save** and then click **Save** in the dialog box to save the tracking file as *Robot1.ftk*. Click **OK** when the message **Analysis saved successfully to file** appears. Minimize the *Robot1.avi* window.

   Note: For more information on feature tracking, please refer to ProAnalyst Tutorial 100: Learning to Use ProAnalyst and ProAnalyst Tutorial 112: Tracking a Rotating Object. Both documents are available at http://www.xcitex.com.

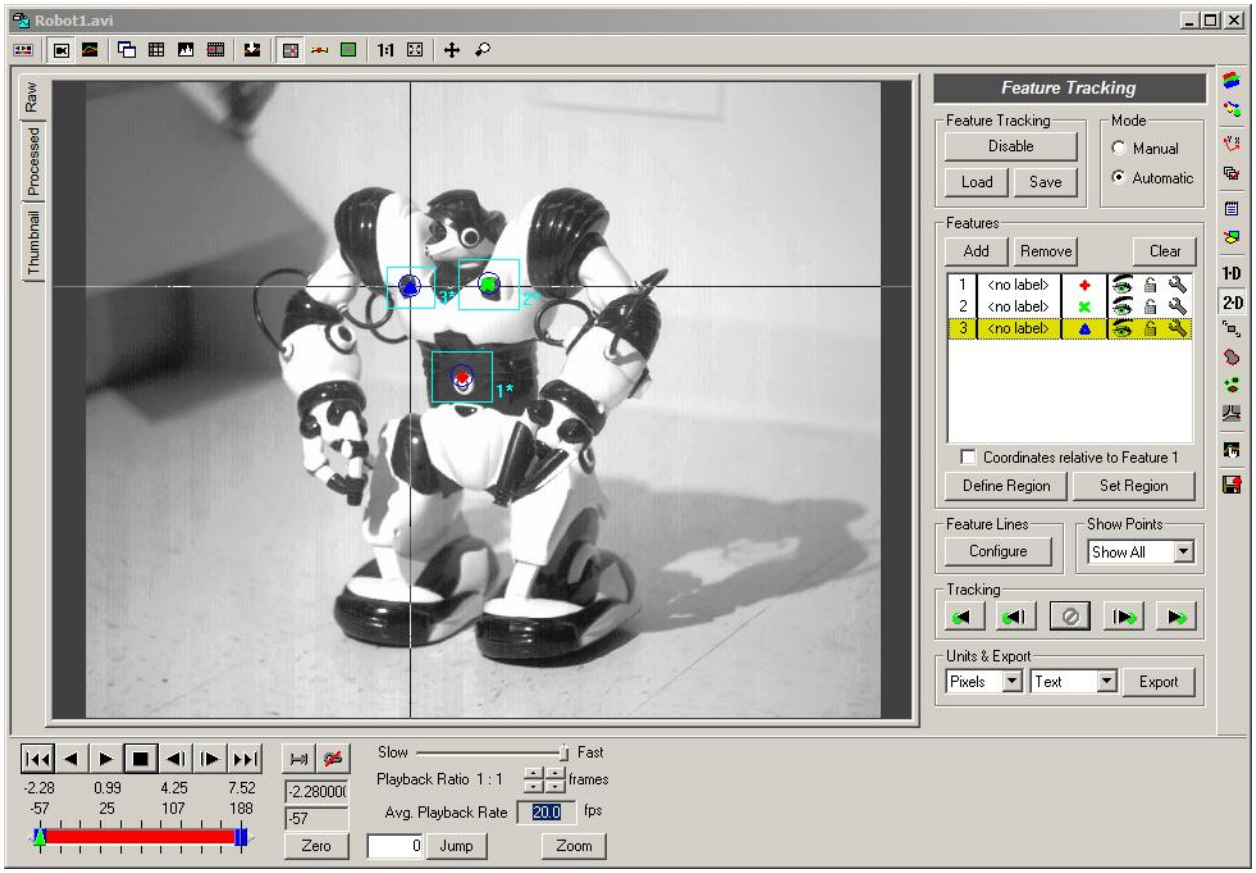

Figure 11. Robot with features defined

5. Restore the *Robot2.avi* Measurement window, click the **2-D** icon, and repeat the previous steps to track and save the same three features on the robot. When defining features in *Robot2.avi*, be certain that the features correspond to the same features in *Robot1.avi* (for example, Feature 1 is the belt buckle in both videos). Save the tracking file as *Robot2.ftk* and minimize the *Robot2.avi* window.

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

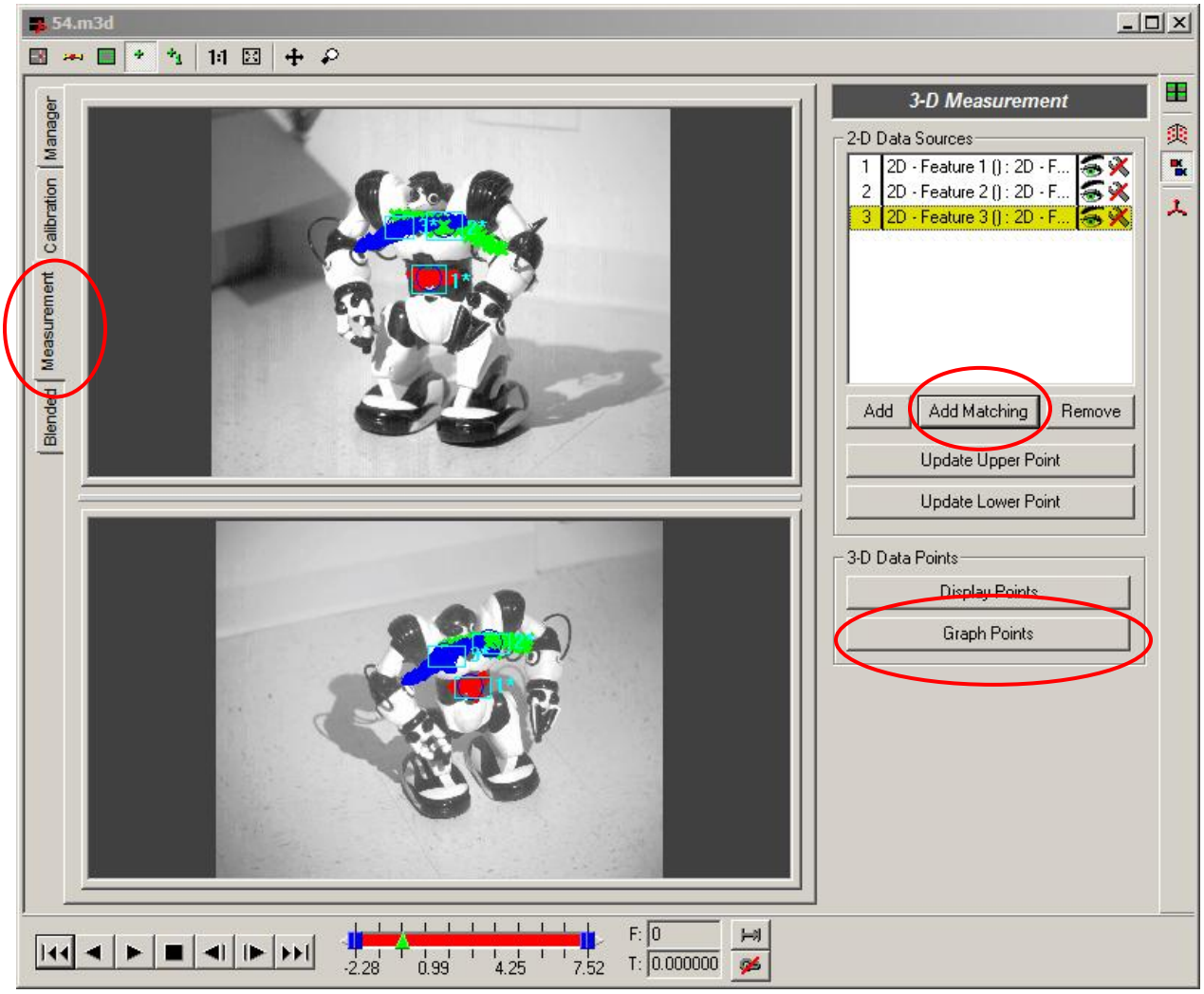

Figure 12. 3-D Measurement panel

7. Click the **Add Matching** button (shown circled in Figure 12) 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. For this reason, it is necessary for the features tracked in Robot1.avi and Robot2.avi to match. If the feature numbers in a pair of videos do not match, feature pairs can be added manually by clicking the **Add** button and selecting each feature pair manually.*

3-D Graphing

1. 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.

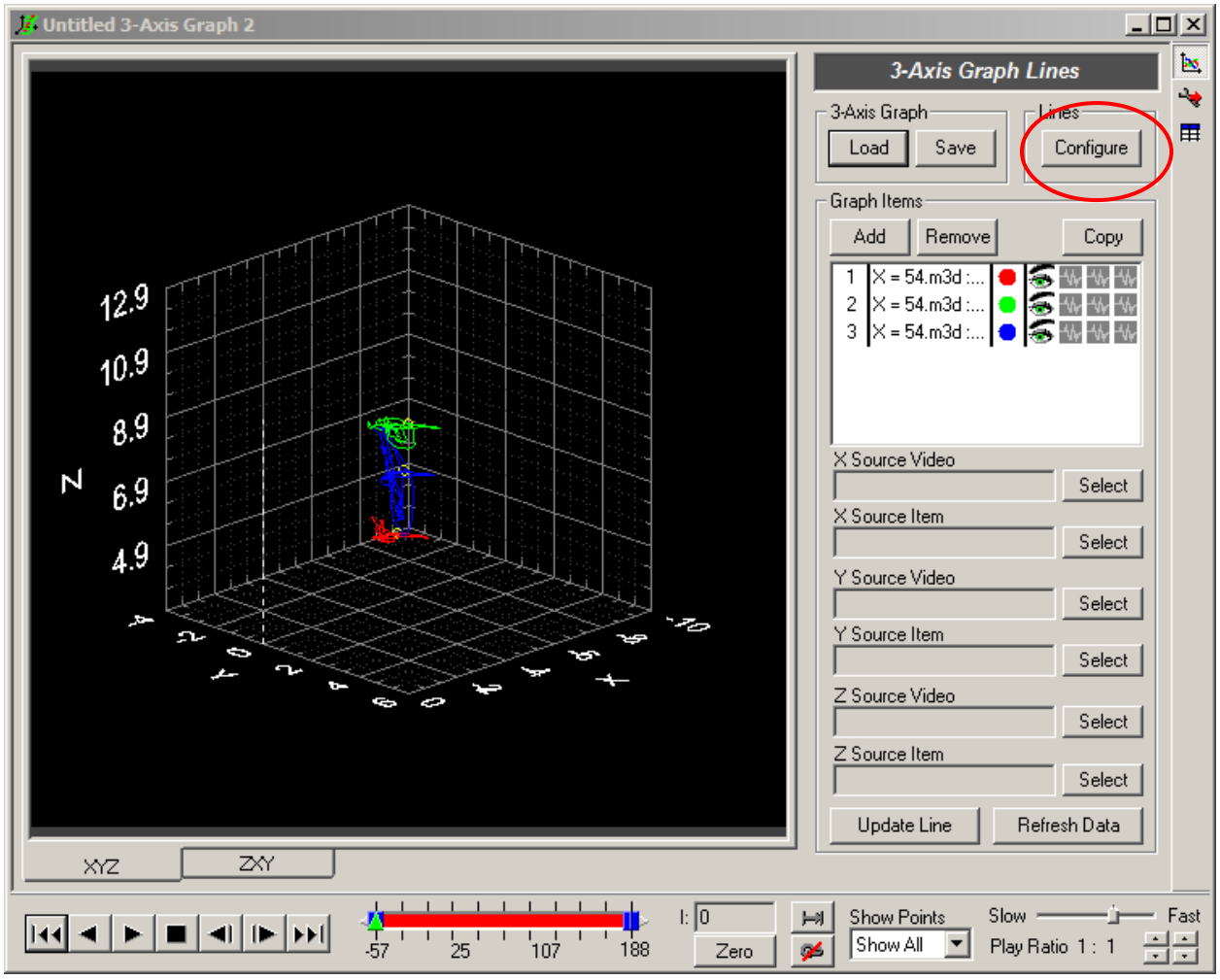

Figure 13. 3-Axis graph of tracked features

2. Click the **Configure** button located in the upper right corner of the graph window to open the Line Configuration window, shown in Figure 14.

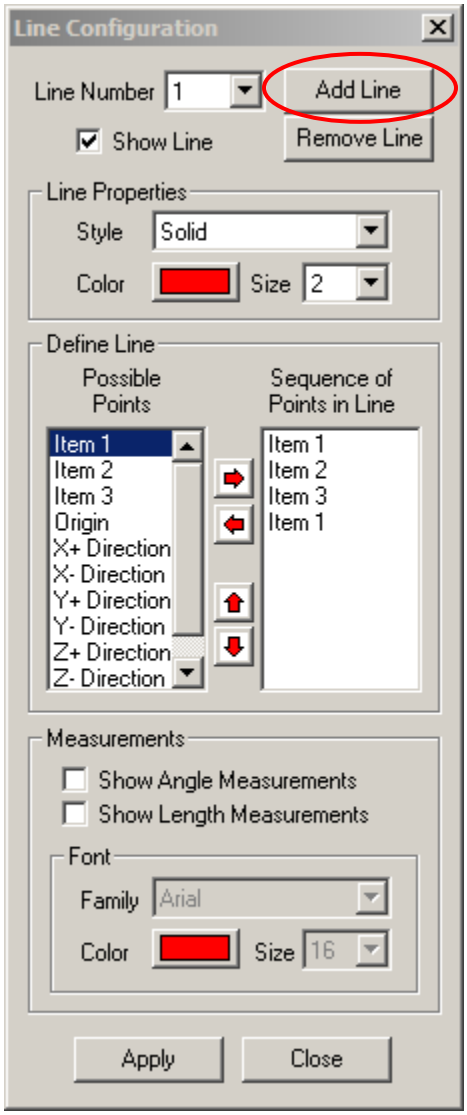

Figure 14. Line Configuration window

3. Now you can add and define a series of lines to connect the tracked points. Click **Add Line** and define the sequence of points in the line as shown in Figure 14.

4. Click the **Apply** button, followed by the **Close** button. The displayed points will now be connected with lines. 3-D length and angle calculations are available for any line sequence. To display these measurements, click the appropriate check box for the sequence in the Line Configuration window before you click Apply and Close.

5. To make the plot easier to see, a number of options can be enabled within the graph window. Click the **Graph Sources/Options** icon to open the 3-Axis Graph Sources/Options tool palette. Under **Options**, select **Fixed** from the **Axes** menu choice to open the Additional Graph Options window.

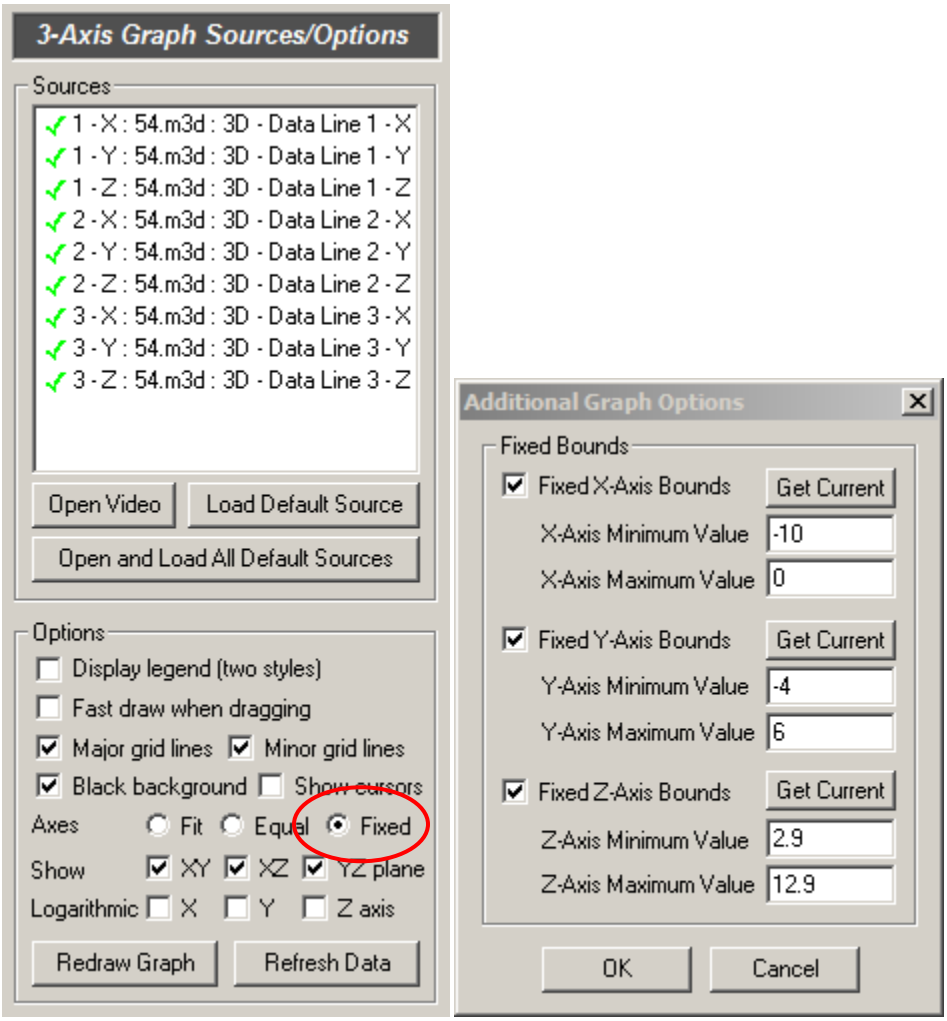

Figure 15. 3-Axis Graph Sources/Options windows

6. Click each **Fixed #-Axis Bounds** checkbox and 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 **OK** to close the window.

7. Finally, select **Show Current** from the Show Points dropdown list at the bottom of the window and press the ▶ button at the bottom of the graph window to see the motion of the tracked features as shown in Figure 16.

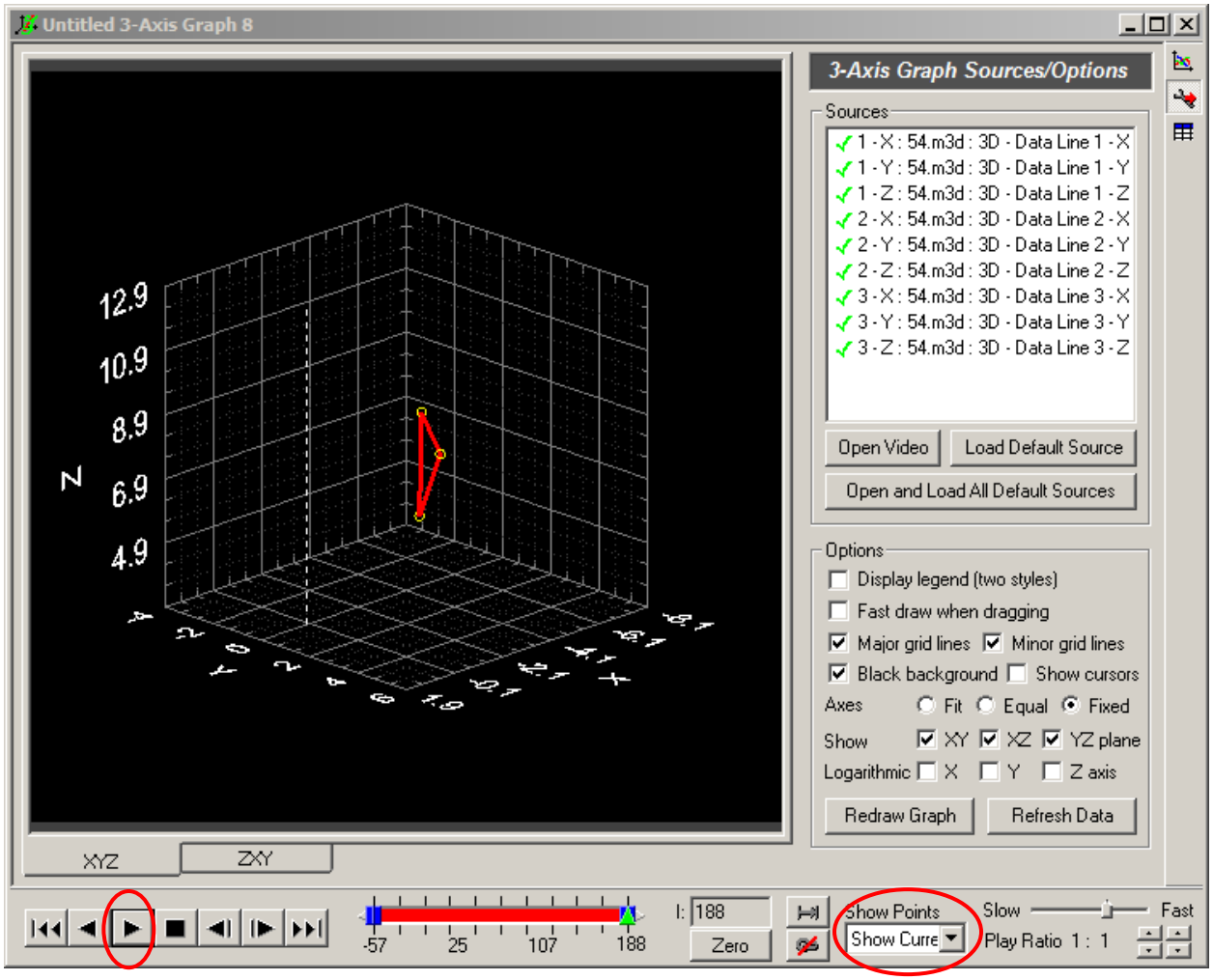

Figure 16. Motion of tracked features

Additional Practice

After you have mastered the basics of 3-D tracking for the three features of the robot as described in this tutorial, try adding and tracking additional features for further practice. Figure 17 shows the graph of the robot with additional features tracked.

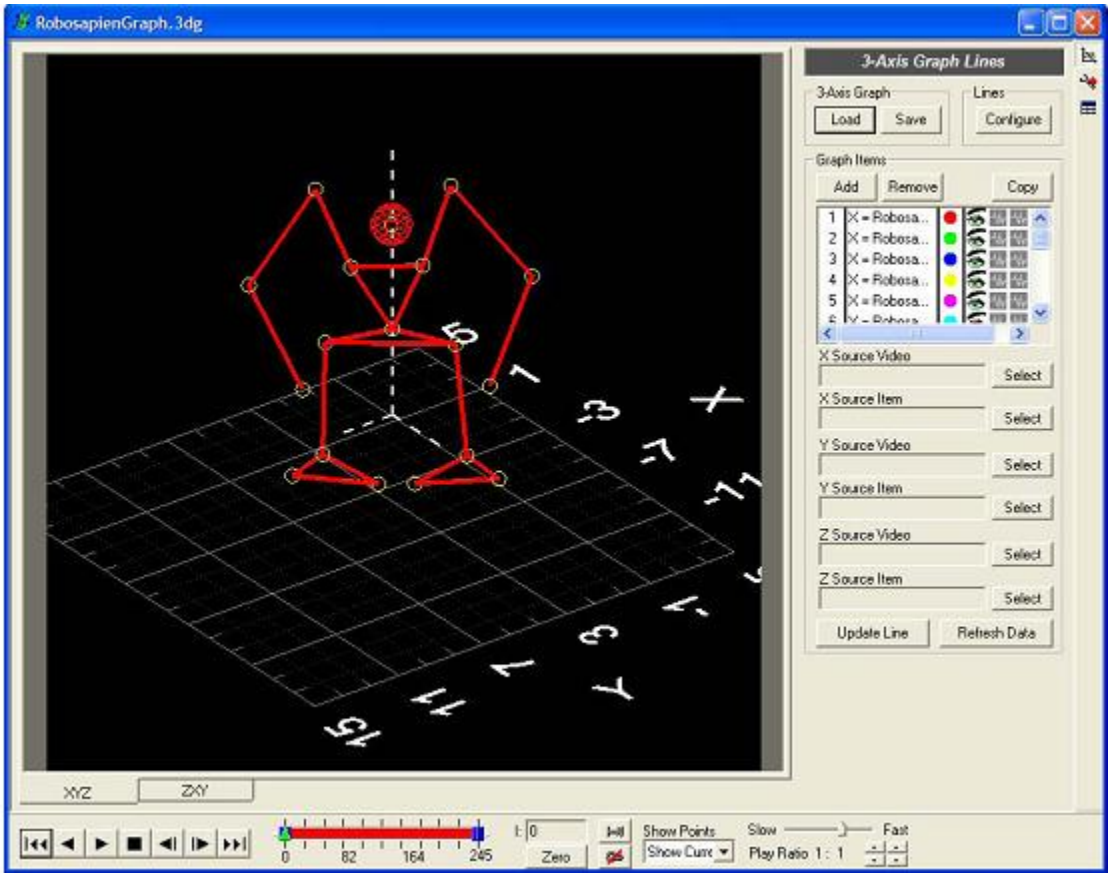

Figure 17. 3-D graph of robot with additional tracked features

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