FROM MOTION TO DATA TO KNOWLEDGE

Tutorial

Tracking Particles in a Flow Environment with ProAnalyst®

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Abstract

This tutorial describes 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. The topics discussed in this tutorial will be filtering an image, tracking and computing statistics of particle flow and data filtering.

Files Needed for this Tutorial

Click here to download these files.

spray_bottle_droplets.avi
Particle_Tracking.mpj

ProAnalyst Toolkits Needed for this Tutorial

ProAnalyst, Professional Edition
Particle Counting and Sizing Tool

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 as shown on the following page in 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.

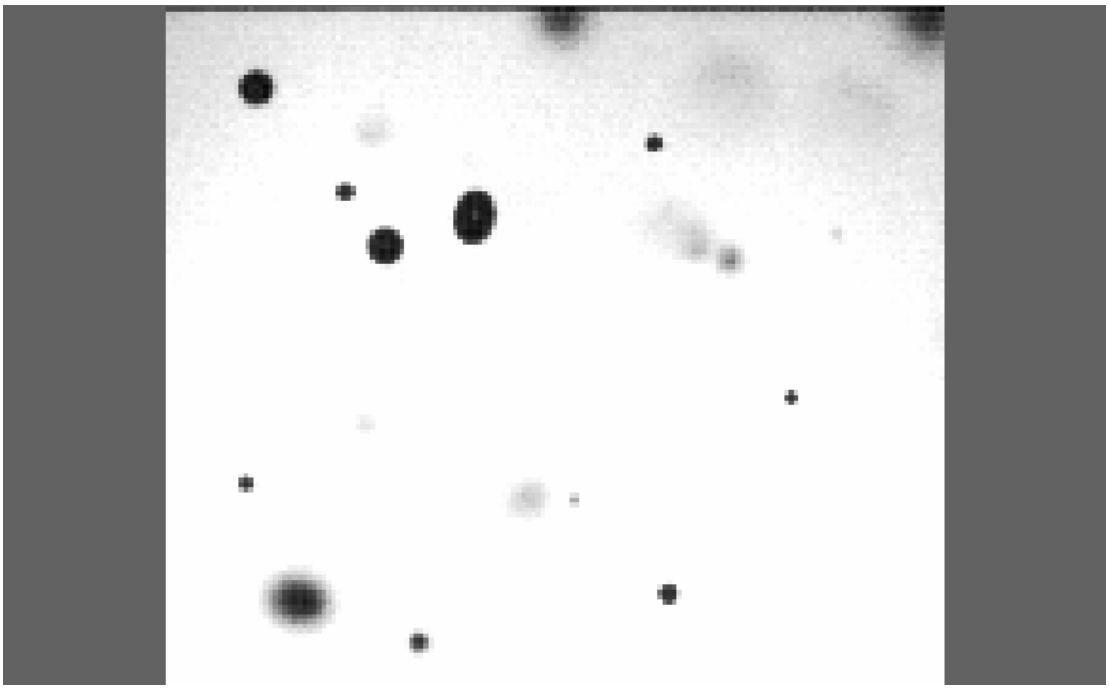

Figure 1:

1. Open ProAnalyst and create a new ProAnalyst project. 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.

5. The **Reverse** filter reverses the pixel values of an image, in effect creating a “negative” of the image as shown below in 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.

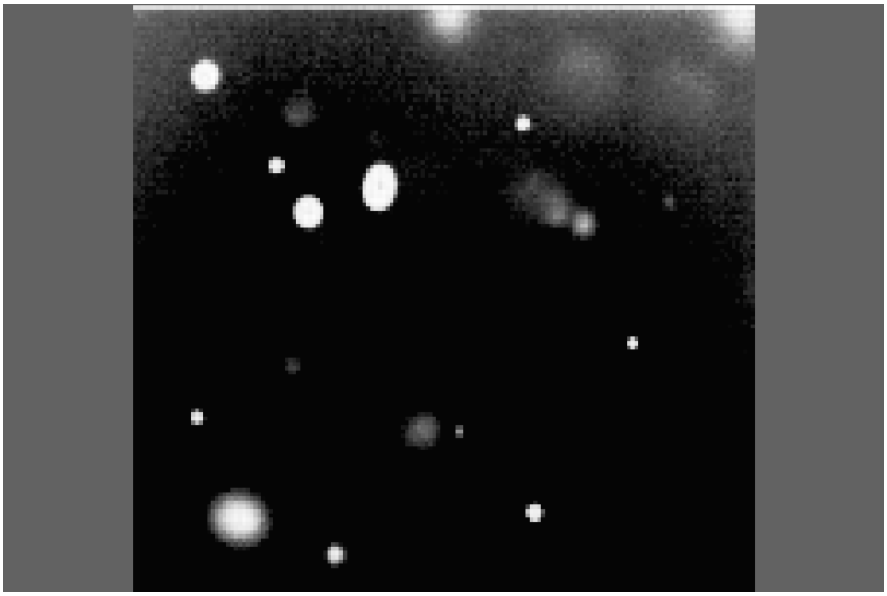

Figure 2:

6. Repeat steps 3-4 to apply a **Common --> Threshold (Binary)** filter. Do not change the filter’s default settings.

7. The **Threshold** operation is an effective tool for isolating bright objects on a dark background, as well as removing background noise as shown below in 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.

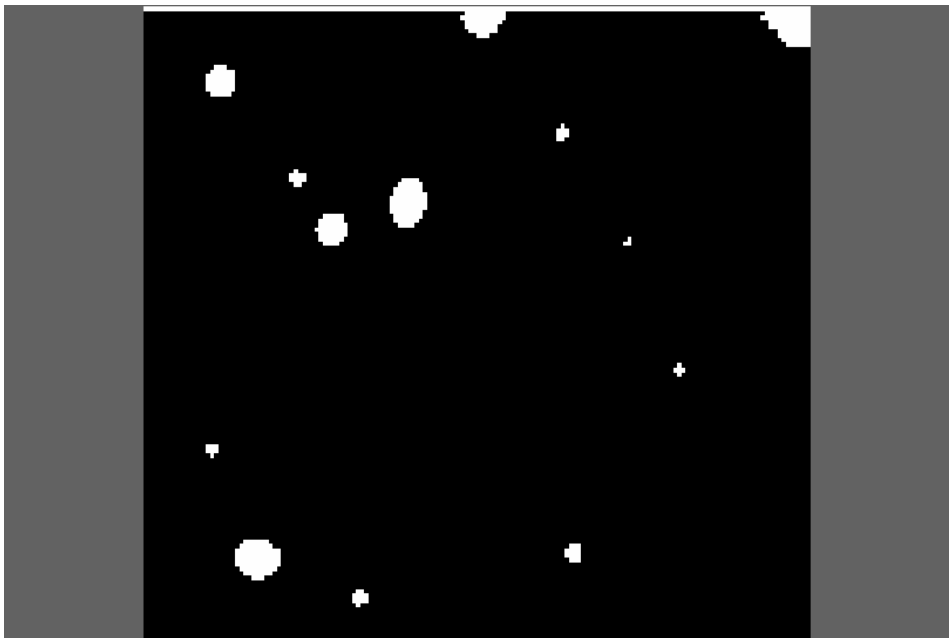

Figure 3:

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 **Wrench** 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 as shown in Figure 4 on the following page, the video image is now ready for particle tracking.

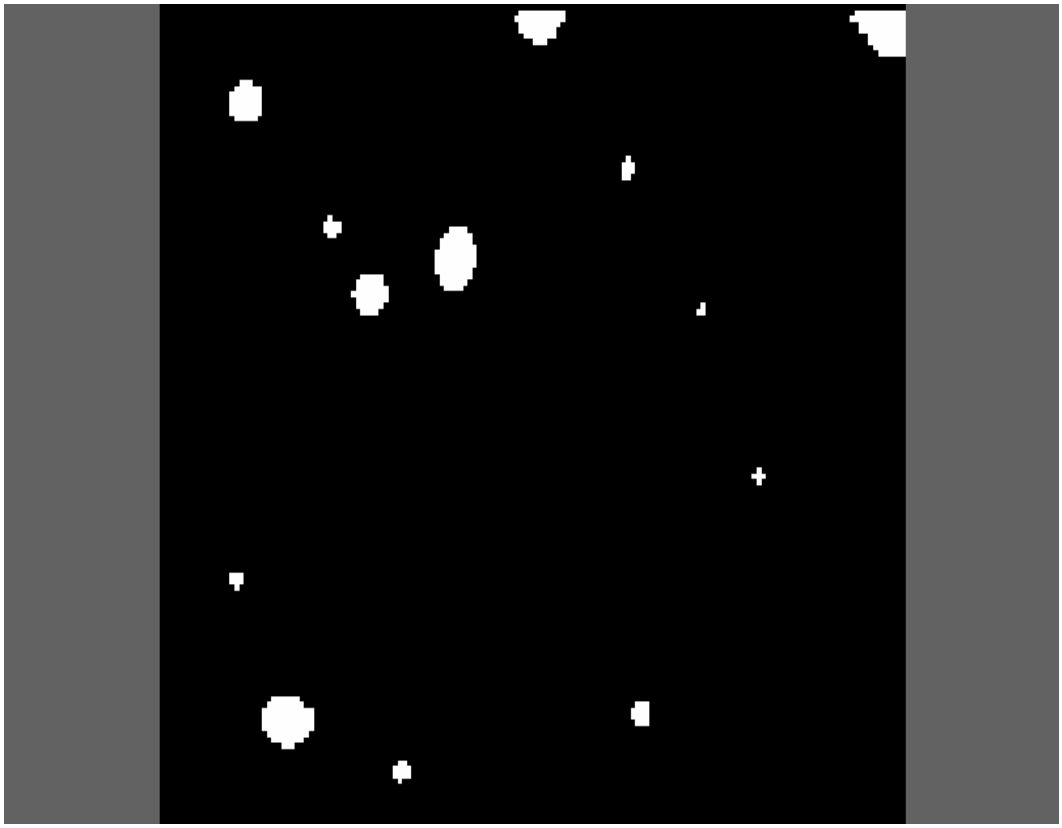

Figure 4:

Tracking and Computing Statistics of Particle Flow

13. Click the button located on the Analysis Modules/Tools toolbar to open the Particle Tracking control panel -

14. Click the Enable button at the top of the control panel to activate the particle tracking functions.

15. 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 as shown below in Figure 5.

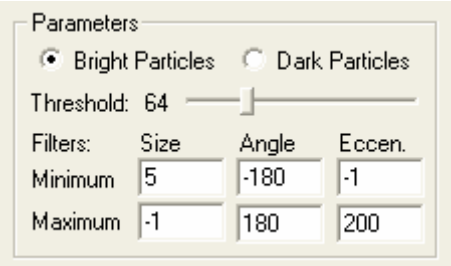

Figure 5:

16. Click the Label field, located in the Display frame, to uncheck it as shown below in Figure 6.

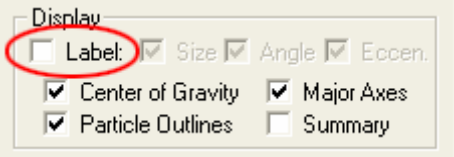

Figure 6:

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

18. As the video advances frame by frame, ProAnalyst will outline any particles that fall within its defined parameters as shown below in Figure 7.

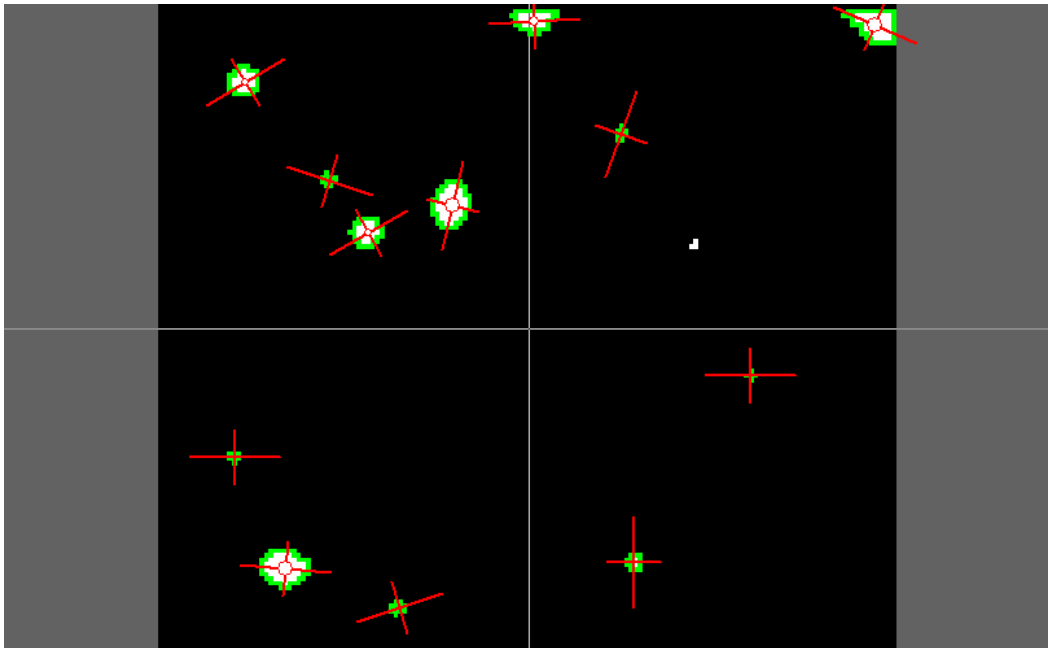

Figure 7:

19. Click the **Raw** video tab to view the results of the particle track against the unprocessed video image as shown below in Figure 8.

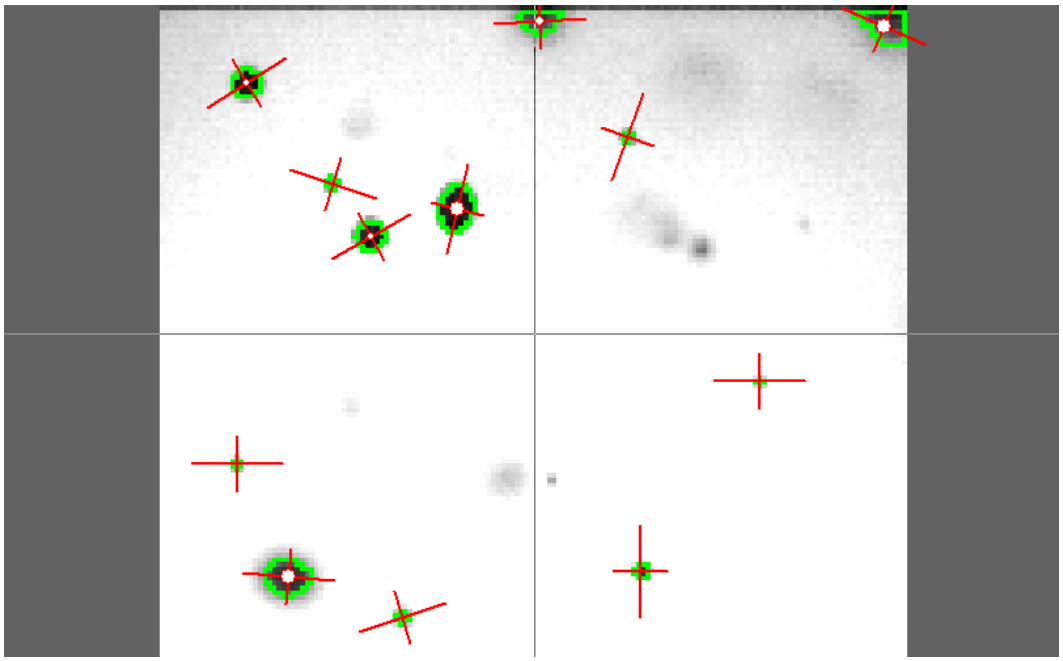

Figure 8:

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.

20. Click the icon to open the Graph Configuration control panel -

21. Click the Add button.

22. Select Particle --> Num Particles from the dialog box.

23. Click OK. The graph pane will now display a plot of the number of particles detected in each frame as shown below in Figure 9.

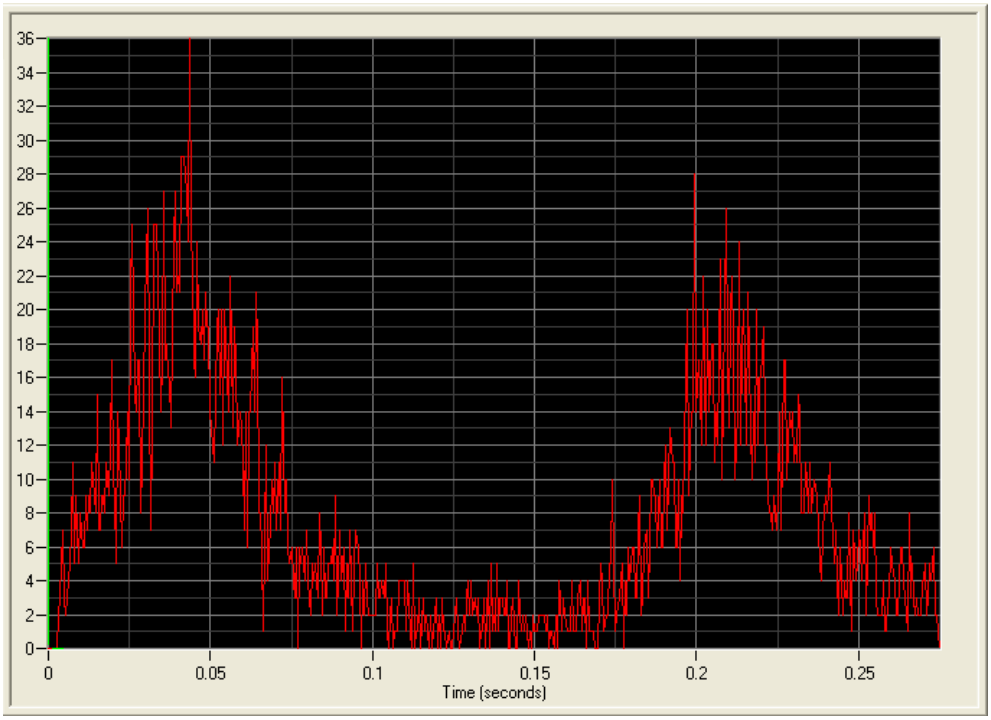

Figure 9:

24. Select the **Particle – Num Particles** channel in the **Graph Lines** list and click the icon to open the **Graph Line Filtering** window -

25. Click the checkbox labeled **Enable Filtering**.

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

27. Select the **Empty Filter** item as shown on the following page on Figure 10.

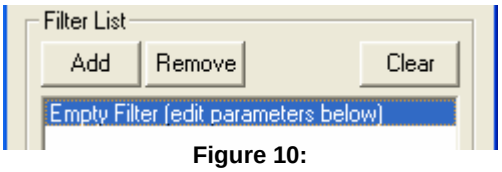

Figure 10:

28. 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 as shown below in Figure 11.

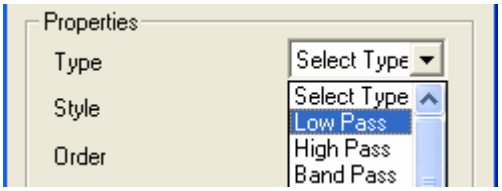

Figure 11:

29. Selecting a Filter type will activate the next dropdown menu, **Style.** From this menu select a **Butterworth** filter as shown below in Figure 12.

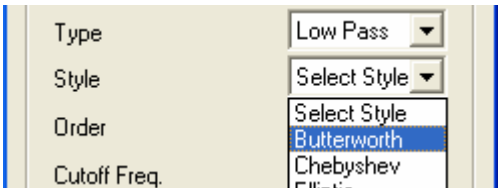

Figure 12:

30. 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 shown below in Figure 13.

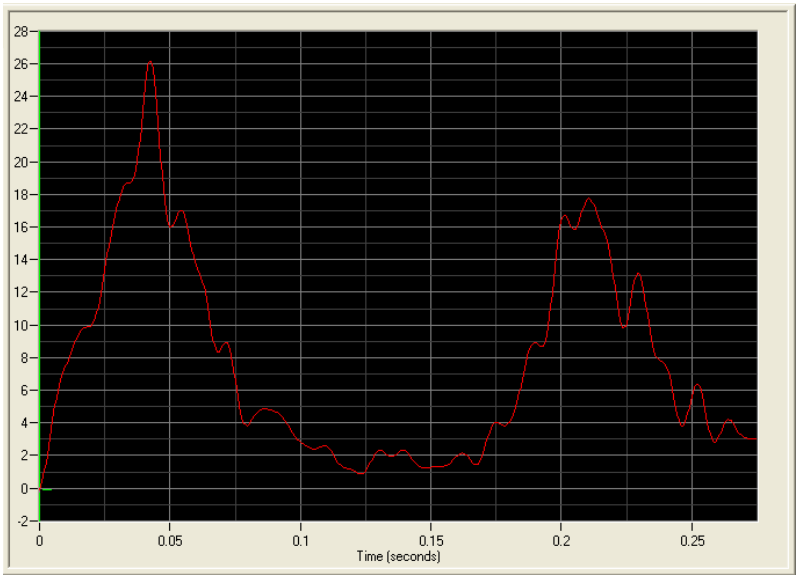

Figure 13:

31. 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.

32. Repeat steps 22 – 23 to select and display another plot of the number of particles in each frame.

Note: 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 as shown below in Figure 14. This can be fixed by removing the filter from Channel 1, and applying it to Channel 2 instead.

33. Repeat step 24 to open the Graph Line Filtering window for Channel 1.

34. Uncheck the Enable Filtering box, then click the **Apply** and **Close** buttons.

35. Open the Graph Line Filtering window for Channel 2.

36. Repeat steps 25 – 30.

37. You should now see a visually less confusing plot of both the raw and filtered graph data as shown on the following page in Figure 15.

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