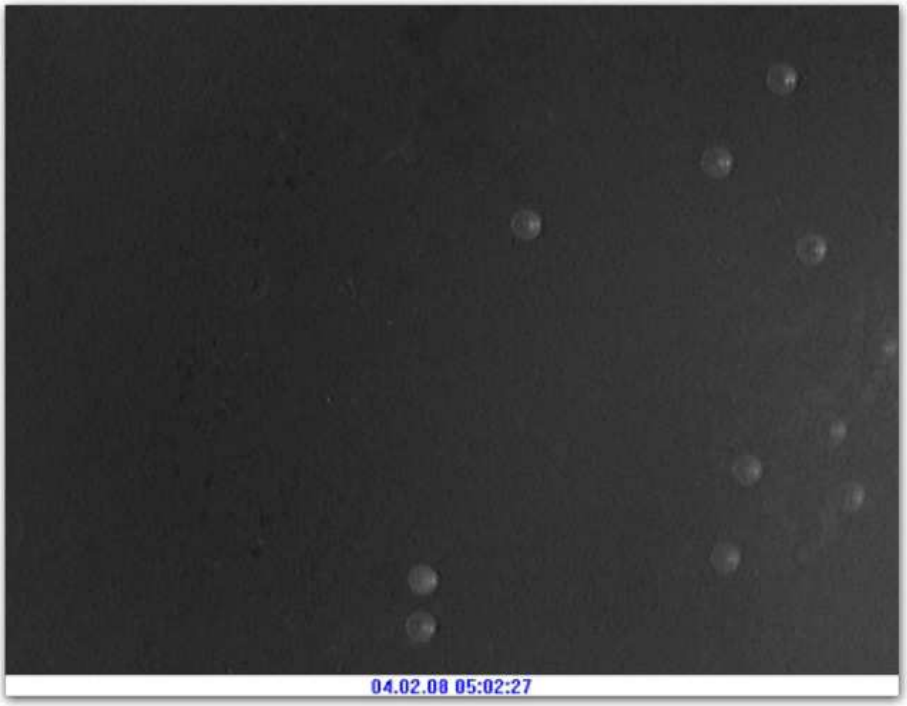
5.3.2.
USE CASE: TRACKING OBJECTS

This use case illustrates the steps to track objects within your image series using the Analysis Pipeline.

The solution will be based on adequate preprocessing of the image data followed by threshold based segmentation and tracking operations. The Analysis Pipeline especially supports you with an easy experimentation environment, where you can freely customize and combine specific analysis operators to your specific need.

The example dataset is a dataset consisting of 33 single images representing Arcella movement. The objective is to track the movement of the arcellas, calculate appropriate statistical data and visualize the results.

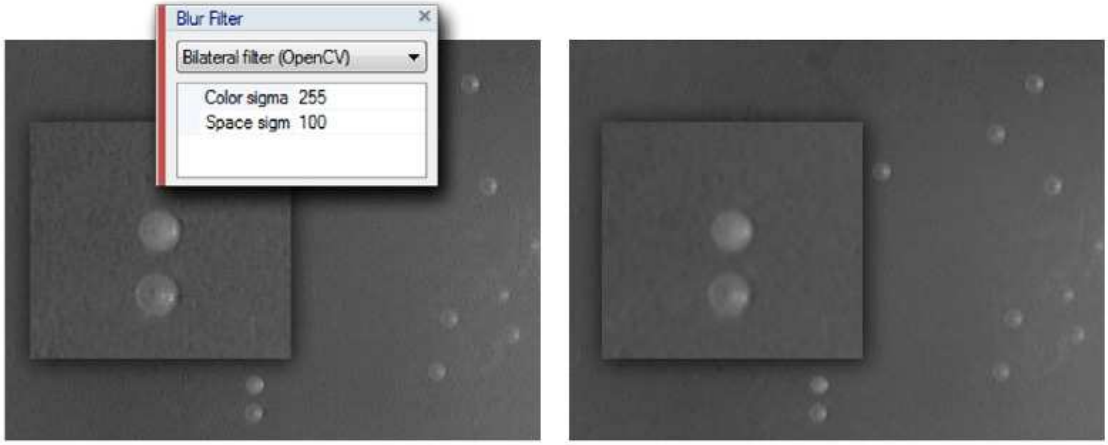


Arcella tracking - Example frame
(data origin: Martin Feike, Rostock)

1. PREPROCESSING

Before starting to trace tracks the images have to be prepared for adequate analysis results. Usual steps include applying blurring or sharpening filters or correcting illumination artefacts.

1. **Select viewport as input**.
   Because you want to experiment with calculation intense filters it might be a good idea to start working on a small portion of image data and not the complete stack. Hence, for quickly experimenting with filter parameters and adjusting them to your data it's a good idea to choose `Viewport`in the Selection Box of the Selection operator.
2. **Add Edge-Preserving Filter**.
   Add a new "Blur Filter" operation to the pipeline and choose "Bilateral Filter" to reduce noise while keeping relevant edge information. Experiment with different parameters by simply pressing the next and previous buttons in the pipeline control bar or by pressing CTRL-Z to undo the last execution step.



Applying Bilateral Filter
(data origin: Martin Feike, Rostock)

3. **Add Illumination Filter**.
   Add a new "Blur Filter" operation to the pipeline and choose "Background Correction" to equalize illumination artefacts. Experiment with different parameters by simply pressing the next and previous buttons in the pipeline control bar or using undo.

Applying Background Filter
(data origin: Martin Feike, Rostock)

4. **Add Histogram Filter**. Add a new "Other Filter" operation to the pipeline and choose "Rescale Range" or "Adaptive Histogram Filter" to equalize the histogram regarding on your data. Stretching the histogram enables you to ease the process of segmentation.

Preprossing your image data has high influence on the quality of the following analysis steps. You should always try design a pre-processing pipeline that emphasizes the objects of your interest and makes them easily segmentable. Filters you could try in addition to the already mentioned ones are morphological filters (erosion, opening, closing) or contour filters (Sobel, Canny). You find them in the Operator Gallery provided by the arivis Analysis Pipeline.

2. FINDING SEGMENTS

1. **Add Segmentation Operator**.
   A segmentation operator will create Volumes that can be used for tracking or analyis tasks by following pipeline operations. Simply Add a new "Threshold" operator to the pipeline (double click) and use the step button in the pipeline control bar to step towards this operator (the current operator is always marked with a triangular marker in the beginning of the headline.
   When the Threshold operator is active (and hence all preceding filters were applied to the image data) you can use the pipette or the provided slider control to define a threshold value and choose the appropriate inclusion method ("select above"). The current segmentation is visualized in the current viewer and gives immediate feedback on the results.

After executing a segmentation opeator, the Analysis Result window will display the result of the segmentation.

2. **Create Segment Annotations**.
   To visualize the segments after using the segmentation operator you could create annotations that can be stored with your image data even after the current analysis experiment. Add a "Create Annotations" operator to the Analysis pipeline by simply double clicking it in the Operator toolbox. Choose "Create Annotations" for Segments.
3. **Add Volume Filter**.
   To filter the detected volumes based on size you need to add Add a Volume Attribute Filter to your pipeline and choose "Surface Area" and

The calulated sizes depend on the currently set pixel size. Use the `data > Set pixel size...` menu option to change the X, Y or Z sizes of your image data. Use the magic wand or measure tools to get an impression of sizes in you data.

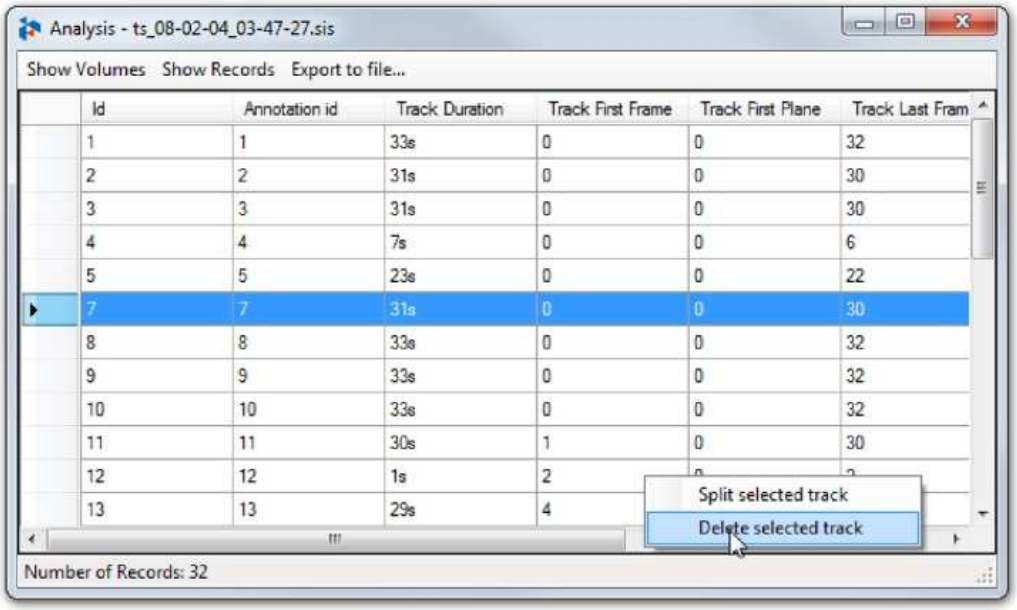
Alternatively, you could always run the analysis pipeline an let it create annotations for you. Use the Viewer Settings from the 2D Viewer to adopt the visual appearance of annotations. The next run of an experiment will ask you wheather to delete formerly created annotations.

3. TRACKING AND REPORTING

1. **Selecting correct image area**
   Change the current selection (first operator) from "Viewport" to "Document". All filters will now be applied to whole document. The tracker operation requires segments for all timepoints and layers of your image data.

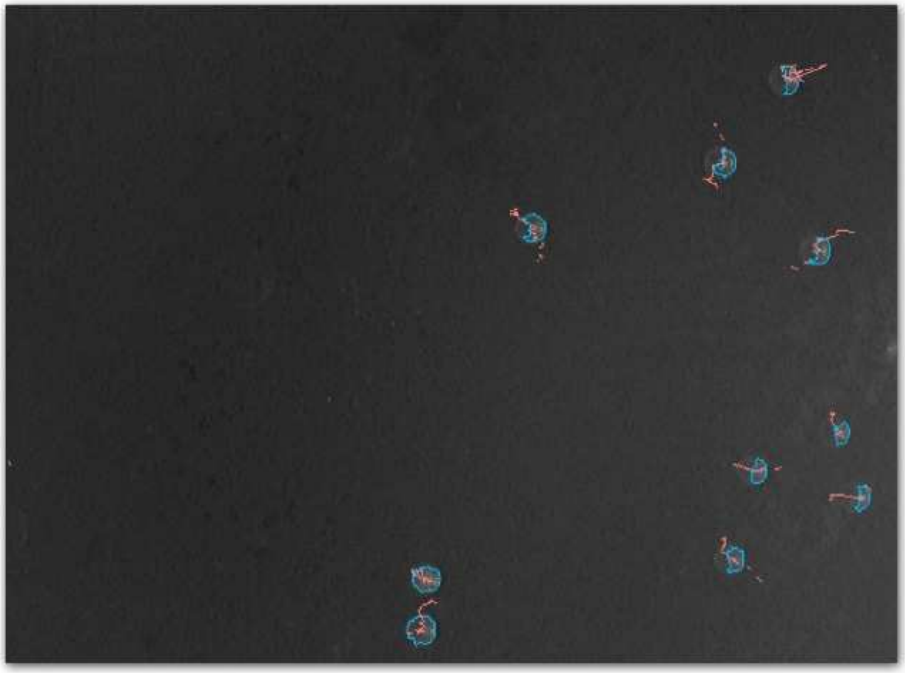
Use "Custom" selection to ignore disturbing portions (e. g. statistical burn-ins) while analysing the data. You could start with the "Viewport" setting and resize the viewport to the desired extend. After changing to the "Custom" setting the top, left, width and height parameters are re-used an you just need to adopt the frame selection to you requirements.

2. **Add Tracker**
   Add a Tracker operation to the pipeline and configure it to use the correct minimal distance (in µm). You could decide to directly switch to a 4D Viewer when detecting 3D-Objects over time. For two-dimensional datasets the 2D Viewer provides adequate visualization of the tracks (You should create track annotations).
3. **Add Record Filter**
   To exclude falsly detected tracks you could simply add a record filter on the track duration or the track length parameters.
4. **Create Track Annotations**
   If you have already added the Create Annotations operator you could also select "Create annotations" for tracks if you want to visualize and persist your detected tracks with the image data.
5. **Create Attributes.**
   Add a Create Attributes operator to add various calculated fields to the Analysis report view. You could e. g. add the length and duration of tracks or the surface area of single detected segments to the Analysis Report.



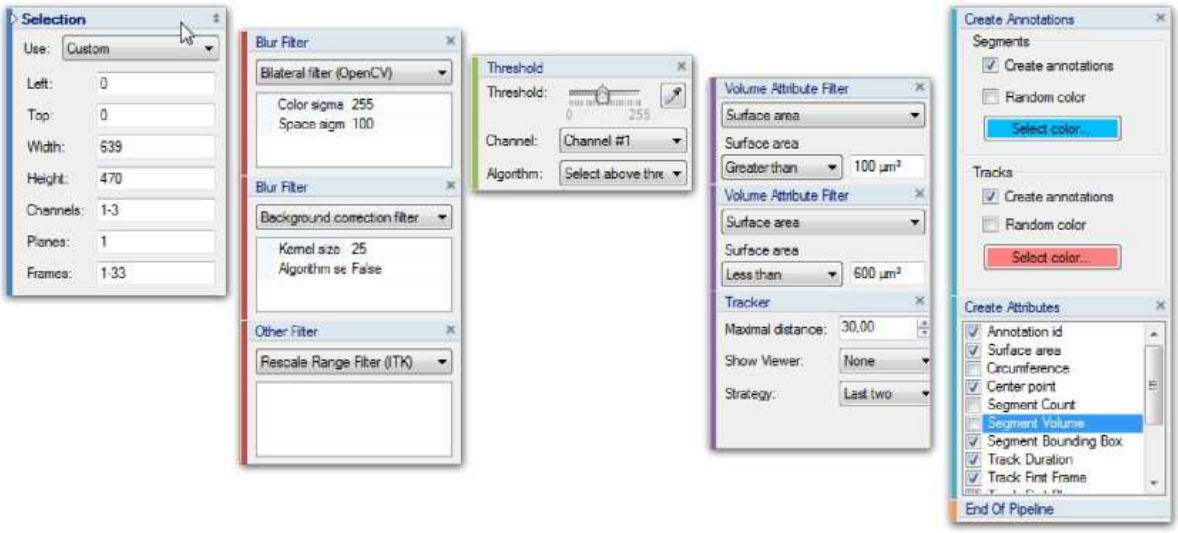
Analysis Result
(data origin: Martin Feike, Rostock)

6. **Exporting Results.**
   After running the pipeline the segment and track annotations are visible within you image data. Use the Navigator Palette or the Movie Player Palette to advance through time an see the segments move on the tracks. Export the Analysis Report by choosing "Export to File..." in the Analysis Report View.



Tracking results

The final pipeline for the described use case consists of the following operators and deonstrates a robust approach for detecting and tracking objects in "difficult" image data.



An example Analysis Pipeline for Tracking objects

Other related sections:

- Analysis Pipeline