



Tracking Particles in a Flow Environment

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Abstract

This tutorial describes in detail ProAnalyst's ability to count, size, and analyze particles as they move through a video sequence. A basic understanding of *ProAnalyst*, including project management and interface navigation, is necessary to make full use of this tutorial. If you have not already done so, it is recommended that you complete the ***Learning to Use ProAnalyst*** tutorial before proceeding any further, as the concepts discussed here will build upon that foundation.

Topics Covered in This Tutorial

1. Filtering an Image
2. Tracking and Computing Statistics of Particle Flow
3. Data Filtering

Files Needed for This Tutorial

1. *spray_bottle_droplets.avi*

ProAnalyst Toolkits Needed for This Tutorial

1. ProAnalyst, Professional Edition
2. Particle Counting and Sizing Toolkit

Filtering an Image

To isolate desired image features, it is often necessary to apply a series of image processing filters to a video sequence. In the case of the droplets emitted from the spray bottle (Figure 1), 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.

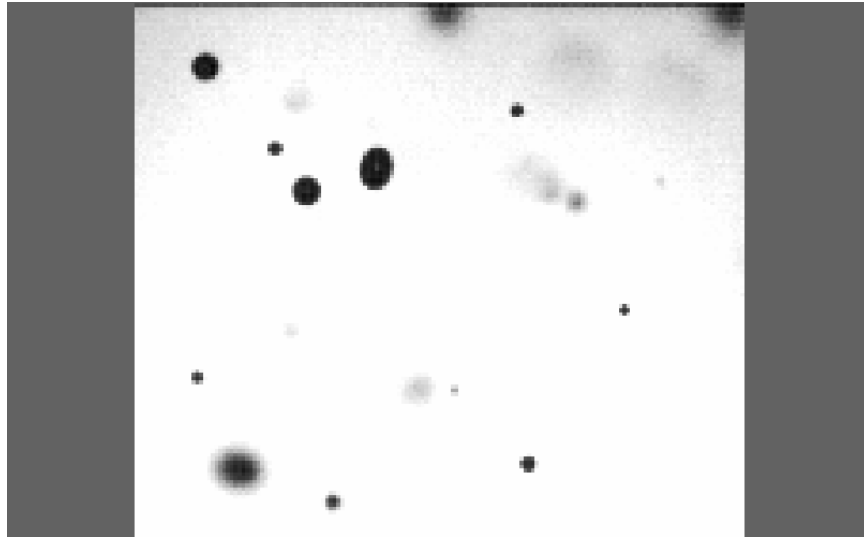



Figure 1

1. Create a new *ProAnalyst* Project and add the *spray_bottle_droplets.avi* video to the new project.
2. Open the **Image Filtering** control panel by clicking the  icon on the **Analysis Modules/Tools** toolbar.
3. Click the **Add** button to open the filter selection window.
4. Select the “**LUT → Reverse**” filter, and click the **OK** button.

- The **Reverse** filter reverses the pixel values of an image, in effect creating a “negative” of the image (Figure 2). The rationale for using this filter is that, logistically, 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. The **Reverse** filter simplifies this task considerably.

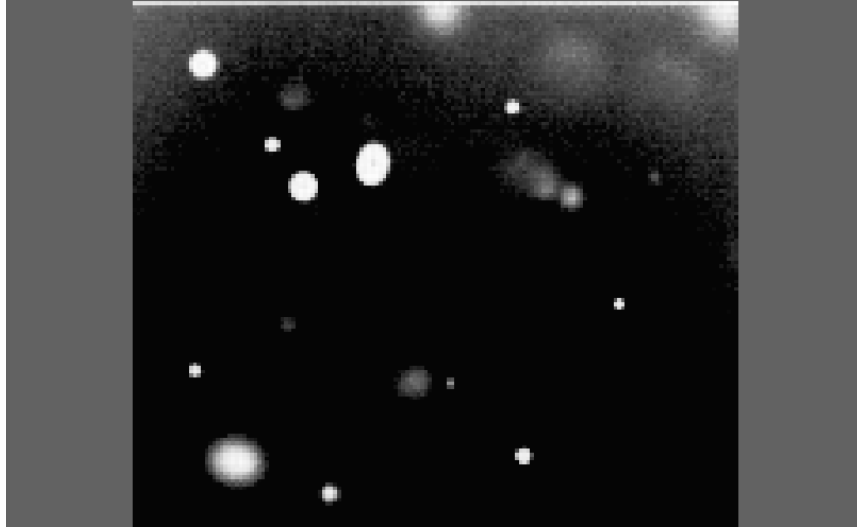


Figure 2

- Repeat steps 3-4 to apply a “**Common → Threshold (Binary)**” filter. Do not change the filter’s default settings.
- The **Threshold** operation is an effective tool for isolating bright objects on a dark background, as well as removing background noise (Figure 3). The **Threshold** filter did not remove the bright strip across the top of the image, however. Another filter will be necessary to accomplish this operation.

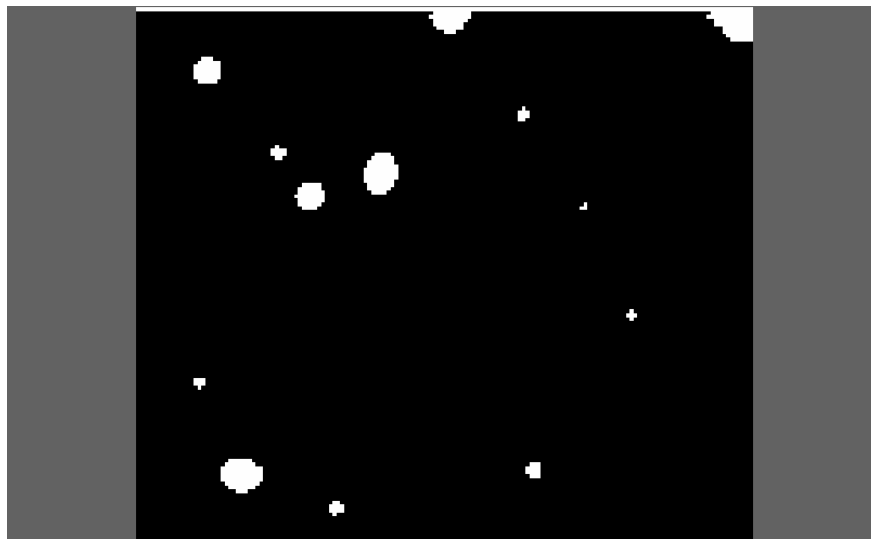



Figure 3

8. Repeat step 3-4 to apply a **“Common → Zero Border”** filter. This filter creates a black border around the edge of an image.
9. Click the  icon to open the filter settings dialog box.
10. 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 set the **“Top Border”** value to 1.
11. Click the **Apply** button, followed by the **OK** button.
12. With the application of the **“Zero Border”** filter (Figure 4), the video image is now ready for particle tracking.

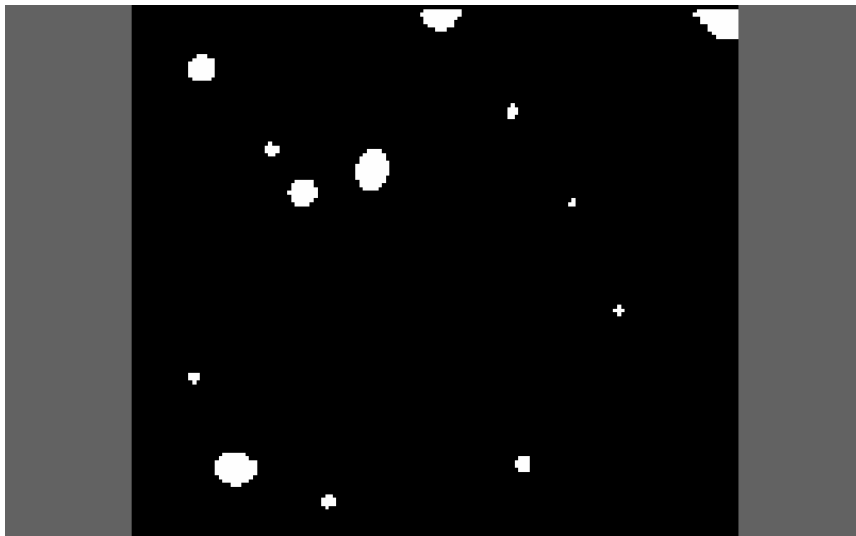



Figure 4

Tracking and Computing Statistics of Particle Flow

1. Click the  button located on the **Analysis Modules/Tools** toolbar to open the **Particle Tracking** control panel.
2. Click the **Enable** button at the top of the control panel to activate the particle tracking functions.
3. 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 (Figure 5).

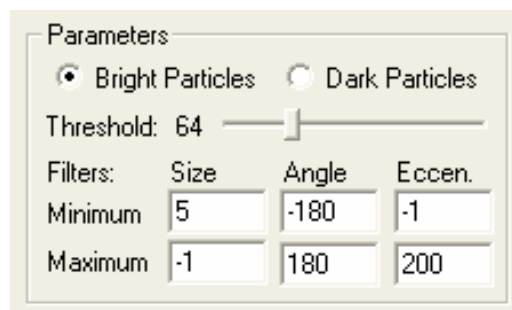


Figure 5

4. Click the Label field, located in the **Display** frame, to uncheck it (Figure 6).

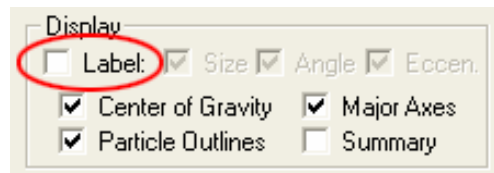


Figure 6

5. Press the **Track Forward** button to begin the particle tracking operation.

- As the video advances frame by frame, ProAnalyst will outline any particles that fall within its defined parameters (Figure 7 shows Frame 38 of the *spray_bottle_droplets.avi* video).

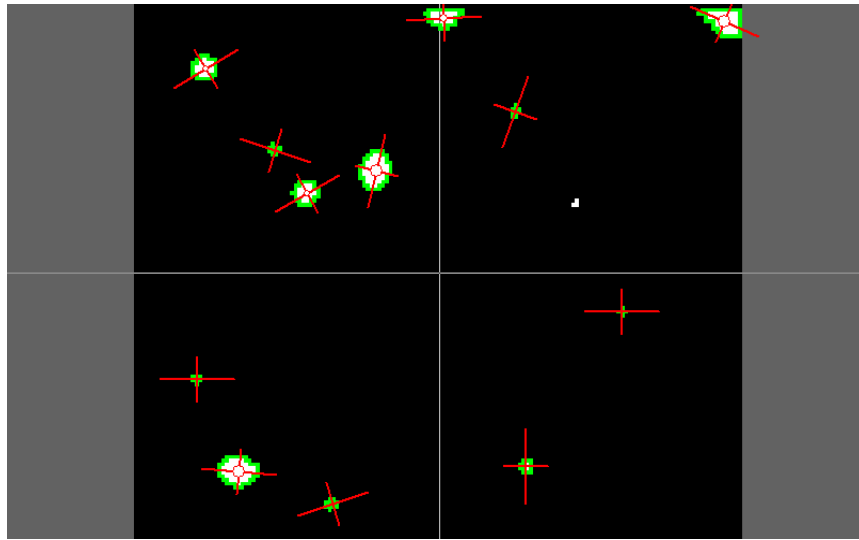


Figure 7

- Click the **Raw** video tab to view the results of the particle track against the unprocessed video image (Figure 8).

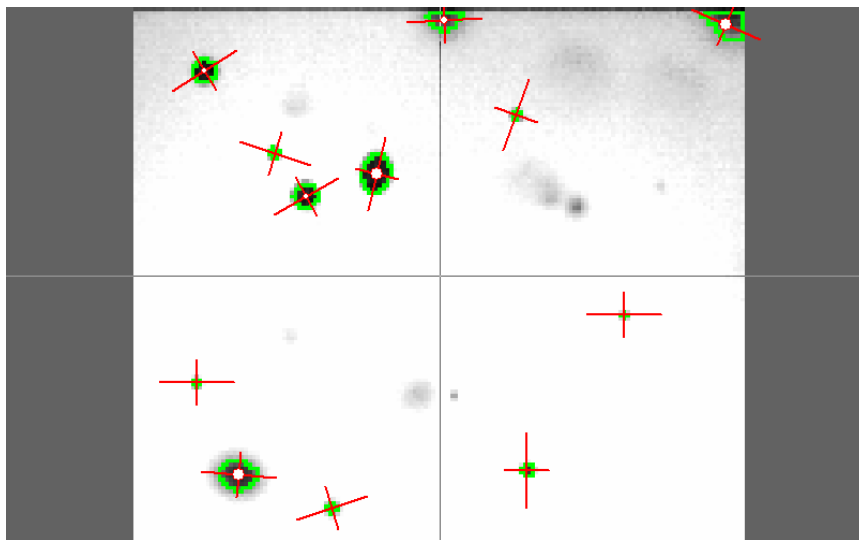



Figure 8

Data Filtering

In addition to displaying data and analysis results, ProAnalyst is equipped with a series of filtering operations for the performance of such operations as noise removal. 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.

1. Click the  icon to open the **Graph Configuration** control panel.
2. Click the **Add** button.
3. Select **Particle** → **Num Particles** from the dialog box.
4. Click **OK**. The graph pane will now display a plot of the number of particles detected in each frame (Figure 9).

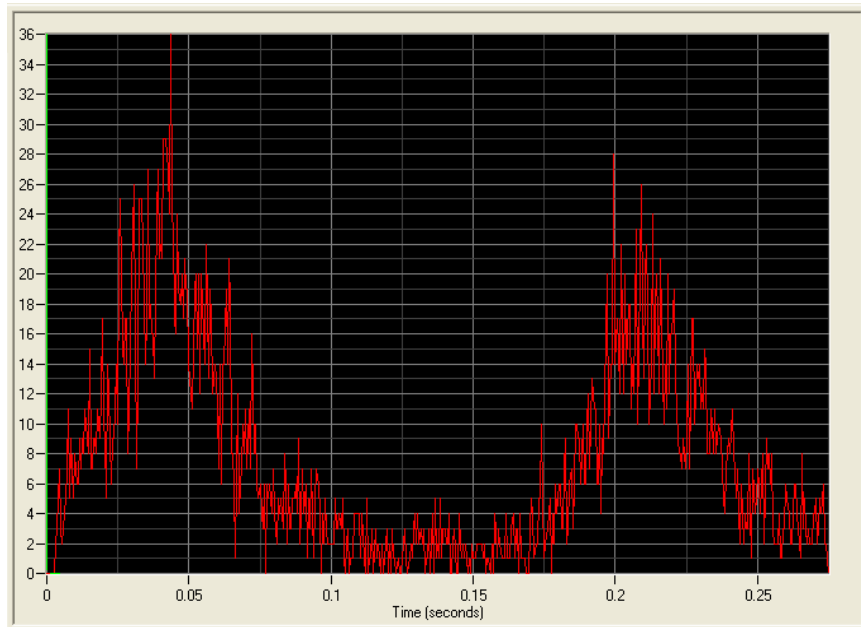



Figure 9

5. Select the “Particle – Num Particles” channel in the Graph Lines list and click the  icon to open the Graph Line Filtering window.
6. Click the checkbox labeled Enable Filtering.
7. Click the **Add** button to create a new data filter.
8. Select the “Empty Filter” item (Figure 10).

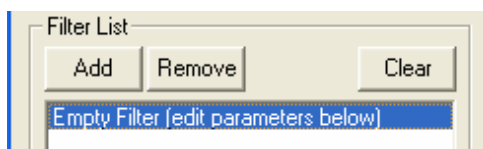


Figure 10

9. 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 11).

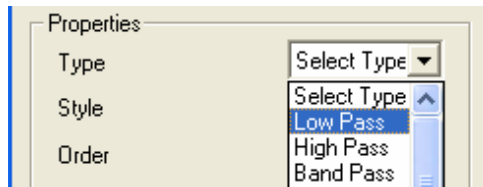


Figure 11

10. Selecting a Filter type will activate the next dropdown menu, **Style**. From this menu select a Butterworth filter (figure 12).

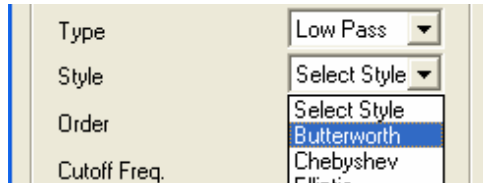


Figure 12

11. 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 13).

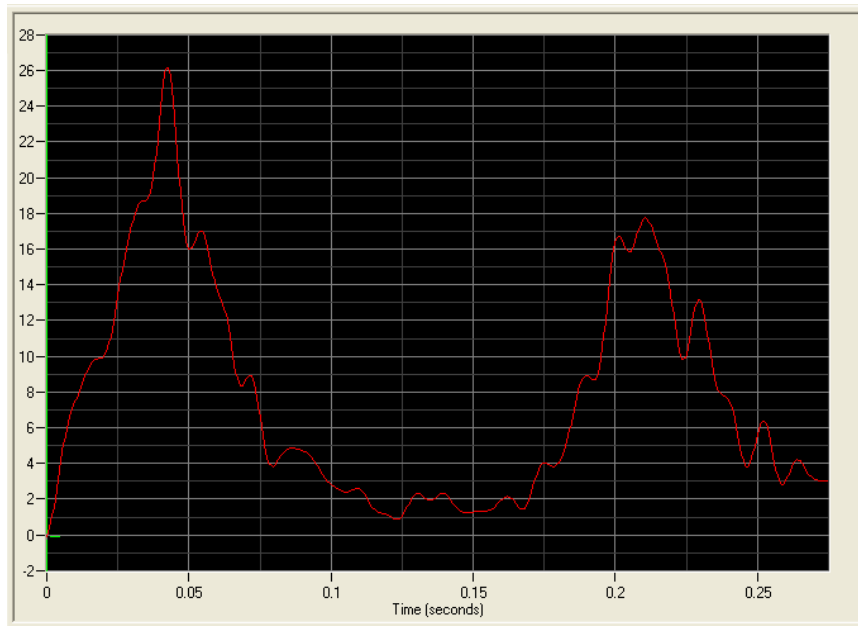


Figure 13

12. It is possible to compare the filtered graph with an unfiltered version of the same data. To do this, start by adding a new channel by clicking on the **Add** button.
13. Repeat steps 3 – 4 to select and display another plot of the number of particles in each frame.

As graph lines are drawn in the order in which they are added, it is very likely that the filtered plot will be almost completely obscured by the unfiltered version of the plot (Figure 14). This can be fixed by removing the filter from Channel 1, and applying it to Channel 2 instead.

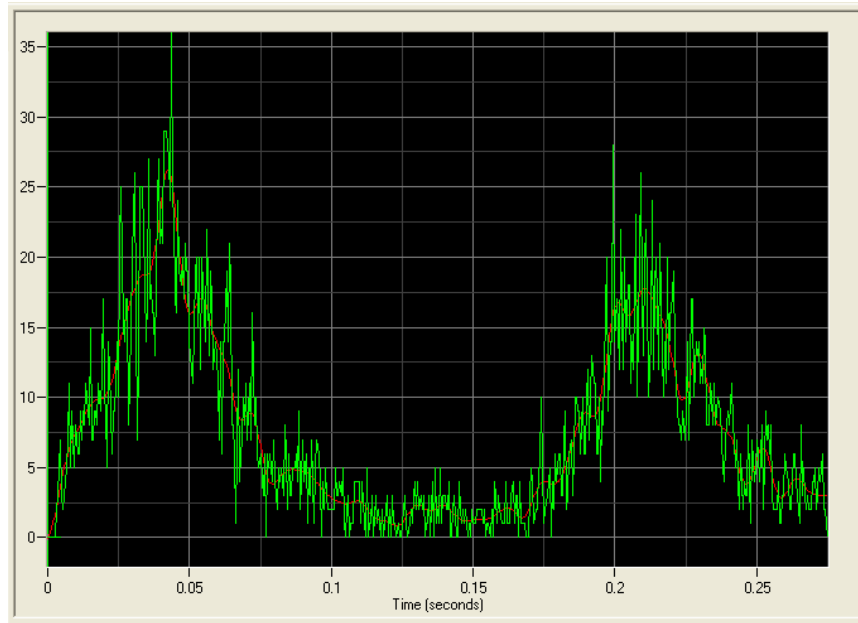


Figure 14

14. Repeat step 5 to open the Graph Line Filtering window for Channel 1.
15. Uncheck the Enable Filtering box, then click the **Apply** and **Close** buttons.
16. Open the Graph Line Filtering window for Channel 2.
17. Repeat steps 6 – 11.
18. You should now see a visually less confusing plot of both the raw and filtered graph data (Figure 15).

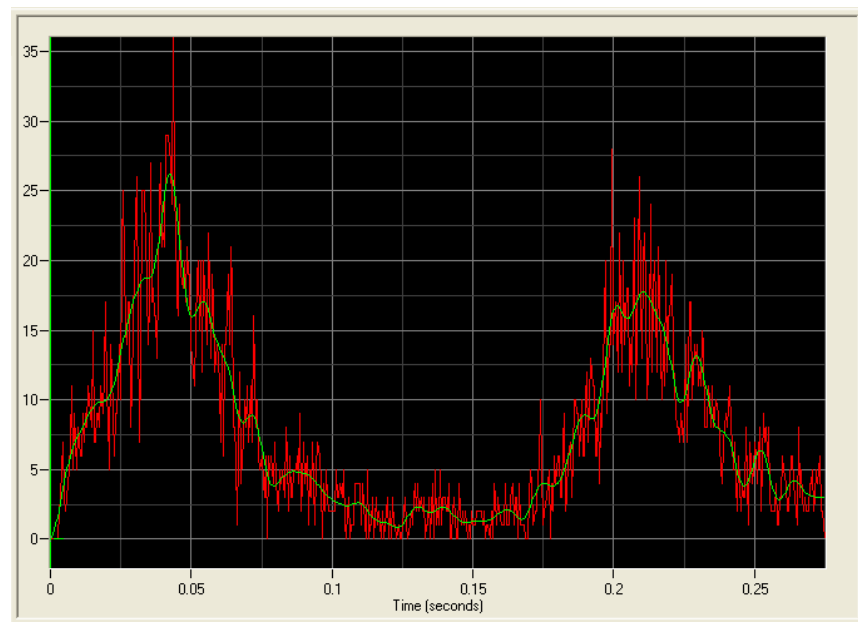


Figure 15